THE HISTORY OF THE GREATER CASPIAN; THE LATE PLIOCENE BASINS OF THE CASPIAN

The present article addresses the Late Pliocene history of the Greater Caspian Basins: the system of pools that existed in lieu of the present-day Caspian Sea and the lowlands that surrounded it. The transgressive history of the Caspian was preceded by the long term regressive Balakhany Stage characterised by active accumulation of continental sediments and the deep incision of the river valleys linked to the low level of the Caspian troughs. The Akchaghil Time that replaced it was the greatest and longest transgressive epoch; the transgression covered a vast area from the Middle Volga Region to the piedmonts of Alborz, with the sea level reaching 100 m abs. alt., and with the diverse lithofacial composition of deposits characterised by the endemic mollusc fauna. Approximately 1.8 Ma BP, after a minor regression caused by the discontinuation of the marine water inflow, the Akchaghil Basin was replaced with the Absheron Sea. That was a landlocked brackish basin of the smaller dimensions with the lower (60–80 m abs. alt.) level but the as diverse facial composition of deposits and the sharply distinct mollusc complexes. Termination of the Absheron transgression occurred at the very end of the Late Pliocene and coincided with the considerable climatic cooling when the first glaciers emerged in the northern part of the Russian Plain.

Keywords: the Greater Caspian, Balakhany, Akchaghil, Absheron, development history.

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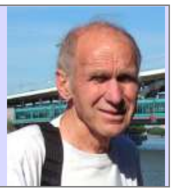

Introduction

By the Greater Caspian we mean the system of pools that existed in the Late Pliocene – Pleistocene in the place of the present-time Caspian Sea and the lowlands that surround it (Figure 1).

The Caspian Sea is located in the inner area of Eurasia, and is the largest closed pool on the planet. This unique pool extended from the piedmonts of Alborz to Vyatka and Kama, from the Black Sea to the Sea of Aral, and then restricted to the size of the Sea of Azov at different times in its existence period spanning over the 3.3 Ma. It is precisely the magnitude of level and area changes coupled with salinity and faunal composition alterations that make the Ancient Caspian sharply different from the history of the open marine basins.

The study of the Caspian Sea that was started by the academic expedition of the Russian Academy of Sciences in the mid-17th century has seen a great many scientific publications. There are many dozens of works dedicated to the newest history of the Caspian Sea alone; the most prominent among them were the works by N.I.Andrusov, A.A.Ali-Zade, K.A.Ali-Zade, E.N.Alikhanov, V.V.Bogachev, D.V.Golubyatnikov, O.K.Leontyev, N.Y.Zhidovinov, G.I.Karmishnaya, V.V.Kolesnikov, S.A.Kovalevsky, Y.G.Mayev, A.V.Mamedov, E.E.Milanovsky, D.V.Nalivkin, L.A.Nevesskaya, G.I.Popov, G.I.Popov, P.A.Pravoslavlev, G.I.Rychagov, A.G.Eberzin, A.A.Svytoch, P.V.Fedorov and V.L.Yakhimovich. Almost all these works are rather old: they were completed 70–50 years ago; however, as a rule, they are the most founded in terms of documentation. The extensive factual material on the geology of the Caspian Region was collected during the geological shooting and thematic researches by Hydroproject, Soyuzburgaz, the universities of Moscow and Saratov, the Institute of Water Problems of the Russian Academy of Sciences (RAS), the Palaeontology Institute of the RAN, the Oceano-

Figure 1. The Caspian Region; a space image

logy Institute of the RAS, the Southern Scientific Centre of the RAS and other organisations.

The interest in studying various aspects and issues of the geology and history of the Caspian Sea has been intensifying over the past two decades because of the high prospects of finding oil and gas fields in the offshore area as well as the coastal environmental problems caused by the sharp Sea level fluctuations over the 50 years past. There have been the numerous publications (Основные положения…, 1992; Невеская и др., 1997; Свиточ и др., 2002; 2010; 2012; Сиднев, 1985; Янина, 2005; 2012; Quanternary statigraphy…, 2010; Стратиграфия и седиментология нефтегазоносных бассейнов… и др.).

The colleagues from the Netherlands, Belgium, the UK, Azerbaijan, Kazakhstan, Iran and several other countries are taking an active part in the studies of the Caspian Region. The Russian-Dutch studies carried out under the international programmes INTAS 99-01-39 International Geological Correlation Programme (IGGP)-481 (S.Kroonenberg) were especially fruitful. The research findings were published and discussed periodically at various scientific conferences in Russia and abroad (IGGP-481; Final report INTAS 99-01-39, 2002; Dating Caspian Sea Level Change (2003–2007); IGGP-521; Black Sea — Mediterranean corridor during the last 30 ky et al.).

However, and despite the abundance of scientific publications on the Caspian, the main problem of its history, namely, the emergence and existence of a series of various pools ranging from an immense marine basin in the Akchaghil to the present-day closed lake, has remained understudied and accompanied by various contradicting solutions offered. One of the main reasons for the current situation is that there is no common and systematic description of the Greater Caspian basins' development history. And then, this work that was written on the basis of the author's long-term (1960–2012) observations done on all the Caspian coasts and on the basis also of the generalisation of the large library and fund materials is dedicated specifically to this subject-matter.

The Caspian Sea Level Fluctuations

The Caspian Sea is characterised by different order sharp level fluctuations just like all the major inland basins are. Such fluctuations are conditioned by various causes: hydrological, tectonic and so forth. The level of the Caspian Sea has changed constantly, with the varied amplitude and rate, during the whole long term development history of this basin.

The extensive geological, palaeogeographic, archaeological and historical literature on the Caspian and the level fluctuation records got at various coasts make evident the conclusion that the sea has the characteristic hierarchic structure of level fluctuations (Figure 2) where each fluctuation is the result of a whole range of conditions that either intensified or weakened the main trend in any given time span. The Caspian level fluctuations' classification given in the table builds on such criteria as the duration and amplitude of a specific event; this classification wholly reflects its Pleistocene rhythms as well as the rhythms of the Late Pliocene, though in a generalised and sketchy manner. The transgressions and regressions of the Caspian put together provide the high unit of fluctuations – a period (a class). Within it, the positive fluctuations of the transgression are grouped in the following sequence: stages – stadiums – phases – oscillations – convulsions. All put together, they represent the different order rhythms of the Sea level fluctuations. The transgressive stages and stadiums discussed below form the macro-rhythmics of the Caspian lasting over dozens and hundreds of thousands of years as well as the sea level rises by dozens of metres and more.

The Greater Caspian Basins

The long term history of the Greater Caspian has the clearly visible stage-by-stage development of its basins that differed substantially in terms of water environments and faunal composition but, none the less, represented one development period that started in the Akchaghil, was current in the Absheron and, later, in the Pleistocene and exists in the modern epoch (see the Table).

The Prehistory of the Greater Caspian (the Balakhany Time)

The Prehistory of the Caspian Sea corresponds to the long Balakhany Stage. It started with the deep regression of the Pontian basins and the beginning isolation of the Caspian from the Black Sea that lasted for over 2.5 Ma. According to the palaeomagnetic data, the accumulation of the Balakhany (Productive Series) deposits of Azerbaijan encompasses the lower part of the positive palaeomagnetic Gaussian epoch and the whole of the Gilbert epoch in the interval of 5.12 Ma–3.3 Ma (Зубаков, Кочегура, 1973; Исмаил-Заде и др., 1967; Сиднев, 1985). Most of the researchers (Гурарий и др., 1976; Певзнер, 1965; Трубихин, 1977 и т.д.) assign the beginning of the Akchaghil transgression to the beginning of the Gaussian epoch (3.3 Ma BP). Considering this, the duration of the Balakhany Age apparently did not exceed 2 Ma while the accumulation of the upper part of the Productive Series (the Surakhany Suite) occurred at the beginning of the Akchaghil transgression.

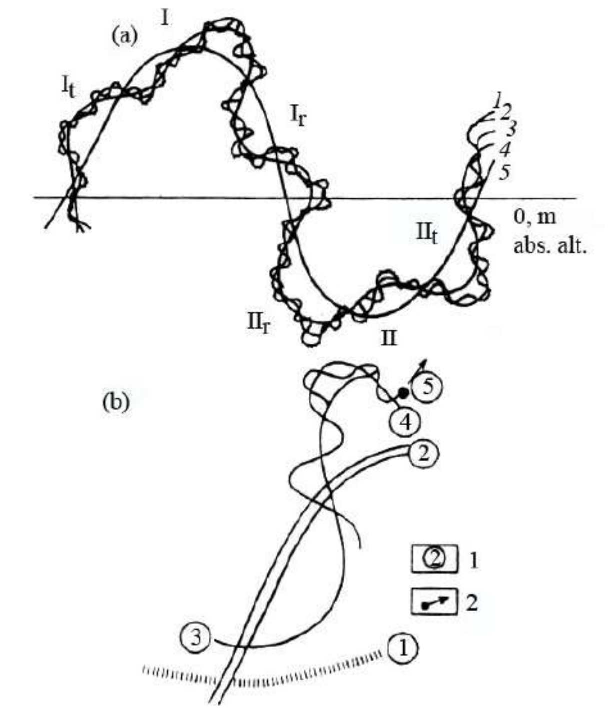

Figure 2. The Hypothetical Curve of the Sea level change of the different order (a). **1** — the transgressive stage (**I_t** — the transgressive phase, **I_r** — the regressive phase), **II** — the regressive stage (**II_r** — the regressive phase, **II_t** — the transgressive phase) microrhythmicity — convulsion **1** (the duration — ten of years – years); mesorhythmicity— oscillation **2** (the duration — thousands of years – hundreds of years) and the phase **3** (thousands of years), microrhythmicity — stage **4** (the duration — dozens of thousands of years) and stage **5** (the duration — hundreds of thousands – dozens of thousands of years). The position of the present-day Caspian Sea in the Post Khvalyn Rhythmicity (b). **1** — the rhythmicity of the Late Holocene-modern fluctuations (**1** — the post-Khvalyn regressive stage, **2** — the New Caspian transgressive stage, **3** — the Late New-Caspian transgressive phase, **4** — regressive oscillation, **5** — the positive convulsion); **2** — the position and evolution trend of the modern Caspian in the system of hierarchic series

The Systematics of the Transgressional-Regressional Rhythmics of the Caspian Basin

Periods	Transgression: Epoch	Transgression: Stage	Transgression: Phase	Regression
Caspian	Novocaspian	Novocaspian	Novocaspian	
				Izberbash
			Dagestan	
				Mangyshlak
	Caspian	Khvalyn	Late Khvalyn	
				Enotaevskaya
			Early Khvalyn	
				Atelskaya
		Khazar	Late Khazar	
				Chernoyarskaya
			Early Khazar	
				Singilskaya
		Baku	Urunjik	
				Venedskaya
			Baku	
				Tyurkanskaya
	Old Caspian	Absheron	Late	
			Middle (maximum)	
			Early	
				Domashkinskaya
		Akchagyl	Late	
			Middle (maximum)	
			Early	

The Balakhany Age is characterised by the intensive uplifts and dislocations of the Alpine structures that frame the Caspian on the South, namely, the Greater Caucasus and the Lesser Caucasus, the Talysh, Alborz and Kopetdag, and the subsidence of the adjacent structures: the Terek-Caspian, the Kura and the Prekopetdag depressions. The folding movements are also observed in the Absheron-Gobustan and Absheron-Prebalkhan areas and in West Turkmenistan.

There were two subsiding areas in the Caspian Sea depression to the North and the South of the Absheron Range with the faster subsiding South Caspian depression. There, the 3–4 km thick series of deposits were formed by drilling data.

The northern part of the Caspian Region limited by the South Urals and the Volga Upland in the East and the West was a vast lowland area open to the North, with a well-developed network of rivers and the erosion-accumulative and erosion-denudation relief conditioned by the tectonic structures and the latest activity of the platform structures of the Russian Platform's eastern part as well as by the Hercynides of the South Urals.

In the Balakhany Age, the relief of the Caspian Region had the characteristically deeply incised river valleys linked to the low level of the Caspian Basins (Кайнозой…, 1965; Плиоцен…, 1981; Милановский, 1963; Востряков и др., 1964; Сиднев, 1985; Али-Заде, 1961 и др.) (Figure 3). For instance, the vast (250×500 km) Balakhany Lake was filled with the sediments of the palaeo-rivers of Volga, Karyn-Zharyk, Uzboy, Araz, Samur, Kura, et al. that had the depth of incision equalling hundreds of metres. The Palaeo-Volga valley traced from Vetluga to the Absheron Range was especially grand in terms of its length and scale of incision that reached 300–350 m in the region of Saratov and 500–600 m where it reached the Precaspian Depression (Figure 3) and where the width of its valley exceeded 100 km (Милановский, 1963). The Palaeo-Volga sediments were first identified within the modern aquatic area of the Caspian on the Absheron Range by V.P.Baturin (1937) based on the similarity between the mineralogical composition of the Productive Series deposits and the modern Volga alluvium. Its valley was found at the depth of 2–3 km in the zone of faults, filled with the 0.2–06-km thick sediments with reliance on the geological materials (Гаджиев и др., 1984).

Various continental deposits were accumulated in the Balakhany Age that eventually formed the bed for the deposits of the Akchaghil transgression: the Productive Series sediments in Azerbaijan; the Red Series in West Turkmenistan; the Kinel Series in the Volga Region and the South Preurals; the Kushum sediments in the Precaspian; and the sub-Akchaghil sediments in the East Precaucasia.

The Productive Series is composed of rhythmically bedded sand – shale sediments of the large freshwater pool and flowing into it fluvial systems with the very high total thickness reaching to 8 km (Алиханов, 1978). These deposits unconformably overlie the Pontian and Sarmathian sediments.

The Red Series deposits (the Cheleken Suite) are the analogue of the Productive Series in West Turkmenistan. Those are the sand-shale sediments of the mostly deltaic origin and with the predominance of red colours; the thickness of the Cheleken Suite exceeds 2 km. (Али-Заде, 1957).

The Kinel deposits (Suite) are well-developed in the Middle Volga Region and in the South Preurals (Ананова, 1971) where they fill in the erosion palaeo-relief and structural depressions. In the stratotype region, the deposits fill in the channel of the Kinel River (the Palaeo-Kama) and consist of a series of alluvial, lacustrine-alluvial and lacustrine deposits of the various lithological composition ranging from the pebbles to ribbon-like clays and sits. Similarly to the deposits of the Productive Series, the age of the Kinel Suite is loger than the duration of the Balakhany Time to which only probably the lower part of the Suite corresponds (I–III the Chebenkov horizons (Яхимович, 1965)), while the upper part corresponds to the Early-Middle Akchaghil Age.

The deposits of the Kushum Suite are the age and genetic analogues of the Kinel deposits in the regions farther to the South, namely, in the Lower Volga Region and the North Precaspian (Жидовинов, Курлаев и др., 1966). Similarly to the Kinel formations, they occur in the erosion depressions of the Preakchaghil relief. The top of the sedimentary beds is hypsometrically located at -340 – -480 m while the base is at the -415 – -540 m. Composition-wise, the lower part of the succession is dominated by the rough boulder-pebbly and pebbly-sandy sediments; upward the section-sandy-shaly sediments.

As regards the NE Precaucasia (the Terek-Sunzhen Province, Dagestan, the Back Terek Plain), there, the upper part of the Sub-Akchaghil Series of the surface-water deposits probably pertains to the Balakhany deposits (Геология и нефтегазоносность…, 1957); that is mostly represented by pebbles, conglomerates and sandy shales with the thickness of up to 1.0 km and more.

Figure 3. The Diagram of the Late Pontian palaeo-valleys (?) – the Early Kimmerian and the retaining Kimmerian basins in the Caspian Sea and the North Precaspian (Милановский, 1963): **1** — the highlands and slopes of the Urals, the Central Caucasus and the Trans-Caucasus; **2** — uplands; **3** — aggradational plains; **4** — the Late Pontian (?) river palaeo-valleys – of the Early Kimmerian; **5** — the salty sea-lake; **6** — the boundaries of the Kimmerian basin in the South Caspian and the North Precaspian ; **7** — the Kimmerian Age rivers' deltas; **8** — wells and incisions' absolute marks; **9** — river flow directions

Judging by the composition of the Productive Series deposits, they are – with the exception of the deposits of the South Caspian and the Middle Caspian (?) basins – grossly dominated by the continental sediments: alluvial, deltaic, lake et al., whilst there are no proven large pool deposits there. Several researchers (Али-Заде, 1961; Попов, 1971; Сиднев, 1985) mentioned the presence of several vast desalinated basins in the Caspian Region in the Balakhany Age. For instance, according to A.Ali-Zade (1961), there was a gigantic fresh-pool akin in size to the maximum development of the Akchaghil transgression at the end of the Balakhany Age there. According to A.V.Sidnev (1985) there was a series of fresh-water polles towards the end of the Cimmerian (that is, in the Pre-akchaghil Age). None of those ideas are underpinned by factual material, while what factual material is had actually contradicts them. The presence of ancient pools should be proved by many factors, such as, existence of large isolated sinks filled with uniform deposits, which have constant laterally thickness, and are composed of the fine terrigeneous material that is characteristic of the vast shallow basins.

The relief of the bed of the Akchaghil deposits north of the Derbend Trough there are no major depressions that would correspond to the said pools. The Kinel and Kushum deposits are mostly forming the Preakchaghil erosion relief (Figure 4) and have the lithologically motley composition with the considerable content of the coarse-grained material. This is especially true of the Kushum deposits that only fill the palaeovalleys of the Volga and Ural rivers partly and have the predominant relatively coarse sandy-pebbly composition (Жидовинов, Курлаев, 1966) – very uncharacteristic of vast pools' sediments. Of course, there are fresh-water pool sediments in the non-continental Kinel Series, too, especially in its northern regions, but, judging by their intermittent occurrence; they correspond to small and landlocked basins.

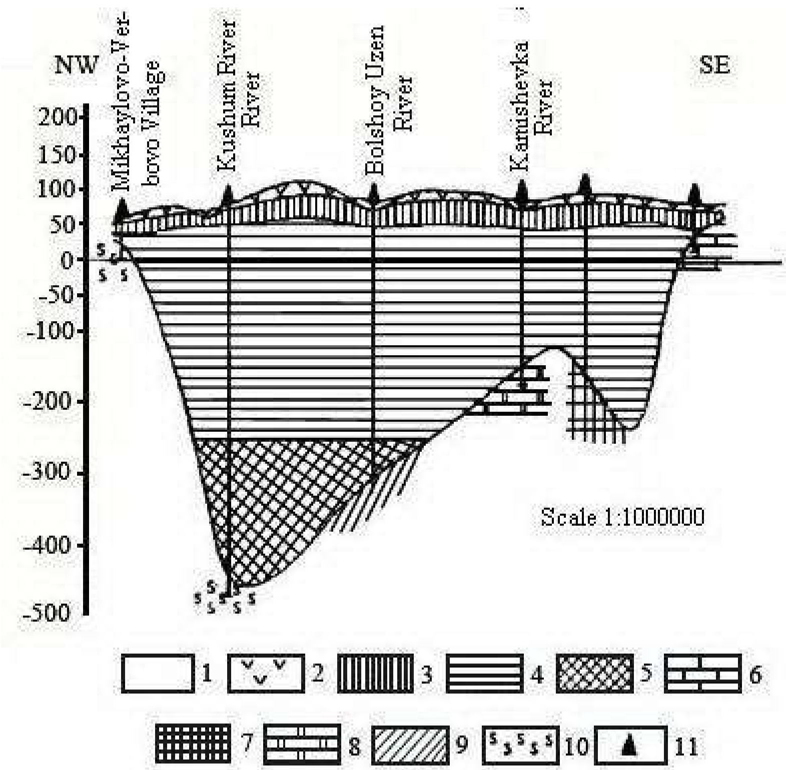

Figure 4. The cross-section via the Buried Volga Valley North of the Yershovo Village (towards the Kushum, Uzen and Kamyshevka rivers). **1** — the Khvalyn deposits; **2** — the dun clay loams; **3** — the Absheron deposits; **4** — the Akchaghil deposits; **5** — the Kinel deposits; **6** — the Upper Cretaceous deposits; **7** — the Lower Cretaceous deposits; **8** — the Jurassic deposits; **9** — the Triassic and Permian deposits; **10** — the Carboniferous deposits; **11** — wells (Vostryakov et al., 1964)

The Caspian Region's climate and vegetation were very diverse and had a sharp zonal differentiation in the Balakhany Age. N.I.Andrusov and D.V.Golubyatnikov presumed that in the South there was a hot semi-desert climate, which, in their opinion, is evidenced by the red colour of the deposits and their high gypsum content. Commenting on the remnants of warm climate vegetation as well as of the forest and steppe animals, S.A.Kovalevsky (1944) mentioned the presence of evergreen forests and warm-climate steppes in the SE Caucasus. To the North, in the Kushum deposits' dispersal areas, the beginning of their accumulation saw the steppes with the predominance of chenopodiacious phytocoenoses. The climate became warmer and moister in the Late Kushum Time; the steppe areas reduced in size but broad-leaved forests with the rich grass cover became widely occur.

The Kinel flora of the Middle Volga Region, the Back-Volga Region and the Precaspian belongs to the boreal coniferous forest type. The sharp zonation is observed in the vegetation occurrence from the South to the North that shows the transition from the open woodless landscapes to the pine woods and dark coniferous forests with the Tugai flora relicts (Квасов, 1966). The climate became more continental at the end of the Early Akchaghil (Preakchaghil) Age.

The clear zonation is noted in the Preurals, too (Плиоцен …,1981) where forest steppes and forb steppes dominated in the South, broad-leaved forests farther to the North and pine-fir forests with the inclusions of abies and hemlocks in the Lower Kama Region.

Thus, the Caspian Region was a vast continental territory with the diverse relief, climate and landscapes at the end of the Balakhany Age and on the eve of the Akchaghil transgression, that is, approximately 3 Ma BP. In the centre of the Caspian Region there was a longitude oriented Caspian Depression occupying 144,000 km^2 (Aladin, Plotnikov, 2006), while the southern part had a deep Trough – a large fresh-water pool (lake) that was subsiding actively and being filled with the Productive and Red Series' deposits.

The northern part of the depression was incised by the deep (hundreds of metres) river valleys running into the Balakhany Lake. The bounding piedmonts and high mountain systems of the actively-rising alpine structures of the Greater Caucasus, the Lesser Caucasus, the Talysh, Alborz and Kopetdag alternant with the deep intermountain and foredeep depressions (the Kura, the Precaspian, the Prekopetdag, the West Turkmen, etc.) were situated in the lowland territory's South, SE and SW, and opened to the Caspian Depression.

The vast northern regions of the Caspian Region: the North Precaspian, the Lower and the Middle Volga Regions, the Prekama and the South Preurals, limited by the Yergens and the Prevolga Upland in the West and by the Urals' piedmonts in the East and open towards the North, had the predominantly plain erosion-denudation relief with a well-developed network of river valleys that were filled with the Kinel deposits.

Importantly, the deep river valleys that are so characteristic of the Balakhany Age had only partly been filled with the Kinel and Kushum alluvial material by the beginning of the Akchaghil transgression (Figure 4). Consequently, the erosion relief that was levelled off by the Akchaghil and post-Akchaghil deposits eventually had been preserved by that time yet. It should be mentioned also that, with the sole exception of the South Caspian Lake, there were no major fresh-pools in the Caspian Region in the Balakhany Age. The climate of the territory was generally warm and moderately-warm; it was hot and arid in the SE, wet in the SW and wet and cool in the North, without any traces of abrupt cooling events that would bear evidences of glaciation of the adjacent northern regions.

The Akchaghil Stage (transgression)

The first, this is the greatest and the longest (~1,6 Ma) period in the history of the Greater Caspian that occupied a great territory from the Middle Volga Region and the Preurals to the piedmonts of Alborz, and extended from the Sea of Aral to the Pont at the end of Pliocene.

It is named after the Akchaghil layers that N.I.Andrusov (1889) identified in the sectionof the Ak-Chaghil Elevation in West Turkmenistan.

The limits of the basin. The area of the expansion of the Akchaghil transgression was first outlined by N.I.Andrusov (1902, 1911). The later researchers (Ковалевский, 1933; Колесников, 1940; 1950; Милановский, 1963; Найдин и др., 1992) concretised the boundaries of the Akchaghil Sea. The area of the Akchaghil Sea by (Aladin, Plotnikov, 2006) is equalled to 969.9,000 km^2.

One of the most detailed palaeogeographic schemes of the maximum of the Akchaghil transgression was drawn by A.Ali-Zade (1961) (Figure 5). It shows the presence of the three meridionally-extended pools: the major Central Caspian one and the smaller ones that were located western (the Pontian-Azov) and eastern (the Aral) of it and were connected to the Caspian via straits.

The basin was very vast (Figure 6). The Akchaghil transgression occupied large areas between the Yergens and the River Emba in the Volga Region in the northern part of the region. It reached far to the North, namely, to the mount of the River Belaya and the West Preurals, via the palaeo valleys of the Volga and the Kama (Figure 7). In the SE, the sea reached the Common Syrt, extended along the western slopes of the South Urals and filled the river valleys of the Ural, the Saghiz and the Emba. The transgression reached the South Preurals and the Aral Sea's depression. In the South, it encompassed the Cis-Kopetdag Downwarping and the southern part of the Kara Kum, and formed a spacious Kara Kum Bay northern of which the Manghishlak-Ustyurt Island Massif was located. In the South, the Akchaghil Sea was limited by the mountain systems of Alborz, Kopetdag, the Talysh Mountains and the Lesser Caucasus.

The big bays of the Akchaghil Sea were situated in the deep intermountain depressions along the Caucasian coast of the Caspian: the Kura, the Gusar and the Terek ones. To the West from the Back Terek Plain and via the Manych Gulf, the sea reached into the Azov-Black Sea region and, judging by the Akchaghil fauna discoveries near Gallipoli in the Dardanelles (Taner, 1982), it extended farther westward into the East Mediterranean.

The relief expression. The Akchaghil Basin is situated amongst the geomorphologically diverse territories that preconditioned the diverse structures of its coasts. In the NW, the abrasive slopes of the Yergens and the Prevolga Upland served as its coasts while the sea formed deep estuaries (via palaeo valleys) and flooded the lowlands of the Ural Plateau, the Common Syrt and the western slopes of the Sub-Ural Plateau (where there were the depression and ria shoreline types were present) farther to the North (Леонтьев и др., 1977). The character-wise akin coastlines are located farther to the NE, namely, in the valleys of the Uhil, the Saghiz and the Emba. The lowland aggradational shores of the Aral type existed in the Farthermost East of the poolin the Kizil Kum and Kara Kum sands, in the lower band of the Hungry Steppe and of the Kazakh small bald mountain area. To the West, on the border with Ustyurt and Mugajars, the shores were abrasive and abrasive-aggradational. There were islands in the active saline dome areas in the Precaspian Depression (Inder, Chelkar, Bogdo, Elton, et al.).

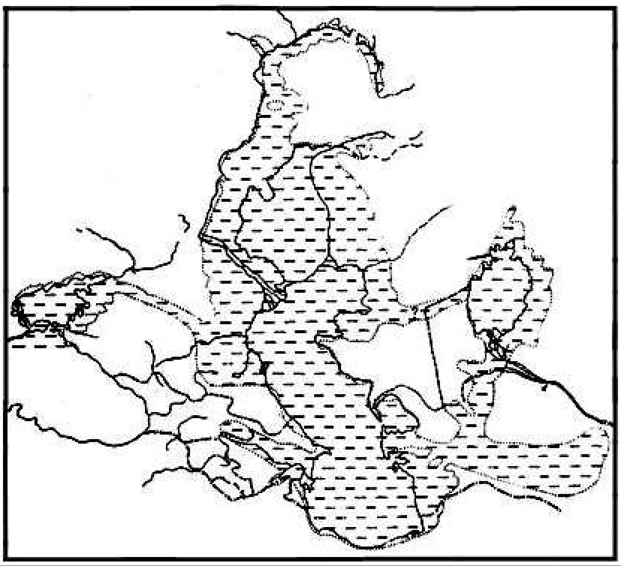

Figure 5. The Palaeogeographic Map of the Akchaghil Basin for the Upper Akchaghil Time (A.Ali-Zade, 1969)

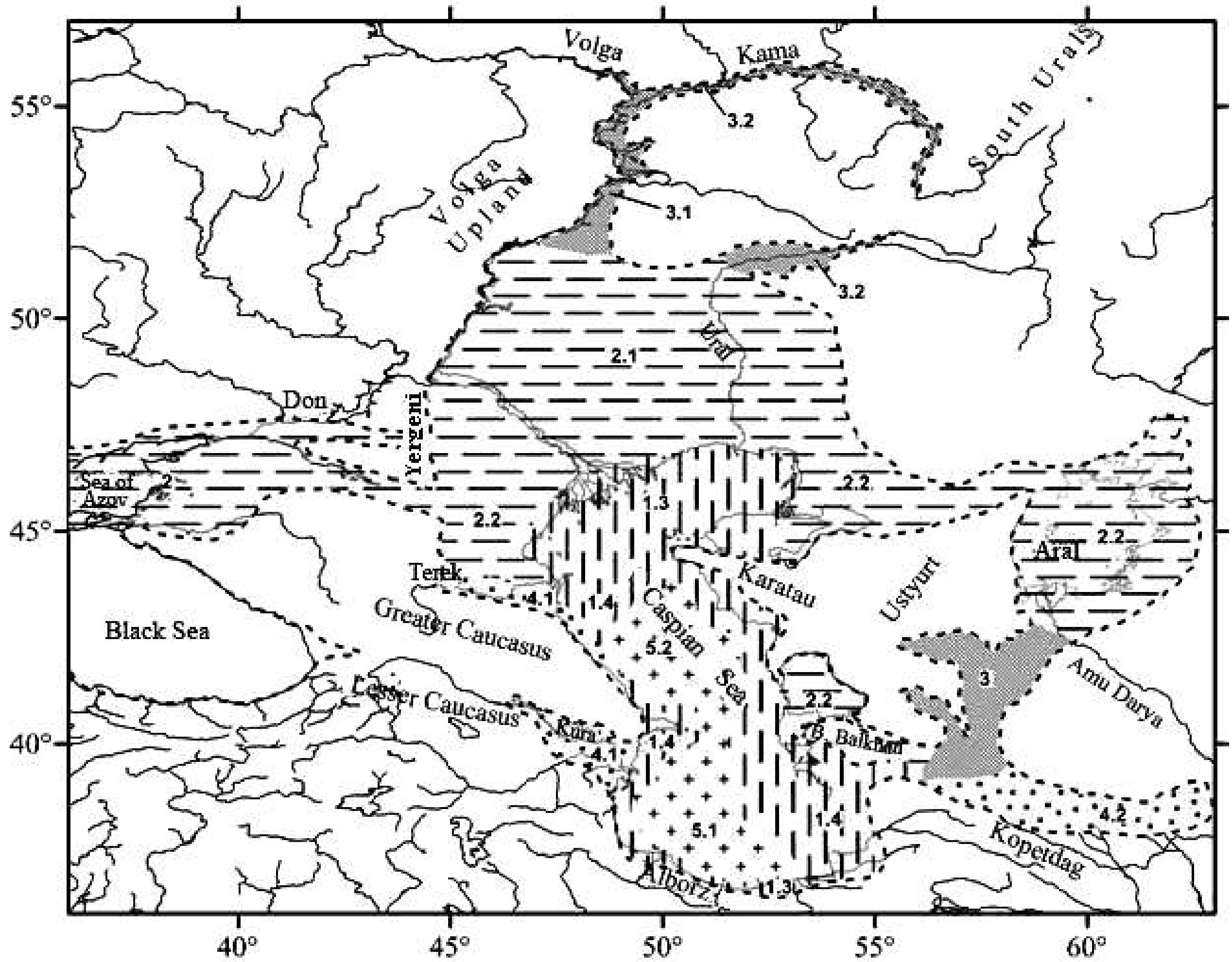

Figure 6. The Scheme of occurrence of the Transgression and the Genetic Facies of the Akchaghil Sea.
The Legend. The facies types: **1** — the shelf (the mesofacies: **1.1** — coastal, **1.2.** — shoreface, **1.3.** — relatively deep areas, **1.4.** — dynamic areas); **2** — epicontinental basins (the mesofacies: **2.1.** — shallow-marine, **2.2.** — relatively deep areas, **2.3.** — estuaries and lagoons); **3** — ingressional bays and estuaries (the mesofacies: **3.1.** — desalinated areas, **3.2.** — flooded valleys, **3.3.** — near-delta areas); **4** — intramontaines and the piedmonts (the mesofacies: **4.1.** — the Caucasian Type, **4.4.** — the Kopetdag Type); **5** — deep Troughs (the mesofaciealls: **5.1.** — the South Caspian, **5.2.** — the Middle Caspian)

There were major ingressive bays with the predominant Dalmatian-type shores along the Caucasian coastline. The ria shores were in the depressions along the Eastern slope of the Stavropol Upland.

The high elevation of the Akchaghil Sea at the differently-structured shores activated the two contradictory processes. The erosion basis was growing, the abrasive processes were dying out, the water collection basins dropped off and the relief depression were filled with deposits in the lowland territories. For instance, all the lowland Volga Region was a vast underwater accumulative plain. On the contrary, the deep insertion of the sea in the intermountain depressions of the Caucasus and Kopetdag and the sea reaching the boards of Ustyurt, Manghishlak and the Volga Upland, conditioned by the sea level rising, sharply activated the abrasion processes whereby fragmentary material was washed up on the shelf and contrasting forms (cliffs, benches, etc) were developed in the shoreline relief.

Figure 7. The Akchaghil Basin in the Volga Region (Геология…, 1967)

The driangle system of the Akchaghil Sea was diverse. The sea filled most of the major water collectors of the river valleys and thus reduced their areas and lengths dramatically. For instance, the length of the Palaeo-Volga valley equalled approximately one third of its current length that equals 3690 km. The water collector's area was less than a half of the modern Caspian Sea's situation. Judging by the Akchaghil deposits making palaeo valleys, the river network was very similar to the present-day analogue. In the North, the sea flooded most of the Preakchaghil valleys of the Volga, the Kama and the other rivers. In the East, the Amu-Darya flowed into the Kara Kum Bay while the palaeo Syr-Darya and the palaeo Irghiz ran into the Aral part of the basin. In the southern part of the poolwere situated the 'abridged' palaeo-valleys of the Sefidroud, the Atrek, the Kura, the Araz and other rivers.

The sea level. There are two differing opinions upon the estimated level of the Akchaghil Sea. The first one (Сиднев, 1985; Востряков, 1964 и др.) builds on the modern levelled situation of the Akchaghil deposits in the Low/Middle Trans-Volga Region at + 150–180 m abs. alt. and presupposes the high level of the transgression that reached 180 m abs. alt. According to the second viewpoint (Милановский, 1963; Леонтьев и др., 1977; Ковалев, 2004 и др.), the level of the Akchaghil transgression was lower and close to the oceanic one or to the level of the Early Khvalyn transgression. The main arguments underpinning both are that there is no proof of the Akchaghil waters entering the Pont and the Aegean Sea as well as none of their deposits was found in Ustyurt and Manghishlak.

Meanwhile, it is not quite appropriate to use the reference on the modern hypsographical position of the Akchaghil deposits to reconstruct the level of their basin (the first point of view). The current hypsographic occurrence range of the Akchaghil deposits exceeds 2 km. In the Trans-Volga region, they are at up to 180 m; in Dagestan, Turkmenistan and the Lesser Caucasus, they are elevated to 1.2–1.4; 0.5–0.8 km; and 0.7–0.8 km abs. alt. respectively and in the North Precaspian they are subsided to 0.4–0.5 km. Within the temporal range of the Akchaghil from 3.3 Ma to 1.8 Ma, the tectonic motions in even the relatively stable or low-activity regions of the Middle Trans-Volga Region, Ustyurt and Manghishlak could have set considerable values and distorted the initial sea level substantially.

The second viewpoint is contradicted by the information about the Akchaghil fauna discoveries in the Pontian-Kuyalnik (Семененко, 1980) and in the sequences of the Dardanelles (Taner, 1979) that would indicate the infiltration of the Akchaghil waters into the Pontian-Aegean Basin. Two outcomes of the faunstically characterised Akchaghil rocks were found in Manghishlak (Геология..., 1972). Apparently, the true maximum level of the Akchaghil transgression was somewhere between the values indicated in the two above-mentioned opinions. Evidently, it was higher than that of the Early Khvalyn transgression the area of which was twice as small as the Akchaghil Sea that was actually situated hundreds of kilometres NE of the boundaries of the Khvalyn Basin. At that, the great territories of the completely different structural position (the Russian Platform, the Greater Caucasus, etc.) were flooded to + 180 m abs. alt. presumably, at the maximum of the Akchaghil transgression, its level could be reaching 100 m abs. alt. as is seen from the fact that the Akchaghil deposits lie at the absolute marks of up to 100–110 m in the northernmost periphery of the basin, that is, downstream the River Belaya (Сиднев, 1976) and, at that, they are found in the newest elevations as well as depressions.

The basin's saline water inflow was doubtless associated with the inland seas of the oceans and its level at the beginning and at the maximum of the transgression. There are very different estimations of the oceanic level in that age: they range from below-zero to major (~200) positive indications. The analysis of the modern onshore area flooding done by A.O.Selivanov with allowances for downwarping of oceanic abyssal depths, accumulation of deposits on the oceanic bed and inflow of juvenile waters showed that the ocean level was close to +100 m (Клиге и др., 1998) in the Late Pliocene. Most of the estimations converge on a level close to the present-day ocean level or a little higher than that. The Atlantic waters again infiltrated the Mediterranean and maybe also the Pont in the Late Pliocene after the Messinian crisis in Miocene as is witnessed by the emergence in the Astian Mediterranean sequences of the typical representatives of the oceanic foraminifers Globorotalia tosaensis (the zone 21) and the subzone nannoplankton Discoastertomaris and Discoasterpentaradiates (История…, 1986).

<u>The age and duration of the transgression.</u> One can make a judgement on the age and longevity of the Akchaghil transgression quite confidently with reliance on the palaeomagnetic materials that indicate that it started in the Gaussian normal polarity period, that is, approximately 3.3 Ma BP, and ended in the Matuyama negative polarity period when the Olduvai abnormal horizon existed – that is, approximately 1.8 Ma BP. Consequently, the Akchaghil transgression continued approximately 1.5 Ma.

<u>The facial composition</u>. The gigantic area of the Akchaghil Reservoir, the diversity of the facial conditions (Figure 6). Among them stood out the facies of the marine deposits: of the shelf, of the epicontinental basins, of the ingression bays and estuaries, of the inter-mountain and piedmont depressions and deep-water hollows. The greatest special development was

achieved by the diverse epicontinental formations represented by the shallow-water, steep-to area, silted estuary and lagoonal deposits. They are situated in the territories of the Precaspian Depression, the South of the Middle Volga Region and the Scythian-Turanian Platform. For composition, those are the predominantly fine clayey and sandy-silty formations, as well as the coarser sandy-pebbled ones in the dynamic shallow-water areas and silt-loam in lagoons.

At the maximum of the Akchaghil transgression when the sea went far up river valleys to the North of the Middle Volga Region and the Preurals, the fine sediments with the desalinated and fresh water fauna and vegetation remnants of ingression bays and estuaries developed there broadly. Then, also, the sea abraded the mountainous shores in the western and eastern parts of the basin the most actively; the gravitational avalanchine-talus facies were widely occurred there – the wave processes reformed them in the diverse beach sediments eventually.

The extremely motley lithofacial composition and thickness of deposits are characteristic of the Akchaghil mountainous shores as well as the piedmont, intermountain and intermontane depressions of the Caucasus and West Turkmenistan. As a rule, this is a combination of fine shales typical for tranquil steep-to areas that change facially for coarse pebbly facies of the dynamic shallow-water areas. On the Caucasian shores and in Turkmenistan, lava ashes and breccias abound among deposits; in West Turkmenistan, biogenic carbonates are characteristic as well.

The facies of the shelf and the Caspian Trough s are fine and argillaceous-silt in composition; they have the characteristic micro-layered nature that reflects the rhythmicity of deposition. The peripheral parts of the basin have the repeated alteration of deposition conditions over time that is conditioned by the deposition's transgressive-regressive rhythmics. For instance, the Middle Volga Akchaghil sequence shows the sheer alteration from desalted facies of deposits (the beginning of the transgression) to lagoonal-marine (the maximum of the transgression) and again to fresh-water (regression).

Palaeohydrology. The Akchaghil pool is characterised by the diversity of the palaeohydrological circumstances. N.I.Andrusov (1902) estimated the depths of the Akchaghil Sea in its southern part and identified the following three bathymetric facies: 1 — the conglomerated one that marks the coastal line; 2 — the sandy-clay one that abuts the coast and 3 — the malmrock-limey one that accumulates far from the shores. A.Ali-Zade (1961) assumed that the depth did not exceed 200 m in the Aral-Caspian part of the basin. In the southern part of the basin, he identified two deep-water relicts of the Pontian of the pool — the Lenkoran and Khachmaz ones, both of which were deeper than 700–800 m in the Akchaghil Age. The northern part beginning from the North Caspian and ending at the River Kama was shallower and had the depths of 50–100 m and less; also, it was relatively contrasting in the flooded river valley areas where the depth could exceed a hundred metres.

The salinity of the Akchaghil Sea is determined by the faunistic criteria, namely, the molluscan communities, the ostracods and the foraminifers. N.I.Andrusov (1902) believed that the sparse species molluscan set-up witnessed that this semi-marine fauna of the 'euxinic' type inhabited the waters the salinity of which exceeded that of the Caspian's. According to K.Ali-Zade (1954), the average salinity of the Akchaghil Sea was higher than of the present-day Caspian Sea but lower than that of the Black Sea; that is, it was interim to these two and was also in the 12.3%–18.5‰ range. The similar thoughts on the basin's salinity were entertained by Uspenskaya (1931); Ali-Zade (1954); and Cheltsov (1965). The salinity changes over time as considered on the basis of the alternations of molluscan complexes in (История…, 1986). The salinity did not exceed 5-9% at the beginning of the Early Akchaghil Age when the reservoir was only inhabited by the brackish-water Clessiniolas and Mactrides. The salinity rose considerably when the Potomides and

Cerastoderms were widely occurred; still, it did not exceed 18%–19‰ on the whole. By the other data (Чепалыга, 1980), the salinity of the Akchaghil Sea reached 20%–25‰, which is close to the salinity of the present-day Marble Sea.

Apparently, the pool desalinated considerably (down to 10% and less of salinity) during the regression at the end of the Akchaghil. This is signified by the extinction of the majority of the marine endemic molluscs (Истории…, 1986) and the growth in the number of the brackish-water and fresh-water ostracods (Кармишина, 1975).

The considerable changes in the salinity of the Akchaghil Basin were caused by its regressive-transgressive conditions as well as by the vast area of the pool whereby it was present in various natural regions. In its northern reaches, it had as tributaries the numerous water full rivers, and the climate was cool; the basin was considerably desalinated there as can be seen by the presence of the numerous fresh-water species Pisidium amnicum, Unio pictorum, Cerithium caspicum, Viviparus sinrovi, Clessiniola utvensis, Limneasp, et al. among the brackish Akchaghil molluscs (Жидовинов и др., 1972). In the South and, especially, in the SE of the basin – in its Turkmen part, that is – the malacofauna complexes are the most abundant in composition but have no or very rare fresh-water elements; this signifies the relatively high and maximal (for the basin) salinity that maybe exceeded 20‰. The absence of constant river tributes and the hot climate in the Turkmen part of the pool led to concentration of salt in the seawater, and the accumulation in several bays and lagoons (the Lesser Balkhan and the Krasnovodsk Plateau) of brine accompanied with the precipitation of salt rock and mirabilite (А.Али-Заде, 1961).

The character of the climatic zone-based division of the Akchaghil Age set the temperature regime for the most part of the pool that was perhaps akin to the waters of the present-day Black Sea (summertime ~20–25). This is witnessed by the stenothermic nature of the Akchaghil fauna that evolved in a relatively warm-water ambience (А.Али-Заде, 1961). As regards the salt composition in the Akchaghil Sea, it had a clear association with the open marine basins letting us to suppose its proximity to the chloride-sodium composition of the oceanic waters. This is especially true of the maximum of the transgression even though the salts were doubtless diluted by fresh water locally and episodically.

The palaeogeography of the coastal regions and the possible correlations. The diversity of the controversial palaeontological reference on the Akchaghil provided the grounds for the very different palaeogeographic reconstructions of that age. S.A.Kovalevsky (1944) believed that there were two major continental and mountain congelations separated by the hot inter-glacial climate during the Akchaghil Age. The traces of a major congelation in the Akchaghil are found in the Caucasus by E.E.Milanovsky (1963). According to A.I.Moskvitin (1962), the Akchaghil transgression was brought about by the inflow of glacial waters in many respects while the northern periphery had the periglacial fenland; the moraine remnants and the banded clays are discovered in the Akchaghil deposits. The contradicting opinion was offered by V.P.Grichuk (1991) who maintained that the Russian Platform was covered with forest vegetation with the predominance of coniferous species – Pinus in the West and Picea in the East – in the Akchaghil Age. The forest formations were characterised by the richness of the flora that numbered more than 30 tree genera and were not analogous to the present-day taiga boreal forests. Grichuk concluded that the climate of the majority of the Russian Platform was weakly warm-temperate and close to the sub-tropical one in the Late Pliocene. According to (Найдин, Найдина, 1992), the forestless coastal areas were replaced with forests dominated by fir-trees with the inclusions of elm-trees and hemlocks in the middle of the Mid-Akchaghil; this, according to this offered opinion, signifies a moderately warm and humid climate. The dark coniferous forests with hemlocks, abies and oak-tree inclusions were widely represented during the climate cooling in the Middle Akchaghil, while there was aridisation and the xerophytic vegetation developed at the end of the transgression. According to K.Ali-Zade (1954), the Akchaghil climate was arctic in the northern part of the basin, moderate in the South and dry, and sharply continental in the East in the Akchaghil.

Let us consider the natural conditions of the Akchaghil Age per major region. In Turkmenistan, the Akchaghil deposits were found to contain the imprints of tropical and subtropical plants as well as the remnants of Mediterranean calcareous algae and numerous insects associated with abundant vegetation and once inhabiting lakes and stagnant gats. According to V.V.Rodendorf (А.Али-Заде, 1961), the presence of Parandras among the fossil beetles indicates the proximity of the contained fauna to the subtropical regions of the South Caspian where this relict beetle has survived to our days in the Talysh Mountains. The study of the flora and entomological specimens from Turkmenistan determined the uniformity of type among the discoveries found in the lower and upper layers of the sequence, which signifies that the climate was but altering little during the Akchaghil (А.Али-Заде, 1961).

The xerophytic vegetation formations were widely represented in Manghishlak at the beginning of the Middle Akchaghil; they were replaced then with the suffruticous and herbaceous plants with the inclusion of the pine trees – Pinus sect. Cembrae and Pinussect. strobus (Величко и др., 2011).

The Caucasian shore had a dissected mountainous relief with active volcanic manifestations in the Akchaghil. I.V.Polybin (А.Али-Заде, 1961) discovered numerous remnants of hardwood forests (Fagus orintalis, Quercus, Salixalba, Punicagranatum) in the Akchaghil deposits; this discovery witnessed the presence of that epoch's forests with the dominance of the beech and oak trees and the other species that are present in Azerbaijan in our time. The similarly-composed but richer flora was found in Eastern Georgia's Akchaghil. The abundant and diverse bone-bed fossils were found in the in the Akchaghil of the East Trans-Caucasus, namely, in the interfluve area of the Yori (the Gabyrri) and the Kura. There, among the marine coastal deposits containing Cardium dombra and Mactra subcaspia were found the remnants of the once index fossil of the Khapry Complex — the Archidiskodongromovi elephant, as well as of deers, gazelles, mastodons and so forth. In the opinion of N.A.Lebedeva (1978), the established faunistic set also inhabited the shores of the Akchaghil Bay and lived in the mountain landscape of the humid and warm climate. The palynological fossils typical of the open grass-covered areas (the ostrich egg shells and the bones of camels, hyparions and horses) are encountered in the upper parts of the sequence – which signifies a certain aridisation of the climate.

The findings of the Khapry Series' studies carried out in the Azov Area (Величко и др., 2011) found the transition from the forest-steppe landscapes to the steppe ones in the western periphery of the Akchaghil Sea. In that time, the gramineous-varied herb and the orach-desert vegetation groups existed, while the fauna was dominated by camels, horses and ostriches. The plentiful palynological materials on the Akchaghil formations of the northern part of the Volga-Ural Province, the Preurals , the Middle Volga Region and the North Precaspian (Плиоцен…, 1981; Кузнецова, 1959; Вопросы стратиграфии…, 1976; Итоги…, 1977; Геологические…, 1985; и др.) made it possible to reconstruct with the sufficient completeness the landscapes and climates of the Akchaghil Age (Яхимович и др., 1985). In its first half (the Gaussian palaeomagnetic age, 2.4 Ma–3.3 Ma), the whole of the Volga-Ural Region had boreal forests with the progressing impoverishment of their species-wise diversity and the transition from the polydominant dark coniferous species in the Middle Pliocene to the monodominant modern-type taiga in the Late Akchaghil. The fenland communities with club moss and dwarf trees emerge in the Middle Urals for the first time.

There were two now notable stages of the occurrence of boreal forests in the Preurals and the North Precaspian that correspond to the times of climatic cooling and moistening and are divided by the period of domination of the coniferous-deciduous forests including the broad-leaved trees. The similar development is described (Величко и др., 2011) for the Kama-Volga Interfluve; there, dark coniferous forecasts became wide developed during the first cooling. In the second cooling (approximately 2.6 Ma), the landscapes were dominated by spruce forests, the sphagnous and green moss species, and the marshed dishes also had the scrub birch and the willows.

The Middle Volga Region the taiga vegetation with the inclusion of the American-Eurasian and American-Mediterranean elements were widely developed in that time (Величко и др., 2011)

In the maximum of the Akchaghil transgression (the boundary between the Gaussian-Matuyama ages, 2.4 Ma) the whole Volga-Ural Region had the boreal vegetation degradation in connection with the setting-in warming and aridisation of the climate. Three alterations of the warm and cold conditions are observed in the coastal areas of the North Precaspian in the same time; they were expressed through the six-fold consequential vegetation change: forest-steppe communities (the warm and dry climate), boreal forests (cooling and increased humidity); deciduous forests with the broad-leaved elements (warming); boreal forests (cooling), deciduous forests (warming) and boreal forests (cooling). The similar sequence of the palaeogeographic events was found in the Middle Volga Region and Preurals. The fir boreal forest persisted and no foliage trees existed in the northernmost part of the region, namely, downstream the River Belaya (Сиднев, 1976).

The deflation processes with the total wind loss of ~15 000 km^3 formed the Aral Trough with the watering by the Late Akchaghil reservoir in SE, that is, in the Aral-Sarikamish lowlands (Пинхасов, 2002).

There was a cooling and the replacement of forest-steppes with the cold and open areas of thin birch forests in the Precaspian and the Preurals during the ending of the Akchaghil transgression. The dried areas had the accumulative relief of the silted estuary-marine plain in the West and the East, complete with the major river systems of the Palaeo-Volga and the Palaeo-Kama (Пролеткин, 2011).

On the whole, the climate of the Akchaghil Age was characterized by the spatial and temporal differentiation of the course and dynamics of development. The climate was closer to the subtropical one – moderately dry – in the extreme SE (Turkmenistan), while it was yet hotter and dryer farther to the North (in Manghishlak and also probably in the Preurals). To the SW, most of the epoch was dominated by the warm and humid climatic conditions with a certain degree of aridisation towards the end of the transgression. The climate of the vast northern regions can be characterised in generic terms as moderately cool, relatively humid and with the predominance of dark coniferous forests. It was characterised also by the variable temperature and humidity that left their sheer impacts on the vegetation mantle of the shores where coniferous forests were replaced by the deciduous ones. These, and the other signs helped determine two cooling periods in the first half (3.3 Ma–2.5 Ma BP) of the Akchaghil Age. However, neither these nor the cooling periods in the second half of the epoch had left reliable signs of periglacial fenlands and other traces of the proximity of glacial shields to the North. In the early beginning of the Middle Akchaghil, the July temperature ranged from 15° to 21°, while in January the temperature ranged from -2° to -8°. The warming epoch (the Late Urdinian) of the Middle Akchaghil have the average July and January temperatures estimated at 19° – 22° and 2° – -2° respectively (Изменение..., 1999).

The sub-division (the development stages). The history of the Akchaghil Sea can, just like the history of any long termbasin, be divided in the three development stages: the initial one, the maximum one and the ending one; these will reflect the evolution of the impounded body. They are identified by an assembly of features such as the fossil fauna set-up, the sequence's structure and lithofacies, the level regime and the aquatic area coefficient. The boundaries that separate the stages are normally blurred and often conventional similarly to the stratigraphic subdivision of the Akchaghil. Besides, they are aggravated by the events of the lower orders.

The initial stage (Akchaghil) is the time of the first and quite long termdemonstration of the transgression, at the beginning of the palaeomagnetic Gaussian Age; probably, it lasted for longer than 0.5 Ma. The fauna of the Early Akchaghil Sea had the characteristically sparse mollusc assamblagies. The first mass development was recorded by the gastropods of the genus Clessiola, to be followed by the Aktschagylia bivalves and, eventually yet, by the assemblies with the key species Aktschagylia subcaspia and Cerastodrma (Cardium) dombra (История..., 1986). On flooding the existing southern and middle Caspian basins and the adjacent lowlands, the Early Akchaghil Sea developed such major bays as the Turkmen Bay in the East, the Kura and Terek bays in the West and the Cisvolga Bay in the North (История..., 1986). The latter incorporated the areas of the Volga and North Precaspian regions and was the largest, shallowest and the least saline one. Its deposits demonstrate not only Avimactra subcaspia, Cerastoderma dombra, Potamidessp. and Clessiniola polejaevi but also Dreisens, Unionidae and Valvata (Плиоцен…., 1981).

Several researchers (А.Али-Заде, 1961, Невесская, Трубихин, 1984) indicated the broad regression at the end of the Early Akchaghil that is singled out as a phase, while its sediments are ranged as a sub-stage. This viewpoint is based on the perturbations in the Akchaghil deposits that were found in the sequences of Turkmenistan and identified as the traces left by the fresh water fauna (Dreisena polymorpha) and the alteration of the assemblies of foraminifers and ostracods (История…, 1986). This is clearly insufficient to identify a major stand-alone regressive Akchaghil Basin. This is contradicted by the expansive factual material on the Akchaghil deposits. In the most part of the sea's aquatic area between the lower and middle Akchaghil formations there are no traces of perturbations and erosions. They were identified in the tectonically active regions of West Turkmenistan as well as in the northernmost parts of the Middle Volga Region and the Preurals. In the former case, they were apparently caused by local tectonic adjustment movements that are especially characteristic of West Kopetdag the sequences of which have the traces of sedimentation perturbations, angular displacement and lithofacial alteration in not only the Akchaghil but also the younger deposits (Геология..., 1972).

In the Preurals, the upper reaches of the Lower Akchaghil have the Kumurlin Horizon made up of fresh-water and brackish ingressive deposits and situated between the Karlaman and Zilim-Vasilyev horizons (Итоги..., 1977). This structure of the Lower Akchaghil is only observed along the northern periphery of the basin while no traces of desalination and sequence perturbations were discovered farther to the South (in the North Precaspian) (Жидовинов, Федкович, 1972). Consequently, one can assume that what the Preurals' sequences do contain was associated with a local shove of the shoreline that might be brought about by not only the basin's regression but also other causes (river flow increases, local upheavals and so forth).

If there was a major regressive phase in the Early Akchaghil, it would have left a footprint in the form of deep cut-outs in the sequences of the Akchaghil deposits and in the form also of the ubiquitous alteration of its waters' salinity and, as a result, in the fauna and microfauna changes. However, nothing of the kind was discovered in the main part of the basin's aquatic area. Of course, there were various geo-ecological inhabitation conditions in the waters of the vast and long termpool that predetermined the specificity of the molluscan, foraminiferous and ostracodal communities that populated this reservoir. And yet, those were only the particularities that only aggravated the general course of the organic life‘s evolution in the Akchaghil Sea but never changed that course. The evolution started with the infiltration and population by the marine euryhaline fauna at the initial stage of existence of the pool and was followed by its flourish at the maximum of the transgression, and its demise and extinction in the final (regressive) stage of the impounded body's life.

The marine basin became considerably larger at the maximum stage of the Akchaghil transgression. It flooded the river valleys of the Volga and the Ural in the North and formed the deep ingressive bays there, of up to 750 km in the Precaspian, up to 200 km in the Volga Region, up to 100 km in the Kama Region and 60–20 km in the Preurals (Сиднев, 1985). In the West, it flooded the Azov-Kuban Depression going via the Manych depressions and reached Kerch and Taman; to the South, it flooded the Terek Downfold and the Kura Depression complete with the ancient river systems of the Araz, the Iori and the Alazani. In the East, the sea intruded deep into the lowland West Turkmenistan and the Prekopetdag Depression and reached the Aral via the Upper Uzboy Corridor thus forming the extensive Bay of Amu Darya.

The maximum of the transgression was characterised by the diverse fauna dominated not by the Mactrides (as at the early stage) but by the Cardiids (История…. 1986). The especially rich mollusc, foraminiferous and ostracodal assemblies were characteristic of the southern regions of the basin where the environmental situation was the most favourable for them.

The final stage (phase) of the Akchaghil Basin's evolution was conditioned by the stoppage of sweater inflow, and the basin's regression and considerable desalination, which caused the extinction of the majority of the marine endemic molluscs and the considerable expansion of the brackish-water Dreissenas as well as of the euryhaline and fresh-water ostracods (История…, 1986). It should be mentioned that the regression of the sea level on the boundary between the Akchaghil and the Absheron was not as intense as it is often presumed to be: it only impacted the peripheral parts of the basin in the main but did not encompass the areas of the eventual Absheron Sea Basin. This is confirmed by the fact that there are no notable perturbations between the Akchaghil and the Absheron deposits in the majority of the impounded body's area.

The Absheron Stage (transgression)

The major (835,000 km^2) and long term (1.8–0.7 Ma BP) transgression of the Caspian Sea at the end of the Late Pliocene (the Eopleistocene).

Is named after the Neogene deposits of the Absheron Peninsula containing the original brackish-water mollusc fauna discovered and separated by G.Sjögren (Sjögren, 1891) to make the Absheron series.

The limits of the basin. The vast Absheron pool (835,000 km^2 (Aladin, Plotnikov, 2006) filled the whole of the modern Caspian Bowl and extended into the adjacent lowland areas of the Lower Volga Region, the East Precaucasia and West Turkmenistan via broad bays (Figure 8).

The sea reached the latitude of the Greater Irghiz (via the River Volga valley) in the Lower Volga Region; in the NW, it approached the South Yergens. Farther to the East, it extended until it reached the western slopes of the Transural Syrts. The basin filled all the lowland areas of the Kara Kum, the West Turkmen Depression and a considerable portion of the Krasnovodsk Peninsula; its narrow strait reached far along the piedmonts of Kopetdag. It perhaps also reached the Aral Depression and the West Kizil Kum in the Uzboy-Sarikamish direction and bathed the Alborz piedmonts in the South. The sea formed two major bays on the Caucasian shore – the Kura and the Terek-Kum ones; both entered the continent far inland. Via the Manych Depression, the sea also reached the Azov-Black Sea Bowl.

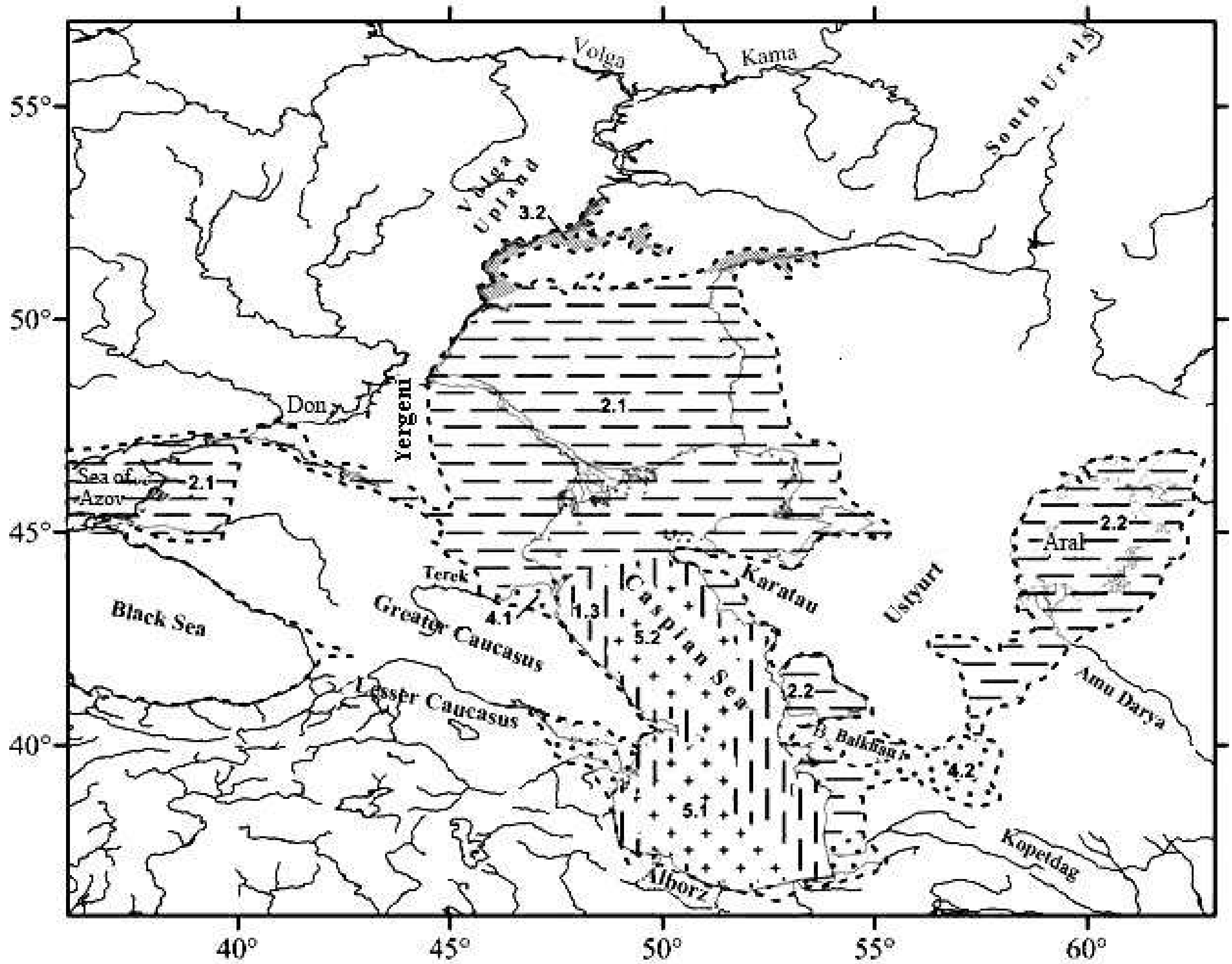

Figure 8. The Scheme of occurence of the Transgression and the Genetic Facies of the Absheron Sea. The Legend. See Figure 6

The Absheron Sea was much smaller than the precedent Akchaghil Basin in spite of its impressive size at the maximum of the transgression when it was more than double the size of the Caspian as we know it now. It was especially large in the North, namely, in the Middle Volga Region and in the South Preurals the rest of which the Absheron Sea practically never reached. Smaller areas were affected by the Absheron transgression in West Turkmenistan as well. The singular cases of the transgression's expansion greater than that of the Akchaghil were found in the South Yergens (Колесников, 1950) and the Preurals.

The relief expression. The transgression of the Absheron Sea and the level rise associated with it caused the activation of abrasive processes on almost all the shores; those processes were particularly dynamic in the elevated submontane southern shores. The abrasive shores went along the Yergens and the foot of the Common Syrt in the West. Farther to the North lay the palaeovalleys of the Volga and of the Ural. The Palaeo-Volga had a wide, weakly incised valley with the smooth slopes in the southern reaches of the Mid Volga Region after it passed the Zhiguli Dam.

There were the islands developed by the salt dome tectonics in the Absheron Sea's shallow regions (in the North Precaspian) (Inder, Chelaker, Elton, et al.). The major delta fronts of the Uhil and the Emba were located in the Sub-Urals Plateau.

The eastern coast of the Absheron Sea was on the shallow scroll western of the present-day shores. The sea reached inland via a broad bay in the region of the Kara Bogaz Gol (Леонтьев и др., 1977). Two levels (80–100 m) of accumulative terraces made of organogenous Absheron limestones are found in the coastal relief in the North of the Krasnovodsk (Turkmenbashi) Peninsula (Федоров, 1957). The Absheron Sea abraded the piedmonts of Kopetdag actively via the deep ingression bays.

The coastal relief on the Caucasian side was in many respects determined by the diversity and combination of the coastal processes, namely, of abrasions on the capes and peninsulas and of accumulations in the bays. In the greatest ones of them (those of Kura, Terek, etc.) there were the deltas formed by the alluvial cones made of coarse-grained deposits. Most of the Dagestani coasts had abrasion as the dominant relief-forming process. An abrasive ledge of the Absheron Sea was discovered in the Trans-Terek Valley at the absolute elevation of 110–120 m (Федоров, 1957).

The sea level. There are various estimations of the level of the Absheron Sea. By N.I.Andrusov (1923), it was somewhat lower than the ocean level with the maximum depth of the basin never exceeding 150 Russian fathoms in the Early Absheron Age while it was not greater than 40–80 Russian fathoms in the Middle and Late Absheron Age.

V.P.Kolesnikov (1950) determined the basin depths as ranging from 200–300 to 40–80 m. in his opinion, it is particularly at those depths that the molluscs akin to the Absheron forms inhabit the present-day Caspian Sea.

O.K.Leontyev et al. (1977) determined the height of the maximum of the Absheron Sea at not higher than 50 m of abs. alt. based on the specificity of the deposition patterns in the Precaspian's North and South. Z.S.Chernysheva (1960) sets the level of the basin at 16–18 m of abs. alt. and not more than that, relying on the drilling data obtained in the Middle Volga Region. Using the reference on the height of the Absheron deposits' occurrence and of the abrasive terraces in the southern part of the Common Syrt, V.A.Sidnev (1985) sets the maximum level of the Absheron pool at 60–80 m. Apparently, those values match better the true situation of the maximum level of the Absheron Sea. The area of the basin exceeded the territories affected by the subsequent Pleistocene transgressions notably in its northern and relatively tectonically calm shores. This is true also of that area's maximum ever Early Khvalyn transgression that reached +50 m. The sea impounded the Aral Basin and reached the Bozdag Ridge in the East and in the West.

Judging by the different areas that the Akchaghil and Absheron pools occupied, the level of the Absheron Sea was considerably lower (below 20–40 m) than that of of the Akchaghil Sea.

The age and duration of the transgression. According to the palaeomagnetic data (Трубихин, 1977; Гурарий, 1980; Храмов, 1963, Певзнер, 1972), the Absheron deposits are situated in the upper portion of the negatively magnetised Matuyama Zone, higher than the Olduvai Episode (1.8 Ma–1.67 Ma) and in the 1.8 Ma–0.7 Ma interval. Consequently, the duration of the Absheron transgression was perhaps 1 Ma or a little longer. The track analyses that determined the age of the Late Absheron as equalling to 1.0 Ma and 0.95 Ma (Ганзей, 1984) do not contradict this, either.

The facial composition. The facial composition of the Absheron deposits is as diverse as it was in the Akchaghil (Figure 8); there are the shelf facies', epicontinental basins', ingressive bays' and estuaries', intermontane and submontane depressions' and deep-water bowls sediments there. The deep-water silty-clayey deposits fill up the Caspian bowls that are limited by the fields of the varied shelf deposits. Just like in the Akchaghil, the epicontinental basin facies are different in lithological composition, and were the most recorded in the Absheron Sea. The reduction in size of the Absheron Sea in the North Precaspian and West Turkmenistan caused the notable shrinkage of the ingressive bay and piedmont depression facies' occurrence areas there. The sea reached the Samara Trans-Volga Area via the relief depressions at the maximum transgression in the northern part of the basin where it left the fine ingressive silty-sandy-clayey sediments with plant fossils and fresh-water mollusc shells. More to the South, namely, in the North Precaspian and the present-day aquatic area of the North Caspian, they were replaced with the lithologically diverse epicontinental facies; among them stand out the predominantly sandy shallow-water sediments that evolved along the periphery of the basin and the sandshale, with abundant shells, shallow-water sediments, all relatively steep-to and predominantly clayey (Васильев, Обрядчиков, 1962).

The exceptionally motley lithofacial composition is characteristic of the Absheron deposits of the Caucasian shores. In South Dagestan, those are conglomerates, bench gravels, sandstones, detritus limestones and clays (Геология…, 1968). The intermontane depressions of Azerbaijan are dominated by the land-to-sea transition zone sandshale sediments with sandstone, shell and conglomerate interlays (Геология…, 1972). On the eastern side, the Absheron Sea reached the Aral and Sarikamish bowls where it left various shallow-water coarse epicontinental sediments: gravel benches, conglomerates, oolitic sandstones and shelly limestones, and – more seldom – sands and silts with clay intercalations (Геология…, 1970).

In West Turkmenistan, there are two zones identified by the lithofacial structure (Геология…, 1972): the northern territory with weak tectonic activity and the relatively lithofacial homogeneity and the southern territory associated with the tectonically active structures that determined the facial mottling of its sequences.

On the whole, the lithofacial composition of the Absheron deposits has certain areal and sequential regularities just like the Akchaghil deposits have. These are brought about by the structural situation and the greater meridional stretch of the basin, which, in turn, created its climatic differentiation. In the North of the water reservoir, in a relatively calm tectonic situation and with the abundant inflow of fresh water, the spatially, composition-wise and thickness-wise sustained lithofacies of deposits prevailed. To the South – on the Turanian Platform and in the area of differentiated tectonic shoves, the facial composition of deposits of the basin was more diverse and also coarser. The actively converging Caspian bowls continued being filled with the deep-water facies' thin sediments. The southern areas with their subtropical climate and active alpine tectonics were characterised by the diverse terrigenous composition (from gravel benches to sits and clays) and had the abundance of carbonate rocks as well as the sequence of varying thickness.

Palaeohydrology. While estimating the general salinity of the Absheron sea-lake by the malacofauna's nature, N.I.Andrusov (1923) arrived at the conclusion that it was generally matching the salinity of the present-day Caspian Sea. Indeed, the brackish-water Absheron fauna is sharply different from the precedent Akchaghil fauna of the fresh water marine habitats. This is firstly seen from the disappearance of the marine forms (Cardium, Avimactra, Potamides) and the emergence of the fresh-water elements (Streptocerella, Micromelania, Clessiniolla, et al.). The Absheron fauna is a mixture of the molluscs of different origins, the Akchaghil fauna fossils, the colonisers from the Pont and fresh-water basins that inhabited the landlocked basin akin to the type later represented by the Pleistocene basins that were populated by the descendants of the Absheron molluscs (История…, 1986). Given this, it is natural to suppose concentration of salts in the 7%–15% range with the average value being ~13‰. As regards the chemical composition of the water in the Absheron Sea, it was perhaps somewhere between the chloride (55.29) – sodium (30.59) composition of the ocean and the sulphate (23.49) — chloride (41.73) — sodium (24.82) composition of the present-day Caspian Sea's water (Касымов, 1987). Doubtless, the Absheron Sea's various parts and especially its periphery had different salinities and that this fact was reflected in the mollusc and microfauna assemblies' make-ups. For instance, judging by the numerous fresh-water elements (Dreissena, Sphaerium, Micromelania, Cleissiniola, Viviparus, Valvata and Neritina) present in the Absheron fauna of the North Precaspian, its aquatic area had evidently undergone considerable water conversion and its salinity was down to 10‰ and lower. Judging by the diversity of the Absheron molluscs and the fact there are endemic species among them (История..., 1986), there were a relatively high concentration of salts and a relatively high water temperature in the southern part of Azerbaijan and in West Turkmenistan.

The changes in the salinity of the Absheron Sea developed over time. The pool was quite desalinated at the first and the final stages of its existence while it was a typical brackish basin at the maximum of its transgression – then, the brackish-water molluscs of the genii Hyrcania, Didacnoides, Monodacna, Apsheronia, et al inhabited it extensively (История..., 1986).

The palaeogeography of the coastal provinces of the Absheron Sea is studied worse than that of the precedent Akchaghil Stage and much worse than that of the subsequent Pleistocene, while the current perceptions of the Absheron climate and vegetation are quite contradictory. For instance, G.I.Popov (1961) presumes that the climate of the age was warm enough, while A.I.Moskvitin (1958), on the contrary, referred to glaciation of the Russian Platform's northern part and maintained that the shores of the Absheron Sea were covered in taiga boreal forests, replaced with the polar desert (periglacial steppe) landscapes periodically. According to (Изменение…, 1999), the maximum cooling of the Absheron saw the forest zone's reduction but, then, no traces of glaciation have been found.

The Absheron had the repeated climatic fluctuations that impacted the floral and faunal patterns of the territories that surrounded the brackish Caspian Basin. Among them are found the forest to forest-steppe vegetation types – and further to the semi-desert types. The forests were pine-fir, coniferous-deciduous and deciduous (birth-trees and broad-leaved trees). The steppe and semi-desert vegetation was represented by the Chenopodiaceae, Chenopodiaceae-forb and forb groups. The ratios among them changed over time but, in general, the set-up remained monotypic and numbered 85 genii and 30 families (Чигуряева, 1984) that were akin to the modern flora.

There is the interesting reference on the Absheron landscapes in such northern territories as the Preurals, the Middle/Lower Volga Region and the Precaspian. In the Preurals (Плиоцен..., 1981), the climate was warm and there was forest-steppe vegetation dominated by the pine-birch forests and forb steppes at the beginning of the geological time. The beginning of the Middle Absheron with the existing broad-leaved forests along the valleys has a warm climate, too. It became colder and dryer, and forestless areas emerged at the end of the age.

The history of the Absheron landscapes is better studied in the Precaspian where the eight-fold climatic alteration is shown clearly by the four vegetation cover change cycles (Чигуряева, 1984; Яхимович и др., 1985). Forest landscapes changed for forest-steppe ones twice in the Early/Middle Absheron, and boreal forests were replaced with cold steppes twice – in the second half of the Middle Absheron and in the Late Absheron.

According to (Изменение…, 1999), the climate was cold in the Precaspian in the Early Absheron Time when the pigweed steppes with fenland elements developed widely on the shores of the Absheron Sea and the average January and annual temperatures equaled -10° and 4° respectively. The rigorous climate and the siccocolous steppe landscapes existed in the North of the territory at the very end of the Absheron Age.

Little is known of the landscapes of the southern shores of the Absheron Sea. The discovery of the Palan-Turkan mammal fauna and fresh-water mollusc fossils in the East Trans-

Caucasus helped to reveal the occurrence of desalinated marine lagoons and lakes, and forest-steppe landscapes with the alternating woodlands and open plains (Лебедева, 1978). The constant spores of green moss and pollens of Chenonodiaceae (>50 %) are always presented in the sparse palynological spectrums of the Lesser Balkhan clays in Turkmenistan.

The difference between the climatic rhythmics of the northern and southern territories of the Caspian Region became more contrasting in the Absheron Age than they were in the Akchaghil Age. The cold and warm stages alternated in the North while the humid (pluvial) and dry (arid) stages alternated in the South. By N.Y.Filippova (1997), there were 5 pluvial and 3 arid stages in the South in the Absheron Age; the arid stages became longer since the Middle Absheron.

The sub-divisions (the development stages). The Absheron Basin experienced a series of level, area, water composition and fauna changes throughout its long term history that reflected the stages of the basin's evolutiom. According to V.P.Kolesnikov (1940, 1950), the Absheron Sea replaced the Akchaghil Sea because of the active tectonic movements and the basin's intense size reduction and desalination (the first stage); Dreisens and Linnea became massively distributed in its waters. However, the main cause was that marine water inflows stopped and a closed water reservoir was formed. The Caspian-type fauna infiltrated the Caspian Sea from the Black Sea via Manych and achieved a flourish here at the maximum of the transgression in the Middle Absheron (the second stage). In the Late Absheron (the third stage), the Absheron Basin shrank again because of the continued activation of mountain-forming processes and so did its brackish-water fauna; the Manych Strait re-opened and, probably, the crassoid Didacnas found their way into the Caspian Sea. Following V.P.Kolesnikov, the majority of researchers divide the evolution of the Absheron Sea in three stages. According to V.A.Sidnev (1985), the three Absheron transgressions were separated by regressions. According to E.A.Bludorova et al. (1983), each of these three stages was characterised by the diverse climatic phases, namely, the cool, the maximally favourable and the cool xerothermic ones.

L.A.Nevesskaya and V.M.Trubikhin (1984) divide the Absheron Basin in two phases. The first phase lasted for 0.6 Ma and was the time of existence of a large bay via Manych and on to the Sea of Azov; that was also the time of the wide development of the fresh-water/brackish-water fauna. The second phase lasted for 0.5 Ma and was the time of the maximum development and evolution of the brackish-water Cardiidae. Volume-wise, this phase corresponds to the 2nd and 3rd phases by V.P.Kolesnikov (1940). In it, the authors conglomerate the events that were very different in content and direction, such as the maximum transgression with the rich brackish-water fauna and a warm climate, and the subsequent reduction of the basin, the extinction of the majority of the Cardiidae, the emergence of fresh-water elements and an abrupt cooling of the climate. It is evident, though, that that was the quite different palaeohydrological and palaeogeographical epochs and, if one considers these significant events, then, one will perceive of the history of the Absheron Sea as consisting of the following three stages: the first one as the beginning of the transgression and the basin's colonisation by the fresh-water (Corbicula luminalis, Theodoxussp., Lymnaeasp., et al.) and the brackish-water (Dreissena rostriformis, Apscheronia) facies; the second one was the the maximum of the transgression that coincided with the warm climate and extensive development of the brackish-water Cardiidae (Didacnoides, Catilloides, Apscheronia, Hyrcania, et al.) and the third one was the sea's regression, the brackish-water fauna's depletion and partial disappearance, the development of the fresh-water of molluscs and the considerable cooling of the climate when, perhaps, the first glaciers emerged in the North of the Russian Plain.

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BÖYÜK XƏZƏRİN TARİXİ, XƏZƏRİİN GEC PLİOSEN HÖVZƏLƏRİ

A.A. Svitoç

Böyük Xəzərin hövzələrinin müasir Xəzərin və onu əhatə edən düzənlik sahələrinin yerində mövcud olmuş su hövzələri sisteminin gec pliosen tarixi nəzərdən keçirilir. Xəzərin transqressiv tarixinin başlanmasından əvvəl kontinental çöküntülərin aktiv toplanması və Xəzər çökəkliklərinin alçaq səviyyəsinə bağlanmış çay dərələrinin dərinləşməsi ilə səciyyələnən uzun müddətli reqressiv Balaxanı epoxası baş vermişdir. Onu əvəz edən Akçaqıl mərhələsi ən iri və uzun transqressiv epoxa olub, Orta Volqa boyundan Elbrusun ətəklərinə qədər yayılmışdır. Burada dənizin səviyyəsi 100 m mütləq yüksəkliyə çatmış və dəniz molyusklarının endemik faunası ilə səciyyələnən çöküntüləri müxtəlif litofasial tərkibə malik olmuşlar. 18 mln. il bundan əvvəl dəniz sularının gəlməsinin kəsildiyi üçün baş vermiş kiçik reqressiyadan sonra Akçaqıl hövzəsi Abşeron dənizi ilə əvəz edilmişdir. Bu qapalı, daha kiçik ölçülü, şor sulu, daha alçaq səviyyəli (60–80 m mütləq yüksəklikli), lakin o cür də müxtəlif fasial tərkibli çöküntülərə və molyuskların kəskin fərqli tərkibinə malik hövzə olmuşdur. Abşeron transqressiyasının başa çatması gec pliosenin ən sonuna təsadüf edir və iqlimin əhəmiyyətli soyuqlaşması ilə üst-üstə düşür. Ehtimal ki, bu zaman Rus ovalığında ilk buzluqlar meydana gəlmişdir.

ИСТОРИЯ БОЛЬШОГО КАСПИЯ. ПОЗДНЕПЛИОЦЕНОВЫЕ БАССЕЙНЫ КАСПИЯ

А.А. Свиточ

Рассматривается позднеплиоценовая история бассейнов Большого Каспия — системы водоемов, существовавших на месте современного Каспия и окружавших его низменных территорий. Началу трансгрессивной истории Каспия предшествовала длительная регрессивная балаханская эпоха с активным накоплением континентальных отложений и глубоким врезом речных долин, привязанных к низкому уровню Каспийских впадин. Сменивший ее акчагыльский этап был самой крупной и продолжительной трансгрессивной эпохой, распространявшейся от Среднего Поволжья до предгорий Эльбурса, с уровнем моря, достигавшим 100 м. абс. выс., с разнообразным литофациальным составом отложений, охарактеризованных эндемичной фауной морских моллюсков. Около 1,8 млн. л. назад, после небольшой регрессии, вызванной прекращением поступления морских вод, акчагыльский бассейн сменился апшеронским морем. Это был замкнутый солоноватоводный водоем меньших размеров с более низким (60–80 м. абс. выс.) положением уровня, но столь же разнообразным фациальным составом осадков и резко отличным составом моллюсков. Завершение апшеронской трансгрессии приходится на самый конец позднего плиоцена и совпадает со значительным похолоданием климата, когда на севере Русской равнины, возможно, появились первые ледники.

THE DEVELOPMENT STAGES OF PLANKTONIC FORAMINIFERAS AND THE ZONAL STRATIGRAPHY OF THE PALAEOGENE DEPOSITS OF GOBUSTAN-WEST ABSHERON AREA

The Palaeogene deposits widely occur in the geological structure of the South-East Caucasus.

The identification of the phases of development of the organic world is of intense interest and has a stratigraphic importance. The present article focuses on the study of the Palaeogene foraminifers from layer-by-layer measured sections in the Gobustan-West Absheron region. The data show the 4 phases of the foraminiferas' development: the Palaeocene-Early Eocene (the Globorotalia stage), the Middle Eocene (the Acarinina stage), the Upper Eocene (the Globigerina stage) and the Early Oligocene (the recession stage).

The investigation of the staging in the foraminiferas' development made it possible to develop the zonal stratigraphic chart of the Palaeogene deposits of Gobustan-West Absherons area that consists of 16 zones.

Keywords: the Palaeogene, phase, zone, the foraminifers, the Palaeocene, the Eocene, the Oligocene.

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Introduction

Paleogene deposits are widely occur in Azerbaijan, and were studied by many researchers. Among them are K.A.Alizadeh, T.A.Mamedov, M.A.Bagmanov, Sh.A.Babayev, D.M.Khalilov and others. Several field campaigns focused on the study of the Paleogene sediments in the Gobustan and Western Absheron area were conducted by experts from the Geology Institute of Azerbaijan National Academy of Sciences during last years. Among studied Paleogene outcrops are Khilmilli, Yunusdag, Goturdag, Perekishkyul, Nagdali, Govundag, Jengi, Sumgaitchay, Goytapa, Gyshlak (Figure 1).

Detailed microfaunal investigations allowed the construction of accurate Paleogene zonal scheme of the region. This scheme consists of 16 zones (Table 1).

The lithological and microfaunal description of the defined zones is given below.

The zonal scheme of Paleogene sediments based on the planktonic foraminiferas of tropical, subtropical and other climatic zones might be applied to the study of the Paleogene sediments in the region under study.

Foraminiferas are widely developed in the Paleogene deposits in the Gobustan and West Absheron area (Figure 1). The four stages in the foraminiferas' evolution are identified.

The first phase encompasses the Palaeocene-the Early Eocene. This phase is characterised by the robust development of globorotalia and can be called the globorotalia phase therefore. In turn, this phase is divided into 3 subphases as follow:

The first sub-phase encompasses the Danian. This lever is divided from the base to the top into the *Globorotalia daubjergensis* and *Acarinina schachdagica* zones.

The *Globoconusa daubjergensis* zone encompasses the Lower Danian. The lower boundary of the zone is characterised by the disappearance of the typical Maastrichtian genera of *Globotruncana, Rugoglobigerina, Pseudotextularia,* etc., and the appearance of the representatives of the genera of *Globigerina, Globorotalia, Acarinina*. Apart from the index-species, the following species were discovered within this zone: *Nuttalloides trumpyi, Heterohelix irregularis, H. crinita, H. midwayensis, H. concinna, Globigerina pseudobulloides, G. moskvini, G. fringa, Globorotalia compressa, Cibicides perlucidus,* etc.

The *Acarinina schachdagica* zone corresponds to the Upper Danian and stands out for the appearance and wide occurrence of the subcopped *Acarininae* (*Acarinina schachdagica, Ac. inconstans, Ac. indolensis,* etc.). Besides, this zone has the species composition of *Globorotalia, Globigerina* and the other genera changed in comparison with the underlying zone. The following species were discovered within this zone: the index-species, *Acarinina inconstans, Ac. indolensis, A. trifida, A. spirialis, Globorotalia globosa, G. azerbaidjanica, G. compressa, Globigerina moskvini, G. triloculinoides, G. trivialis, G. quadrata, G. pseudobulloides, G. trifola, G. taurica, Heterohelix midwayensis, H. irregularis, H. pumilia, H. crinita, Nuttalloides trumpui, Cibicides spiropunctatus,* etc.

The species composition of this zone shows that, apart from the abundance of the *Acarinina* species, it is characterised by the continued development of the *Heterohelix* species and the emergence of a number of new *Globigerina* species *(quadrata, trifola, taurica)* as well as the increased number of the *Globorotalia* species *(globosa, azerbaidjanica)*. Here, *Globoconusa daubjergensis, Acarinina spirialis* and *Globorotalia compressa* end their development. *Globigerina triloculinoides* and *G. trivialis* are the transit species. The rare *Globorotalia angulate* shells are found in the upper portion of this zone.

Sediments of the *Acarinina schachdagica* zone are similar with sediments of the underlying zone. This zone was recorded in the Khilmili (15 m thick) and Yunusdag (25 m thick) outcrops.

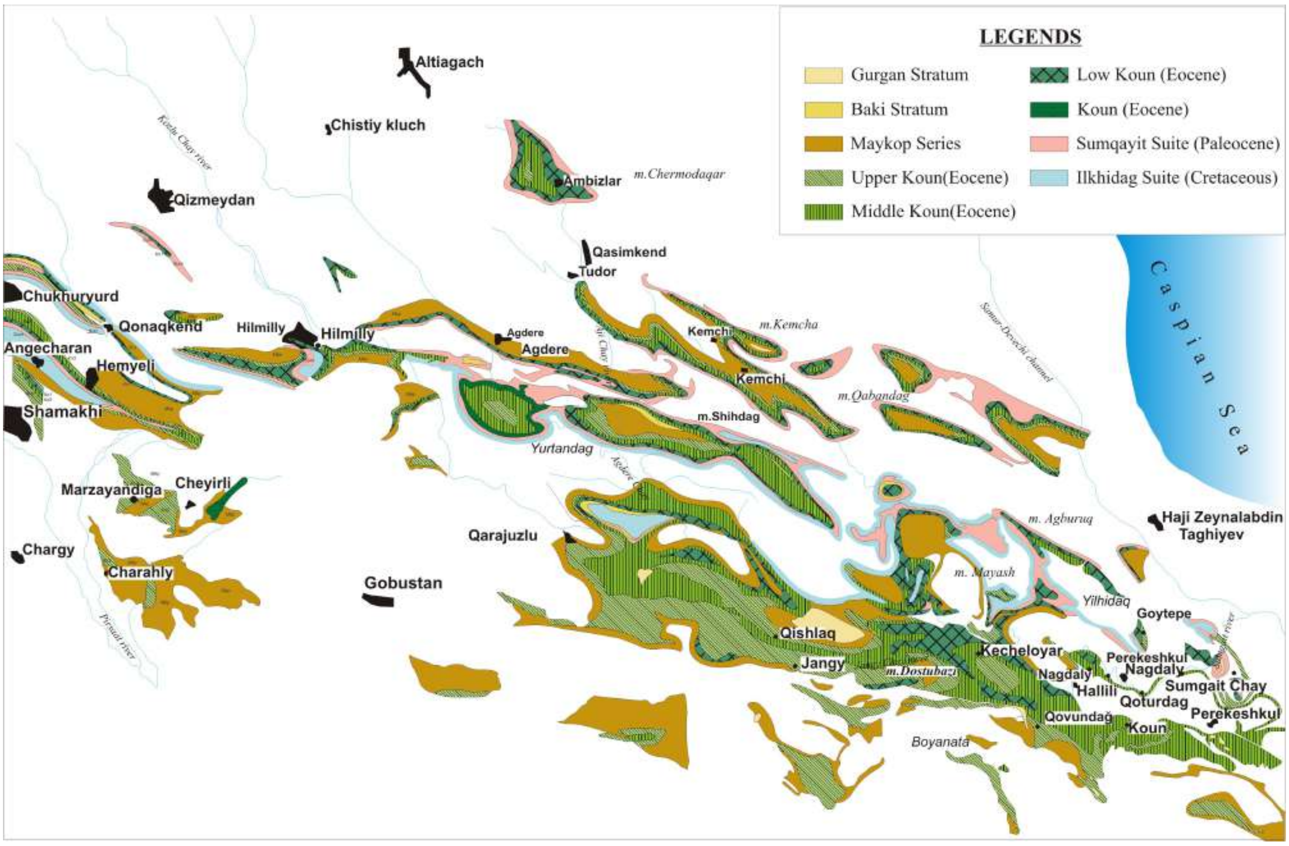

Figure 1. Location map of Paleogene sections of the Gobustan-West Absheron

The second sub-phase is characterised by the proliferation and development of the relatively flat globorotalia. The shell structure and time of their occurrence make them the immediate descendants of the rotalia-like globorotalia. The relatively flat globorotalia replicate the rotalia-like globorotalia at the early phases of their development, but, at the later phases of development, differ by the greater shell's convexity, and ventral side convexity in comparison with the dorsal side.

Table 1

The Zonal Chart of the Palaeogene deposits of the Gobustan-West Absheron area

System	Division	Subdivision	Stage	Zone	Phase
Palaeogene	Oligocene	Upper	Chattian		IV
		Lower	Rupelian	*Caucasina schischkinskaja*	
				Globigerina tumbeli	
	Eocene	Upper Eocene	Priabonian	*Globigerina officinalis*	III
				Globigerina corpulenta	
		Middle Eocene	Bartonian	*Globigerina turkmenica*	II
			Lutetian	*H. alabamensis?* / *Acarinina rotundimarginata*	
				Acarinina bullbrooki	
		Lower Eocene	Ypresian	*Globorotalia aragonensis*	I
				Globorotalia marginodentata	
				Globorotalia subbotinae	
	Palaeocene	Upper Palaeocene	Thanetian	*Acarinina acarinata*	
				Acarinina subsphaerica	
			Selandian	*Globorotalia angulata*	
		Lower Palaeocene	Danian	*Acarinina schachdagica*	
				Globoconusa daubjergensis	

This sub-phase encompasses the Late Palaeocene and most of the Early Eocene. The deposits that were formed at this sub-phase demonstrate the following 4 zones from the base to the top: *Globorotalia angulata* (the Selandian stage), *Acarinina subsphaerica, Acarinina acarinata* (the Thanetian stgae) and *Globorotalia subbotinae, Globorotalia marginodentata* (the Early Eocene-Ypresian stage).

The Globorotalia angulata zone is characterised by the slightly conic, keeled, sharp-edged shell of the index species and the morphologically allied globorotalia. The planktonic complex of the zone includes the following: the index species, *Globorotalia pusilla, G. ehrenbergi, G. chapmani, G. pseudomenardi, G. conicotruncata, Globigerina triloculinoides, G. pseudobulloides, G. varianta, G. moskvini, G. pileata, Acarinina uncinata,* etc. A portion of this complex passed here from the Danian (*Globigerina varianta, G. moskvini, G. pileata,* etc.). Speaking of the typical Upper Palaeocene species found here, one can mention *Globorotalia angulata, G. pusilla, G. ehrenbergi* and *G. conicotruncata. Globigerina trina, G. zeidensis* and *G. edita* are the transit species and migrate also into the overlying zone.

The Acarinina subsphaerica zone encompasses the lower section of the Thanetian stage. The zone is characterised by the mass development of the index species and the allied species of the sub-spherical Acarinina with the wide oval peripheral edge and tightly folded spiral. Besides, this zone has the material changes in the species composition of the globigerina and globorotalia in comparison with the underlying zone.

Globorotalia occlusa, Globigerina velascoensis, G. eocaenica, G. nana, G. triangularis and *G. quadritriloculinoides* appeared for the first time in this zone. Also, *Globigerina triloculinoides, G. varianta, G. trivialis* and *Globorotalia angulata* moved into this zone from the underlying deposits and stop their development at this zone's various level.

Globigerina triloculinoides, G. triangularis, G. quadritriloculinoides, G. pileata, Globorotalia compressa, etc. can be counted as transit species.

The main complex of the zone comprises *Acarinina subsphaerica, Globorotalia pseudomenardii, Globigerina velascoensis, G. nana, G. pileata* and *G. quadritriloculinoides.*

This zone is distinguished in the Goturdag section (65 m), and is composed by alternating grey, greyish-greenish shales and marly sandstones.

The *Acarinina acarinata* zone encompasses the upper portion of the Thanetian Tier. This zone is characterised by the first occurrence of the abundance of the index species' units as well as of *Acarinina primitiva* and the frequent occurrence of *Acarinina intermedia*. Of the globigerinae, *Globigerina velascoensis* and *G. nana* are encountered relatively frequently though less so than in the underlying zone. Besides, *Globigerina compressaformis* makes the first appearance in this zone. *Globigerina pileata, G. eocaenica, Globorotalia occlusa* and *G. chapmani* moved into this zone from the lower one.

This zone abounds in the agglutinated the foraminifers of which *Ammodiscus incertus, Trochamminoides irregularis, Glomospira charoides, Rhabdammina cykindrica,* etc. can be referred to.

Globigerina triloculinoides, G. eocaenica, G. nana, G. compressaformis, Acarinina acarinata, etc are the transit species.

The zone was identified in the Yunusdag (10 m thick), Goturdag (30 m thick), Perikyushkul (43 m thick), Khilmilli (25 m thick) sections. Lithilogically the sediments are represented by redish-brownish, greenish-greyish shales and sandstones.

The Globorotalia subbotinae zone encompasses the lower section of the Ypresian stage of the Lower Eocene.

Globorotalia subbotinae is for the first time represented in abundance in this zone; *Globorotalia marginodentata* and *Bolivina aduncosutura* are present to a lesser amount and *Globorotalia perclara* are seldom encountered. Besides, Radiolaria are numerous here. The planktonic complex of this zone is dominated by globigerina.

Globigerina nana, G. triloculinoides, G. varianta, G. nana, G. pileata, G. quadritriloculinoides and *G. compressaformis* and from the species of the other genera *Anomalina pseudoacuta, Eponides subumbonatus,* etc. continue their development within this zone.

Speaking of the transit species, we can mention *Cibicides felix, Nuttalloides trumpyi, Globigerina eocaenica, Globorotalia marginodentata, Acarinina acarinata, Anomalina affinus*, etc.

The lower boundary of the zone extends to the abundant occurrence of the index species as well as the presence of *Globorotalia marginodentata, G. turgida, Acarinina triplex, A. pseudotopilensis, Globigerina eocaenica,* etc. In this zone, *Globorotalia perclara, G. wilcoxensis, G. aequa, Acarinina subintermedia, A. clara,* etc. end their development.

The *Globorotalia marginodentata* zone encompasses the middle part of the Ypresian stage. The zone stands out for the mass development of the index species, the continued development of Globorotalia subbotinae and the emergence of *Globorotalia kajmatica, G. formosa gracilis* and *G. lensiformis.* A number of species pass to this zone from the underlying complex. Of these, *Globigerina varianta, G. eocaenica, G. triloculinoides, Acarinina acarinata, Anomalina affinus, Cibicides felix, C. cabardinicus, Nuttalloides trumpyi, Bolivina aduncosutura, Bulimina pseudopuschi, Glomospira charoides,* etc. can be distinguished. The radiolaria *Cenosphaera ispharensis* and *C. turkmenica* abound in this zone (Khalilov, Mamedova, 1984). Individual representatives of *Acarinina quadripartitaformis* and *Globorotalia pseudoscitula* are encountered in the upper part of this zone. Speaking of the transit species, we can mention *G. triloculinoides, Globorotalia pseudoscitula, Nuttalloides trumpyi, Bulimina pseudopuschi, Cenosphaera turkmenica* and so forth.

The third sub-phase encompasses the upper portion of the Ypresian stage. This phase is characterised by the dominance of the highly conical globorotalia (*G. aragonensis, G. marksi, G. caucasica*), the new Acarinina species (*interposita, pentacamerata and aspensis*) and the globigerinae (*pseudoeocaena, eocaena, turgida and inaequispira*).

This sub-phase corresponds to the Globorotalia aragonensis zone that is distinguished by the index species and the appearance of the certain complex of species: *Globorotalia caucasica, G. formosa formosa, Acarinina pentacamerata, A. interposita, A. broedermanni, A. marksi, Globigerina pseudoeocaena, G. inaequispira* and *Pseudohastigerina micra.* Besides, radiolaria *Cenosphaera turkmenica, C. ispharensis,* etc. are widely occur here. A number of the species that migrated from the underlying deposits finish their development in this zone: *Globorotalia subbotinae, Acarinina camerata, A. acarinata, Globigerina compressaformis,* etc. Speaking of the transit species, we can mention *Globigerina eocaenica, G. posttriloculinoides, Acarinina soldadoensis* and *Pseudohastigerina micra.*

The zone of *Globorotalia aragonensis* is recorded in the Khilmilli (22 m), Jangi (40 m), Goturdag (11 m), Perekyushkul (20 m), Gyshlak (20 m), Geytepe (50 m), Yunusdag (20 m) sections. Lithologically these sediments are composed of dark grey, greenish-greyish, redish-brownish shales.

The second phase encompasses the Middle Eocene (the Lutetian and the Bartonian stages). This phase is characterised by the robust development of the *Acarininae* and can be referred to as the *Acarinina* phase therefore. The globorotaliae disappear almost completely but the genera *Hantkenina* and *Globigerapsis* occur and the genus *Pseudohastigerina* is developed more widely at this phase.

This phase is divided into two sub-phases. The first sub-phase encompasses the Lutetian stage and is characterised by the robust development of *Acarinina.* The second phase corresponds to the Bartonian stage and is characterised by the relative recession of the *Acarinina* and the development of the thin-walled globigerinae.

The three zones are identified within deposits that match the *Acarinina* phase (from the base to the top): *Acarinina bullbrooki, Ac. ro-*

tundimarginata (the Lutetian stage) and *Globigerina turkmenica* (the Bartonian stage).

The *Acarinina bullbrooki* zone encompasses the lower portion of the Lutetian stage. The zone is characterised by the mass development of *Acarinina bullbrooki,* the appearance of *Hantkenina aragonensis* only developed within this zone and the wide occurence of *Globigerina posttriloculinoides, G. pseudoeocaena, G. eocaenica, Pseudohastigerina micra,* etc. that migrated here from the underlying zone. Besides, *Globigerinatheka subconglobata* and *Globigerinella voluta* occur in this zone for the first time. *Acarinina pentacamerata, Ac. soldadoensis, Globigerina varianta,* etc. finish their development at various strata of the zone. The radiolaria *Cenosphaera turkmenica* and *C. alveolatus* are frequently encountered here.

As regards the transit species, we have recorded *Globigerina posttriloculinoides, G. eocaenica, G. pseudoeocaena, Pseudohastigerina micra* and so forth.

The zone is found in the sections of Khilmilli (19 m), Gyshlak (20 m), Perekyushkul (20 m), Geytepe (20 m), Yunusdag (20 m), and is composed of grey, dark grey, greenish-greyish shales and coarse grey sandstones.

The *Acarinina rotundimarginata* zone encompasses the upper portion of the Lutetian stage. It is mostly characterised by the mass development of the index species and the renovation of the systematic composition of the planktonic foraminiferas.

The lower boundary of the zone is identified by the abundance of the index species units, the frequent occurrence of *Globigerinatheca subconglobata* and *Globigerina frontosa,* the wide development of the *Hantkenina lehneri* and the presence of *Globigerina inaequispira, G. mexicana, G. eocaenica, Pseudohastigerina micra,* etc. In this zone, *Globigerina inaequispira, G. senni, Acarinina spinuloinflata,* etc. finish their development.

The deposits corresponding to this zone are recorded in the Gyshlak (20 m), Perekyushkul (60 m), Govundag (30 m), Geytepe (25 m) outcrops; consist of alternating marly shales and sandstones.

Because of the insufficient faunistic material we can determine conventionally that the upper part of the *Acarinina rotudlimarginata* zone and also possibly the lower strata of the *Globigerina turkmenica* zone correspond to the *Hantkenina* alabamensis zone.

The *Globigerina turkmenica* zone corresponds to the Bartonian stage of the Middle Eocene. The zone complex comprises the index species that first appears in this Eon, and is found in a great amount. As regards the other species, we have recorded the following: *Globigerina ouachitaensis, G. praebulloides, G. eocaena, G. eocaenica, G. posttriloculinoides, G. subcorpulenta, G. azerbaidjanica, Acarinina rotundimarginata, Pseudohastigerina micra, Globigerinatheca subconglobata*, etc.

The lower bondary of the zone is defined by the wide occurrence of the index species and the presence of *Globigerina azerbaidjanica, G. subcorpulenta, G. praebulloides* and so forth. In this zone, the species *Acarinina bullbrooki, Ac. rugosoaculeata, Globigerina azerbaidjanica, G. posttriloculinoides, Globigerinatheca subconglobata,* etc. finish their development.

As regards the transit species, we can mention *Globigerina praebulloides, G. ouachitaensis, G. subcorpulenta, Bolivina antegressa,* etc.

The deposits of the zone are composed of greenish-greyish, light grey marly shales and sandstone beds, and take place in the Sumgaitchay (124 m), Perekyushkul (10 m), Geytepe (40 m), Yunusdag (60 m), Khilmilli (10–185 m), Jengi (180 m) sections.

The third phase encompasses the Late Eocene. This phase is characterised by the evolution of the globigerinae. This phase is divided in two sub-phases. The first sub-phase (the *Globigerina corpulenta* zone) is characterised by the wide occurrence of the large-sized globigerinae.

The second sub-phase (the *Globigerina officinalis* zone) is characterised by the abundance of the small globigerinae and the material development of the *Bolivina* species as well as a number of other benthic the foraminiferas.

The *Globigerina corpulenta* zone occupies the lower portion of the Priabonian stage. This zone stands out for the mass development of *Globigerina, Globigerapsis*, etc that, in turn, are distinguished by their large size. The zone complex comprises: the index species, *Acarinina rotundimarginata, Globigerapsis index, Globigerina ouachitaensis, G. inflata, G. eocaenica, G. praebulloides, Globigerinoides rubriformis, Pseudohastigerina micra, Globigerinatheca tropicalis, Globorotalia cerroazulensis, G. pseudopalmaraensis, G. centralis,* etc. Besides, *Bolivina binaensis, Nonion rotulum, Cibicides perlucidus, Anomalina hantkeni, Bulimina woodwardsi,* etc. are encountered here as well.

In this zone, the species *Acarinina rotundimarginata, Globigerina subcorpulenta, G. incretacea* and several others that migrated from the underlying deposits finish their development. As regards the transit species, *Globigerina. praebulloides, G. eocaenica, G. ouachitaensis, Pseudohastigerina micra, Cibicides lobatulus, Bulimina woodwardsi,* etc are recorded in the zone.

The *Globigerina corpulenta* zone is composed of grey, dark grey shales, and were identified in the Khilmilli (10–38 m), Jengi (30 m), Gyshlak (13–35 m), Perekyushkul (20 m), Nagdali (34 m), geytepe (30 m), Yunusdag (20 m), Govundag (15 m) sections

The zone *Globigerina officinalis* encompasses the upper portion of the Priabonian stage.

The lower extent of the zone is defined by the occurrence of the index species, *Globigerina compacta, G. pseudocorpulenta, G. ampliapertura,* etc. and the presence of *Globigerina praebulloides, G. praebulloides, G. ouachitaensis, G. irregularis, G. corpulenta, G. postcretacea, Pseudohastigerina micra, Globorotalia centralis,* etc. *Globigerina eocaena, Acarinina rugosoaculeata* and *G. eocaenica* finish their development in this zone. It should be mentioned that benthos is well-developed and stands out for its diversity here. The bolivinae (*Bolivina tuberna, B. gradata, B. antegressa* and *B. optima*) are abound here. Besides, it should be mentioned that *Nonion curviseptum, Eponides praeumbonatus, Cibicides lobatulus, Bulimina truncana, Anomalina zeivensis*, etc. are present within the zone.

As regards the transit species, we can mention *Globigerina. praebulloides, G. inflata, Pseudohastigerina micra,* etc.

The fourth phase encompasses the Early Oligocene (Rupelian stage). At this phase is evident the reduction of the dimensions of the planktonic the foraminifers and the relative sparseness of the benthic the foraminifers.

This stage is divided into two sub-phases. The first sub-phase corresponds to zone *Globigerina tumbeli*. This zone was first identified in the Agjakend trough by D.M.Khalilov (1984). This zone with the characteristic fauna complex was also identified in West Absheron-Gobustan for the first time as a result of our research work.

According to our data, the *Globigerina tumbeli* zone complex includes the index species, *Globigerina bulloides, G. praebulloides, G. tetracamerata, G. subangulata, G. postcretacea, G. ampliapertura, G. pseudoedita, G. officinalis, Pseudohastigerina micra, Nonion pseudomartkobi, Melonis dosularensis, Bolivina antegressa minor, Cibicides perlucidus, C. lopyanicus, Fsterigerina bracteata,* etc.

It should be mentioned that *Globigerina tumbeli, G. tetracamerata, G. subangulata, G. pseudoedita, Bolivina antegressa minor, B. inortata, Rotalia zeivensis* and *R. maragensis* first occur specifically in this zone. *Nonion pseudomartkobi, Melonis dosularensis, Cibicides lobatulus, Globigerina officinalis* migrated here from the underlying strata.

Globigerina praebulloides, G. postcretacea, G. officinalis, G. pseudoedita, Pseudohastigerina micra pertain to the transit species.

Globigerina tumbeli zone is recorded in the Khilmilli (90 m), Yunusdag (120 m), Gyshlak (85 m), Lehgi (45 m), Perekishkyul (50 m), Geytepe (85 m), Sumgaitchay (100 m), Govundag (68 m), Nagdali (89 m) sections, and composed of dark grey shales alternating with greenish-greyish, greenish-brownish shales.

The second sub-phase corresponds to *Caucasina schischkinskaya oligocaenica* zone. This zone encompasses the upper portion of the Rupelian stage. A.A.Alizade et al. identified this zone in the region of our study in 1989. However, the complex of species that they described comprised only the species of the wide stratigraphic range (*Globigerina* ex gr. *triloculinoides, Nonion pseudomartkobi, Bolivina antegressa minor* and *Cibicides lobatulus*) on considering which the containing deposits can be associated with the Lower Oligocene. However no zonal strtaigraphy is possible.

Thus, the *Caucasina schischkinskaya oligocaenica* zone was for the first time defined reliably in the area under study by us based on the characteristic complex comprising *Caucasina schischkinskaya oligocaenica, C. tenebricosa, Globorotalia denseconvexa, Heterohelix gracillima, Bolivina elongata, Hastigerina subangulata, H. evoluta, Cibicides stavropolensis, Siphonodosaria subspinosa,* etc. The species *Globigerina praebulloides, G. postcretacea, G. officinalis, G. pseudoedita* migrate here from the underlying zone.

No ostracod horizon fauna was found within the researched area. The *Caucasina schischkinskaya oligocaenica* zone corresponds to the *Caucasina schischkinskaya oligaenica, Chilostomella normalis* and *Disopontocypris oligocaenica* zones by the zonal scale of the Palaeogene in Azerbaijan.

Caucasina schischkinskaya oligaenica zone is found in the Nagdali (66 m), Geytepe (180 m) outcrops where these sediments are composed of alternating dark and red-brown shales.

Only *Hastigerina subangulata* was revealed in the deposits that are associated with the Hattic stage, so, no foraminifer zone was identified there.

The detailed study of the distribution of the foraminifers in the Palaeogene deposits of the researched area led to the following conclusions:

1. There are 4 phases (the Paleocene-the Early Eocene, the Middle Eocene, the Late Eocene and the Early Oligocene) were identified in the evolution of the Paleogene foraminiferas of West Absheron-Gobustan.

There are the traceable changes in the species complexes and the morphology of foraminiferas' shells at those stages.

The first phase – Paleocene-Early Eocene, can be called as globorotalia phase. Besides abundant *Acarinina* species the characteristic feature of the zone is continuous development of the *Heterohelix s*pecies and appearance a number of *Globigerina* species.

The second phase – Middle Eocene, is characterised by a plentiful development of the *Acarinina* species. At this phase *Globorotalia* species disappear, and *Hantkenina, Globigerapsis* come into sections.

The third phase – Late Eocene, is characterised by the evolution of *Globigerina.*

The fourth phase – Early Oligocene, is stand out by the decreased size of the planktonic foraminiferas.

2. The fact that the above-said changes are traceable phase by phase made it possible to develop the zonal stratigraphic chart of the Palaeogene deposits that consists of 16 zones (Figure 2). The *Acarinina acarinata* zone in the Tanetian stage of the Upper Paleocene as well as *Caucasina schischkinskaya* zone in the Rupelian stage of the Lower Oligocene have been identified for the firsts time.

The changes in the complex compositions along the Palaeogene deposits' section were described in detail.

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PLANKTON FORAMİNİFERLƏRİNİN İNKİŞAF MƏRHƏLƏLƏRİ VƏ QOBUSTAN-QƏRBİ ABŞERON PALEOGEN ÇÖKÜNTÜLƏRİNİN ZONAL BÖLGÜSÜ

H.A. Allahverdiyeva

Paleogen çöküntüləri Cənubi-Şərqi Qafqazda geniş yayılmışdır.

Üzvi aləmin inkişaf fazalarının ayrılması böyük maraq kəsb edir və mühüm strafiqrafik əhəmiyyətə malikdir. Təqdim edilən məqalə Qobustan-Qərbi Abşeron kəsilişlərinin Paleogen foraminiferlərinin tədqiqinin nəticələrini əks etdirir. Alınmış məlumatlar Paleogen ərzində foraminiferlərin inkişafında 4 fazanın olduğunu gösrərir: Paleosen-Erkən Eosen, (Qloborotaliya-lar mərhələsi), Orta Eosen (Akarininalar mərhələsi) və Gec Eosen (Qlobigerinalar mərhələsi) və Erkən Oliqosen (tənəzzül mərhələsi).

Foraminiferlərin mərhələli inkişafının tədqiqi Qobustan-Qərbi Abşeronun Paleogen çöküntülərinin 16 zonadan ibarət zonal bölgü sxemini tərtib etməyə imkan vermişdir.

ЭТАПНОСТЬ РАЗВИТИЯ ПЛАНКТОННЫХ ФОРАМИНИФЕР И ЗОНАЛЬНОЕ РАСЧЛЕНЕНИЕ ПАЛЕОГЕНОВЫХ ОТЛОЖЕНИЙ ГОБУСТАН-ЗАПАДНОГО АБШЕРОНА

Х.А. Аллахвердиева

Палеогеновые отложения широко распространены в геологическом строении Юго-Восточного Кавказа.

Выделение фаз развития органического мира, представляет большой интерес и имеет важное стратиграфическое значение. Настоящая статья представляет собой результаты изучения палеогеновых фораминифер послойно снятых разрезов Гобустан-Западного Абшерона. Полученные данные показывают 4 фазы развития фораминифер: палеоцен-ранний эоцен (этап глобороталий), средний эоцен (этап акаринин), поздний эоцен (этап глобигерин) и ранний олигоцен (этап спада).

Изучение стадийности развития фораминифер дало возможность составить зональную схему расчленения палеогеновых отложений Гобустан-Западного Абшерона, состоящую из 16 зон.

THE CORRELATION BETWEEN THE LOWER CRETACEOUS SEDIMENTS OF THE PLAIN CRIMEA AND THE CONTEMPORANEOUS ANALOGUES IN THE ADJACENT PROVINCES: BY THE FORAMINIFERAS OCCURENCE OF BIOSTRATONS, THE POSITION IN THE ISC, THE CORRELATION CRITERIA

The present article represents the results of the inter-regional correlation between the Lower Cretaceous sediments of the Plain Crimea and the contemporaneous analogues in the adjacent regions of the West and Eastern Mesotethys, drawn by foraminifera. The inter-regional correlation was carried out using the comparison of the zonal stratigraphic schemes of the Lower Cretaceous sediments by the foraminifera of the territories that belong to the Tethys Area as well as the Atlantic and Pacific basins. We have identified the correlation criteria and constructed the chart of inter-regional correlation whereby the regions are grouped into the West and Eastern Mesotethys.

Keywords: the Lowland Crimea, the Lower Cretaceous, foraminifera, correlation, the West Mesotethys and the Eastern Mesotethys.

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Introduction

The South of Ukraine (the Highland Crimea and the Lowland Crimea as well as the adjacent territories of the West and North coasts of the Black Sea, also, the Black Sea and the Sea of Azov water areas) is a correlation link situated on the Eastern-West division in the Tethyan Belt. Therefore, not only the comprehension and solution of many issues related to the local and regional stratigraphy but also the solution of several common inter-regional problems among which the most important one is the stratigraphic correlation between the Eastern and the Western territories of the Mediterranean Palaeozoogeographic region, and the restoration of the very complicate and region-specific Early Cretaceous history of development of that particular part of the Mesotethys depend on the detailed stratigraphy of this area.

The Material

The comparison of the zonal stratigraphic charts of the Lower Cretaceous sediments done by the foraminifera of the territories belonging to the Tethys Area as well as the Atlantic and Pacific Basins (Figures 1 and 2) was used to carry out inter-regional correlation. The regions of the Tethyan Area were grouped into the Western and the Eastern Mesotethys.

The Method

We have traced the occurrence of the distinguished biostratons within the limits of the said basins and identified the correlation criteria [including the index species, the presence of the commonly characteristic taxons (the correlative species) in the zonal associations and the binding of the foraminiferal biostratons to the ammonite zones] that predefine the clear-cut stratigraphic positions.

The Findings; Discussions

In spite of the facies-lithological diversify of the Lower Cretaceous deposits in not only the Lowland Crimea but also in the adjacent territories as well as the discovery of the rock lithotypes that do not contain foraminifera remains or have sparse foraminifera shells, the fact that this group of fossils are sensitive in reaction to various (and sometimes slight) changes in the physic-chemical conditions of the environment predetermined the diverse distribution and ratio of the benthos and plankton foraminifera in the zonal complexes. This, in turn, provided the grounds for the identification of various categories and ranks of biostratigraphic subdivisions within their territories.

Therefore, the detailed bio-subdivisions identified on the foraminiferas assume such types that should be considered as local ones, whilst others should be considered as the strata with the corresponding foraminifera complex and only a few have the status of the common foraminiferal zones owing to their regional and, sometimes, global distribution. It is precisely these biostratigraphic subdivisions that detail and unify the General Stratigraphic Scale have the status of the principal ones.

This inadequate nature of the detailed subdivisions distinguished by foraminiferas is no obstacle to correlation of the biostratons because the analysis of the zonal complexes made it possible to identify the common and characteristic types within their associations while the binding of the foraminiferal bio-subdivisions to the ammonite zones provides for the determination of their exact stratigraphic position.

The comparative analysis of the systematic composition and specific features of the stratigraphic and geographic distribution of the Lower Cretaceous foraminiferal associations in the Lowland Crimea made it possible to find their analogues beyond the limits of the examined region – namely, in the North Caucasus, Georgia, the Precaspian Lowlands, the Manghishlak Peninsula, Ustyurt, West Turkmeniya, the British Isles, France, Switzerland, Germany, Spain, the Netherlands, Romania, North Africa, the Atlantic and the Pacific oceans, the Carpathian Mountains and in Mordovia (see Figures 1, 2).

The Hauterivian Stage. The Hauterivian Stage sediments widely occur within the limits of the Tethys Area (the Mediterranean, the Highland and Lowland Crimea, the North Caucasus, Georgia, the Precaspian Depression, Manghishlak, Ustyurt) (see Figures 1, 2). They are present in two sub-stages with the full sections in the West Europe. The shortened sections are matched eastwards and westwards until their complete pinching out in West Turkmeniya, North Mexico, the Caribbean Basin and the Atlantic Ocean. The territories of the Highland Crimea, the North Caucasus and the Precaspian Lowland are the exceptions: there, the Hauterivian sections are almost matching that in the Mediterranean. They are absent in some regions of the Atlantic and Pacific oceans. The Hauterivian stratigraphy in the said regions of the Tethys Area is based on the benthic as well as planktonic foraminiferas. In terms of the planktonic foraminifera, the Hauterivian sediments of several regions correspond to the volume of the common biostratigraphic subdivision *Globuligerina hoterivica* (=*Clavihedbergella hauterivica*) (Горбачик, 1986; Андреева-Григорович, 1991; Зональная стратиграфия…, 2006; Практическое руководство…, 1991; Харленд и др., 1985; Цирекидзе, 1998; Caron at al., 1985; Pflaumann, Cepek, 1982; Salaj, 1980; Sigal, 1977), which can provide sufficient grounds for creation of a common zonal foraminiferal scale for the remote enough territories.

The Hauterivian Stage sediments in the Lowland Crimea are prominent in the lower sub-stage and are united to make a single biostratigraphic sub-division that was defined by foraminifera, – the strata with *Marginulinopsis sigali* to *Dorothia kummi* (Тузяк, 2011 и др.).

Because of the absence of planktonic forms these sediments can only be compared on the basis of the complex of benthic foraminiferas.

It is impossible to tie-in to ammonite zones because the molluscs have the severed complex of the characteristic species among which *Crioceras* ex gr. *duvali* (Lev.) (Лещух, 1992) that diagnoses the Lower Hauterivian sediments within the limits of the Mediterranean (Harland et al., 1985) is of the stratigraphic significance.

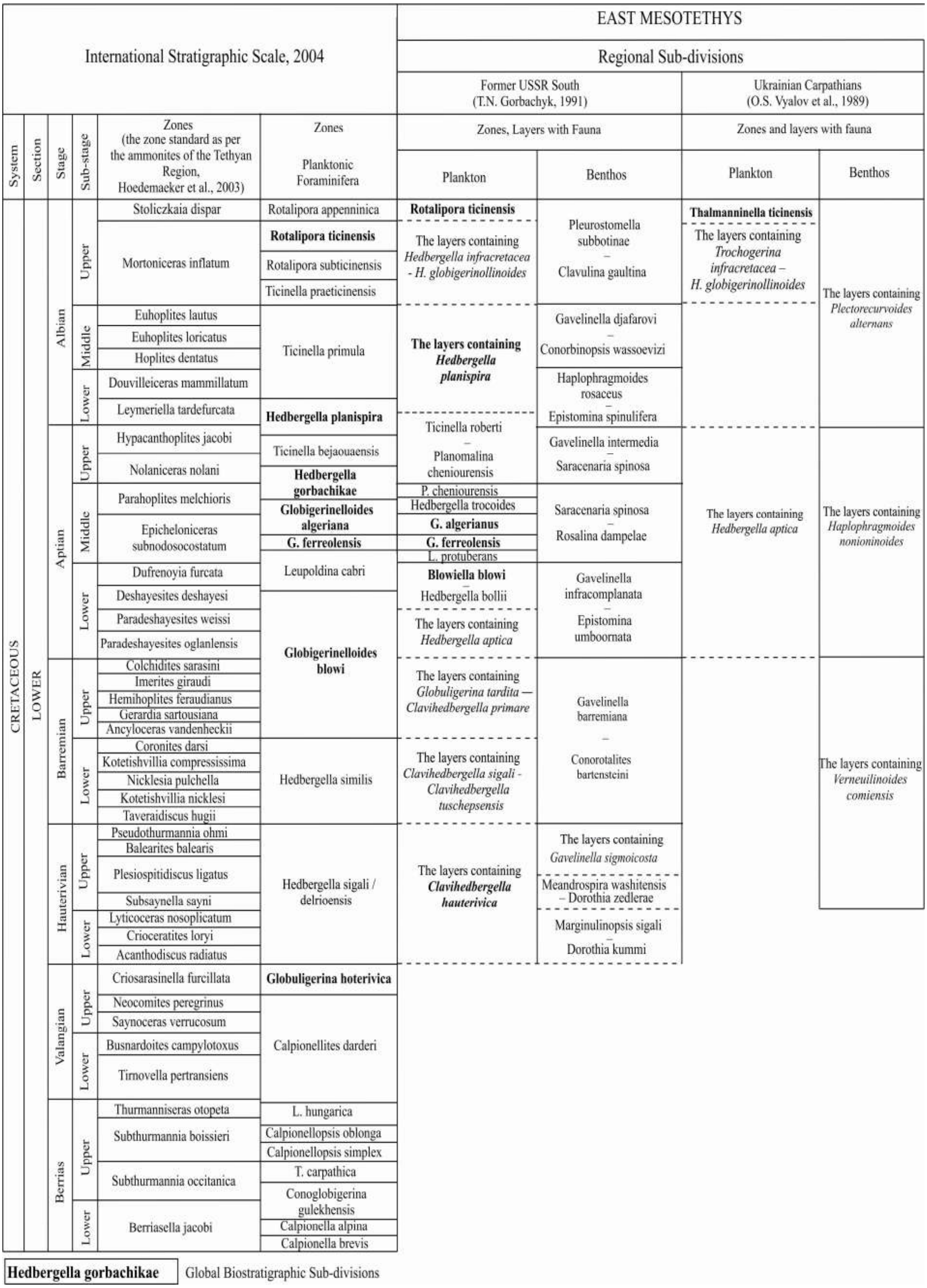
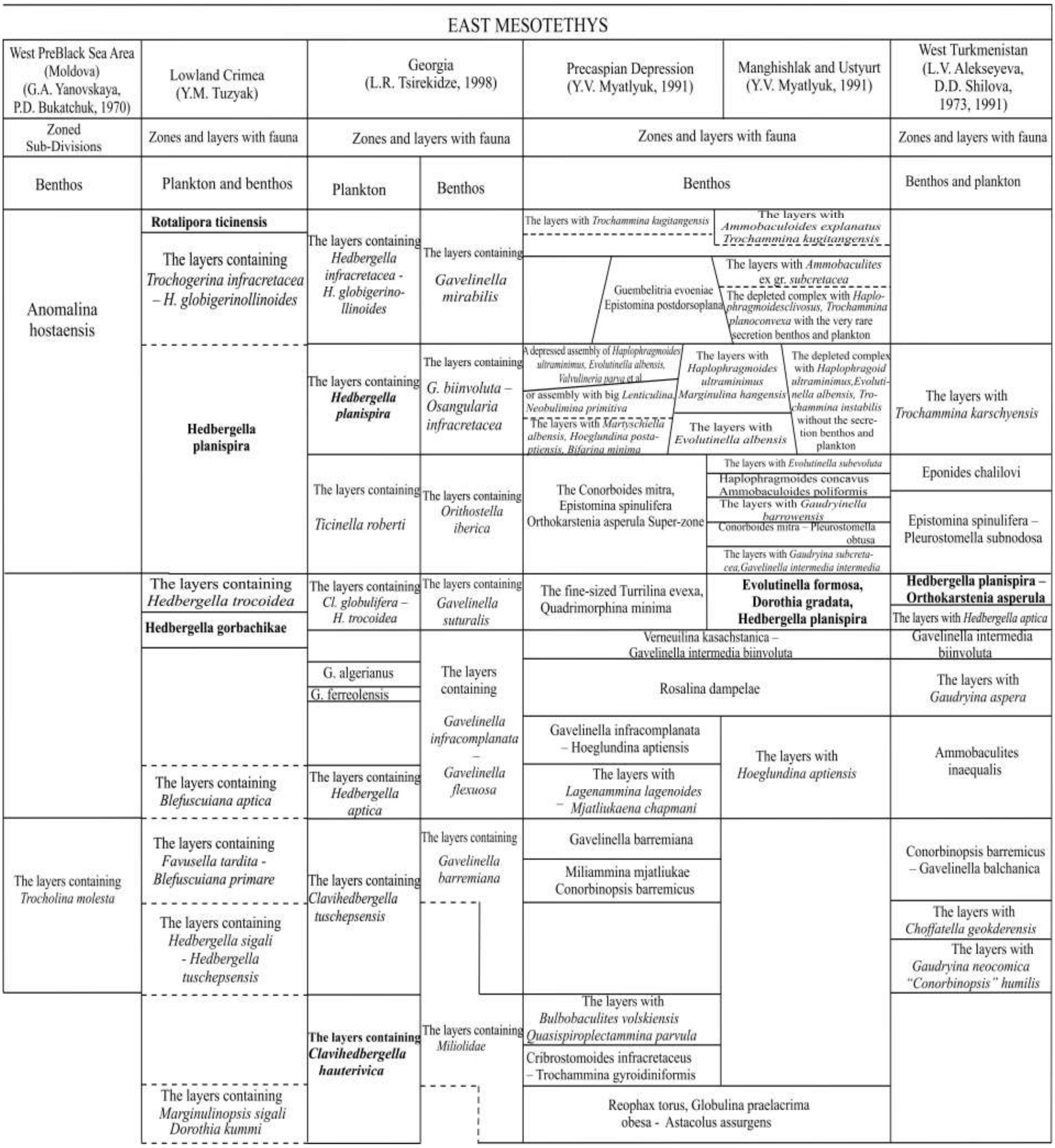


Figure 1. The Chart of Inter-Regional Correlation of the Lower Cretaceous Biostratons of the Eastern Mesotethys and Pacific Ocean's Regions

continuation of the ***Figure 1***



continuation of the ***Figure 1***

PACIFIC OCEAN		
Japan (Caron, 1985)	West Pacific (Caron, 1985)	East Pacific (Caron, 1985)
Zones	Zones	Zones
Plankton Foraminifera	Plankton Foraminifera	Plankton Foraminifera
	R. ticinensis – Pl. buxtorfi	Planomalina buxtorfi
Ticinella breggiensis	Ticinella breggiensis	**Rotalipora ticinensis**
		Ticinella breggiensis
	Ticinella roberti	Ticinella roberti
	Ticinella primula	
	Hedbergella gorbachikae - Planomalina cheniourensis	Hedbergella pacifica
	Globigerinelloides algeriana	**G. ferreolensis**
	G. ferreolensis	**Globigerinelloides blowi**
	Hedbergella aptica	
	Globigerinelloides gottisi	**Hedbergella sigali**
	Hedbergella sigali	

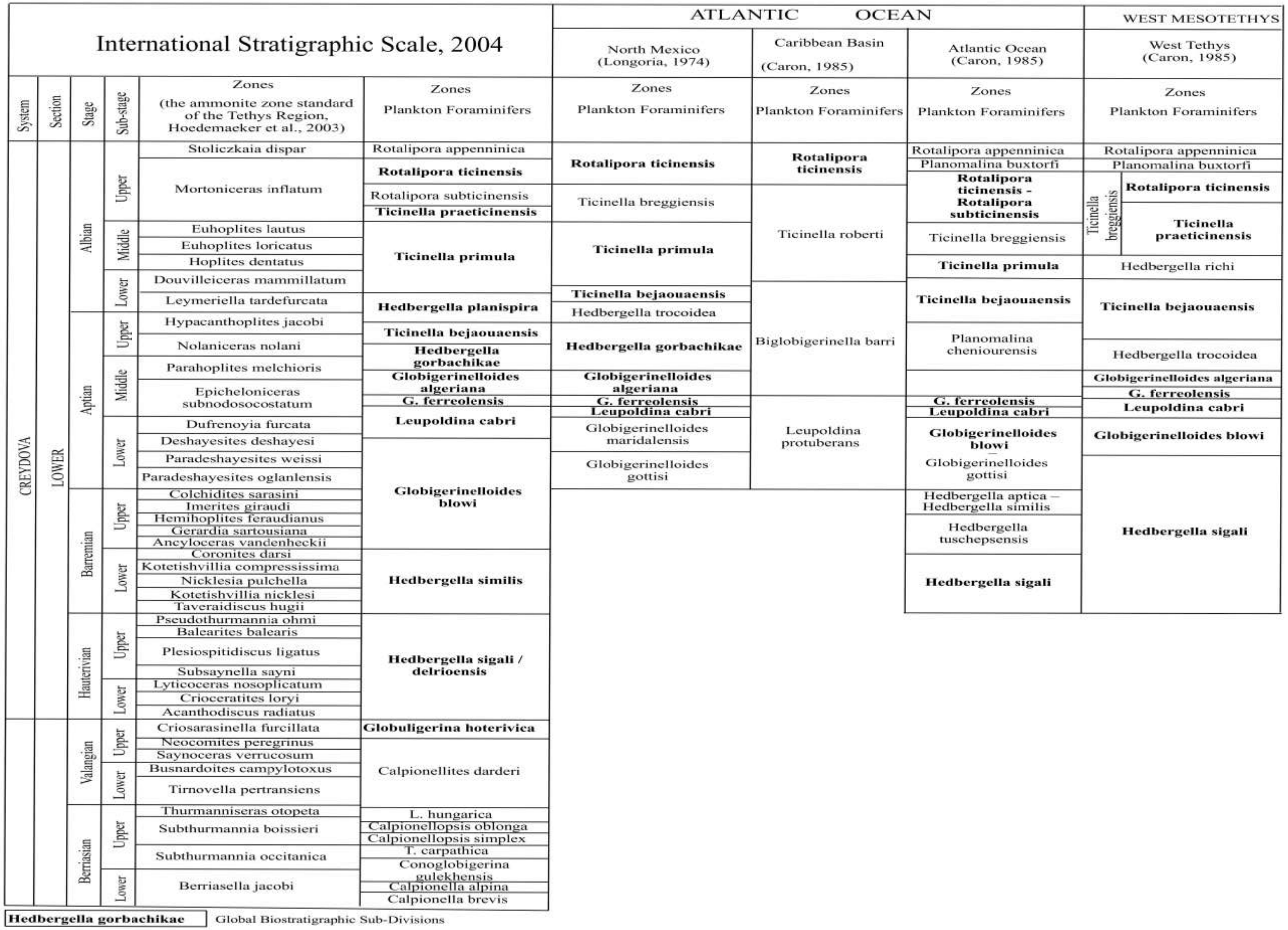


Figure. 2. The Chart of Inter-Regional Correlation of the Lower Cretaceous Biostratons of the Atlantic and West Mesotethys Regions

continuation of the **Figure 2**

WEST MESOTETHYS					
Центральный Тетис (Sigal, 1977) ; (Caron, 1985)	East Tethys (Caron, 1985)	West Africa (Pflaumann, Cepek, 1982)	Tunisia (Salaj, 1980)	Slovak Carpathians (Salaj, Samuel, 1984; Gašparikova, 1984)	Polish Carpathians (Geroch, Nowak, 1983)
Zones Plankton Foraminifers	Zones Plankton Foraminifers	Zones Plankton Foraminifers	Zones Plankton Foraminifers	Zone Sub-Divisions Plankton and benthos	Zone Sub-Divisions Benthos
Rotalipora appenninica - Planomalina buxtorfi	**Rotalipora ticinensis**	Rotalipora appenninica	Rotundina stephani	Whiteinella gandolfi	Plectorecurvoides alternans
Ticinella breggiensis	Hedbergella infracretacea	**Rotalipora ticinensis**	**Thalmanninella ticinensis ticinensis**	**Thalmanninella ticinensis**	Haplophragmoides nonioninoides
Hedbergella richi – **Ticinella primula**		Ticinella breggiensis	Thalmanninella ticinensis subticinensis	Thalmanninella subticinensis	Pseudobolivina variabilis - Reophax minutus
Hedbergella planispira	**Hedbergella planispira**	**Ticinella primula**	Ticinella roberti	Ticinella roberti	Gaudryina oblonga ?
Ticinella bejaouaensis			Hedbergella roberti	Hedbergella rohri	Dorothia aff. hauterivina
Hedbergella trocoidea	T. roberti + Pl. cheniourensis	**Ticinella bejaouaensis**	Biglobigerinella barri	Biglobigerinella barri	Verneuilinoides neocomiensis
Globigerinelloides algeriana	Planomalina cheniourensis	Hedbergella trocoidea	**Globigerinelloides algeriana**	**Pl. (Globigerinelloides) algeriana** - Epistomina (Br.) spinulifera polipoides	Pseudoreophax cisovnicensis
G. ferreolensis	Hedbergella trocoidea	**Globigerinelloides algeriana**	**G. ferreolensis**	**Pl. (Globigerinelloides) ferreolensis** - Conorotalites aptiensis	
Leupoldina cabri	**Globigerinelloides algeriana**	**G. ferreolensis**	Schackoina pustulans	Conorotalites bartensteini - Epistomina (Br.) spinulifera	
G. maridalensis + G. blowi	Leupoldina protuberans	**Leupoldina cabri**	Clavihedbergella subcretacea	Conorotalites bartensteini - **Hedbergella sigali**	
Globigerinelloides gottisi - Globigerinelloides duboisi	**Globigerinelloides blowi** - Clavihedbergella subcretacea	**Globigerinelloides blowi**	**Hedbergella sigali**	Epistomina (Br.) hechti - **Hedbergella sigali**	
Hedbergella similis	Hedbergella aptica	Globigerinelloides duboisi	**Caucasella hoterivica**	**Hedbergella sigali** - Lingulogavelinella sigmoicosta barremiana	
	Clavihedbergella tuschepsensis	**Hedbergella similis**		**Caucasella hoterivica** - Lingulogavelinella sigmoicosta sigmoicosta	
Hedbergella sigali		Hedbergella aptica		Lenticulina (Marginulinopsis) djaffaensis - Haplophragmoides nana	
	Hedbergella sigali	Clavihedbergella tuschepsensis		Lenticulina (L.) ouchensis - Lenticulina (L.) eichrenbergi	
Globuligerina hoterivica		**Globuligerina hoterivica**		Conorboides hofkeri - Epistomina (E.) ornata	
				Tirtinopsella carpathica - Calpionella elliptica	

However, the position and the relative geological age are clearly traceable thanks to the index species and the complex of the characteristic species, namely, *Dorothia kummi* (Zedl.), *Lenticulina akmetchetica* Mjatl., *L. infravolgensis* (Furs.), *L. guttata guttata* (Dam), *L. nodosa* (Reuss), *L. ouachensis ouachensis* Sigal, *L. subgaultina* Bart., *L. turgidula* (Reuss), *Marginulinopsis sigali* Bart., Bett. et Bolli, *Vaginulinopsis parallela* (Reuss) and many epistominas. The association of the characteristic taxons permits correlation of the Lower Hauterivian strata in the Lowland Crimea to the same named bio-subdivisions of the Highland Crimea (Горбачик, 1986; Практическое руководство …, 1991) and the North Caucasus (Зональная стратиграфия …, 2006) where there is only one biostraton matching the whole volume of the sub-stage is identified – just like in the Lowland Crimea. On the Lower Cretaceous Geologic Time Scale (Gradstein at al., 2004), this part of the succession is correlated to the foraminiferal zone *Hedbergella sigali/delrioensis*.

For the Atlantic Ocean (Крашенинников, 1978), the following bio-subdivisions are identified in the Hauterivian sediments (bottom to top): *Hedbergella occulta, Globigerina graysonensis, Caucasella hoterivica.* In the Mediterranean (Харленд и др., 1985; Sigal, 1977) are identified *Haplophragmoides vocontianus, Dorothia ouachensis* (the Lower Hauterivian) and *Caucasella hoterivica – C. kugleri, Gavelinella sigmoicosta* (the Upper Hauterivian). The West (Slovak) Carpathians have the similar stratigraphy (Вялов и др., 1989); there, the study of the benthic foraminifera identified two sub-stages: the lower one within the *Lenticulina (Marginulinopsis) djaffaensis – Haplophragmoides nana* zone and the upper one within the *Caucasella hoterivica – Lingulogavelinella sigmoicosta sigmoicosta* zone. The Hauterivian of the Polish Carpathians is identified within the one *Dorothia* aff. *hauterivina* zone (Вялов и др., 1989). In the West Africa scheme (Pflaumann, Cepek, 1982), the stratigraphy of the Hauterivian is based on planktonic foraminiferas whereby the *Globuligerina gulekhensis* (the base of the stage) and the *Globuligerina hoterivica* zones were identified. The Hauterivian sediments of Tunisia (Salaj, 1980) are identified within the upper sub-stages that correspond to the *Caucasella hoterivica* zone.

The correlation of the identified strata to the contemporaneous deposits of the Eastern Mesotethys (the Precaspian Depression, Manghishlak, Ustyurt) (Мятлюк, Василенко, 1988; Практическое руководство …, 1991) showed that the Hauterivian deposits are recorded within two sub-stages. The foraminiferal biostratons are characterised by a different zonal composition of associations with the prevalence of agglutinated benthos and the subvalence of the secretional one. The Lower Hauterivian is identified within the *Reophax torus – Globulina praelacrima obesa – Astacolus assurgens* zone. The Upper Hauterivian is identified within these two biostratons: the *Cribrostomoides infracretaceus – Trochammina gyroidiniformis* zone and the strata with *Bulbobaculites volskiensis* - *Quasispiroplectammina parvula*. In some Eastern Mesotethys regions (the Ukrainian Carpathians, Mordva, West Turkmeniya) (Алексеева, Шилова, 1973; Практическое руководство …, 1991) as well in the Boreal Belt of Russia (Зональная стратиграфия …, 2006) the Hauterivian stage has no zonal stratigraphy by foraminiferas.

The correlation of the Hauterivian sediments by benthic foraminifera is difficult to an extent. In spite of the different names of the zones and strata due to the choice of various index species, all the said zonal divisions have either the akin or similar compositions of the diagnostic or accompanying species including those that are the most characteristic ones for the Lower Hauterivian, namely, *Dorothia kummi* (Zedl.), *D. subtrochus* (Bart.), *Lenticulina nodosa* (Reuss), *Citharina rudocostata* Bart. et Brand, *Marginulina gracilissima* Reuss, *M. robusta* (Reuss), *M. striatocostata* (Reuss), *M. pyramidalis* (Koch) and epistominas. This makes it possible to speak of the similar features of these regions' complexes as well as of the uniform sequences in the development of the foraminifera and a wide migration of marine benthic faunas within the boundaries of the European aquatic area in the Early Cretaceous.

The Barremian Stage. The Barremian Stage sediments have a wide occurrence within the boundaries of the Tethys Area as well as in the Atlantic and Pacific regions (the upper portion of the Barremian). The fullest successions are composed of the Lower and Upper Barremian sediments, and are located in the Atlantic Ocean as well as in the Western (the Mediterranean, the West (Slovak) Carpathians) and the Eastern (the Highland and Lowland Crimea, the North Caucasus, the West Turkmeniya) Mesotethys (see Figures 1, 2). The shortening of the Barremian successions is traceable in the eastern and western directions. The stressed foraminiferal complexes were encountered in the Polish Carpathians (Вялов и др., 1989) and Mordva (Яновская, Букатчук, 1970). No biosubdivisions are prominent in the Ukrainian Carpathians (Вялов и др., 1989). For instance, in the Pacific Ocean, the Barremian deposts are represented only by the upper portion of the upper sub-stage while they are completely absent in the western region (North Mexico and the Caribbean Basin).

The presence of the cognominal biostratons at the same stratigraphic level in the majority of regions can provide sufficient grounds for construction of a common (standard) foraminiferal zonal scale.

The Barremian Stage sediments in the Lowland Crimea are represented by two sub-stages each of which corresponds to the foraminiferal strata as follows: the lower sub-stage does to *Hedbergella sigali – Hedbergella tuschepsensis* and the upper one to *Favusella tardita – Blefuscuiana primare* (Тузяк, 2011 и др.). The Barremian sediments contain varied species associations of foraminifera the composition of which includes the widely occurring forms, which provides solid ground for their correlation. The absence of the zonal stratigraphy of these deposits by ammonites hardens the correlation of the identified biostratons to the analogues in the adjacent territories. However, the presence of the cognominal biostratigraphic subdivisions by foraminiferas or one of the index species on the same stratigraphic level in the Atlantic, West and partly also East Mesotethys (the Highland Crimea, the North Caucasus and Georgia) gives us enough reasons to diagnose the enclosing rocks and determine their relative geological ages as well as the stratigraphic positions in the GSS.

The formation of the Barremian species composition was taking place during considerable transgressions that affected vast territories. Most of its characteristic components permit a correlation of the Barremian sediments and not only in the Tethys Belt. The planktonic foraminifera *Hedbergella sigali* (Moul.) and *Hedbergella tuschepsensis* (Ant.) which are matched in the Early Barremian and have a wide occurrence should be highlighted among other species. The global distribution of these species can be interpreted as a sign of a link between the basins of not only the West Mesotethys and the East Mesotethys but also among the basins of the other tectonic belts (the Atlantic and the Pacific oceans) and as a sign also of the same-aged interval of their formation stages.

The Barremian sediments in the majority of regions of the West Mesotethys are identified within two sub-stages. They are absent in North Mexico and the Caribbean Basin. By the chart made for the Atlantic (Крашенинников, 1978), the Barremian sediments correspond in the volume to the strata of *Hedbergella globigerinellinoides, H. simplex* and *Globigerinelloides ultramicrus*. In the Mediterranean, they are divided into the following zones: *Hedbergella sigali, Clavihedbergella eocretacea* (the lower sub-stage), *Conorotalites intercedens* and *Conorotalites aptiensis* (the upper sub-stage)

(Харленнд и др., 1985; Sigal, 1977). The Barremian has a similar stratigraphy in the West (Slovakian) Carpathians where two foraminiferal zones were identified in each of the upper and lower sub-stages. Namely, *Hedbergella sigali – Lingulogavelinella sigmoicosta barremiana* and *Epistomina (Br.) hechti – Hedbergella sigali* were recorded in the Lower Barremian and *Conorotalites bartensteini bartensteini – Hedbergella sigali* and *Conorotalites bartensteini intercedens – Epistomina (Br.) spinulifera* (Вялов и др., 1989) in the Upper Barremian. In the West Africa (Pflaumann, Cepek, 1982), they match *Hedbergella tuschepsensis* and *Hedbergella aptica* and in Tunisia (Salaj, 1980) the lower sub-stage is identifiable within the *Hedbergella sigali* zone while the upper one within the *Clavihedbergella subcretacea* and *Schackoina pustulans* zone. The Barremian of the Polish Carpathians has a somewhat different stratigraphy. According to the distribution benthic foraminiferas, three zones (bottom to top) have been identified there: the upper portion of *Dorothia* aff. *hauterivina* that is matching the lowers of the Lower Barremian; *Gaudryina oblonga* (?) that encompasses the upper portions of the Lower Barremian and the lower portion of the Upper Barremian, and the lower part of the *Pseudobolivina variabilis – Reophax minutus* zone that corresponds to the uppers of the Upper Barremian (Вялов и др., 1989).

The stratigraphy of the Barremian sediments within the limits of the East Mesotethys is based on benthic foraminiferas. So, in Mordva the strata containing *Trocholina molesta* and corresponding to the Barremian stage, and in the Precaspian Depression the *Miliammina mjatliukae – Conorbinopsis barremicus, Gavelinella barremiana* (the upper sub-stage) zones are the age analogues (Зональная стратиграфия ..., 2006; Практическое руководство ..., 1991), while in West Turkmeniya (Алексеева, Шилова, 1977; Практическое руководство ..., 1991)) those are the strata containing *Gaudryina neocomica – "Conorbinopsis humilis" humilis* and *Choffatella geokderensis* (the lower sub-stage) and the *Conorbinopsis barremicus – Gavelinella balchanica* (the upper sub-stage) zone. The exception is constituted by the territories of the Highland Crimea, the North Caucasus and Georgia for which there is a common biostratigraphic chart of planktonic and benthic foraminiferas and to which the territory of the Lowland Crimea is added. The stratigraphy of the Barremian in Georgia (Цирекидзе, 1998) contradicts the overall picture somewhat as there, the planktonic (the strata containing *Clavihedbergella tuschepsensis*) and benthic (the strata containing *Gavelinella barremiana*) biostratons have been identified that correspond to the whole stage. In the Highland Crimea (Горбачик, 1986; Практическое руководство ..., 1991) and in the North Caucasus (Зональная стратиграфия ..., 2006), there are the identified cognominal strata containing *Hedbergella sigali – Clavihedbergella tuschepsensis* (for the Lower Barremian) and *Globuligerina tardita – Clavihedbergella primare* (for the Upper Barremian). According to the Lower Cretaceous on the Geologic Time Scale (Gradstein at al., 2004), the Barremian has two foraminiferal zones of *Hedbergella similis* and *Globigerinelloides blowi* (the lower part).

The comparative analysis of the systematic composition the zonal Barremian complexes in the Lowland Crimea and in the West and East Mesotethys made it possible to identify within their composition not only the identical index species but also a complex of characteristic taxons common for the whole Tethys Belt. The following species should be considered as such: *Conorotalites bartensteini intercedens* Bett., *C. bartensteini aptiensis* Bett., *Gavelinella barremiana* (Bett.), *Favusella tardita* (Ant.), *Clavihedbergella globulifera* (Kretsch. et Gorb.), *Blefuscuiana primare* (Kretsch. et Gorb.), *Hedbergella tuschepsensis* (Ant.), *H. sigali* (Moul.) and *H. aptica* (Agal.).

The Aptian Stage. The Aptian sediments widely occur not only in of the Tethys Area, but also beyond its boundaries, namely, in the regions of the Atlantic and the Pacific oceans (see Figures 1, 2). The fullest Aptian successions, represented by three sub-stages and detailed stratfied by foraminiferas, are located in Western Europe (Харленд и др., 1985; Sigal, 1977) and the West Carpathians (Вялов и др., 1989). The Aptian Stage has the three-part stratigraphy also in the regions of the Atlantic Ocean (Крашенинников, 1978; Caron at al., 1985), the Highland Crimea (Горбачик, 1986; Практическое руководство ..., 1991) and the Lowland Crimea (Лещух, 1992; Тузяк, 2008), the North Caucasus (Зональная стратиграфия ..., 2006), Georgia (Цирекидзе, 1998), the Precaspian Depression (Мятлюк, Василенко, 1988; Практическое руководство ..., 1991) and West Turkmeniya (Алексеева, Шилова, 1977; Практическое руководство ..., 1991). Eastwards, the fullness of the Aptian stratigraphic column diminishes and the bio-subdivisions identified by the benthic foraminiferas dominate within the limits of the Precaspian Depression, Manghishlak, Ustyurt and West Turkmeniya. Also, the shortened Aptian section is traced in the Caribbean Basin (Caron at al., 1985).

The Aptian sediments in the Lowland Crimea are divided by foraminiferas into three biostratons (Тузяк, 2011 и др.), which correlate to the age analogues in the Antarctic, the Tethyan Area and the Pacific Ocean in terms of the common elements present in the zone associations and their association to the ammonite zones. This makes it possible to speak of the adequacy of the volumes of biostratons identified in the Lowland and Highland Crimea as well as in the North Caucasus.

The strata containing *Blefuscuiana aptica* correspond to the same ammonite zone of *Deshayesites deshayesi* both in the Highland (Горбачик, 1986; Практическое руководство ..., 1991) and Lowland Crimea (Тузяк, 2011 и др.) even though there are much wider in a volume in the North Caucasus, where they encompass two bio-subdivisions identified by the ammonites: *Paradeshayesites weissi* and *Procheloniceras albrechtiaustriae* (Зональная стратиграфия …, 2006), both of which correspond to the basal portion of the Lower Aptian substages. Besides, the Lower Aptian of the North Caucasus is divided by foraminiferas into the following two biostratons: the strata containing *Hedbergella aptica* and the *Blowiella blowi – Hedbergella bollii* zone (Зональная стратиграфия …, 2006), each of which corresponds to two ammonite zones. In Georgia, these strata encompass three ammonite zones (Цирекидзе, 1998). In West Turkmeniya, they widely occur on the level of the zonal ammonite Acanthohoplites prodromus and correspond to the Upper Aptian (Алексеева, Шилова, 1977; Практическое руководство ..., 1991), while in the Precaspian Depression, the Lower Aptian is manifest in two foraminiferal bio-subdivisions that correspond to three ammonite zones (Мятлюк, Василенко, 1988; Практическое руководство ..., 1991). The Aptian of the Polish and the Ukrainian Carpathians as well as of Mordva has a completely different characteristic stratigraphy. The Aptian Stage is manifest in the Polish and the Ukrainian Carpathians within one zone. For instance, it is *Pseudobolivina variabilis – Reophax minutus* (Вялов и др., 1989) in the Polish Carpathians and the strata containing *Hedbergella aptica* (Вялов и др., 1989) in the Ukrainian Carpathians. There are no bio-subdivisions in Mordva (Яновская, Букатчук, 1970).

The somewhat different stratigraphy of the Lower Aptian is found in the Atlantic, the West Mesotethys and the Pacific Ocean. Thus, in the Mediterranean (Харленд и др., 1985; Sigal, 1977), the Lower Aptian is divided into the following foraminiferal zones (bottom to top): *Hedbergella similis, Globigerinelloides gottisi – Globigerinelloides duboisi, Globigerinelloides maridalensis – Globigerinelloides blowi* and the lower part *Schackoina cabri*, all of which correspond in a volume to two ammonite zones. In the West (Slovakian) Carpathians, the Lower Aptian is subdivided into the following two zones but those containing the different index species: *Planomalina (Globigerinelloi-*

des) ferreolensis – Conorotalites aptiensis (the lower part of the Lower Aptian), *Planomalina (Globigerinelloides) algeriana – Epistomina (Br.) spinulifera polipoides* (the upper portion of the Lower Aptian) (Вялов и др., 1989). In West Africa, it is considered in the volume of three foraminiferal zones – *Hedbergella similis, Globigerinelloides duboisi, Globigerinelloides blowi* (Pflaumann, Cepek, 1982), while the following zones are identified in Tunisia: *Planomalina (Globigerinelloides) ferreolensis* and *Planomalina (Globigerinelloides) algeriana* (Salaj, 1980), in North Mexico, these are *Globigerinelloides gottisi, Globigerinelloides maridalensis* (Longoria, 1974) while in the Atlantic these are *Globigerinelloides maridalensis – Globigerinelloides gottisi* (Krashennikov, 1978). In the Pacific Ocean, the strata containing *Globigerinelloides ferreolensis*, *Globigerinelloides algerianus*, *Leupoldina cabri* correspond to the whole volume of the Aptian (Крашенинников, 1978) (see Figures 1, 2).

According to the Geologic Time Scale of the Lower Cretaceous (Gradstein at al., 2004), the Lower Aptian has the following two foraminiferal zones: the upper portion of *Globigerinelloides blowi* and *Leupoldina cabri*; the first one combines three zones and the second one does just one zone.

This different interpretation of the stratigraphy of the Lower Aptian sediments is regulated by a number of features such as the different transgression rates, the climatic zonation and the location as well as the palaeogeographic specificities of the sedimentatary basins. The comparison of the foraminiferal units revealed that they correlate the best to the cognominal and contemporaneous analogues of the Highland Crimea, the North Caucasus and Georgia to which they are kin thanks to the common associations within the zonal complexes. In terms of the benthic forms, the Lowland Crimean strata correlate to the biostratons of the Precaspian Depression, Manghishlak and Ustyurt. In spite of the differing index species in the Lowland Crimea and in the West Mesotethys, the associations of the zonal complexes still manifest the following common elements: *Tritaxia pyramidata* Reuss, *Vaginulina* (*Psilocitharella*) sp., *L. nodosa* (Reuss), *Astacolus crepidularis tricarinella* (Reuss), *Conorotalites bartensteini aptiensis* Bett., *C. bartensteini intercedens* Bett., *Gavelinella barremiana* (Bett.), *Clavihedbergella globulifera* (Kretsch. et Gorb.), *Hedbergella sigali* (Moul.) and *Blefuscuiana aptica* (Agal.), *B. primare* (Kretsch. et Gorb.).

The Middle-Upper Aptian sediments of the Lowland Crimea are differentiated within the *Hedbergella gorbachikae* zone and the strata containing *Hedbergella trocoidea,* which correspond to the zonal ammonites *Acanthohoplites nolani* and *Hypacanthoplites jacobi* stratigraphically.

The following zones are identified in the Middle-Upper Aptian of the Atlantic (Крашенинников, 1978): *Leupoldina cabri, Globigerinelloides algerianus, Hedbergella trocoidea, Ticinella bejaouaensis*. The following zones are identified in West Africa: *Leupoldina cabri, Globigerinelloides ferreolensis, Globigerinelloides algerianus, Hedbergella trocoidea, Ticinella bejaouaensis* (Pflaumann, Cepek, 1982) and in the Mediterranean (Харленд и др., 1985; Sigal, 1977) are identified *Globigerinelloides blowi – Globigerinelloides maridalensis, Leupoldina cabri, Globigerinelloides ferreolensis, Globigerinelloides algerianus, Hedbergella trocoidea, Ticinella bejaouaensis*. *Biglobigerinella barri* (the Middle Aptian) and *Hedbergella rohri* (the Upper Aptian) are identified in the West (Slovakian) Carpathians (Вялов и др., 1989). The Middle-Upper Aptian of North Mexico (Longoria, 1974) is divided into the *Leupoldina cabri, Globigerinelloides ferreolensis, Globigerinelloides algerianus, Hedbergella gorbachikae* and *Hedbergella trocoidea* zones. The somewhat other stratigraphy is offered for the Middle-Upper Aptian of Tunisia (Salaj, 1980) where *Biglobigerinella barri* and *Hedbergella/Ticinella roberti* were identified. It is an important feature that the majority of the recorded bio-subdivisions are common for the considerably distant territories in spite of the different positions of the basins (their association with the different geotectonic elements).

The Middle-Upper Aptian biostratons of the East Mesotethys are differentiated by the benthic as well as the planktonic foraminiferas. In the Highland Crimea (Горбачик, 1986; Практическое руководство ..., 1991) and in the North Caucasus (Зональная стратиграфия ..., 2006) those are *Leupoldina protuberans, Globigerinelloides ferreolensis, Globigerinelloides algerianus, Hedbergella trocoidea, Planomalina cheniourensis* and *Ticinella roberti*, in Georgia (Цирекидзе, 1998) – *Globigerinelloides ferreolensis, Globigerinelloides algerianus* and the strata containing *Clavihedbergella globulifera – Hedbergella trocoidea.* According to the biostratigraphic chart, the Precaspian Depression, Manghishlak and Ustyurt (Мятлюк, Василенко, 1988; Практическое руководство ..., 1991) have the following zones within the Middle Aptian sections: *Rosalina dampelae*, *Verneuilina kasachstanica – Gavelinella intermedia biinvoluta*, and the following ones within the Upper Aptian sections: *Turrilina evexa, Quadrimorphina minima* (the Precaspian Depression) and *Evolutinella formosa, Dorothia gradata* and *Hedbergella planispira* (Manghishlak and Ustyurt). In West Turkmeniya, the Middle-the Upper Aptian is divided into the strata containing *Gaudryina aspera*, the *Gavelinella intermedia biinvoluta* (the middle sub-stage) zone and the strata containing *Hedbergella aptica* as well as the *Hedbergella planispira – Orthokarstenia asperula* zone (the upper sub-stage) (Алексеева, Шилова, 1977; Практическое руководство ..., 1991).

In spite of this diversity of foraminiferal biostratons, the index species *Hedbergella gorbachikae* and *Hedbergella trocoidea* that is characterised by the global occurrence serves as the interlink. The first of those was discovered in the contemporaneous sediments in a number of regions of the Tethyan Area and the Atlantic, namely, on Trinidad (Caron at al., 1985), in the Highland Crimea (Горбачик, 1986) and in South France (Moullade at al., 2002; 2005/02). This provided the grounds for identifying and adding the cognominal zone to the Geologic Time Scale of the Lower Cretaceous (Gradstein at al., 2004). As regards the second species, it is considerably numerous in the West and East Mesotethys alike. Besides, the characteristic forms that are common for the whole Tethys Belt were found in the zonal complex associations. A particular importance have the planktonic taxons *Blefuscuiana aptica* (Agal.), *Hedbergella gorbachikae* Long., *H. trocoidea* (Gand.) and *H. praetrocoidea* Kretsch. et Gorb, even among the benthos there are some forms that have a wide lateral occurrence – such as the members of the *Gavelinellidae family*, for instance.

The Albian Stage. The Albian Stage sediments have a wide occurrence in the Tethyan Area, the Atlantic and the Pacific oceans (see Figures 1, 2). The fullest Albian successions are represented by three sub-stages and are differentiated in detail by foraminiferas; they are located in Western Europe (Харленд и др., 1985; Sigal, 1977). The three-part stratigraphy of the Albian is traceable in other regions as well though the fullness of its stratigraphic successions varies. Eastwards, the Albian successions are shortened; the biostratons differentiated by benthic foraminiferas prevail in the Precaspian Depression, Manghishlak and Ustyurt (Мятлюк, Василенко, 1988; Практическое руководство …, 1991) and West Turkmeniya (Алексеева, Шилова, 1977; Практическое руководство …, 1991).

In the Lowland Crimea, the Albian deposits are represented within three foraminiferal biostratons (Тузяк, 2011): *the Hedbergella planispira* (the Lower-Middle Albian) zone, the strata containing *Hedbergella globigerinelloides – Trochogerina infracretacea* and the *Rotalipora ticinensis* (the Upper Albian) zone. The first one corresponds to the ammonite zones *Leymeriella tardefurcata* and *Hoplites dentatus* as well as *Anahoplites intermedius*, while the second one does to *Hysteroceras orbigny* and the third to *Stoliczkaia dispar*. In the majority of the Tethys Area regions, there is different understanding of the *Hedbergella planispira* biostraton volumes. In the West Mesotethys, it encompasses two ammonite zones – the upper portion of *Hypacanthoplites jacobi* (the uppers of the Upper Aptian) and the whole *Leymeriella tardefurcata* zone (the Lower Albian). In the East Mesotethys, namely, in its central part (the Highland Crimea and the North Caucasus), its stratigraphic range is much wider because the index species *H. planispira* is encountered not only on the level of the Lower Albian ammonite zones but also on the level of the Middle Albian ammonite zone. According to the Geologic Time Scale of the Lower Cretaceous (Gradstein at al., 2004), *Hedbergella planispira* encompasses a somewhat wider stratigraphic range and corresponds to the upper portion of the *Hypacanthoplites jacobi* ammonite zone (the Late Aptian) and the *Leymeriella tardefurcata zone* (the Early Albian).

The stratigraphic position of the biostraton in Georgia, the Precaspian Depression, Manghishlak, Ustyurt and West Turkmeniya is interpreted somewhat differently. Thus, according to the biostratigraphic chart of Georgia (Цирикидзе, 1998), the strata containing *H. planispira* correspond to the *Hoplites dentatus* and *Oxytropidoceras roissyanum* ammonite zones. Pursuant to the charts (Мятлюк, Василенко, 1988; Зональная стратиграфия …, 2006; Практическое руководство …, 1991) constructed for Manghishlak, Ustyurt and West Turkmeniya, the *Hedbergella planispira* zone is differentiated at a lower chronostratigraphic level and so it characterises the Upper Aptian deposits. The reason for this situation of the biostratons is provided by T.N.Gorbachik who indicated that the index species whereby the zone is identified in the Precaspian Depression has the morphological features that vary from *H. planispira,* and it is quite possible that this is *Ticinella* aff. *bejaouaensis* (Горбачик, 1986, с. 211). Practically, the bio-subdivision encompasses the ammonite zone *Leymeriella tardefurcata* in the majority of the aforementioned regions, which is what determines its age and global correlation.

Another sequence of foraminiferal zones is identified in the non-stratified in sub-stages the Atlantic and Pacific Ocean Albian: in the Atlantic, they correspond to five bio-subdivisions, namely, the upper portion of *Ticinella bejaouaensis, Ticinella primula, Ticinella breggiensis, Rotalipora ticinensis* and the lower portion of *Rotalipora appenninica* zones (Крашенинников, 1978), while in the Pacific Ocean these are the strata containing *Ticinella roberti*, *Hedbergella trocoidea* and the lower part of the *Rotalipora appenninica* zone (Крашенинников, 1978). In West Africa, the Lower and Middle Albian sediments encompass the following zones: the upper portion of *Ticinella bejaouaensis, Ticinella roberti* and *Ticinella primula* (Pflaumann, Cepek, 1982). The Albian of Tunisia is divided into the *Thalmanninella ticinensis subticinensis, Thalmanninella ticinensis ticinensis* and *Rotundina stephani* zones (Salaj, 1980). Four foraminiferal zones are identified in the Albian of the West (Slovakian) Carpathians. Namely, to the Lower Albian corresponds to the *Ticinella roberti* zone while the *Thalmanninella subticinensis* zone and the lower portion of the *Thalmanninella ticinensis* zone correspond to the Middle Albian, and the upper portion of the *Thalmanninella ticinensis* and *Whiteinella gandolfi* zones corresponds to the Upper Albian (Вялов и др., 1989). The Albian stratigraphy is different to a degree in the Polish and Ukrainian Carpathians as well as in Mordva. In the Polish Carpathians, there are two benthic foraminifer zones: *Haplophragmoides nonioninoides* that corresponds to the Lower Albian and *Plectorecurvoides alternans* that encompass the Middle-Upper Albian and transits into the Upper Cretaceous (Вялов и др., 1989). In the Ukrainian Carpathians, it is the strata containing *Hedbergella infracretacea – Hedbergella globigerinelloides* and the *Thalmanninella ticinensis* zone, both of which are only identified in the Upper Albian (Вялов и др., 1989) and characteristic of the Crimea and the Caucasus. In Mordva, the *Anomalina hostaensis* zone corresponds to the whole of the Albian (Яновская, Букатчук, 1970).

There is some divergence in the stratigraphy of the Upper Albian sediments. It is based in the main on planktonic forms. The benthic forms with the agglutinated wall only prevail in the East Mesotethys, to be precise, in the Precaspian Depression, Manghishlak and Ustyurt. This gives a reason to believe that the transgression covered all the regions of the Tethys Belt in the Late Albian. The presence of the practically identical index species witness either akin or identical conditions of sedimentation while also pointing at the uniform abiotic factors: depth, salinity and temperature (see Figures 1, 2). The Precaspian Depression, Manghishlak and Ustyurt are the exceptions: their zonal complexes are unvaried and practically do not contain secretional benthos and plankton. Therefore, the wide occurence of benthic foraminiferas in that part of the Tethys can signify either the shallow nature of the basin (its peripheral area) or another climatic zone. There are no Upper Albian deposits in West Turkmeniya (Алексеева, Шилова, 1977; Практическое руководство …, 1991).

The Lower Albian biostratons identified in the Lowland Crimea are best correlated to the contemporaneous analogues of the Highland Crimea (Горбачик, 1986; Практическое руководство …, 1991), the North Caucasus (Зональная стратиграфия …, 2006), Georgia (Цирекидзе, 1998) and the Ukrainian Carpathians (Вялов и др., 1989). It can be said about a single biostratigraphic chart of these regions because the cognominal strata containing *Trochogerina infracretacea – Hedbergella globigerinelloides* are identified on the level of the same ammonite zones, namely, *Hysteroceras orbigny* and *Mortoniceras inflatum*. The upper portion of the Upper Albian is an exception and corresponds to the *Rotalipora ticinensis* zone; it only occurs in the West Mesotethys and, fragmentarily, also in the regions of the East Mesotethys.

As regards the correlation to the other territories of the West and East Mesotethys, the correlation of the foraminiferal biostratons is only possible under condition that they are on the level of identical ammonite zones or that there is a complex of common species in the zone. In the Mediterranean, the Upper Albian was considered within the following two foraminiferal zones: *Ticinella breggiensis* and *Rotalipora appenninica* (Харленд и др., 1985; Sigal, 1977) while in West Africa it was considered within three foraminiferal zones: *Ticinella breggiensis, Rotalipora ticinensis* and *R. appenninica* (Pflaumann, Cepek, 1982).

The correlation of the bio-subdivisions in the Lowland Crimea to the contemporaneous analogues in the Precaspian Depression, Manghishlak, Ustyurt and West Turkmeniya is more difficult because their biostratons are identified by benthic foraminifera. So, the Upper Albian of the Precaspian Depression, Manghishlak and Ustyurt is divided with the separation of the *Guembelitria evoensis – Epistomina postdorsoplan* zone and the pauperate complex of *Haplophragmoides clivosus* and *Trochammina planoconvexa* with the very sparse secretional benthos and plankton, and the layers containing *Ammobaculites* ex gr. *subcretacea, Trochammina kugitangensis*, *Ammobaculites explanatus – Trochammina kugitangensis*. There are the common elements in the foraminiferal complexes though they are not numerous and not characteristic, either. The index species of the distinguished biostratons belong to the genera not recorded on this stratigraphic level in the Lowland Crimea successions (for instance, *Guembelitria, Trochammina* and *Ammobaculites*).

The Lower Albian species associations of the Lowland Crimea have the considerably developed heterohelicidas and pleurostomelids that are not traceable in the sections of the Precaspian Depression, Manghishlak and Ustyurt. These sediments' correlation by the ammonite bio-subdivisions is aggravated as well because the zone species complex differs considerably from the index species of the Central and East

Mesotethys, which can be an indication of the basin's development in another climatic zone or to a considerable depth. The absence of the *Rotalipora ticinensis* zone in the East Mesotethys can be the sign of the fact that the transgression coming from the west did not encompass the regions of the East Mesotethys but only reached the territories of the Lowland/Highland Crimea and the North Caucasus.

Conclusion

Thus, the taxons of benthic foraminiferas, in particular, of the *Vaginulinidae, Gavelinillidae* and *Globorotalitidae* genera widely occurring in the contemporaneous sediments of Germany, the Netherlands and England have been revealed in the Lower Cretaceous sediments of the Lowland Crimea. Even though the researchers did not carry out the zonal stratigraphy of those sediments by foraminiferas, they did give the descriptions of the majority of the characteristic species and provided the information about their occurrence. These data are sufficient to underpin a conclusion that the Lower Cretaceous foraminiferal associations of German, the Netherlands and England do not contain the characteristic planktonic Tethys genera but do contain the numerous benthic species described and known from the East, Central and East Mesotethys regions (Table 1). This gives a reason to stipulate the expansion of the communication paths among the basins of the Tethys and Boreal basins and, simultaneously, presuppose the endemicity of the individual faunal groups that could survive in only one of the climatic zones.

The correlation of the biostratigraphic charts of the Lower Cretaceous sediments in the Lowland Crimea and in the adjacent territories by the foraminiferas revealed the similarities as well as the differences in the nature of the distinguished biostratons. The similar features of the associations signify that periods of time during which the distant enough territories merged and developed simultaneously periodically could be singled out of the evolution of the Early Cretaceous basin. This is said of the Barremian-Early Aptian, the upper portions of the Early-Middle Albian and the Late Albian (considering the stratigraphy and presence of the identical biostratigraphic subdivisions). The differences found in the zone complexes may be pointing at the disruption of such associations and the independent evolution of each basin; this is being said of the Hauterivian, the upper portion of the Early-Middle Aptian and the Middle Albian. The analysis of the foraminifera complexes revealed that the identical associations of foraminifera were developed in the majority of the regions of the Atlantic, the West/East Mesotethys and the Pacific Ocean beginning in the Early Barremian, which provides ground for the correlation of the Lower Cretaceous sediments in those regions (see Figures 1, 2).

The correlation of the biostratons of the Lower Cretaceous in the Lowland Crimea with the contemporaneous analogues of the adjacent territories brought forth the chart of inter-regional correlation (see Figures 1, 2). The inter-regional correlation showed the traceable global occurrence of the components of the Lower Cretaceous as well as the links among the sedimentatary basins, the alteration of the density of the stratigraphic successions of the Lower Cretaceous and the detailed local scales differentiating the global, regional and local biostratons. It was clarified that the fullest successions of the Lower Cretaceous are located in the Mediterranean (Western Europe) as well as that the fullness of the stratigraphic succession is observable westwards and eastwards.

The Lower Cretaceous deposits in the Lowland Crimea are best correlated to the contemporaneous analogues of the Highland Crimea, the North Caucasus and Georgia to which they are akin not only in terms of the common foraminifera complexes but also because of the identical ammonite zones.

Table 1

The Stratigraphic Occurence of Foraminiferas in of the Lower Cretaceous Deposits
in the Lowland Crimea and Other Regions

Ser. No.	Sippes	Lowland Crimea: Hauterivian L	Barreme L	Barreme U	Aptian L	Aptian M	Aptian U	Albian L	Albian M	Albian U	America	England	Netherlands	France	Germany	Africa	Romania	Ukr.Carpathians	Dnepr-Donetsk Trough	Mount. Crimea	N. Caucasus	Ciscaspian Plain	Manghishlak, Ustyurt	West Turkmenistan
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	*Lagenammina distributa* Mjatliuk					□	□	□														■	■	
2	*Saccammina aptica* Samyschkina				□																■			
3	*Dorothia kummi* (Zedler)	□											■	+	■		+			+	■			
4	*Dorothia subtrochus* (Bartenstein)	□												+	+		+			■	+			
5	*Marginulinita pyramidalis* (Koch)		□									+	+		■					+	+	+	+	
6	*Tristix acutangulum* (Reuss)					□	□				■	+	■	■	■		+	■	+	+				
7	*Lingulina loryi* (Berthelin)					□	□	□	□	□	+	■	+	■	+	+	+			■	■			■
8	*Lenticulina akmetchetica* Mjatliuk	□																				+		
9	*Lenticulina busatchensis* Vassilenko					□	□																■	
10	*Lenticulina diademata* (Berthelin)					□	□					+		+						■	+	+	■	+
11	*Lenticulina gaultina* (Berthelin)				□	□	□	□	□	□	+	■	■	■	+	+	■		■		■	■	■	■
12	*Lenticulina guttata guttata* (Dam)	□											■		■		■			■				
13	*Lenticulina infravolgensis* (Fursenko)	□														+	■					■		
14	*Lenticulina kuegleri* Bartenstein, Bettenstaedt et Bolli		□	□																■				
15	*Lenticulina nimbifera* (Espitalie et Sigal)		□	□												■				+				
16	*Lenticulina nodosa* (Reuss)	□	□	□	□							■	■	■	■		■			■	■	■	+	
17	*Lenticulina subgaultina* Bartenstein	□															■							
18	*Lenticulina turgidula* (Reuss)	□													+		■			■	+			
19	*Lenticulinella shutskajae* (Samyschkina et Saidova)				□																■			
20	*Marginulinopsis gracilissima* (Reuss)		□	□								+	+		■					■				
21	*Marginulinopsis sigali* Barttenstein, Bettenstaedt et Bolli	□												■		■				■				
22	*Marginulinopsis striato-costata* (Reuss)		□	□								+			■		+		+				+	
23	*Planularia madagascariensis* Espit. et Sig.		□	□												+				+				
24	*Saracenaria compacta* Espitalie et Sigal	□														■				■				
25	*Saracenaria cretacea* Gorbatchik				□															■				
26	*Palmula kasachstanica* Alekseeva					□	□																+	
27	*Astacolus tricarinella* (Reuss)		□	□	□							+		■	■		■	+		■	■			
28	*Marginulina inaequalis* Reuss					□	□				+	+	+	+	+		+						■	
29	*Marginulina linearis* Reuss							□				■			+		+		+				■	
30	*Marginulina zaspelovae* Romanova subsp. *nordcaspiensis* Mjatliuk		□	□																		+		
31	*Vaginulinopsis parallela* (Reuss)		□	□											■				+		+			
32	*Citharina rudoccostata* Barten. et Brand	□													+	+	■			+		+	+	
33	*Vaginulina kochii* Roemer	□													+		+			+	+			
34	*Globulina exerta* (Berthelin)								□	□	■	■		■	+		+		■					

continuation of the ***Table 1***

35	*Lamarkina lamplughi* (Sherlock)							□				+	+	+	+				+	◙	◙		◙	
36	*Conorboides caucasicus* (Z. Kuznetzova et Antonova)		□	□	□																◙	◙		
37	*Hoeglundina aptiensis* (Mjatliuk)				□															◙	◙	◙	◙	
38	*Mironovella juliae* (Mjatliuk)				□								+				◙		+	◙	◙	◙	◙	◙
39	*Heterohelix washitensis* (Tappan)									□	◙								◙					
40	*Hedbergella globigerinelloides* (Subbotina)									□	+					+		◙	◙	◙	◙			◙
41	*Hedbergella gorbachikae* (Longoria)					□	□							◙		◙				◙	◙			
42	*Hedbergella planispira* (Tappan)							□			+	◙		+				+	◙	+	+	+		
43	*Hedbergella portsdownensis* (Williams-Mitchel)									□	+	+		+		+		+			+	+		
44	*Hedbergella praetrocoidea* (Kretzschmar et Gorbatchik)					□	□							◙		◙				◙				
45	*Hedbergella sigali* (Moullade)		□											◙			◙			◙				
46	*Hedbergella trocoidea* (Gandolfi)					□	□				+			◙		◙	+	+			+			
47	*Hedbergella tuschepsensis* (Antonova)		□	□	□									◙		◙				◙	◙			
48	*Trochogerina infracretacea* (Glaessner)									□		+		+	+		+	◙	◙	◙	◙			◙
49	*Blefuscuiana aptica* (Agalarova)				□	□						◙		+		+	◙	+		◙	◙			
50	*Lilliputianella globulifera* (Kretzschmar et Gorbatchik)				□	□						◙		◙		◙				◙				
51	*Favusella tardita* (Antonova)			□	□															◙	◙			
52	*Clavihedbergella primare* (Kretzschmar et Gorbatchik)			□	□									◙		◙				◙				
53	*Valvulineria gracillima* ten Dam							□				◙	◙	◙	◙		+					+	+	
54	*Valvulineria parva* Khan								□	□		◙		◙								◙	◙	
55	*Conorotalites bartensteini aptiensis* (Bettenstaedt)				□							◙		◙	◙									
56	*Conorotalites bartensteini intercedens* (Bettenstaedt)		□	□	□							◙		◙	◙		◙			◙				
57	*Gyroidinoides infracretaceous* (Morozova)				□	□	□	□	□	□							+			◙	◙			
58	*Gyroidinoides nitidus* (Reuss)								□	□		◙							+	◙	◙	+	+	+
59	*Gavelinella barremiana* (Bettenstaedt)			□	□										+	+	+			+		+		
60	*Gavelinella biinvoluta* (Mjatliuk)					□	□													◙	+	◙	◙	
61	*Gavelinella djaffarovi* (Agalarova)								□											◙	◙			◙
62	*Gavelinella infracomplanata* (Mjatliuk)				□															◙	◙	◙	+	+
63	*Gavelinella hostaensis* (Morozova)						□	□				+									+			◙
64	*Gavelinella sagizensis* (Mjatliuk)							□				◙			◙							◙		◙

Note: ● – the occurence of the taxons in of the Lower Cretaceous sediments in the Lowland Crimea; ◙**;** + – the taxons occurence in the Lowland Crimea and other regions; ◙ – the taxons recorded in the contemporaneous analogues of the regions identical to those of the Lowland Crimea. The letters denote the sub-stages: l – Lower; m – Middle; u – Upper.

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DÜZƏNLİK KRIMIN ALT TƏBAŞİR ÇÖKÜNTÜLƏRİNİN BİTİŞİK REGİONLARIN EYNİYAŞLI ANALOQLARI İLƏ FORAMİNİFERLƏR ÜZRƏ KORRELYASIYASI: BİOSTRATONLARIN YAYILMASI, BSŞ-DA VƏZİYYƏTİ, MÜQAYİSƏ KRİTERİLƏRİ

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Məqalədə Düzənlik Krımın Alt Təbaşir çöküntülərinin Qərbi və Şərqi Mezotetisin bitişik regionlarının eyniyaşlı analoqları ilə foraminiferlər üzrə regionlararası korrelyasiyasının nəticələri verilmişdir. Regionlararası korrelyasiya zamanı Tetis vilayətinə, Atlantik və Sakit okean hövzələrinə məxsus olan ərazilərin foraminiferlər üzrə Alt Təbaşir çöküntülərinin bölünməsinin zonal sxemlərinin müqayisəsindən istifadə edilmişdir. Müqayisə kriteriləri ayrılmışdır. Regionlararası korrelyasiya sxemi tərtib edilmişdir ki, onda regionlar uyğun olaraq Qərbi və Şərqi Mezotetisə qruplaşmışdır.

КОРРЕЛЯЦИЯ НИЖНЕМЕЛОВЫХ ОТЛОЖЕНИЙ РАВНИННОГО КРЫМА С ОДНОВОЗРАСТНЫМИ АНАЛОГАМИ ПРИЛЕГАЮЩИХ РЕГИОНОВ ПО ФОРАМИНИФЕРАМ: РАСПРОСТРАНЕНИЕ БИОСТРАТОНОВ, ПОЛОЖЕНИЕ В МСШ, КРИТЕРИИ СОПОСТАВЛЕНИЯ

Я.М. Тузяк

В статье приведены результаты межрегиональной корреляции нижнемеловых отложений Равнинного Крыма с одновозрастными аналогами прилегающих регионов Западного и Восточного Мезотетиса по фораминиферам. При проведении межрегиональной корреляции использовано сопоставление зональных схем расчленения нижнемеловых отложений по фораминиферам территорий, принадлежащих Тетической области, Атлантическому и Тихоокеанскому бассейнов. Выделены критерии сопоставления. Построена схема межрегиональной корреляции, в которой регионы сгруппированы соответственно в Западный и Восточный Мезотетис.

PSEUDO-BEDDING AND BURROW SILICIFICATION IN THE KOMETAN FORMATION OF THE DOKAN AREA (NORTHEASTERN IRAQ)

Silicified burrows and stylolite seams are common in the chalky pelagic limestones of the Kometan Formation (late Turonian-early Campanian) of the Dokan area in northeastern Iraq. The shape of individual and packed network branched chert nodules, which are the result of the early diagenetic mobilization of radolarian silica, are controlled chiefly by pre-existing Thalassinoides burrow system. Frequent appearance of Thalassinoides may reflect periodical formation of discontinuity (omission) surfaces on the canyon margin (or near the listric fault) of the Dokan area resulted from combination of tectonic and eustatic processes. It is also proven that many so-called bedding planes of the Kometan Formation are merely pressure solution stylolites in massive homogeneous pelagic limestones (pseudo-bedding). It is concluded that the association of silicified burrows (chert nodules) with stylolite veins refers to regressive discontinuity surfaces, while the separation of these two features indicates either winnowed permeable surfaces or true bedding planes. The clay constituent of such stylolites is found to be formed mainly by transformation of smectite during burial processes.

Keywords: Pseudo-bedding, Chert nodule, Thalassinoides, Silicified burrows, Kometan, Stylolite.

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Introduction

The Kometan Formation, which is Late Turonian-Early Campanian in age, comprises the lower part of the most widespread Late Turonian-Danian megasequence (AP9) of Sharland et al. (2001) in northeastern Iraq (Figure 1). This formation, which is extensively exposed in the Sulaymaniya Province, was firstly described by Dunnington (1953, in Bellen et al., 1959) near Kometan village (northwest of Sulaymaniya city) (Figure 2). He described the type section as 36 meters of light grey, thin bedded, globigerinal-oligosteginal limestone, locally silicified, with flattened ramous chert concretions, and occasionally glauconitic at the base beds. The formation has unconformable lower and upper contacts.

Due to facies similarity and age equivalence, the so-called "Mushorah Formation" is regarded as a facies of the Kometan Formation (Buday, 1980). Consequently, the entire Kometan Formation reaches a maximum thickness of 300 meters between the Qara-chauq and Hamrin structures; its depositional environments varied from shallow restricted shelf ("oligosteginalfacies") to open marine ("globigerinalfacies") (Jassim and Buday, 2006).

The studied exposures are located near the Lesser Zab River and close to Dokan Dam in northwest Sulaimaniya (Figure 2). They consist of ~120 meters of highly fractured fine-grained (micritic), middle to upper bathyal homogeneous chalky limestone, which includes mudstones, wackestones, and packstonesfacies. In contrast to the other sections, the Dokan exposures are characterized by extensive and continuous stylolites associated with branched, finger-like, and full-relief chert nodules. In addition to the detailed field and petrographical investigations, two representative bulk samples (one from ramous chert nodules and the other from stylolite vein material) were analyzed using a Philips XRD (PW3710) scanning from 2θ = 4° to 6° in the laboratories of the Department of Earth Science of the Royal Holloway, University of London. The present study attempts to interpret the origin and genetic connection between branched chert nodules and highly developed extensive stylolite veins and their material composition in the Dokan area.

Role of the compaction

Although the importance of the overburden thickness to produce compaction structures is controversial (Flugel, 2004), the closest association of many prominent compaction features cannot be understood without the assumption of gradual accumulation of a thick overburden succession. In this regard, the co-occurrence of stylolization, stylobrecciation, nodular silicification, and conversion of semectite to illite in the Kometan succession is thought to be connected diagenetically owing to continuous extensive overburden pressure of thousand meters of sediments. Furthermore, the relatively low amount of clay minerals (<5 %) in the studied limestones of Dokan area make it more susceptible to compaction and pressure solutions in comparison with the underlying Gulneri and overlying Shiranish formations.

Compaction is commonly followed by pressure solution recorded by stylolites and solution seams (e.g., Flugel, 2004; Boggs, 2006). The mechanisms of pressure solution occur either by dissolution in a thin solution film as a result of compressive stress inside grain-to-grain boundaries (Rutter, 1983; Scholle et al., 1983) or by dissolution at or just outside the rim of grain contacts resulting in an undercutting (Bathurst, 1975; Toda and Siever, 1986). Calcite released by pressure solution is believed to be a significant source for the formation of porosity-occluding subsurface cements in deep burial setting, although it may create conduits for fluids and open migration paths (Flugel, 2004). In this regard, it is believed that the both fracturing and pressure solution are dominant factors in diagenesis of the oil and water reservoir rocks of the Kometan Formation in some oil fields northern Iraq.

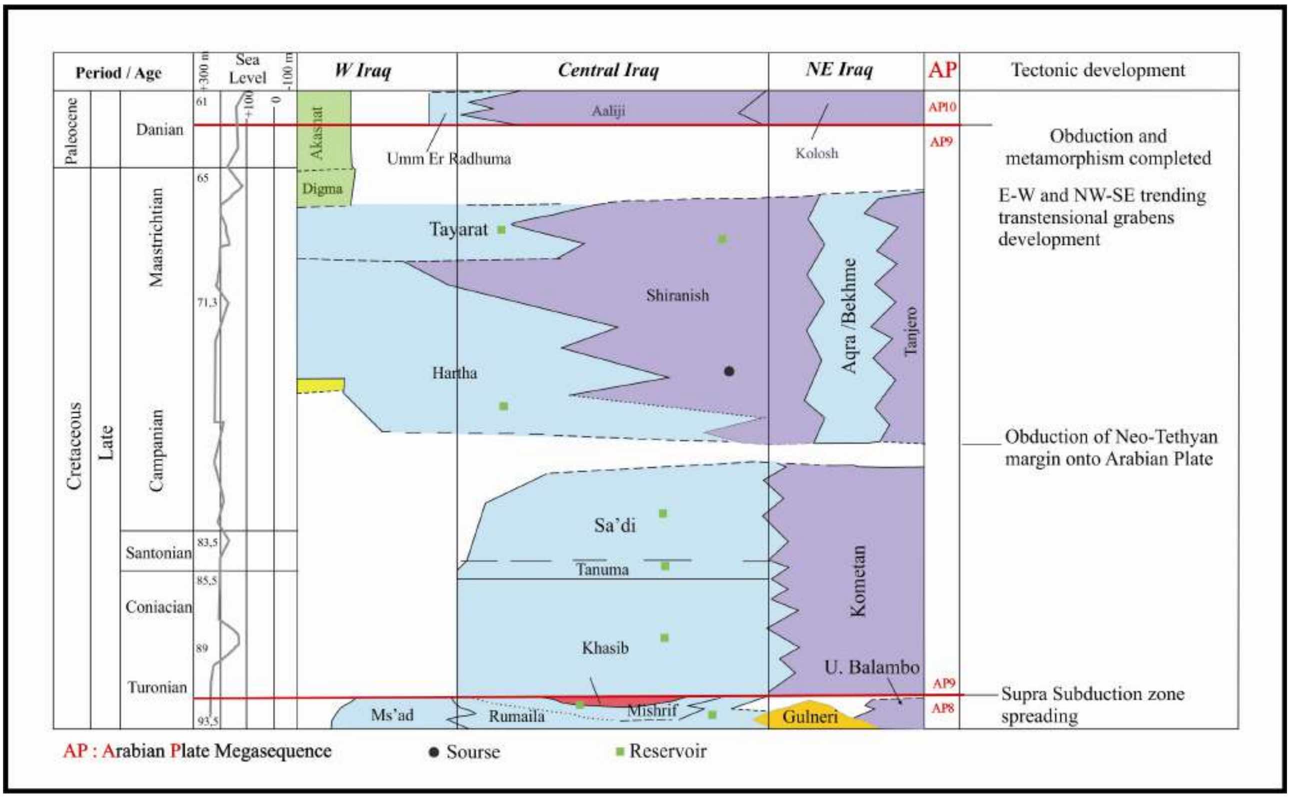

Figure 1. Stratigraphic outline of the Late Early Turonian-Danian Megasequence in Iraq (modified after Jassim and Buday, 2006)

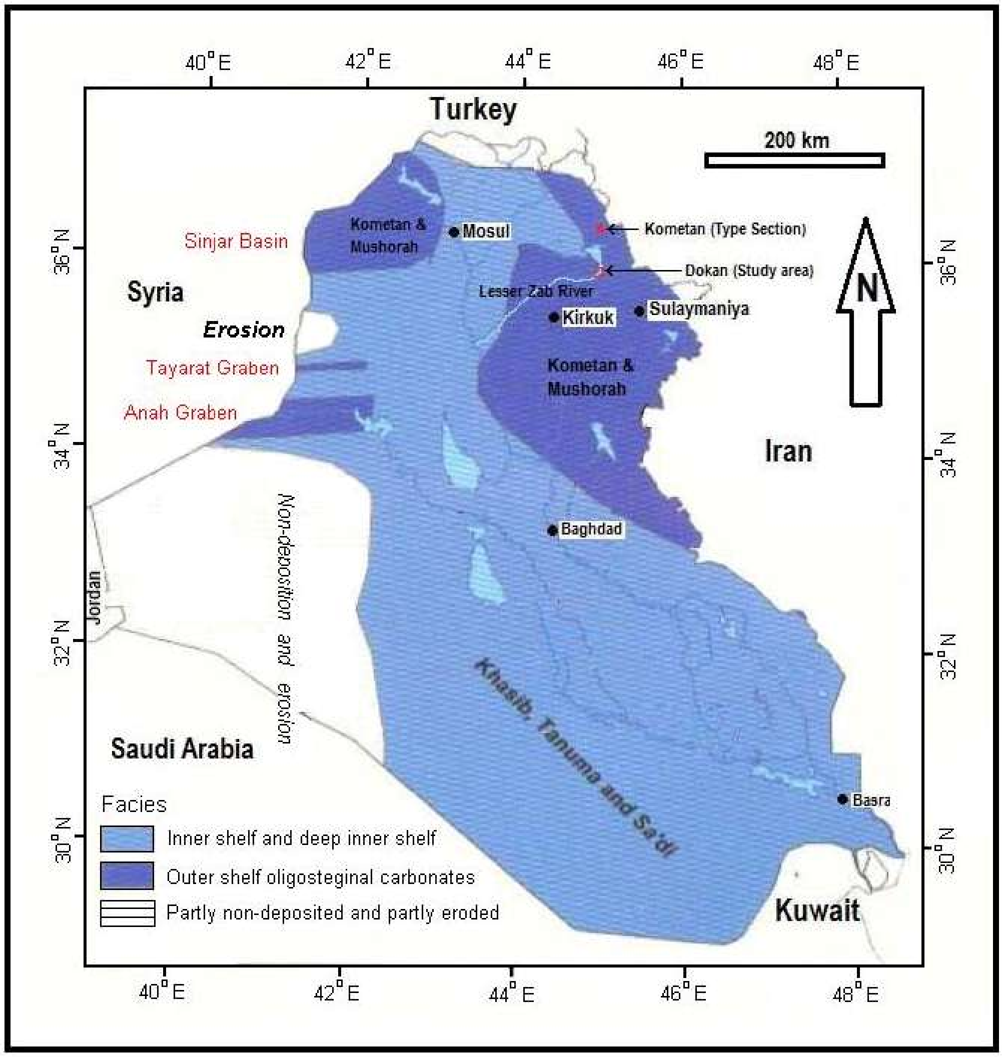

Figure 2. Late Turonian-Early Campanian palaeogeography of Iraq (modified after Jassim and Buday, 2006) and the location of the study area

Regional tectonic evolution and silica origin

In addition to the Arabian Plate supra-subduction through the Turonian-Early Campanian time interval, contemporaneously a new subduction zone was activated in the Neo-Tethys along the southwestern margin of the Sanandaj-Sirjan zone. The latter subduction resulted in the formation of the Katar-Rash arc volcanics in northeastern Iraq and extensive arc volcanics in the Sanandaj-Sirjan zone of southwestern Iran (Jassim and Goff, 2006). These volcanics are 1800 m in thickness, and they are represented by calc-alkaline andesite-rhyolite association, intruded by granodiorite, granites, and quartz diorites. They are interpreted as products of the early Late Cretaceous island arc (that was formed on the southwestern margin of the Sanandaj-Sirjan zone (Jassim et al., 2006). Simultaneously, the foreland basin (including the Kometan basin) was formed around the northern margin of the Arabian Plate in response to the loading of the foreland crust by thrust sheets as a result of compression (Jassim and Goff, 2006).

The simultaneous volcanic activity and hydrothermal activity on oceanic floor could play an important role in supplying silica to the Kometan basin. In addition to the volcanic ash contribution, Boggs (2006) stated that silica is added to the oceans through reaction between seawater and hot volcanic rocks along mid-ocean ridges and by low-temperature alternation of silicate particles on the sea floor. Then, soluble silica could be extracted by siliceous organisms (e.g., radiolarians).

Radiolarian occurrence

Diagenetic processes mobilizing silica are silicate pressure solution, replacement of silicates by carbonates, and clay mineral diagenesis linked to conversion of smectite to illite (Flugel, 2004). No recognizable remains of any siliceous organisms were reported from the Kometan Formation previously (e.g., Dunnington, 1953, in Bellen et al., 1959; Buday, 1980; Jassim and Buday, 2006). However, the present study indicates that this formation contains frequent, basically spherical spumellaria-type radiolarian tests usually less than 150 µm in diameter. It is noticed that the original opaline silica of Kometan radiolarian tests was partially or completely replaced by calcite (Plate 1). Thus, these tests are rarely well-preserved, as the structural details disappeared partially or entirely, and they are better preserved in chert nodules. On the other hand, complete calcified radiolarian tests are often overshadowed by the abundant planktonic foraminiferal tests (Plate 1). Following Flugel (2004) and Boggs (2006), it is hard to differentiate between circular sections of such calcified radiolarian casts and sections of calcispheres, globular foraminifera, smaller calpionellids, or even echinoid spicules. Careful petrographical investigation of some Kometan circular test sections shows that their margins appear toothed. According to Adams and Mackenzie (1998) and Flugel (2004), such tests belong to radiolarians, and carbonate (mud or spar) filled the pores of test surfaces giving the toothed appearance (Plate 1 B, E).

However, the dead opaline organism is more soluble than crystalline quartz; and transformation of such opal into microquartz is a solution-reprecipitation process (Boggs, 2006). Although some of released elements (like silica) result in partial pressure dissolution of such grain boundaries settle down at pressure point contacts, the diffusion mechanism leads much quantities to move away from the contacts to trap in the adjacent pores and burrows of the sediments; and this silica does not

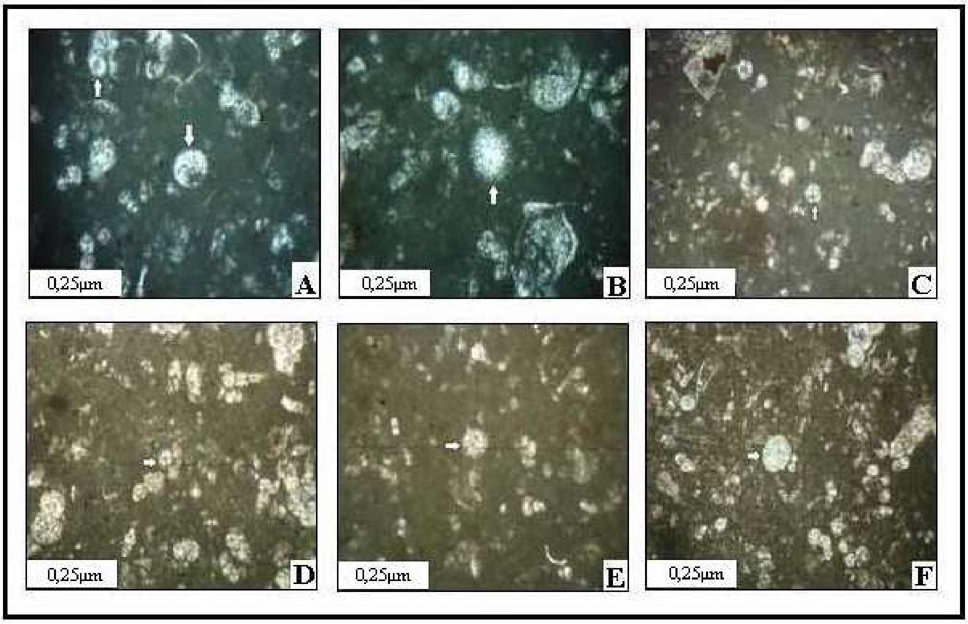

Plate 1. Partially and completely calcification of radiolarian tests, occasionally overshadowed by the abundant planktonic foraminiferal tests; some radiolarian test margins have toothed appearance

escape back to the open ocean (Boggs, 2006). Thus, pore water becomes increasingly enriched in silica, leading eventually to precipitate the chert. Accordingly, it is realized that the precipitation of the Kometan biogenic silica occurred on grain surfaces within burrows situated either close to the stylolized pressure surface contact or in the adjacent sediment (Plate 2).

Chert nodules

Silicified cylindrical and branched Kometan nodules occur either individually or as tight network. They had been embodied by arthropod feeding and dwelling burrows represented by *Thalassinoides*. As silicification is linked to early diagenetic mobilization of silica, the shape of chert nodules is mainly controlled by pre-existing *Thalassinoides*. The outcrops appearance of these silicified burrows are full relief, commonly segmented as Y, T, and + -shaped branching (Plate 3 A, B). They are swollen at the point of branching and elsewhere with no preferred orientation and their sizes range from millimeters to a few centimeters up to decimeters (Plate 3). However, the most distinctive feature of these burrows is the downward branching pattern, where there is a marked and systematic decreasing in tube diameter at junctions and terminations (Plate 3 C). Such burrow linings, which may be simple secretion of mucus or particulate walls agglutinated by organic compounds, are preferred sites for subsequent mineralization (Pemberton, 2002). It becomes clear from the XRD studies that such a mineralization in Kometan burrows is represented by silicification (Figure 3). Therefore, silicification processes that obliterate Kometan radiolarian tests by calcification played an important role in preservation of trace fossils.

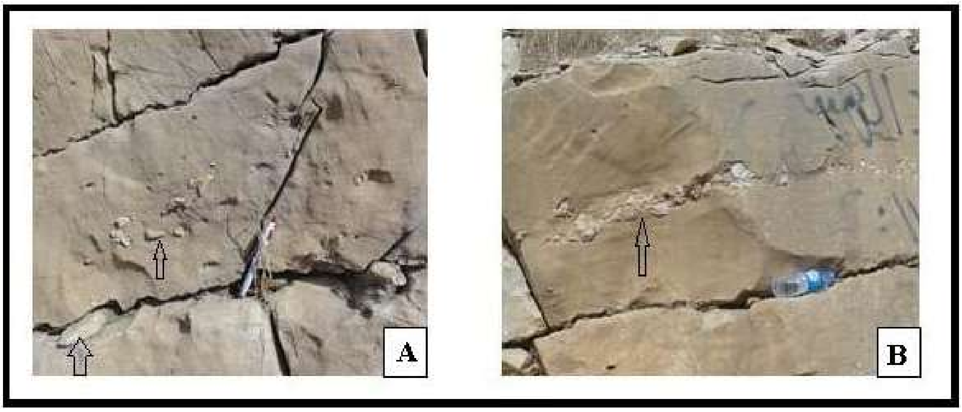

Plate 2. Burrows chertification (arrows) either close to stylolization surface (**A, B**) or in vicinity sediments (**A**)

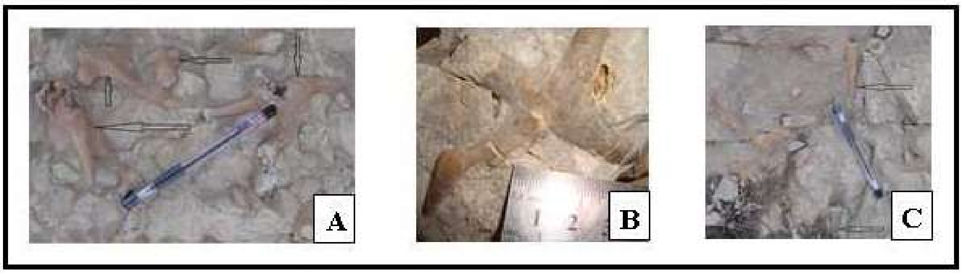

Plate 3. Types of burrows segmentation and swollen (**A, B**); and decreasing in tube diameter at junctions and terminations (**C**)

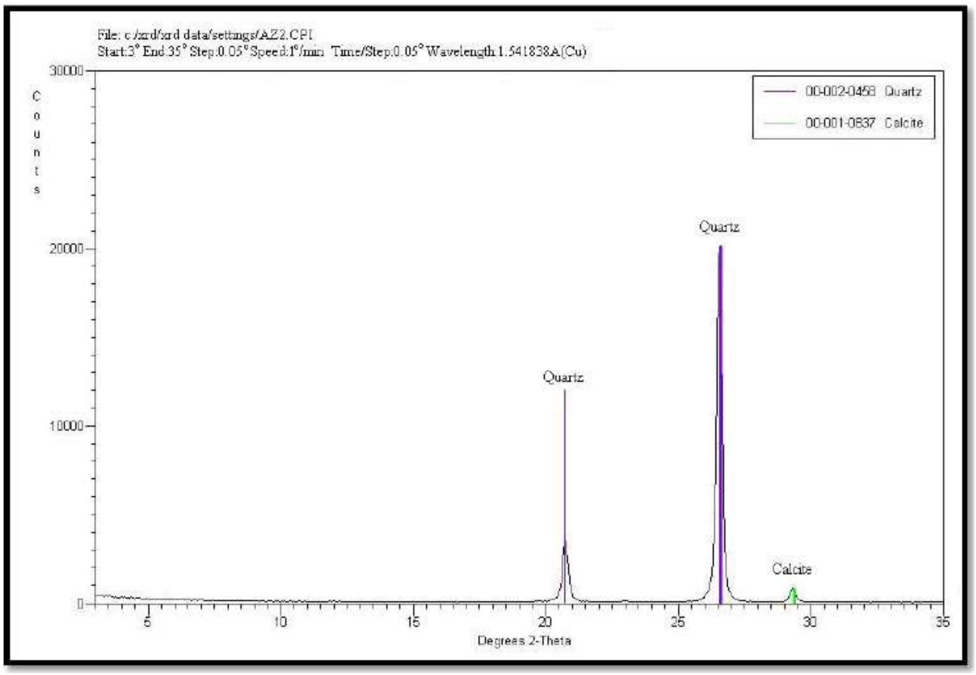

Figure 3. XRD analysis reveals mineralogical composition of Kometan chert nodule

Reality of bedding in the Kometan Formation

The Kometan Formation in the study area has been frequently described as thin to very thin, well bedded limestones (e.g., Dunnington, 1953, in Bellen et al., 1959; Buday, 1980; Jassim and Buday, 2006). But the present study, depending upon the careful field examination of the extensive new road-cut sides and microfacies analysis, reveales that it is a homogeneous massive pelagic limestone with only few true bedding surfaces representing primary change and breaks in deposition. The most dark sharply defined apparent bedding surfaces unlikely to be true bedding. It is just pressure solution stylolites in homogeneous limestone succession, where the darker colour is attributed to higher concentration of clay and organic materials along pressure contact surfaces (Plate 4). This type of bedding is known as pseudo-bedding (Flugel, 2004) or apparent bedding (Nichols, 2009).

Under very high overburden pressures, boundaries between grains become complex sutured contacts. Hence, the stylolites of the Kometan Formation are single or swarm cogged shaly seam oriented horizontally in response to overburden pressure. They are marked by the presence of clay minerals and other fine-size in soluble residue that accumulates as carbonate minerals dissolve. According to Scholle and Ulmer Scholle (2003), such surfaces represent differential grain interpenetration depending on the relative solubilities of grains present on each side of the surface.

Therefore, the Kometan Formation reveals the extension of less soluble fingers or small protrusions within more soluble parts (Plate 4). On the other hand, the Kometan swarm stylolites commonly reveal embedded pseudo-limestone nodules. In the light of Nichols (2009)'s explanation, the pressure dissolution can result in the removal of large amounts of calcium carbonate. The further concentration of clay component on an impure, muddy limestone leaves such nodules of limestone within a wavy-bedding. Clayey material giving a brecciated appearance (stylobreccia) with a fitted fabric to such pseudonodules, especially in the case of extreme pressure dissolution.

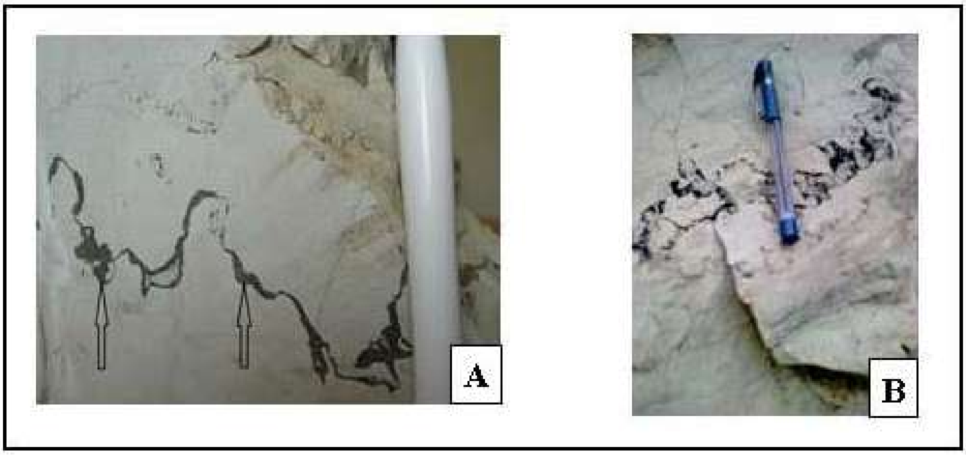

Plate 4. Higher concentration of clay and organic materials along the pressure contact surface showing extension of less soluble fingers within more soluble parts

The correlation of the so-called bedding planes between the new and old exposures of the same sedimentary succession on the both banks of the Lesser Zab River implies that the extensive parallel stylolized pseudo-bedding succession of the new road-cut on the lift bank of the river becomes abruptly irregular with wavy illusive bedding planes, parallel to each other at the right bank of the river and other relatively old exposures (Plate 5 A, B). This misleading feature is attributed to differential erosion processes, which removed gradually the friable clayey stylolite seams and subsequently refined the jagged lower and upper internal surfaces of the relic casts. So, the final configuration of the older exposures simulates the true bedding planes appearance (Plate 5 B).

Transformation of smectite to illite

Generally, the formation of smectite occurs diagenetically by alternation of any silicate minerals in deeper more offshore settings at relatively low temperature (Flugel, 2004). However, smectite is not stable at higher burial temperatures and tends to transform into illite at ~55–200°C. The transformation occurs through a mixed-layer illite-smectite series (Boggs, 2006; Nichols, 2009). This serial conversion is connected with the increase of crystallization degree and the formation of denser, less hydrous minerals. Thus, it is possible to use an illitecrystallinity index as measures of burial temperature (Nichols, 2009).

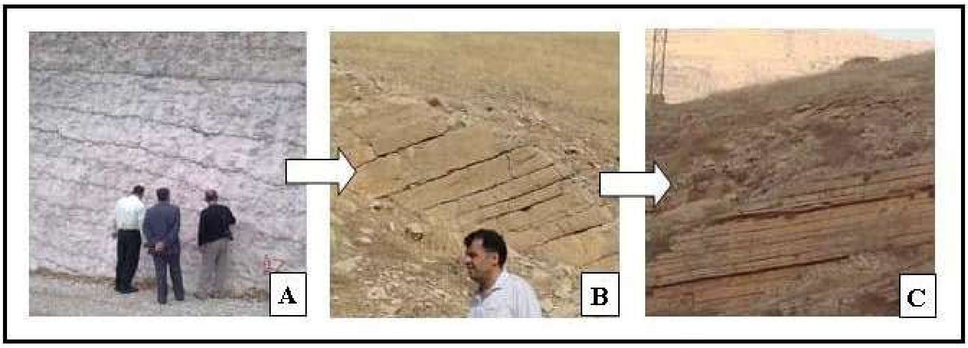

Plate 5. Gradual formation of pseudo-bedding: (**A**) extensive normal parallel stylolization stage at a new road-cut, (**B**) transformation stage, and (**C**) pseudo-bedding stage

The XRD analysis of raw unaltered friable, black material of the Kometan stylolites revealed that it is mineralogically composed of illite, calcite and quartz (Figure 4). The recognizable illite peaks of such raw samples may reflect the significant concentration of illite and its high degree of crystallization. Such thermally driven diagenesis of clayey sediments association with dewatering of clays and transformation of smectite to illite may form dilute solutions that decrease the saturation state and thus cause fluid flow (Flugel, 2004). The present study records microscopically common occurrence of such flowage within stylolite seams represented by fluid flow traces.

Discussion

According to MacEachern et al. (2007), sequence boundaries (discontinuities) forming on submarine canyon margins encouraged colonization of *Thalassinoides* and a few other traces. Such boundaries excavated subaqueously in the marine environment. Thus, the high energy sediment-gravity flows scour the canyon margins, but generally lead to little deposition. The same authors also emphasized that during such periods of regression, submarine canyons served as zones of sediment bypasses and funnels directed to the deep sea.

At least two subduction zones activated in the Neo-Tethys at the time of Kometan carbonate deposition (Jassim and Goff, 2006). These events with subsequent canyon margins occurring in Dokan area due to listric faults might lead together to cyclic discontinuities corresponding both tectonic and eustatic processes. Thus, frequent occurrences of *Thalassinoides* burrows may reflect frequent occurrences of those regressive discontinuity (omission) surfaces. Discontinuities resulting from basin-margin tectonic uplift may represent fault wall to be excavated in the Kometan basin. Frequent colonization of the canyon wall by firmground trace markers in the Dokan area preceded gradual burial of the canyon margins by shaly carbonate turbidities of the Shiranish Formation (Late Companian-Early Maastrichtian).

An increase in temperature by 10°C during burial can cause double or triple chemical reaction rates, thus mineral phases that were stable in the depositional environment may become

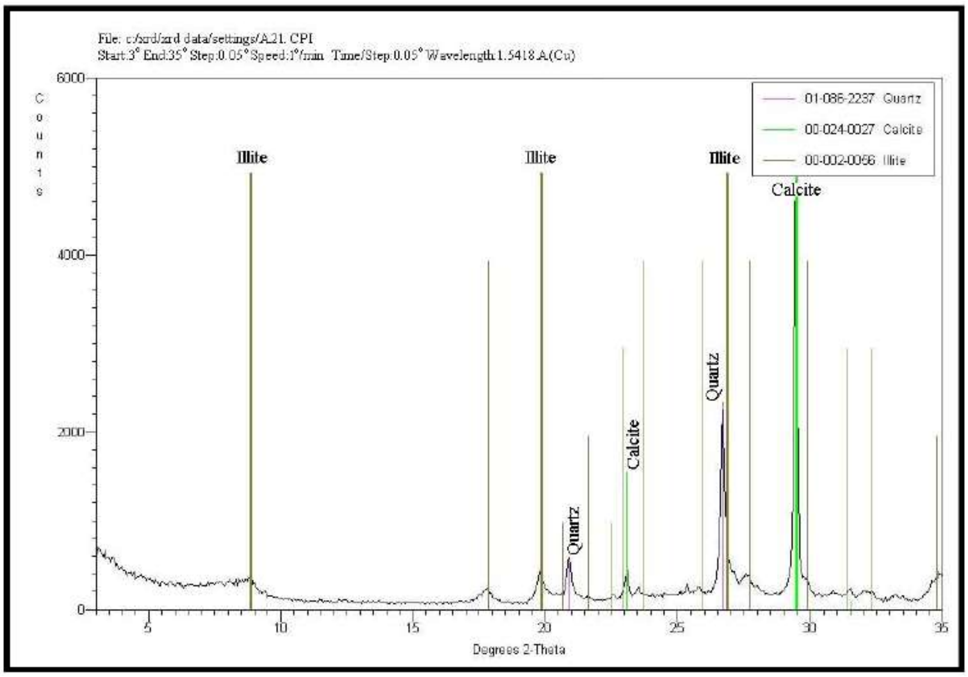

Figure 4. Diffractogram revealing mineralogical composition of a raw unaltered black stylolitic material

unstable after deep burial (Boggs, 2006). Allen and Allen (2005) stated that although compactionally-driven fluid movement is slow and relatively ineffective thermally, gravitationally-driven flow through aquifers is very important. They also added that water recharge areas in topographically elevated areas around the basin displace basinal brines and strongly affect the temperature history of basin sediments. Such a temperature increase leads to the formation of denser, less hydrous minerals and also causes an increase in the solubility of most common minerals except for carbonate minerals; thus, silicate minerals dissolve with greater burial depth and higher temperature (Boggs, 2006). In addition to compactional fluid flow, diagensis of the occasionally presence of clay associated with dewatering of smectite to illite may form dilute solutions that decrease the saturation state and cause fluid flow (Flugel, 2004).

Consequently, it is thought that the occurrence of such processes within the Kometan carbonate succession of the Dokan area result in 1) conversion of smectite to illiteand 2) calcification of whole opaline tests of radiolaria. On the other hand, quite as stated by Boggs (2006) that decrease in pH of pore waters with depth (due to decomposition of organic materials) may cause dissolution of carbonates. The increased pressure during deep burial causes an increase in the solubility of minerals at point contacts resulting in the partial dissolution of the minerals. This process, which releases silica into pore waters, is an important mechanism for furnishing silica that can later precipitate new silicate minerals in the form of pre-existing *Thalassinoides* burrows in the Kometan carbonates.

Most bedding surfaces of homogeneous deep marine chalk sequence in the Kometan Formation may be attributed to the winnowing increase caused by the abrupt sea-level changes during deposition processes. Such surfaces commonly represent zones of improved permeability (Scholle et al., 1983). Accordingly, it is thought that the most favorite trends of stylolization are the pre-existing of such permeable surfaces, in addition to normal bedding planes and regressive discontinuity surfaces. Consequently, it is found that the coincidence of mainly silicified burrows and stylolite veins refers to regressive discontinuity surfaces, while their separation indicates either winnowed surfaces or true bedding planes (Plate 2).

Conclusions

The attempted investigation allows several important conclusions, which are as follows.

1. Contrary to the previous descriptions, the present study implies that there are abundant calcified radiolarian tests in the Kometan limestone, which could play an important role in the concentration of silica in chert nodules.
2. The famous ramous shape of Kometan chert nodules in the Dokan area represents the early silicification of pre-existing *Thalassinoides* burrows.
3. It is deduced that the most so-called “bedding planes” of the Kometan Formation are merely pressure solution stylolites in massive homogeneous pelagic limestones.
4. The clay matter of stylolite veins is represented by illite resulting from smectite alteration during burial processes.
5. Such repeated *Thalassinoides* suits may be attributed to periodical subjection of an incised submarine canyon to relative sea-level lowstand followed secondly by marine conditions, before burial. Therefore, they represent regressive surface of erosion and sequence boundaries. This needs more forthcoming studies, especially in sequence stratigraphy.

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DOKAN ƏRAZİSİNİN KOMETAN FORMASİYASINDA ORQANİZM PSEVDOTƏBƏQƏLİLİYİ VƏ ORQANİZMLƏRİN HƏRƏKƏT YOLLARININ SİLİSİUMLAŞMASI (ŞİMALİ-ŞƏRQİ İRAQ)

Əbdül Əziz M. Əl-Həmdani

Orqanizmlərin silisiumlaşmış hərəkət yolları və stilolit əmələgəlmələri Şimali-Şərqi İraqın Dokan rayonunun Kometan formasiyasının (Gec Turan-Erkən Kampan) təbaşirvari pelagik əhəngdaşlarında geniş yayılmışlar. Tək-tək və qrup halında rast gələn silisiumlu duzların, radiolyariyaların diagenetik mobilizasiyasının nəticəsi olan forması talassinoideyaların mövcud hərəkət yolları sisteminin, əsas etibarilə, nəzarəti altındadır. Talassinoideyaların sıx inkişafı Dokan ərazisində kanonun kənarında (və ya listrik yarığın yanında) vaxtaşırı qeyri-müntəzəm səthlərin tektonik və evstatik proseslərin müştərək təsiri nəticəsində formalaşmasını əks etdirə bilər.

Sübut edilmişdir ki, Kometan formasiyasında çoxsaylı laylaşma səthləri massiv homogen pelagik əhəngdaşlarında stilolit əmələgəlmələridir (psevdotəbəqəlilik). Nəticədə təsdiq edilir ki, orqanizmlərin stilolit venalı silisiumlu hərəkət yolları assosiasiyası reqressiv müntəzəm səthə aid olub, bu iki əmələgəlmənin təklikdə rast gəlməsi ya keçirici üfürülmə səthinə və ya həqiqi laylaşma səthinə işarə edir. Belə stilolitlərin gilli təşkiledicisi gömülmə zamanı smektitin transformasiyası nəticəsində əmələ gəlir.

ПСЕВДОСЛОИСТОСТЬ И ОКРЕМНЕНИЕ ХОДОВ ОРГАНИЗМОВ В ФОРМАЦИИ КОМЕТАН ТЕРРИТОРИИ ДОКАН (СЕВЕРО-ВОСТОЧНЫЙ ИРАК)

Абдул-Азиз М. Аль-Хамдани

Окремненные ходы организмов и стилолитовые образования имеют широкое распространение в мелоподобных пелагических известняках формации Кометан (поздний турон-ранний кампан) района Докан северо-восточного Ирака. Форма отдельных и встречающихся в группе ветвящихся кремниевых друз, являющихся результатом диагенетической мобилизации кремния радиолярий, контролируется, главным образом, существующей системы ходов талассиноидей. Частое развитие талассиноидей может отражать периодическое формирование прерывистых поверхностей на краю каньона (или же около листрического разлома) на территории Докан в результате совместного действия тектонических и эвстатических процессов.

Было доказано, что многочисленные поверхности напластования в формации Кометан являются стилолитовыми образованиями в массивных гомогенных пелагических известняках (псевдослоистость). В заключении утверждается, что ассоциация окремненных ходов организмов (кремневые друзы) со стилолитовыми венами относятся к регрессивной непрерывной поверхности, в то время как, отдельное появление этих двух образований указывает или на образование проницаемой поверхности выдувания, или же на формирование истинных поверхностей напластования. Глинистая составляющая подобных стилолитов образуется в результате трансформации смектита во время захоронения.

GLOBAL EUSTATIC CONTROL ON THE JURASSIC SHORELINE SHIFTS IN THE BACK-ARC BASIN OF THE GREATER CAUCASUS: A NEW INSIGHT

Eustasy may be an important control on shoreline shifts in sedimentary basins. If the global sea-level rose in stepwise mode (with no falls) through the Jurassic, transgressions and regressions established in the back-arc basin of the Greater Caucasus differed strongly from the eustatic changes. However, the increase in the spatial distribution of marine environments in this region in the Late Jurassic relatively to the Early Jurassic reflected the global tendency towards sea-level rise. Certain eustatic control on the regional shoreline shifts should be postulated in such a case, although Early Jurassic basin subsidence altered the influence of the global factor. Further improvement of the global sea-level curve (with regard to new conclusions about the Jurassic climate and plate tectonics) may lead to reconsideration of the eustatic control on the shoreline shifts in the Greater Caucasus.

Keywords: transgression, regression, eustasy, Greater Caucasus, Jurassic.

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Introduction

Deciphering eustatic control on basin-scale shoreline shifts is always a challenging task, especially when the evidence of global sea-level changes is ambiguous and the basin had an active tectonic setting. However, successful accomplishment of this task is highly important because of two reasons. Firstly, this provides important information for further application of sequence stratigraphical models. Secondly, this facilitates inter-regional correlation of sedimentary successions. In the both cases, sufficient knowledge for petroleum exploration is obtained.

Previous studies by Ruban (2007, 2008) revealed only partial (if any!) global eustatic control on Jurassic transgressions and regressions in the back-arc basin of the Greater Caucasus. However, some ideas expressed by Hallam (2001) and proven by Zorina et al. (2008) allow a new insight into this issue, which is the main objective of the present brief paper. To avoid repetitions from the earlier works (e.g., Ruban, 2007, 2008; Zorina et al., 2008), I do not provide here the explanations of the alternative global sea-level curves and the methods of reconstruction of the regional shoreline shifts in the Greater Caucasus. My paper, however, pays more attention to the original eustatic reconstruction proposed by Hallam (1988) and its possible modification in the light of the later considerations of the same specialist (Hallam, 2001).

Geological setting

In the Jurassic, the Greater Caucasus was a back-arc basin that evolved on the northern periphery of the Neotethys Ocean (Ershov et al., 2003; Ruban, 2006; Saintot et al., 2006; Tawadros et al., 2006; Adamia et al., 2011; Nikishin et al., 2012) (Figure 1). Siliciclastic-dominated Lower–Middle Jurassic package and carbonate-dominated Upper Jurassic package with a total thickness of more than 10 km were accumulated there (Ростовцев и др., 1992; Ruban, 2007, 2008). The age of these deposits is controlled by various fossil groups, including ammonites (Ростовцев и др., 1992; Али-Заде, 2007; Топчишвили и Ломинадзе, 2007). Normal marine conditions persisted in the Greater Caucasus Basin through the Jurassic (Ясаманов, 1978), although this basin did not escape serious palaeoenvironmental changes (Ruban, 2007).

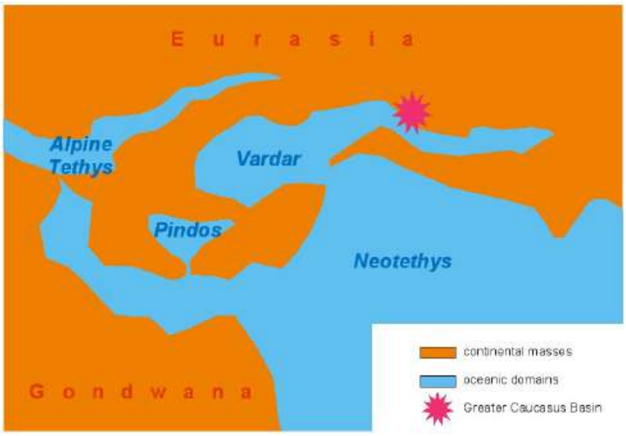

Figure 1. Palaeotectonic location of the Greater Caucasus Basin in the Jurassic. Base map (plate tectonic reconstruction for the Oxfordian Stage) is strongly simplified from Stampfli and Borel (2002)

Geodynamic regime did not remain stable on the territory of the Greater Caucasus during the Jurassic, and there were significant tectonic re-organizations (Ershov et al., 2003; Ruban, 2006, 2010; Saintot et al., 2006). This was a force to produce the shoreline shifts reconstructed by Ruban (2007, 2008). However, the punctuated, but significant rise of the global sea-level during the same period (Haq et al., 1987; Hallam, 1988, 2001; Haq and Al-Qahtani, 2005) might have also been a kind of control on the basin-scale transgressions and regressions. This Jurassic tectonic-eustatic interplay in the Greater Caucasus is yet to be fully understood.

Regional trajectory of shoreline shifts and "no-fall" eustatic curve

Multiple eustatic rises and falls in the Jurassic have been documented by Haq et al. (1987), Hallam (1988), and Haq and Al-Qahtani (2005). However, Hallam (2001) demonstrated clearly that the only Jurassic global-scale fall occurred near the beginning of this period; the sea level either rose or remained stable later. This idea coincides well with the observations of Zorina et al. (2008), who did no find any planetary-scale concentration of sedimentary breaks in the Jurassic, except for that at the beginning of this period. If so, the observed Jurassic regressions were only basin-scale, and they should be explained in the only terms of the regional/local tectonic activity (Hallam, 2001). This evidence implies the urgency of the "new-generation" eustatic standard, which is, however, lacking.

For the purposes of this study, I transform the original eustatic curve proposed by Hallam (1988) into the tentative "no-fall" eustatic curve, where the earlier-thought falls are replaced with the stable position of the global sea-level (Figure 2). The resulting curve depicts stepwise eustatic rise after the lowstand at the Triassic-Jurassic transition, which echoes the idea of Hallam (2001). The global sea level rose relatively quickly during the Hettangian-Pliensbachian. Then, it stabilized, and this situation persisted until the Callovian (Figure 2). This was followed by the other phase of relatively quick rise. It should be noted that the Hettangian-Pliesbachian and Callovian-Tithonian intervals differed with regard to the eustatic changes. The latter accelerated toward the end of the first interval, whereas they were more rapid in the first half of the second interval than in its second half (Figure 2). It appears that the Pretoarcian and post-Bathonian global sea-level rises were more or less comparable in their magnitude.

The "no-fall" eustatic curve has to be compared with the trajectory of shoreline shifts documented in the Greater Caucasus Basin by Ruban (2008) (the reconstruction by Ruban (2007) is less detailed). Striking difference between them are evident (Figure 3), which implies serious alterations of the eustatic influences by any basin-scale factors (most probably, tectonic activity). But I tend to stress that the Late Jurassic marine environments occupied a larger portion of the Greater Caucasus than in the Early–Middle Jurassic. This corresponds to the global tendency towards eustatic rise (Figure 3). The geodynamic regime along the basin margins (Ershov et al., 2003) and the distribution of sediments in the basin (Ростовцев и др., 1992) do not imply that the established correspondence

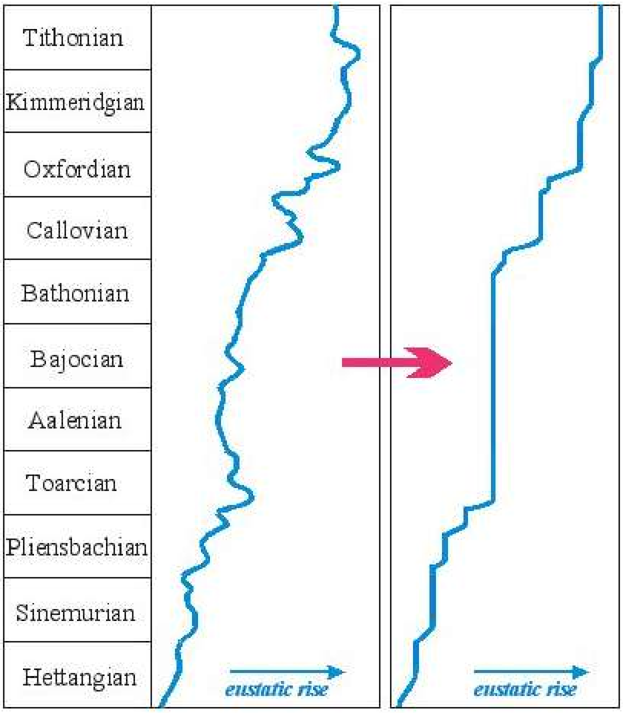

Figure 2. Transformation of the Jurassic eustatic curve proposed by Hallam (1988) (re-scaled from Hallam, 2001)) into the "no-fall" curve on the basis of conclusions by Hallam (2001)

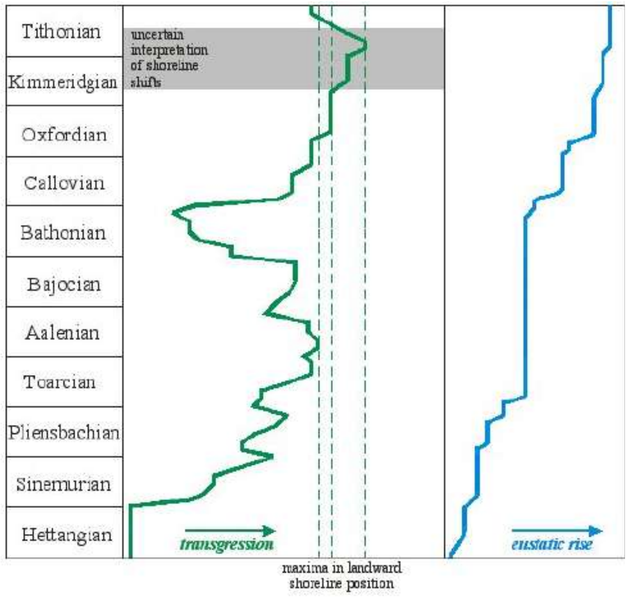

Figure 3. Comparison of the trajectory of the Jurassic shoreline shifts in the Greater Caucasus Basin (after Ruban, 2008) with the "no-fall" eustatic curve

is occasional and linked to the influence of regional tectonics or accumulation rates. Most probably, it indicates directly the global eustatic control on the Jurassic shoreline shifts in the back-arc basin of the Greater Caucasus, which is visible in a long-term perspective. As sea-level falls and relevant regressions were only basin-scale in extent and linked to the regional/local tectonic activity (Hallam, 2001), it is not surprising that there were many major and minor regressive events in the Greater Caucasus Basin (Figure 3), and the latter is not a strong argument against the eustatic control.

The attempted comparison poses the other question. Maximum extent of the sea was reached in the Greater Caucasus already at the Early-Middle Jurassic transition, and the sea size increased only slightly (by about a quarter) in the Late Jurassic (Figure 3). Moreover, if the Kimmeridgian-Tithonian evaporite-bearing deposits and overlying siliciclastics of variegated colour should be interpreted differently from Ruban (2008, 2009), i.e., if they do not indicate mixed marine and lagoonal environments, the general tendency towards transgression through the Jurassic becomes even weaker (see maxima in landward shoreline position on Figure 3). In contrast, the magnitude of the global sea-level rise was more or less comparable for the Hettangian-Pliensbachian and Callovian-Tithonian intervals (see above). This permits two hypotheses. Firstly, subsidence of the basin margins in the Early Jurassic would make the transgression faster than it would occur thanks to the only eustatic mechanism. Secondly, uplift of basin margins in the Late Jurassic would diminish the strength of the eustatically-driven transgression. Most likely, the second hypothesis has to be rejected, because the entire Greater Caucasus and adjacent areas tended to subside in the Late Jurassic (Ershov et al., 2003; Saintot et al., 2006).

Discussion and conclusion

The new insight into the issue of eustatically- versus tectonically-driven transgressions and regressions in the Greater Caucasus Basin has become possible due to the re-consideration of the Jurassic eustasy by Hallam (2001). However, the idea of the latter needs further discussion, because new information about the Jurassic climate and planetary-scale tectonic events has appeared in the past decade. Hallam (2001) pointed out that the Jurassic world escaped glaciations (and, consequently, glacioeustatic phenomena) and the only plume-triggered tectonic activity might have provoked global sea-level lowstand at the Triassic-Jurassic transition. But was it so in fact?

The dominance of greenhouse conditions in the Jurassic is mentioned in the modern synthetic works (Price, 2009; Retallack, 2009; Chen et al., 2012; Zelasiewicz and Williams, 2012). But the possibility of the Late Pliensbachian glacial episode was considered by Dromart et al. (2003), and the Late Pliensbachian cooling was also mentioned by Gómez et al. (2008) and Gómez and Goy (2011). The Callovian glacial episode was hypothesized by Dromart et al. (2003), although Wierzbowski et al. (2009) questioned this hypothesis. Consequently, short-term establishment of icehouse conditions and relevant glacioeustatic mechanisms were not so impossible in the Jurassic. The new plate tectonic reconstructions by Seton et al. (2012) demonstrate voluminous generation of the young oceanic crust in the Pacific sector of the Earth through the Jurassic, the appearance of some new spreading zones, and the partial subduction of the Neotethys oceanic ridge in the Late Jurassic. These events (at least) might have influenced global eustatic changes.

New achievements in the understanding of the both Jurassic climate and plate tectonics imply that the "no-fall" eustatic curve used as a reference in the present paper (Figure 2) may be corrected in the future. Evidently, there is still much work to do until we will be able to judge definitely about the Jurassic eustasy and its controls on the regional transgressions and regressions. But I tend to say that until the appearance of new eustatic curve(s), we can believe that the Jurassic shoreline shifts in the back-arc basin of the Greater Caucasus were facilitated by the global eustatic rise on the long-term scale, if even these shifts were strongly controlled by the regional tectonic activity.

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BÖYÜK QAFQAZIN QÖVSARXASI HÖVZƏSİNDƏ SAHİL XƏTTİNİN YURA YERDƏYİŞMƏLƏRİNİN QLOBAL EVSTATİK NƏZARƏTİ: YENİ BAXIŞ

D.A. Ruban

Evstatika çökmə hövzələrində sahil xəttinin yerdəyişməsinin mühüm amili ola bilər. Əgər dənizin qlobal səviyyəsi Yura ərzində pilləli (aşağı düşmədən) artırsa da, Böyük Qafqazın qövsarxası hövzəsində müəyyən edilmiş transqressiyalar və reqressiyalar evstatik dəyişmələrdən fərqlənirdilər. Lakin Gec Yurada bu regionda dəniz şəraitinin məkan paylanmasının genişlənməsi dəniz səviyyəsinin artmasının qlobal təmayülünü əks etdirirdi. Bu halda sahil xəttinin yerdəyişmələrinə müəyyən evstatik təsir qeyd edilməlidir, lakin Erkən Yura hövzəsinin çökməsi qlobal amilin təsirinin üzünü pərdələmişdir. Dəniz səviyyəsinin qlobal dəyişmələri əyrisinin sonrakı korreksiyası (Yura iqlimi və litosfer plitələrinin tektonikası barədə yeni nəticələri nəzərə alınmaqla). Böyük Qafqazda sahil xəttinin yerdəyişmələrində evstatik amilin rolunun yenidən baxılmasına gətirib çıxara bilər.

ГЛОБАЛЬНЫЙ ЭВСТАТИЧЕСКИЙ КОНТРОЛЬ ЮРСКИХ СМЕЩЕНИЙ БЕРЕГОВОЙ ЛИНИИ В ЗАДУГОВОМ БАССЕЙНЕ БОЛЬШОГО КАВКАЗА: НОВЫЙ ВЗГЛЯД

Д.А. Рубан

Эвстатика может быть важным фактором смещений береговой линии в осадочных бассейнах. Если глобальный уровень моря рос ступенчато (без падений) на протяжении юры, трансгрессии и регрессии, установленные в задуговом бассейне Большого Кавказа, сильно отличались от эвстатических колебаний. Однако увеличение пространственного распространения морских условий в этом регионе в поздней юре отражал глобальную тенденцию к подъему уровня моря. В таком случае должно быть отмечено определенное эвстатическое влияние на региональные смещения береговой линии, однако раннеюрское погружение бассейна затушевало влияние глобального фактора. Последующая коррекция кривой глобальных колебаний уровня моря (с учетом новых выводов относительно юрского климата и тектоники литосферных плит) может привести к пересмотру роли эвстатического фактора в смещениях береговой линии на Большом Кавказе.

TO THE HISTORY OF DISCOVERY OF THE TIMAN BAUXITES

The Timan bauxites form two bauxite ore basins: the South Timan and the North Timan ones, both of which are united to form the Timan Bauxite Ore Province. The South Timan Basin comprises the developed loped Visean aqueous bauxites of the valley and karstic-pitted types, mostly boehmite x in composition. Only the northern side of the province contains the boehmite-hydrargillite bauxites. The Middle Timan Province is represented by lateritic bauxites and their reprecipitation products: the diluvial, proluvial, alluvial, lacustrine-boggy and karstic boehmite compositions. The bauxite discovery started in the South Timan and progressed northwards.

Keywords: Timan, bauxites, pioneers, the Visean sediments, valleys, the Kedva depression, a mine field.

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Introduction

The Komi Republic is known far beyond the boundaries of Russia thanks to its oil and gas resources contained in the Timan-Pechora Petroleum-Bearing Province that also has major deposits of the titanic ore within the oil-titanium mine field Yaregskoye and the polymineral mine field Umbinsko-Srednenskoye.

The fields of at first the Lower Carboniferous and then the Middle Devonian bauxites that were discovered there half-a-century ago account for 26.35 of the total bauxite resources of Russia. Their total quantity if estimated by the A+B+C_1 categories equals 347.95 mn tonnes and they are accumulated in the following two bauxite ore provinces: the South Timan and the Middle Timan ones, both of which when put together form the Timan Bauxite Ore Province that happens to be one of the biggest ones in Europe. E.P.Kalinin (2010) put Russia in the 6th position globally in terms of bauxite resources. As regards the bauxite extraction, our country shares the 8th and the 9th positions with Kazakhstan and is in the 7th position, also globally, in terms of aluminium utilisation.

The history of the Timan bauxites' discovery stands out for its many stages and, to an extent, also, intricate evolution. Therefore, various sources give different and sometimes even contradicting information as to when those fields were discovered and who discovered them.

The Visean Bauxites

The first steps to the Timan bauxite discovery were made by the geologists B.K.Likharev and P.I.Antonov. B.K.Likharev found allite fragments with the Al_2O_3 content of up to 39% and the siliceous module of 1.0 during the geological survey in the basin of the rivers Vychegda and Cher Izhemskaya in the South Timan in 1929. However, no interest was demonstrated in that finding then. In 1931, *P.I.Antonov* found the red ochreous-clayey rocks on the Kraska-Mylk Fell in the North Timan in 1931. The hopes of finding aluminium and iron fields were pinned on those rocks at first and so, *A.G.Kitayev* led the attempt to find a bauxite mine field there in 1933 – the attempt was unsuccessful. That notwithstanding, in 1935, *G.P.Sheiko* did not, having analysed the previous work's outcomes, lose the hope of finding the '*true bauxite clays*' near that fell. Looking ahead, we should note that we undertook a detailed study of the weathering profile in that area in the 1960s; there, we found the presence of allites in the upper fringe but no bauxites were ever found.

The first suppositions that bauxites might have to be associated with the Lower Carbon rocks in the Middle Timan surfaced in the 1930s. *I.G.Dobrynin* who had conducted research upstream the river Neritza spoke of that in his relevant mine field work report in 1933. He indicated that the alum earth content in the claystone-like shales was up to 32.5%. On the outside, those shales looked very much like some varieties of the Tykhvin bauxites. I.G.Dobrynin wrote a staff report entitled 'Bauxites in the Middle Timan' in 1953. Our subsequent revision work that included drilling (1962) did not confirm that statement.

The reality of the bauxite-bearing prospects in Timan were analysed and supported for the first time in the report by A.A.Chernov (1947) for the 2nd Geological Conference of the Komi ASSR in 1994.

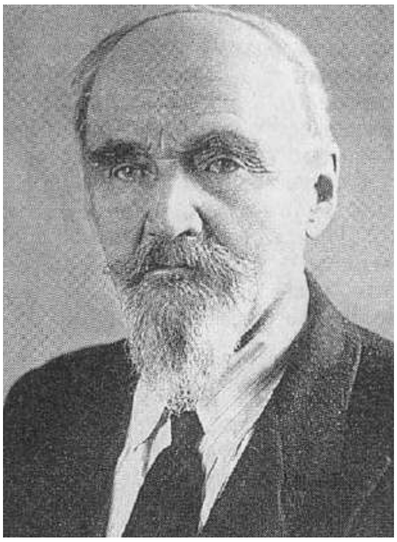

Figure 1. Alexander Chernov

The geologist *A.V.Ivanov* was studying the Visean sediment core samples taken from the depths of 177.3–179.5 m in the test hole No. 1 – Zelenetz in 1949. He found in the samples the true with the content of Al_2O_3 up to 47.6–62.2% and the siliceous module of 1.42 to 3.42 in several samples. That discovery confirmed the Ukhta geologists' assumption of a possible association between the Timan bauxite fields and the Visean sediments. At the same time, the attention was averted from studying the other stratigraphic levels for bauxite-bearing qualities.

Figure 2. Alexey Ivanov

The discovery of the Timan bauxites analogous to the Tykhvin bauxites by age, genesis and composition provided sufficient grounds for prospecting to be started in that region. Not only I.G.Dobrynin and A.V.Ivanov but also V.A.Raznitzin, P.I.Aladinsky, V.A.Kaluzhny, N.A.Syrin and others recommended that such prospecting should be undertaken.

The prospecting and exploration led by the geologist of the North-West Geological Department V.I.Gorsky-Kruchinin and the scientific research led by the scientist of SIMR P.V.Orlova started in 1954 on the basis of the findings and recommendations from many geologists.

V.I.Gorsky-Kruchinin drilled 33 core wells on a sparse array in 1954–1955 and 10 of the wells tapped bauxite rocks with the siliceous module of more than 1.0. In 5 wells, the module exceeded 2.1 while the Al_2O_3 contest was up to 55%. In effect, that confirmed the discovery of the Visean bauxites in the Middle Timan by A.I.Ivanov. However, V.I.Gorsky-Kruchinin put that region down as one of no industrial significance.

The SIMR scientists reviewed the core well samples taken in the Middle Timan in 1953 and examined in detail the Visean sediment development band in the valley of the river Neritza that I.G.Dobrynin identified. *I.V.Orlova* determined the developed chemical weathering crusts in the metamorphous rocks upstream the river Pechorskaya Pizhma. There, she also found the red rock fragments that contained 8.16% of alum earth. The siliceous module of these rocks equalled 1.16. At the same time, she indicated that the Visean pelitic rocks of the weathering crust in this area had the kaolinite composition and had the traces of loose alum earth. She offered an opinion of the possible discovery bauxite-bearing deposits in the region of the rivers Neritza and Pechorskaya Pizhma. To the east of the development region of these variegated deposits she supposed the possible presence of re-deposited weathering product accumulations containing also the loose alum earth minerals.

P.V.Orlova and her colleagues from SIMR N.T.Kalmykov and T.A.Vinogradova studied the research findings obtained by V.I.Gorsky-Kruchinin and arrived at the conclusion that the South Timan was bauxite-perspective. They confirmed the association of the tapped bauxites with the Visean epoch and attributed them to the platform type – the analogues of the Tykhvin and North Onega bauxites.

While assessing the prospecting done by the South Timan team of the North-West State University led by V.I.Gorsky-Kruchinin, P.V.Orlova mentioned that that work was not sufficient for evaluation of the bauxite prospects of the South Timan because the net of bores was very sparse and inadequate to the probable dimensions of the possible ore chambers. Nonetheless, the opinion of V.I.Gorsky-Kruchinin about the bauxite impossibility of the region prevailed and no further bauxite prospecting was done there.

The Ukhta Geological Exploration Expedition oriented for geological exploration within the boundaries of Timan to find solid mineral resources was established to the orders of the head of the Komi-Nenets Geological Department B.L.Afanasyev in Ukhta in 1958. The mainstream operation focused on rare metals and rare earths in the Middle Timan and gypsums and construction materials in the South Timan – to cater for the advancing construction industry of that region.

In 1960, the geologist of the Ukhta GEE *I.S.Sidorova* analysed the Timan bauxite prospect stock materials and designed a revision work project for the area where A.V.Ivanov discovered bauxites and V.I.Gorsky-Kruchinin arranged a sparse net of wells. It should be said that the bauxite problem was one of the biggest ones in our country in those years. The USSR geologists were busy evaluating the relevant prospects of their regions while the Ministry of Geology provided financial allocations in profusion to support the bauxite prospecting and exploration because bauxites were needed in the vehicle manufacturing industry, multi-storey construction, rocket and missile engineering and the aircraft industry. I.S.Sidorova compiled the materials on the bauxite prospects of the South Timan and the exploration work plans, while *A.M.Plyakin* tabled them at the collegial session of the RSFSR Ministry of Geology. The report evoked the attending collegium members’ and the invited bauxite researchers’ intense interest. The collegium of the RSFSR Ministry of Geology decided to begin large-scale bauxite prospecting and exploration in the South Timan. The initial supporting allocations were meagre, though, and only made it possible to carry out route tests covering slight mine roadway.

Figure 3. Yuri Krylov

That work was put in the charge of the young specialist *Y.K.Krylov* who succeeded in performing it. He started with the route research that included a slight scope of light underground mining and, based on that work's findings and the analysis of the in-stock materials of these, he produced the subsequent work plan that suggested detailing of the known bauxite shows and drilling bores in the Upper Volsk Downfold (the Puzlin, Ejvador and Zelenetz depressions). The first well was drilled under the care of the chief tool pusher *I.N.Kozlitin* on 6 April.

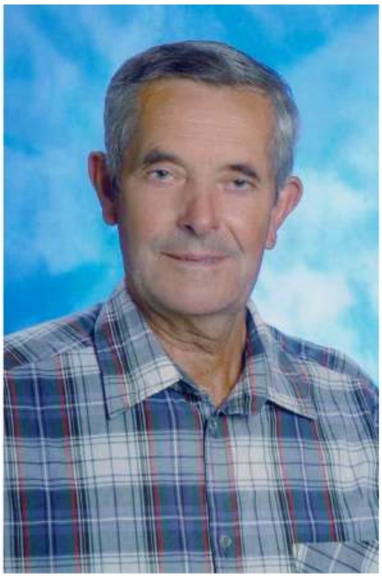

Figure 4. Ivan Kozlitin

The same year, the geologist G.P.Gulyayev began to work in that area. The two bauxite fields – the Western one and the 2nd Timsherskaya one – had been discovered there by the end of 1961 and 5 deposits more were discovered in 1964: the 1st and the 4th Timsherskaya ones and the Northern Field. The prospecting and exploration for the South Timan bauxites were eventually done also by such geologists as V.G.Driga, V.A.Zinchenko, V.G.Kolokoltzev, B.I.Kostushko, V.V.Lebedev, V.I.Petrenko, V.M.Tarssin and others.

The fields of the Timshersko-Puzlinskaya Group were discovered and the Visean-aged bauxites were explored and checked technologically under the geological auspices of Y.K.Krylov. The study of those bauxites was the task of a big group of geologists, researchers in other sciences and industrialists including, among others, V.V.Belyayev (1974), V.N.Dyomina (1977), Y.A.Gulyanitskiy, B.F.Gorbachyov, G.P.Gulyayev, V.G.Kolokoltzev (1977), N.V.Kullanda, M.V.Pastukhova and I.S.Sidorova.

Thus, *A.V.Ivanova and Y.K.Krylov can rightly be regarded as the discoverers of the Timshersko-Puzlinsky bauxites*. Their specific genesis features and deposition conditions as well as the association with the Visean deposits created a momentum behind bauxite prospecting in the provinces that lay farther to the North.

The first attempt at revisiting the site with high aluminium content in the Visean deposits of the basin of the River Neritza (the Middle Timan) as I.G.Dobrynin recommended was undertaken by the Ukhta GEE geologists G.P.Gulyayev and A.M.Plyakin in 1962. The route research and the shallow (down to 52 mn) core drilling provided for a detailed enough study of the Visean section of the red deposits in this area but neither bauxites nor bauxite rocks could be discovered there in spite of the fact that the prospectors did note the heightened Al_2O_3 content in the clays.

The geological survey done in the Kedvin Depression under the leadership of G.I.Gurevich (1963–1964) determined the widespread development of kaolinite clays in the lower terrigenous pack of the Visean deposits. That finding served as the grounds for the special-purpose prospecting done in that area of the South Timan subsequently. *G.P.Gulyayev* executed the geological control of the bauxite prospecting there.

That resulted in the discovery of the second group of bauxite fields of the Kedvin-Tobysskaya Group in 1967. Before that, however, the Loim Delf was discovered, followed by the discoveries of the Upper Ukhta and the Vapovskaya delves. Thus, the geologists of Ukhta discovered a new bauxite-bearing area in 1967; all the three delves were conglomerated into the Kedva-Tobysskoye Mine Field.

The first project justifying the chosen import of the prospecting that started operations in that area was written down by the geologist *P.S.Petrov with the input from I.S.Sidorova.* The geologist V.G.Kolokoltzev worked there throughout the whole operation period. Among the other geologists who were involved in this work were V.N.Baranov, V.K.Makhanov, M.A.Miklashevsky, V.G.Toporkov, S.N.Fadehichev, M.I.Ferapontov, et al.

of those bauxites with the directed water flows and accumulations in the gully-clough relief depressions; their conclusion is based on the complex of sedimentation indications. Other researchers connect the bauxites to the valley fill and karstic-kettle sedimentary types (Колокольцев, 1973; Беляев, 2006). V.G.Kolokoltzev presupposes the possibility of the lateritic bauxites' preservation in the Famennian Age rocks.

Figure 5. Gregory Gulyayev

Figure 6. Vyacheslav Belyayev

The scientists from Syktyvkar V.V.Belyayev and V.E.Zakrutkin (Фишман, 2000) took part in the study of the Kedvin Field's bauxites in 1972; E.S.Sherbanov, S.V.Kolesnikov and M.A.Miklashevsky (1973) joined them in 1973.

Four packs (Дёмина, 1977) were identified within the Visean bauxite-bearing series of that field. The lower one is a sub-bauxite-bearing one and comprises various facial types of sediments: channel, limnic and lagoonal ones. The bauxite-bearing series comprise kaolinite clays, bauxites and ferro-alum ores. The carbonaceous series are composed of coaly clay rocks with the thin coal lenses. The series are completed by the variegated psammitic-shale-aleuritic pack. Some researchers (Щербаков, Колесников, Миклашевский, 1973) associate the generation

P.S.Petro and G.P.Gulyayev can be considered to be the discoverers of the Kedvin Bauxite Field.

The Devonian Bauxites

As was mentioned above, the discovery of the Visean bauxite-bearing level in the Timan meant the end to prospecting at the other stratigraphic levels. The hypotheses about the bauxites' association with the crusts of weathering of the Devonian basalts, dunstones and tuffites was proposed by V.A.Kaluzhny first (1960) and by O.S.Kochetkov and A.M.Plyakin afterwards (1969). Such a presupposition was based on the study findings concerning those rocks' weathering crusts coming from various areas of Timan.

Besides, bauxite rock fragments were found on one occasion within the development area of the Early Frasnian basalts of the Middle Timan – V.I.Gorsky-Kruchinin made that discovery during the geological survey done in 1957. However, he did not attach importance to his discovery just like he did not during the search for the Visean bauxites.

A.M.Plyakin discovered the fragments of bauxite rocks with the alum earth content equalling 33.66% and the siliceous module of 1.94 in the Quarternary deposits upstream the River Mezen' during the geological survey of 1965–1966. Because the Early Frasnian basalts were found to be well-developed in the vicinity of that area, the author connected the high alum earth content rocks to the basaltic weathering crusts at first and this presumption founded the basaltic weathering crust study to determine their bauxite-bearing potential (1968–1970). V.M.Pachukovsky, too, found the bauxite rock fragments with the alum earth contents varying from 32.95% to 34.35% and the siliceous module of up to 2.01 within the basalt development area in 1969. The weathering crust surveying field party discovered kaolinite-hydromicaceous rocks as well as clastic allites and bauxite rocks in the interstream area of the rivers Vorykva and Vezhayu in 1970.

The findings of the above-listed works made it possible to associate the possible development of the Devonian lateritic bauxites upstream the River Vorykva with the basaltic weathering. V.M.Pachukovsky and A.M.Plyakin charted a prospecting pit in the bauxite rock debris discovery region upstream the River Vorykva in order to test this assumption in October 1970. The headway in the 4 shallow (down to 3.2 metres) pits by the mine worker I.Kosevskikh resulted in the discovery of the bauxite bedrock with the thickness equalling 1.2 m (Колокольцев, Плякин, Пачуковский, Беляев 1971). A.M.Plyakin documented and tested the first delf. The chief tool pusher A.F.Drighin drilled the well No. 522 into the above-mentioned trial pit No. 4 in April 1971. That well tapped the full thickness of the delf, which was determined to equal 15 m. The prospecting work that followed resulted in the delineation of the deposit, which was called the Upper Vorykva Field. *A.M.Plyakin and V.M.Pachukovsky were the discoverers of that delf, which was called the Upper Vorykva Field initially;* they were awarded the discoverers' diplomas and lapel badges in 1979. The genetic classification of the Timan Devonian bauxites was first elaborated during 1972–1973 (Плякин, Лебедев, 1973) and it was supplemented and concretised as more factual material was fed in. The weathering crust upon the Proterozoic lime shales is the principal source of the Devonian bauxites; some even consider it the only source at all. Probably, the Devonian or yet more ancient basaltic tuffs played a certain role in the generation of the bauxites. Lateritic bauxites are widely spread there alongside their derivative rocks and reprecipitation (alluvial, proluvial, lacustrine-marsh) deposits. B.B.Belyayev suggested an idea of the possible 'additional bauxitisation' of the incomplete weathering products in the karstic processes format.

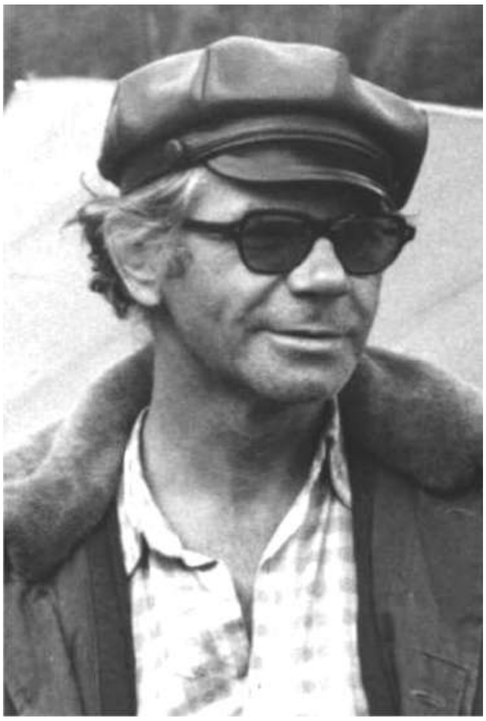

Figure 7. Victor Pachukovsky

The continued prospecting led to the discovery of two more deposits in the basin of the River Vejayu situated on the extension of the Vorykva Field: the Western and the Central ones. Their discovery involved *V.P.Abramov (1979), G.P.Gulyayev and M.I.Ferapontov (1980) who went on to discover the bauxite field* that was called the Vejayu-Vorykva Field and included also the Upper Vorykva deposit. A.A.Lutoyev was added to the rank of the discoverers in 1991.

As the prospecting progressed, it was shifted to the East and North-West of the first major deposit of the Devonian bauxites eventually. That led to further discoveries: the Eastern Field was discovered first, followed by the discoveries of the Upper Shugorskoye, and then of the Volodinskoye, Zaostrovskoe and Svetlinskoe fields of the Devonian bauxites. Those discoveries were pioneered by the geologists of the Ukhta geological exploration expedition but they are not named as such officially yet because the prospecting and exploration work is not complete and ultimately defined. The detailed research of the existing types of the Middle Timan bauxites as well as of their generation conditions, material composition and rare mineral mineralisation was done by A.M.Plyakin (1974), V.V.Belyayev, I.V.Shvetzova (1976), S.V.Levchenko (1981), V.V.Likhachev (1993) and the geologists of various scientific organisations of the country.

Conclusion

The first Visean Age bauxites were discovered within the Timan bauxite-ore province by *A.V.Ivanov* and that discovery was made in the South Timan. The first discovered bauxite deposit received a negative verdict from V.I.Gorsky-Kruchinin, which caused the search to stop. However, the scientific analysis of the geological situation by I.S.Sidorova made certain that the search was resumed, which resulted in the re-evaluation of the prospects of the province and the subsequent discovery of several fields that made up the South Tima Bauxite-Ore Province with the boehmite bauxites. The discovery was repeated by *Y.K.Krylov*. That province was expanded eventually through the discovery of the boehmite and hydrargillite bauxites in its northern part under the leadership of *G.P.Gulyayev*.

The path to the bauxites led through the discovery of bauxite rock fragments within the Quarternary deposits within the boundaries of the Middle Timan. V.I.Gorsky-Kruchinin did not evaluate correctly the first allite fragments found, either. The new allite discoveries by *A.M.Plyakin and V.M.Pachukovsky* and the subsequent discovery of the first Devonian bauxite deposit that these two prospectors made marked the discovery of a bauxite type that had been new to Timan, namely, the Devonian lateritic bauxites. Five more fields were found there eventually that made up the Middle Timan Bauxite-Ore Province. The list of the Devonian bauxite pioneers became longer when the names of *V.P.Abramov, G.P.Gulyayev, M.I.Ferapontov and A.A.Lutoyev* added to it.

The largest field of them all – the Vejayu-Vorykva Bauxite Field – supplies the ore for the Urals plants currently.

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Book review

SAN JUAN BASIN GAS FIELD AND RESERVOIRS

San Juan Basin gas field and reservoirs *by Donald E. Owen & Charles F. Head; Richard A. Ashmore (Ed.), 2011. Four Corners Geological Society, P.O. Box 1501, Durango, CO 81302, USA (order through: www.fourcornersgeologicalsciety.org/store/index.asp). PDF file on CD-ROM, 113 pp. Price USD 20.00. ISBN 978-1-936980-00-0*

Few geologists get the opportunity to analyse on their own a gas field outside their own working area. This is well possible from now on, thanks to a field-trip guide that was prepared for the 59th Annual Meeting (2010) of the Rocky Mountain Section of the American Association of Petroleum Geologists. This field guide has recently been published in the form of a CD-ROM which is generally accessible.

The field trip, which was guided by the authors of this CD-ROM, is a 350-km traverse of the Four Corners area (the area around the only point in the USA where four states – Utah, Colorado, Arizona and New Mexico – touch each other), through the stunning landscapes of the surrounding high desert and southern Rocky Mountains, with emphasis on the hydrocarbons-related geology of the San Juan Basin. This basin is also well known among palaeontologists because of the controversy concerning the age – Cretaceous or Palaeogene – of the youngest dinosaur remnants. The main topic is, however, as the title indicates, the geology (and particularly the sedimentology) of the gas and oil fields. Cretaceous and Tertiary reservoir outcrops, as well as landforms provide the basic data regarding the stratigraphy, history of exploration and development, and hydrocarbon system of the basin. Apart from that, interesting landmarks such as the famous Ship Rock (a neck) and Mesa Verde (a table mountain with prehistoric Indian dwellings) form also part of the trip.

It is interesting to realise that most people – and even many academic earth scientists – think that you can get a good impression of a hydrocarbons field only on the basis of drill cores. This is, obviously, not true, and the excursion described in this field guide shows why. Several places are visited where rocks are exposed that play an important role in the reservoir properties, most commonly in the form of host rocks

Geologists are, as a rule, not satisfied by only hearing about outcrops: they want to see them with their own eyes, investigate the rocks with their own hammers, and take their self-collected samples home. In this case, there are – unfortunately from a geologists' point of view – some restrictions: in Navajo Nation the disturbance or collection of geological, palaeontological or archaeological samples or remains is not permitted. Geologists should first apply for – and receive – a permit from the Navajo Nation Minerals Department (P.O. Box 1910, Window Rock, Arizona 86515). But if such a permit is granted, there is much to see. I mention here only some of the most interesting points described in the guide, as examples. Obviously, the field guide contains much more information.

The first stop is at Carbon Junction (Colorado), where the Pictured Cliffs sandstone and the Fruitland Formation are exposed. Carbon Junction is named for the thick, lower Fruitland Carbonero coal seam that has been historically mined. Along the road, a section is exposed consisting of, from bottom to top the Lewis marine mudstones and siltstones, the Pictured Cliffs shoreface sandstones, and the Fruitland swamp/marsh to fluvial floodplain sediments, including coals. These three formations were deposited in the Cretaceous Western Interior Seaway in a depositional system that included coastal plain, shoreface, and offshore environments.

The Lewis Shale is approx. 400 m thick here; it contains lean hydrocarbon source beds with generally less than 2% total organic carbon (TOC). Tight sandstones, siltstones, and shales are productive gas reservoirs where naturally fractured. The Pictured Cliffs Fm. is a tight sandstone reservoir with low permeability and 4–20% porosity. Pores are generally very small in this fine-grained sandstone, and many pores are at least partially occluded by pore-filling cements and clays. Instead of producing gas from pores, as in sandstones, the coal produces gas from fractures known as cleats. The gas is held in the coal by adsorption.

The next stop is at Cedar Hill in New Mexico, in the Cedar Hill Fruitland Coal Pool, discovered in 1977. British Petroleum disposes of produced coal-bed methane water via evaporation from ponds. The Fruitland Formation has since become the world's most prolific coal-bed methane play, and it has produced more gas than any other interval in the San Juan Basin. Prior to extensive production and depletion, over-pressurized coal-bed methane blowouts and rig fires were a significant drilling hazard. Inside the over-pressured envelope (higher permeability), average coal-gas production rates are an order of magnitude higher than outside. Nearly all the basin's gas comes from Cretaceous reservoirs, which include tight sandstones, coals, and fractured siltstones/shales. The entire section is gas-saturated in a large stratigraphic trap with water updip of gas. Commercial limits of each reservoir are defined by reservoir quality (better updip!), water saturation, and fracture density.

The third stop, in the centre of the Hogback oil field in New Mexico, shows the Tocito Sandstone. Rocks cropping out in the cliffs are the Tocito Sandstone Lentil of Mancos Shale, deposited primarily as sub-tidal sandbars. This outcrop is situated on the Hogback Oil Field anticline. The oil field originally produced from the Dakota Sandstone and, later, Pennsylvanian limestones. Several nearby oil fields (Horseshoe, Cha Cha, Bisti, etc.) also produce from the Tocito Sandstone. At this outcrop, many of the typical facies of the Tocito occur. The base of the channel-fill sandstone is interpreted as merging with the sub-Tocito unconformity along the crest of the anticline. The basal Tocito unconformity is interpreted to be at the change in texture and colour observed near the base of this outcrop. Tocito reservoirs have produced the majority of the oil recovered from the San Juan Basin. This part of the Mancos Shale interval from below the Tocito Sandstone and above it has been referred to by industry as 'The Gallup' since the first commercial production in the 1950s. Tocito reservoirs dominate production in over 20 Gallup pools, and they contribute significant oil and gas in many other fractured Mancos ('Gallup') pools. The Tocito Sandstone has some of the best matrix porosity and permeability in the basin, and it exhibits distinctive log inflections in high-quality, hydrocarbon-saturated reservoirs. The prolific nature of the Tocito Sandstone is directly related to its reservoir stratigraphy, trapping mechanisms, and proximity to oil-prone source rocks. Most of the Tocito reservoirs in the San Juan Basin are now fully developed and pressure-depleted.

The depositional (and erosional) setting of the Tocito in these fields and outcrops have interpreted in different ways: as a strike-valley sandstone, as a longshore bar complex, and as a transgressive sandstone. It is also still under discussion whether the basal Tocito unconformity is subaerial or submarine, what was the role of eustacy versus tectonism, and what were the precise depositional systems.

A stop at Four Corners Platform (NM) shows the Dakota Sandstone near the town of Shiprock. This excellent exposure of the upper part of this formation displays fluvial sandstones, including a spectacular isolated channel sandstone visible in three dimensions, and paludal shales with coal overlain by an onlapping set of thin marine shale and sandstone. Several oil discoveries in the Dakota Sandstone were made on surface anticlines during the 1920s. The Dakota reservoir is the second largest producer of natural gas from sandstones in the San Juan Basin.

All stops are clearly indicated in the text, and also shown on a map which shows the itinary. In addition, the guide contains a wealth of explanations in the form of full-colour illustrations. Several articles which have been published about specific subjects are included as well. This all makes this field guide a most practical and informative piece of work.

I have travelled through the area numerous times, and I was surprised time and again by the beauty of the landscape, the variation in geology and the numerous ideal exposures. But how much more would I have enjoyed these trips if I had had this field guide with me! The low price of the CD-ROM (at least in comparison with a similar work in print) should seduce many geologists. And they might bring their partners on this trip, which will be so satisfactory for both geologists and tourists.

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CONFERENCE INFORMATION

THE INTERNATIONAL PETROLEUM TECHNOLOGY CONFERENCE (IPTC)

19–22 January 2014 in Doha, Qatar

Website: http://www.iptcnet.org/
Website: http://www.iptcnet.org/pages/contact/

94TH AMS ANNUAL MEETING "EXTREME WEATHER–CLIMATE AND THE BUILT ENVIRONMENT: NEW PERSPECTIVES OPPORTUNITIES AND TOOLS"

2–6 February 2014, Georgia World Congress Center in Atlanta, Georgia

Website: http://annual.ametsoc.org/2014/index.cfm

EAGE/FESM JOINT REGIONAL CONFERENCE PETROPHYSICS MEETS GEOSCIENCE

Earth Science, Physics,
17–18 February 2014, Kuala Lumpur, Malaysia

Website: http://www.eage.org
E-mail: conferences@eage.org

GEO 2014: 11TH MIDDLE EAST GEOSCIENCE CONFERENCE AND EXHIBITION BAHRAIN INTERNATIONAL EXHIBITION AND CONVENTION CENTER

9–12 March 2014, Bahrain

E-mail: aapgme@aapg.org
Website: http://www.geo2014.com/

Tel.: +9714 3724201
Fax: +9714 3724204

2014 GSA: SOUTH-CENTRAL SECTION MEETING

17–18 March 2014, Fayetteville, Arkansas, USA

Website: http://www.geosociety.org/Sections/sc/2014mtg/
Website: http://www.geosociety.org/Sections/sc/2014mtg/registration.htm

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2014 GSA: NORTHEASTERN SECTION MEETING

23–25 March 2014, Lancaster, Pennsylvania, USA

Website: http://www.geosociety.org/Sections/ne/2014mtg/
Website: http://www.geosociety.org/Sections/ne/2014mtg/registration.htm

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GEOSCIENCES – INVESTING IN THE FUTURE

7–10 April 2014, Saint Petersburg, Russian Federation

E-mail: conferences@eage.org
Website: http://www.globaleventslist.elsevier.com/events/2014/04/geosciences-investing-in-the-future/

THE 7TH INTERNATIONAL BRACHIOPOD CONGRESS: THE BRACHIOPOD WORLD

22–25 May 2015, Nanjing, China

Website: www.7ibc.org/UploadFiles/FirstCs.pdf

DUST 2014: INTERNATIONAL CONFERENCE ON ATMOSPHERIC DUST

1–6 June 2014, Castellaneta Marina (TA), Italy

E-mail: secretariat@dust2014.org
Website: http://www.dust2014.org/

Tel.: +39 080 5442614 (Chair)
+39 0971 427224 (Secretariat)

XIX GEOLOGICAL CONGRESS OF ARGENTINA

2–6 June 2014, Cordoba, Argentina

Website: http://www.congresogeologico.org.ar//assets/pdf/XIX_CGA_2da_Circular.pdf
E-mail: info@congresogeologico.org.ar; secretaria@congresogeologico.org.ar

SAMPLING 2014: WHERE IT ALL BEGINS

29–30 July 2014, Perth, Western Australia

E-mail: esanneman@ausimm.com.au
Website: http://www.ausimm.com.au/sampling2014/index.asp
Website: http://www.ausimm.com.au/sampling2014/

Tel.: +61 3 9658 6105

PLANET FORMATION AND EVOLUTION 2014

8–10 September 2014, Germany, Kiel, Kiel University

Website: http://www1.astrophysik.uni-kiel.de/~kiel2014/main/index.html

IAEG 50TH ANNIVERSARY IAEG XII CONGRESS

15–19 September, 2014, Torino

Website: http://www.iaeg2014.com/
Website: http://www.iaeg2014.com/full-paper-submission

2014 NMGS FALL FIELD CONFERENCE

24-27 September 2014, Sacramento Mountains

E-mail: ginger@nmbg.nmt.edu (Ginger McLemore)
E-mail: geoff@nmbg,nmt.edu (Geoff Rawling)
Website: http://nmgs.nmt.edu/ffc/
Website: http://nmgs.nmt.edu/ffc/2014/CFP_2014_NMGS_FFC.pdf
Website: http://nmgs.nmt.edu/ffc/authors/home.html

CEGS 2015: INTERNATIONAL CONFERENCE ON ENVIRONMENTAL AND GEOLOGICAL SYSTEMS

13–14 March 2015, Pattaya, Thailand

Website: http://www.waset.org/conferences/2015/pattaya/icegs/
Website: http://www.waset.org/conferences/2015/pattaya/icegs/cfp.php
Website: http://www.waset.org/international.php

GUIDE FOR AUTHORS

The International Scientific Journal "*Stratigraphy and sedimentology of oil-gas basins*" covers the broad topic related to sedimentology and startigraphy of oil-gas basins around the Globe. We publish papers focusing on modern and ancient depositional environments with emphasis on depositional setting of source and reservoir rocks, modeling of the sediment flow, soil formation and diagenesis, paleoclimate, sea level change and sedimentation, modern and ancient faunal, floral assemblages and fossils records for sedimentary environment analysis, stable isotope geochemistry and biogeochemistry, reservoir properties changes in the environmental framework, integration of different stratigraphic methods such as bio-, litho-, chemo, eco-, chrono-, seismo-, sequence startigraphy applied to the sedimentary successions in the oil rich provinces.

The journal is produced twice a year and accepts papers, reviews, discussions and brief information. Papers might be submitted in Azeri, English or Russian.

Manuscripts

Authors should submit their manuscripts to the e-mail address info@isjss.com as a single file. The name of the file should contain the initials of the first author. Figures should be supplied as separate files, but the text should also include the number of figures as position indicators. The name of the files containing figures should include the initials of the first author and the number of the figure.

The text of article should be prepared as a Microsoft Word document (Word 6,0 – 8,0). The body of article should not exceed 20 A4 pages in length, margins from all sides – 2 cm. Recommended font Times New Roman 12 pts. Files should be formatted with 1,5 line spacing. Indent every paragraph 0,8 cm from the left side of a column. Text of a paper should be formatted (lines of the text should be rectified from left and tight and does not break its margins).

The article should include text, supportable figures (at least one figure), references, tables if necessary, and extended summary. The Editorial board does not accept alone text.

The Editorial board also kindly asks authors to provide two hard copies sent to the following postal address: Editorial board of the International Scientific Journal "Stratigraphy and sedimentology of oil-gas basins", Geology Institute of Azerbaijan National Academy of Sciences, 29A H.Javid avenue, Baku, AZ 1143, Azerbaijan. The electronic version should correspond to the hard copy.

Pages **should not be** numbered in the electronic version of article, and **should be** numbered in the top right-hand corner in the hard copy.

The paper should be signed on the last page by all authors and show the date of its submission to the editorial board.

Text should include:

Title should be typed in the middle of page. Please, use font Times New Roman 14 pts, capital bold letters.

Initials and surnames of authors should be typed in the middle of page in a two-line space after the title. Please, use font Times New Roman 12 pts, bold letters, and indicate the corresponding author.

Authors' affiliation should be typed in the middle of page in a two-line space after authors' name using Times New Roman 12 pts, bold letters. Please, provide a full postal address of the place where the study was carried out, and present address of authors if different. If there are several authors the Arabic numerals before their affiliation's name should be placed in the sequential order. The same numerals should be indicated above the author's surname, e.g. I.S. Guliyev[1], A.A. Feizullayev[2].

Abstract should contain a brief summary of the article – maximum 1 page, and key words – up to 8 words. Please, use font Times New Roman 12 pts. The key words should be typed in the bold letters.

The main body of the article should be typed in a two-line space after the abstract and written in compliance with a general form adopted in the international journals with the following subdivisions: "Introduction", "Material", "Methods", "Results and discussion", "Conclusion". The headings should be typed in font Times New Roman 12 pts, bold letters, and given in the middle of page. Each subdivision should be typed in one-line space after the previous one.

Tables are placed in the text of paper, and should be submitted in the Word format, and numbered consecutively above the table in the right – hand corner with Arabic numerals. Use font Times new Roman 12 pts, bold letters, e.g. **Table 1…** Each table should be accompanied by caption given after the table number, font Times New Roman 12 pts, bold letters. Column headings should be brief, with units of measurement in parentheses. The tables should not be beyond the text, and hyphenated to the next page. The maximum number of tables in an article is 5.

Abbreviations except for those generally accepted should be clearly explained in a footnote.

Fossils should be described according to "The International Code of Zoological Nomenclature". Latin names of flora and fauna should be accompanied by the surname of the taxon's author. Latin characters should be printed in italics.

Mathematics

Equations should be typed as text and contain physical units and symbols used in the International System SI. Formulas are given without interstitial calculations, with necessary deciphering of used symbols immediately after the formula. Referred in the text formulas should be numbered using Arabic numerals. Numbers should be given in parenthesis on the right margin of the text and on the same line with the formula. It is recommended to use Microsoft Equation 3 to type the formulas.

References in the text should be given in a two-line space after the main body of the text. They should be cited by giving the author's name with the year of publication in parentheses, and should be given in date order (e.g. Guliyev, 1995; Feyzullayev, 2000). When reference is made to a paper/book by more than three authors, the first name followed by et al. should be used in the reference. If a paper does not refer to authors but to a paper/book's name the first two words of its name should be given, e.g. Stratigraphic code..., 1998.

References should be listed alphabetically at the end of the manuscript and must include names and initials of all authors, year of publication, title of paper/book referred to, journal name, volume, and first and last page numbers. When reference is made to a book, please, indicate an amount of pages. If reference contains several papers by the same author and from the same year, a, b, c, etc. should be put after the year of publication Published abstracts should be cited in the same way as published papers. Surnames and initials of the author(s) are printed in italics.

The references given in Cyrillic should be given at the begging of the reference list, and followed by references in Roman characters.

Authors should use the system illustrated below.

Books:

Meyen, S.V., 1987. Fundamentals of Paleobotany. Chapman and Hall, London, 432 pp.

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

Papers published in periodical journals:

Hinds, D., Aliyeva, E., Allen, M.B., Davies, C.E., Kroonenberg, S.B.,Simmons, M.D., Vincent, S.J., 2004. Sedimentation in a discharge-dominated fluvial-lacustrine system: the Neogene Productive series of the South Caspian Basin, Azerbaijan // Marine and Petroleum Geology, № 21, p. 113–138.

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.

Papers published in volumes (including periodical):

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.

Summary. An extended summary of the paper designed for further translation into Russian and Azeri should be provided. The aim of the summary is to familiarize the Russian and Azeri speaking readers with the articles published in English. The summary should contain essential information, and include the scope and objectives of the work, methods used, results obtained, and conclusions. The Editorial board will provide the translation of the summary submitted in English into Russian and Azeri.

Illustrations. Top quality, high resolution graphics and images are needed in digital form and should be submitted in the separate files. The file's name should contain the first author's initials and the figure number. Please, supply figures as TIFF (300 dpi), high resolution PDF or CDR files. Please export graphics generated in MS Office applications (Word, Excel) as high resolution PDFs. Illustrations should be numbered as they are referred in the text. Size of every figure should not exceed 160 mm x 230 mm. Maps should contain scale. The hard copy of each figure should be numbered on its back side with a pencil, the first author's name and the article's title should be also indicated.

Each illustration must have a caption. The list of captions should be provided in a separate sheet, and submitted electronically and in a hard copy. The number of figures should not exceed 10. **Color figures** are eligible for free color printing.

The editorial board reserves the rights to submit a paper for the review. The makeup of accepted papers will be electronically sent to authors for final checking and corrections. We expect to have authors' response within two weeks after receiving of the makeup paper.

Submitted articles should be original, had not been published anywhere before and has not been forwarded to other publishing houses.

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.

Məqalənin mətni Word formatında (Word 6.0 – 8.0) təqdim edilməlidir. Məqalə A4 formatına uyğun 20 səhifə həcmindən artıq olmamalıdır. Tövsiyə olunan şrift Times New Roman, şriftin ölçüsü 12, sətirlərarası interval – 1,5, hər tərəfdən kənar 2 sm., hər abzas sütunun sol tərəfindən 0,8 sm məsafə ilə başlayır. Məqalənin mətni bu tələblərə uyğun format edilməlidir, bütün sətirlər soldan və sağdan mətnin kənarından çıxmamaq şərtilə düzəldilməlidir. Məqaləyə mətndən başqa müvafiq qrafik material (bir rəsmdən az olmayaraq), istifadə edilmiş ədəbiyyatın siyahısı, cədvəllər, və ehtiyac olarsa geniş rezüme də daxil olmalıdır. Jurnalın redaksiya heyəti rəsmləri olmayan məqalələri qəbul etmir.

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.

Məqalənin elektron variantında səhifələr nömrələnməməlidir. Çap olunmuş variantda hər səhifənin yuxarı sağ küncündə səhifələrin nömrələri yazılmalıdır.

Məqalənin çap variantının sonuncu səhifəsi müəlliflərin hər biri tərəfindən imzalanmalı və onun redaksiyaya təqdim olunma tarixi göstərilməlidir.

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.

Müəllifin çalışdığı təşkilatın adı və elektron ünvanı - Times New Roman – 12 pt şrifti ilə, qalın hərflərlə, səhifənin ortasına nisbətən simmetrik olaraq yazılır. Xahiş edirik məqalənin yazıldığı təşkilatın tam ünvanını, və müəlliflərin cari ünvanını (əgər dəyişibsə) göstərin. Məqalənin bir neçə müəllifi olduqda və onlar müxtəlif təşkilatlarda çalışdıqda, onların adlarının qarşısında artan sıra ilə rəqəmlər yazılmalıdır. Həmin rəqəmlər çalışdıqları təşkilatlara müvafiq olaraq müəlliflərin soyadlarından sonra sətirüstü indeksdə verilməlidir, məsələn İ.S.Quliyev[1], A.A.Feyzullayev[2] və s. Daha sonra iki intervalla məqalənin annotasiyası verilməlidir.

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.

Məqalənin mətni – beynəlxalq jurnal sxeminə uyğun olaraq qurulmalı olan əsas mətn. Burada “Giriş”, “Material”, “Metodika”, “Nəticələr və müzakirələr”, “Son nəticə”, “Ədəbiyyatın siyahısı” kimi yarımsərlövhələrdən istifadə edilməsi tövsiyə olunur. Yarımsərlövhələr qalın Times New Roman – 12 şrifti ilə səhifənin ortasına nisbətən simmetrik olaraq yazılmalı, və hər yarımfəsil əvvəlkindən bir intervalla ayrılmalıdır.

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 х 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.

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CONTENTS

M Ü N D Ə R İ C A T

ОГЛАВЛЕНИЕ