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THE EVOLUTION OF THE BENTHIC FAUNA AND BIONOMIC CONDITIONS OF THE SOUTH CASPIAN BASIN IN THE PLIOCENE-PLEISTOCENE

The article addresses the questions related to the changes in the benthic fauna composition and in the bionomic conditions of the South Caspian in the Pliocene-Pleistocene. Based on the summarised published data are described the macro- and micro-faunal complexes of the differently-timed Caspian basins. The article also shows their evolution depending on the changes of the abiotic factors in. The conclusions about the stages of the most brackish-saline, cold-warm basins' development are done on the basis of the paleontological, biogeochemical and isotopic data on the shell material of the molluscs and the ostracods. While the article is devoted to the South Caspian Basin predominantly, it also provides the data on the faunal composition and bionomy of the Caspian Sea other parts.

Keywords: *PaleoCaspian Sea, Pliocene-Pleistocene, benthic fossils, oxygen and carbon isotopes, microelements, paleoclimate, paleosalinity, paleodepth.*

Introduction

The Caspian Sea, the largest isolated basin in the world, is known for its extremely unstable level regime. The amplitude of the level fluctuations in this basin has exceeded those of the Global Ocean hundreds of times ever since the time that the Caspian Sea was separated from the Black Sea at the end of the Miocene. For instance, the Global Ocean level changes have reached 10 m in amplitude over the 6 Ka past (Shepard, 1956; Fairbridge, 1961) whilst the latest level fluctuation cycle of the Caspian Sea equalled 3 m in the 65 years past. Those processes reflected in the Caspian Sea's water and saline budgets which also stand out for their extreme instability over time that has had its impact on the frequent biocoenosis changes and the intensive speciation during the Pliocene-Pleistocene history of the Caspian Sea. Without going into detail on the reasons for the frequent and abrupt level changes of the Caspian Sea, the authors provide the paleontological and isotopic-biogeochemical facts that show the changes in the bionomic conditions and benthic faunal complexes in the South Caspian Basin during the Pliocene-Pleistocene time.

Ak.A. Ali-zadeh

Azerbaijan National Academy of Sciences,
Geology and Geophysics Institute,
H.Javid ave., 119, Az 1143, Baku, Azerbaijan
E-mail: gia@azdata.net



E.G. Aliyeva

Azerbaijan National Academy of Sciences,
Geology and Geophysics Institute,
H.Javid ave., 119, Az 1143, Baku, Azerbaijan
E-mail: e_aliyeva@gia.ab.az



The Geological Situation of the South Caspian Basin

The South Caspian Basin (SCB) surrounded by the mountain systems of the Greater Caucasus, the Talysh, the Elbrus and the Kopetdag is part of the Caspian Sedimentary Mega-Basin and of the Alpine-Himalayan Orogenic Belt (the International Tectonic Map..., 2002). Seated within the collision zone of the Eastern European and African-Arabian plates, the SCB also experiences the initial phases of subduction along its northern margin as some authors (Jackson, Priestley, Allen, & Berberian, 2002) maintain (Figure 1). The basin and the sur-



rounding territories are characterised by the sharply contrasting tectonic movements and the extremely high sedimentation rate in the Pliocene-Quaternary that resulted in the thick sedimentary cover that reaches more than 25 km in the most submerged parts. Below lies the 'basaltic' layer that is as thick as 15–20 km (the International Tectonic Map ..., 2002). The time of the sedimentary cover of the South Caspian encompasses the Oligocene-Holocene Interval.

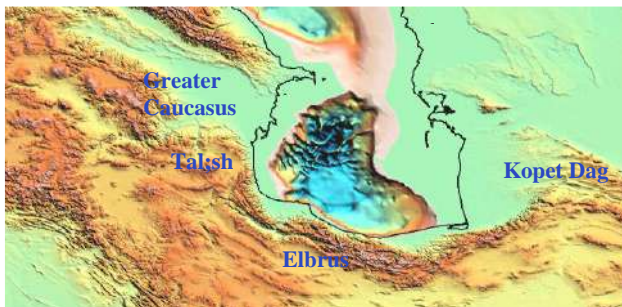


Figure 1. The Tectonic position of the South Caspian Basin (courtesy of Conoco-Phillips)

The Lower Pliocene (the Productive Series Stage)

The Faunal Composition

The Caspian Sea was isolated from the World Ocean as a result of the dramatic subsidence of the South Caspian Basin and the intensive orogenic processes in the surrounding mountain systems at the end of the Miocene and the beginning of the Pliocene (The Paleogeography of the USSR....., 1974, 1975). That was what had predetermined the evolution of the Caspian ecosystem, which developed further under conditions of isolated basin with an extremely unstable sea level followed by periodic connection with the Pontian Sea.

The immense level drop of the Caspian Sea in the Lower Pliocene that varied between 600 m and 1,500 m by different estimates resulted in the drying out of the North/Middle Caspian territories. The sedimentation was focused in the South Caspian Basin where the 8-km-thick series of the lacustrine-deltaic-fluvial

sediments of the so-called 'Productive Series' were accumulated over 2 Ma.

The complete absence of macrofaunal remains and the rare-to-find stressed ostracods and foraminifers are one of the biggest enigmas of the Productive Series. There is no clarity still as to the reasons for such a massive extinction on the border between the Pontian and Pliocene. Thus, the biostratigraphy and the biostratigraphic correlation of the Productive Series sediments have remained unclear for a long period owing to the absence of the organic groups of importance to stratigraphy. The differentiation of the sediments into suites based on their lithofacial characteristics is an approach that has been accepted until now.

D.M.Khalilov (1946), one of the first micro-faunists to study the Productive Series, identified the following forms within the ostracod complex:

- The species that transited from the Pontian Sea and disappeared at the end of the Lower portion of the Productive Series (*Loxiconcha djaffarovi*, *Leptocythere paebacuana*, *L. avena*, *L. rosalinae*, etc);
- The species that continued to inhabit the Akchagylian and Absheronian seas (*Loxiconcha eichwaldi*; *L. petasus*, *Cyprideis littoralis*, etc);
- The species that first appeared in the Lower Pliocene Basin (*Iliocypris bradyi* Sars, *Limnocythere luculenta* Liv., *Cythere balanichica* Chalil., *C. deltica* Chalil., etc).

D.Khalilov determined the lower, medium and upper portions within the Productive Series starting out from the character of the ostracod distribution.

D.A.Agalarova (1948) was the first to notice that the distribution of the reworked foraminifers within the Productive Series' section follows a certain order. For instance, the lower part is dominated by the Miocene foraminifers while the middle part by the Paleogene ones and the upper part by the Cretaceous ones. Based on that, she also divided the Productive Series' sed-

iments in the three parts that differed from those proposed by D.Khalilov.

The questions of the faunal composition, biostratigraphy and bionomy of the Productive Series basin have been subject to many studies in the years that followed and especially so during the few decades past. The re-worked Miocene and Paleogene foraminifers were discovered at the base of the oldest suite cropping out in the Absheron Peninsula, namely, the Pre-Kirmaki Suite (Babazade, 2011). The faunal complexes of the Productive Series of the Absheron Peninsula contain not only the reworked forms, such as foraminifers, ostracods, kidney shaped radiolarians and microscopic gastropods but also a number of the in-situ ostracods and foraminifers. The 15 ostracod species discovered there and pertaining to the 8 genera *Loxiconcha eichwaldi* Liv., *L. djaffarovi* (Schneid), *Leptocythere rosalinae* Schneid, *L. olivine* Liv., *L. cellula* Liv., *L. praebacuana* (Liv.) and *L. subcaspia* (Liv.) represent the relict forms of the Pontian basin that transited throughout the basic PS suites. All those forms take the stressed character upwards the PS section and disappear from the faunal associations gradually. For instance, the very small and stressed *Leptocythere subcaspia* shells that were found in the PostKirmaki Sand Suite (NKP) occurring in the middle part of the Productive Series are completely absent in the uppers of the NKP. Only small *Cyprideis littoralis* (Brady) were found in the overlying PostKirmaki Clay Suite (NKG).

The rare faunal remains were discovered in the Fasila Suite, which is the most sandy suite of the Productive Series. According to D.Agalarova (1948), it is dominated by *Cyprideis littoralis* and the seldom-encountered *C. torosa*. The same forms continue their presence in the overlying Balakhany Suite.

And, finally, the youngest suites of the Productive Series, which are the Sabunchi Suite and the Surakhany ones, were found to contain a relatively richer ostracod complex consisting of *Iliocypris bradyi* Sars, *L. gibba* Ramd., *Cyprinotus salinus* (Brady), *Limnocythere luculen-*

ta Liv., *Heterocypris incongruens* (Ramd.) and *Cypridopsis vidua* (Muller).

Regarding foraminifers, it should be mentioned that the rare discoveries of *Ammonia beccarii* (Linne), *Elphidium macellum* (Ficht. et Moll) and *Nonion granosus* (Orb.), *N. sp.* took place in the lower portion of the PS. There are no foraminifers in the sediments of the upper portion of the Productive Series. Those species are found as the in-situ forms as well as reworked. The current data also testify to the conclusion that D.Agalarova drew about the regularity of the distribution of the reworked foraminifers within the Productive Series' succession. For instance, the Miocene and Paleogene forms were discovered in the lower suites while the Cretaceous ones were found in the middle and upper suites. This is explained by the paleogeography of the Lower Pliocene Caspian Sea which was a transgressing basin that reached its maximum at the end of the Lower Pliocene.

Based on this fact, A.Babazade proposed (2011) the following biostratigraphic scheme of the PS sediments:

1. The zone of occurrence of the in-situ foraminifers (*Ammonia beccarii*, *Elphidium macellum*, *Nonion granosus*, *N. sp.*) as well as of the relict brackish-water ostracods and of the reworked Miocene, Paleogene and Cretaceous foraminifers. It should be mentioned that the reworked Cretaceous forms appear in the upper part of the zone stratigraphically related to lithostratigraphic units corresponding to the PostKirmaki Clay Suite and most of the Balakhany Suite. The lower half of the zone that is characterised by only the occurrence of the reworked Paleogene and Miocene foraminifers corresponds to the PreKirmaki/PostKirmaki Sand suites.

2. The zone of occurrence the fresh-water ostracods where the in-situ foraminifers are absent. Foraminifers were becoming extinct and replaced and the euryhaline ostracods were replaced with the continental fresh-water forms on the boundary between the Balakhany and Sabunchi suites.



The upper boundary of the Productive Series is determined by the emergence of the brackish-water Akchagylian fauna.

The Bionomic Conditions in the Lower Pliocene basin

The Pontian Basin that had preceded the Productive Series basin was characterised by the brackish-water environment with a typical ostracod complex consisting of *Leptocythere lata* (Schneid), *L. rosalinae* (Liv.), *L. praebacuana* (Liv.) *Loxococoncha djaffarovi* (Schneid), etc. together with which are encountered the microscopic *Corbicula fluminalis* (Muller) that had entered into the basin with the fresh surface waters. As we know, the optimal salinity of water required for Corbiculae to survive must exceed 3.5‰ this allows us to suppose that the salinity of the water of the Caspian Sea had reduced substantially by the end of the Pontian Time.

As we mentioned above, the brackish-water Pontian ostracods and some foraminifers continued their existence as relict forms in the Lower Pliocene basin.

Some of those forms inhabit the Caspian Sea in our time, too; those are *Leptocythere olivine*, *L. cellula*, *Ammonia beccari*, *Elphidium macellum* and *Cyprides littoralis*, *C. torosa*. The optimum salinity for those species is between 12‰ and 13.5‰. However, taking into account that all the described ostracods are encountered in the stressed condition in the Productive Series' sediments, it is possible to assume that the salinity of that basin did not exceed 10‰. This is explained easily by the huge river discharge into significantly reduced in size the Caspian basin, which, as we have said above, had only been concentrated within the limits of the South Caspian.

The stressed forms of *Leptocythere subcaspia*, *Cyprideis littoralis* (Brady), *Elphidium macellum* as well as the transparent shells of *Ammonia beccari* and *Nonion granosus* that are recorded upward the PS section are fully replaced by the euryhaline *Cyprideis littoralis* (Brady) in the uppermost portion of the PS.

Thus, the stenohaline ostracods are replaced by the euryhaline ones that were able to tolerate drastic salinity drop. Some researchers presume that the salinity of the Lower Pliocene basin reduced from 12–13‰ to 8‰ at the end of the Lower Pliocene (Baba-zade, 2011).

The biogeochemical study findings confirm the above conclusion. As we know, the biogeochemical methods for recreation of the ancient basins' environments rest on the ideas of V.Vernadsky (1960) and A.Vinogradov (1934, 1937, 1939 and 1944) about the direct correlation between the content of certain chemical elements in then live and fossil faunas and the physicochemical conditions of their habitats and fossilisation areas. We have examined both the microelemental and the isotopic compositions of oxygen and hydrogen within the shelly material of the Caspian Plio-Pleistocene molluscs and ostracods.

The carbon isotope values in the shelly material of the Productive Series' ostracods (as per the *Cyprideis littoralis* (Brady) study findings) are within the 0.5–7.5‰ range while Sr/Ca varies from 1 to 8 (Aliyeva et al., 2008). It testifies to considerable salinity variations in the Caspian Sea in the Lower Pliocene.

The δC^{13} and Sr/Ca curves indicate their clear separation in three parts. The lower part of the curves corresponding to the lower suites of the PS (from the PreKirmaki to the PostKirmaki Sand) demonstrates the biogeochemical indications of the highest salinity of the basin throughout the Lower Pliocene. The mid portion of the curves that encompasses the PostKirmaki Clay, the Fasila and the Balakhany suites is characterised by abrupt leaps in biogeochemical parameters, which points to the frequent changes in the salinity of the basin.

It is in that stratigraphic interval that the stenohaline Pontian species extinct while the euryhaline ostracods *Cyprideis littoralis* (Brady) developed extensively. We should like to emphasise also that the sedimentological data confirm the frequent and abrupt changes in the depositional environment in the middle of the Lower Pliocene.

The upper portion of the Sr/Ca and $\delta^{13}\text{C}$ curves that correspond to the Surakhany Suite displays a substantial reduction in the Productive Series basin's salinity at the end of the Lower Pliocene (Figure 2).

The scarce fossils findings make it impossible to draw reliable conclusions about the depth of the Lower Pliocene basin. The existing complexes that were found in the core samples from the shelf of the present-day Caspian testify

to a very shallow basin the depth of which is equalled to approximately 50 m. Regrettably, the fact that no drilling was made in the central and deep-water part of the South Caspian does not let us to make conclusions about the depths of the PS basin in that part.

The temperature regime of the Lower Pliocene Sea and its salinity were subject to dramatic variations based on the biogeochemical data (Figure 3).

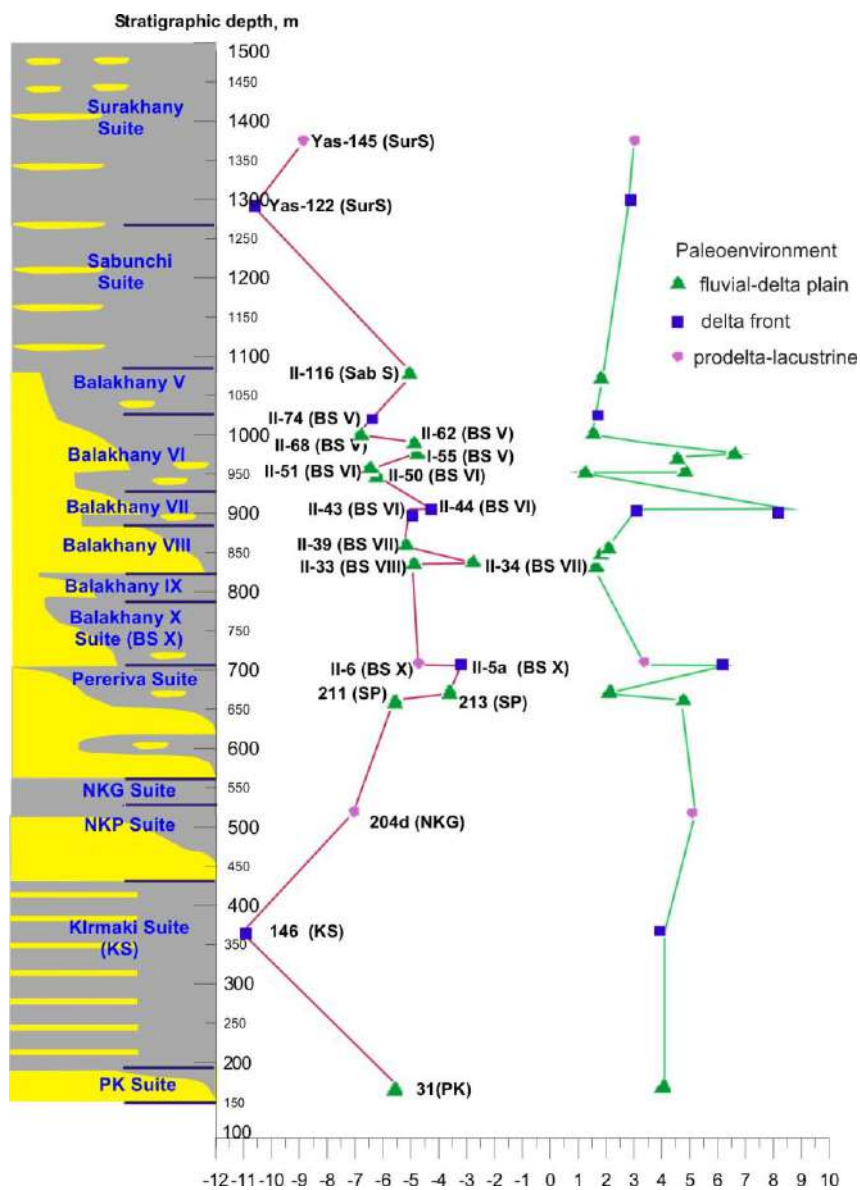


Figure 2. The Sr/Ca (green) and the $\delta^{13}\text{C}$ (red) curves in the Lower Pliocene ostracod shells

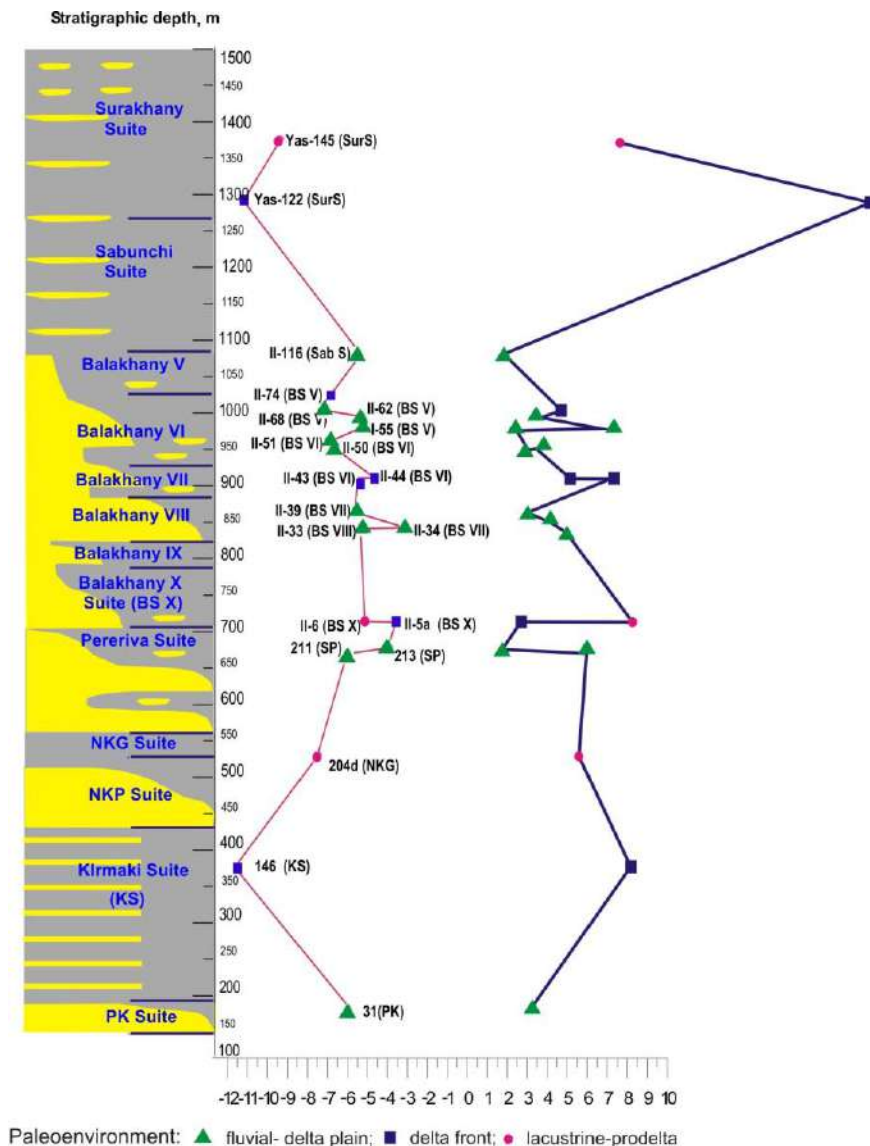


Figure 3. The Ca/Mg (blue) and the $\delta^{18}\text{O}$ (brown) curves in the Lower Pliocene ostracod shells (for legend see Figure 2)

The oxygen isotope value variations reach 10‰ – from 2‰ to -12‰ while the Ca/Mg values change from 2 to 20 (Aliyeva et al., 2008). Because of instability of the isotope composition of the water in the isolated basins it is impossible to reconstruct the paleotemperatures of the water of those pools; we can only trace a tendency in temperature changes throughout the time. From our point of view, the Caspian basin had the warmest temperature regime at the early/late stages of the Lower Pliocene. Evidently, we can speak about the cooling in the Caspian area in the middle part of the Lower Pliocene

that encompasses the interval from the Facial Suite to the Sabunchi Suite inclusively. On the background of the overall drop in temperatures their frequent variations are recorded. This, probably, explains the wide development of eurybiontic ostracod *Cyprideis littoralis* (Brady) as we have mentioned above.

The end of the Lower Pliocene was marked by an evident warming.

According to K.Sultanov and S.Isayev (1982), the shallow-water temperature exceeded 25°C on the avertime in the Caspian Sea in the Lower Pliocene (Figure 4).

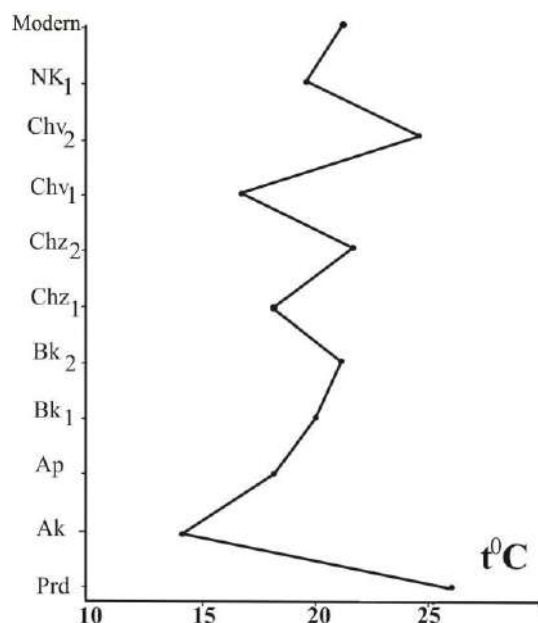


Figure 4. The bottom water temperature in the shallow-water regions of the Tertiary and Quaternary basins of Azerbaijan reconstructed with reliance upon the magnesia content data on molluscan shells (Sultanov, Isayev, 1982)

The Upper Pliocene (the Akchagyl Stage)

The Faunal Composition

The fresh-water and shallow the Productive Series basin was replaced by the relatively deep and brackish-water Akchagyl Sea that was connected to the Black Sea, and, extended far into the north of the Russian Plain.

The paleogeographic situation change was accompanied by the huge changes in the organic world of the Caspian Sea. New mollusc fauna species had emerged. The numerous researchers studying Akchagyl fauna offered various theories about its origin, which can be summarised into three hypotheses: the origination of the Akchagyl fauna from only the relicts of the preceding basins (Bogachyev, 1922; Gubkin, 1931; Zhukov, 1946, et al.); the origination of the Akchagyl fauna from the inhabitants of various other basins (Kovalevsky, 1933, 1951; Arkhangelsky, 1943; Khain, 1950; Muratov, 1951, et al.) and the mixed origination hy-

pothesis (Andrusov, 1918; Davitashvili, 1933; Kolesnikov, 1940; Ali-zade, 1954; Ali-zade, 1961, 1967).

We would like to gravitate on this matter more. The theory of the Arctic species' ingression into the Akchagyl basin has for these past few years been widely discussed and posed as a new one (Gallagher, 2011; van Baak, 2015). Now, this theory has supporters as well as opponents. We would like to note without taking sides that such idea were well substantiated earlier by many scientists, such as S.Kovalevsky (1933), M.Muratov (1951), K.Ali-zade (1954), B.L.Afanasyev and V.I.Belkin (1963).

The K.Ali-zade wrote (Ali-zade, 1954) that the hypsometrical position of the Akchagyl sediments reaches 250 m in West Bashkortostan, which gives a way for Arctic waters to overcome the Northern Ridges that serves as a barrier between the North Dvina-Pechora Basin in the North and the Volga-Kama Basin in the South. The hypsometry declines to 26 m below the Ocean level towards the Caspian Sea. Such a meridional subsidence resulted in gigantic volumes of the northern waters flowing into the Caspian Sea. According to K.Ali-zade, the Sea occupied a narrow area from the Arctic Ocean to the Caspian Sea and extended towards the Azov Sea along the Manych Strait inundating also the Kura Depression and the Trans-Caspian at the beginning of the Akchagyl Transgression. The organic world arrived with the Arctic waters. However, the stenobiont species were not capable of progressing far to the South and so only the euryhaline and eurythermal species, such as the prototypes of *Cardium dombra*, *Cardium pseudoedule*, *Avimactra subcaspia*, *Avimactra ossoskovi* as well as seals, fish, dolphins and other inhabitants of the northern seas penetrated far southward into the Caspian Region.

According to K.Ali-zade (1954), the connection between the Caspian and the Arctic Ocean that occurred at the beginning of the Akchagyl time was short-lived. The separation



that followed resulted in the movement of the fauna to the south of the basin from whence it settled farther all over the Akchagylian Sea. The lowering of salinity in the marginal parts of the basin prevented some stenohaline species (several *Cardium* and *Avimactra* species) from spreading and settling extensively, which resulted in the uneven fauna distribution across the Akchagylian Sea.

The following three stages are identified in the evolution of the Akchagylian mollusc fauna and, consequently, of the Akchagylian basin:

1. The Early Akchagylian: a combined complex mainly consisting of the dominant forms *Cardium* ex gr. *dombra* Andrus., *Avimactra subcaspia* (Andrus.), *A. ossoskovi* (Andrus.) and *Clessiniola vexatilis* (Andrus.).

2. The Middle Akchagylian: the flourish of the fauna dominated by *Cardium nikitini* Andrus., *C. dahestanicum* Usp., *C. radiiferum* Andrus. and *Avimactra nazarlebi* (Alz). and *A. inostranzevi* (Andrus.).

3. The Late Akchagylian: the poor, stunted and stressed fauna consisting of *Cardium dombra* Andrus., *C. modiolopsis* Alz., *Avimactra parvula* n.sp., *A. subcaspia* (Andrus.), *A. miserabilis* (Andrus.) and *Helix*.

In the opinion of K.Ali-zade, the boundary between the Early Akchagylian and the Middle Akchagylian can be drawn relying on the emergence of the rare costata Cardiidae and the evasive Mactridae forms (1954). Drawing a boundary between the Middle Akchagylian and Late Akchagylian is more difficult because the degrading Middle Akchagylian forms became extinct at the different time. The emergence of fresh-water forms could be one of the possibly criteria.

Foraminifers are presented poorly in the microfaunal complex (Ali-zade, 1954) while ostracods are abundant. There are the numerous species of the genera *Paracyprina*, *Ilyocypris*, *Candona*, *Loxoconcha*, *Xestoleberis*, *Cythere*, *Cyprideis*, *Limnocythere*, et al. (Ali-zade, 1954). The new forms such as the numerous representatives of the genera *Cythere* and *Candona* and

the new genus *Limnocythere* appear alongside the forms that had migrated from the Pontian and from the Productive Series basin.

The Bionomy of the Akchagylian Sea

The poor organic world of the Early Pliocene Caspian basin was replaced by the rich complex of the Akchagylian Sea as a result of penetration of external saline waters that had brought with them the fauna from the other basins. Possibly, the salinity of the Akchagylian Sea was high at the beginning of the Akchagylian time; equally possibly, it was reducing gradually (Ali-zade, 1954). That process gave place to the alteration of biocoenosis across the Akchagylian section. The euryhaline cold-water and warm-water forms, such as the *Cardiidae*, the *Mactridae* and the *Potamides*, appeared in the basin at the beginning of the Akchagylian time. From the Black Sea fauna, only three species were able to adapt to the Caspian Akchagylian Basin and of those three only the *Cardium edule* inhabits the present-day Caspian. This shows that the salinity of the Akchagylian Sea was higher than that of the present-day Caspian Sea but lower than of the Black Sea.

Probably, the Akchagylian Basin was also somewhat more saline than the Pontian had been as we can deduce that from the findings of the foraminifers *Cibicides* cf. *lobatulus* Walk. et Jak. and *Cassidulina crassa* d' Orb.

The basin had been strongly desalinated and especially so in its peripheral parts by the end of the Akchagylian time. That had resulted in the settlement of the fresh-water species (*Dreissena*, *Unio* and *Paludina*) there. There were also the strongly saline areas in the territory of the present-day Trans-Caspian where the organic world was very poor.

The study findings witness that the central part of the Akchagylian Sea had the prominently reducing conditions that had accounted for the formation of a stressed faunal complex.

According to K.Ali-zade (1954), the depth of the Akchagylian Sea reached 400 m. Evident-

ly, the Akchaglyian Basin was deeper than the Productive Series basin.

As regards the temperatures of the Akchaglyian Sea, we can tell about the cooling mentioned above. This is proven by the biogeochemical data. The content of Mg in mollusc shells indicates a sharp temperature drop in the shallow-water area of the Akchaglyian Sea in comparison with the Early Pliocene basin, namely, down to 13–14⁰C (Sultanov, Isayev, 1982) (Figure 4).

Thus, the heterogeneity of the bionomic conditions of the Akchaglyian Sea and mostly of water salinity resulted in a considerable lateral and time heterogeneity of the marine complexes.

The Lower Pleistocene (the Absheron Stage)

The Faunal Assemblages

The Absheronian sediments are amongst the best-studied ones within the sedimentary cover of the Caspian Region. Many prominent scientists addressed the questions about their faunal composition and stratigraphy: E.Eichwald (1841), Ch.Sjögren (1891), N.Andrusov (1897, 1904, 1923, and 1964), V.Ruzhentsev (1928), W.Liewenthal (1930), B.Bogachyev (1932, 1936), K.Ali-zade (1936, 1945), V.Kolesnikov (1950), G.Popov (1961), K.Sultanov (1964), A.Ali-zade (1973) and others.

The stratigraphy of the Absheronian sediments consisting of three units was adopted based on the mollusc faunal complexes. A.Ali-zade produced (1973) the fullest table of the Absheronian mollusc fauna having generalised the results of his research as well as of the preceding studies. The same author provided the complete faunal characteristics of all three sub-stages of the Absheronian Stage in Azerbaijan.

The Absheronian mollusc fauna reached its peak in the middle part of the section where one can encounter the representatives of the 82 species pertaining to 24 genera: *Dreissena*, *Neomonodacna*, *Hyrkania*, *Neopseudocatillus*, *Ne-*

oadacna, *Neodidacnomya*, *Parapscheronia*, *Apscheronia*, *Corbicula*, *Pisidium*, *Unio*, *Micromelania*, *Clessiniola*, *Chazarella*, *Celekenia*, *Nematurella*, *Caspia*, *Pyrgula*, *Bithynia*, *Mele-noides*, *Melanopsis*, *Valvata*, *Limnaea*, *Streptocerella* and *Nerithina* (Table 4).

The lower part of Absheronian section is characterised by the much poorer species diversity with only 36 species – with the exception of such genera as *Pyrgula*, *Bithynia*, *Pisidium* and *Neodidacnomya* that are sporadically encountered here as well as in the Middle Absheron – the generic composition of the Lower Absheron is practically the same.

Parapscheronia became extinct completely but *Hyrkania* and *Apscheronia* are widely developed in the Upper Absheron. The species composition slightly decreases – to 74 species.

The generic and species composition of the ostracod fauna repeats in many ways those of the Akchaglyian Basin with the exception of some *Candona* genus species that became extinct in the Absheronian basin (Ali-zade, 1973).

The question is what had caused such drastic biocoenosis composition changes?

The Paleogeography and Bionomy of the Absheronian Sea

The end of the Akchaglyian time and the beginning of the Absheronian time were marked by the intense tectonic processes along the flanks of the Caspian Basin, the drying out of some parts of the Akchaglyian Sea as well as an increase in river discharge (Ali-zade, 1973). Consequently, most of the stenohaline Akchaglyian fauna became extinct and only its euryhaline forms remained – to become transformed into the typical Absheronian fauna eventually (Andrusov, 1923). The shallowing and decrease of salinity of the basin went along with the formation of a poor and stressed complex in the Early Absheronian time. The discoveries of the fresh-water *Dreissena*, *Limnaea* and *Micromelania* in the upper portion of the Akchaglyian in the Absheron Peninsula point to the fact that



the large-scale desalination of the basin began as soon as at the end of the Akchagylian time.

The transgression in the mid-Absheronian, increased salinity and deepening of the basin created favourable conditions for extensive speciation and flourish of the fauna in the Middle Absheronian (Sultanov, 1964).

However, the continuing uplift of the mountain systems that surrounding the depressions made the basin smaller again in the Late Absheron. The high sediment supply that led to the further shallowing of the Absheronian Sea, and the increased river discharge from the emerged network of major alluvial arteries, such as the Kura, the Aras, the Samur and the other small rivers caused the extinction of relatively salt-water species and genera living in the Middle Absheronian Sea. Those processes also caused the extinction of the endemic Absheronian fauna and the emergence of the specific Pleistocene mollusc fauna on the boundary with the Middle Pleistocene.

As regards the depth of the Absheronian Sea, most of the researchers agree that it was relatively shallow. In the opinion of N.Andrusov (1923), the maximum depths never exceeded 320 m and even those were at the beginning of the Absheronian time as the faunal complexes confirm.

The frequent changes in the bionomic conditions of the Absheronian Sea are confirmed by the biogeochemical studies. According to K.Sultanov, S.Isayev (1971), the study of the mollusc shells of *Dreissena distincta*, *Dr. polymorpha*, *Monodacna laevigata*, *M. minor* and *M. sjoegreni* of the Absheron sediments from the Sabunchu locality of the Absheron Peninsula showed that the occurrence of such elements as Sr, Ba, Mg and Ca in the shell material of those molluscs demonstrates not only the salinity and temperature difference between the Early/Middle/Late Absheronian basins, but also more rapid variations of these parameters. That often resulted in frequent alterations of the biocoenosis composition and the index species of the Absheron Stage. The results of the biogeochemical study of the shells of the ostracoda

Trachyleberis pseudoconvexa from the mid-Absheronian sediments from the Shikhovo outcrop in the Absheron Peninsula (Amirov, 2007; Aliyev, Amirov, 2008) (Figure 5) points at the strong variability of the salinity regime and temperatures of the Absheronian Sea, too. The Sr/Ba ratio values vary widely from 5 to 26 with the avertime one equalling 15. There is a well displayed tendency for insignificant growth of salinity upwards the succession.

Such paleotemperature indicators as the oxygen isotope ratios and the Ca/Mg ratio also tell about strong temperature variations in the shallow-water zones of the Absheronian Sea (Figure 5). As was mentioned above, it is impossible to use the oxygen isotopic data to determine absolute water temperatures in landlocked basins but it is possible to trace paleoclimatic change's tendencies for that. For instance, with the exception of the peak value of -8.7‰, the oxygen isotope ratio values vary from 5.5‰ to 1.5‰ in the ostracod shell material. Given the fact that change in O^{18}/O^{16} ratio in the shell carbonate for 1‰ means change in the water temperature for 3°C, one can assume that the difference between the lowest and the highest temperatures is approximately 20°C, that, the most likely, were seasonal variations.

A tendency of insignificant lowering of O^{18}/O^{16} ratio upward the section testifies to a slight warming during the Absheron time that is also confirmed by the data on Ca/Mg ratio.

The avertime temperature of the Absheronian Sea was equalled to 17°C–18°C in the shallow zone, according to K.Sultanov, S.Isayev (1982) (Figure 4). The intensive carbonate rock formation (including that of chemogenic carbonates) shows that there was a warming in the Absheronian time in comparison with the Akchagylian one. There are several hypothesis regarding origination of the Absheronian molluscs (V.Kolesnikov (1940); K.Sultanov (1964); G.Popov (1961) and K.Ali-zade (1936)) that can be divided in three groups as follows: 1. the strongly changed Akchagylian forms capable to survive drastic salinity drops, such as several

forms of *Dreissena carinatocurvata*, *Hyrkania*, *Apscheronia*, *Clessiniola*, also possibly of *Adacna* and *Micromelania*; 2. the molluscs that migrated to the brakish water Absheronian basin from fresh-water pools – *Dreissena polymorpha*, *Corbicula*, *Unio*, *Caspia*, *Melanopsis*,

probably, also *Nematurella* and *Limnaea*; 3. and the strongly changed Euksinian forms, such as some *Dreissena*, *Monodacna*, *Pseudocatillus* and *Didacnomya*. The last fact suggests a short-term linktime with the Black Sea.

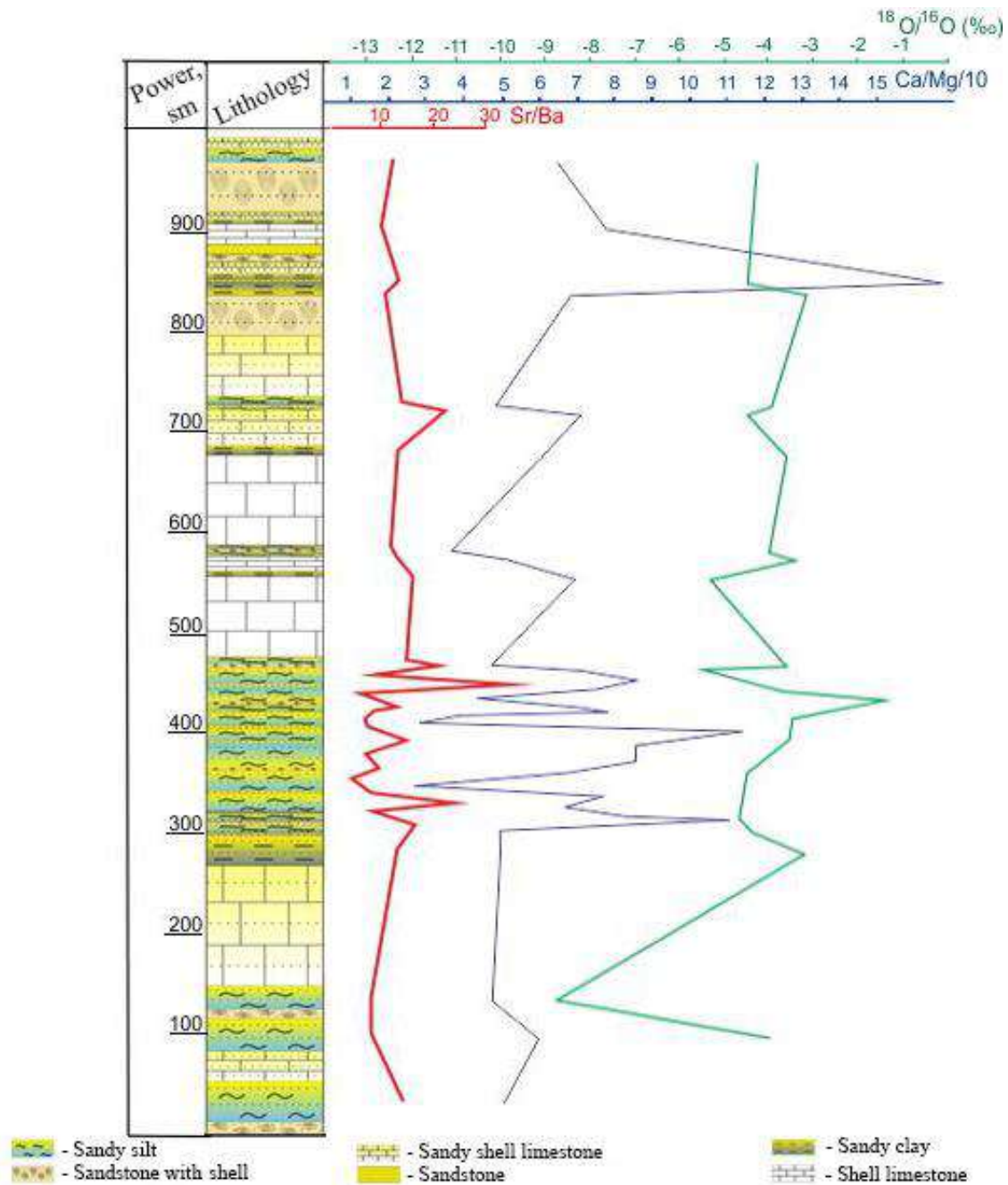


Figure 5. The biogeochemical indicator distribution curve for the *Trachyleberis pseudoconvexa* shells across the Absheron sedimentary sequence (Amirov, 2007; Aliyev, Amirov, 2008)



The Pleistocene

The Faunal Assemblages

The beginning of the Pleistocene was marked by the emergence of the flat costata Cardidae of the genus *Didacna* that is a chief fauna in the stratigraphy of the Pleistocene succession. The first mention of the Caspian *Didacna* was made by P.Pallas in 1776: he identified the mollusc *Cardium trilaterum*. E.Eichwald identified the genus *Didacna* in 1838.

The question of the origins of the Caspian Pleistocene *Didacna* gives rise to numerous discussions. Similarly to the hypotheses about the origins of the Akchagylian and Absheronian conchilofauna, there are three groups of researchers that adhere to the hypotheses of the aboriginal, polyphylic and invasive origins of the Pleistocene *Didacna* of the Caspian.

We know six transgressions of the Caspian Sea that occurred during the Pleistocene. Three of them, namely, the Bakunian, the Early Khazarian (Gurgan) and Khvalynian transgressions were the largest ones and had the sea level risen up to +40 m and beyond (Svytoch, 2012). The other three Urunjik (Mingachevir), Late Khazarian and New Caspian transgressions were of a smaller scale.

The Bakunian transgression is said to have two (Fedorov, 1978) or three (Yanina, 2005) stages. Each of them has a characteristic *Didacna* complex; for the Early Bakunian transgression it is *Didacna parvula* while the mollusc fauna of the Middle Bakunian transgression was dominated by the catilloid *Didacna*, and *Didacna rudis* and *D. carditoides* made the complex characteristic of the Late Bakunian transgression. There are 19 *Didacna* species and subspecies identified in the Bakunian sediments (Yanina, 2005). There are also the *Dreissena*, *Monodacna*, *Adacna* and *Micromelania* molluscs, the fresh-water *Unio* and others.

The Venedian regression and the Urunjik transgression that followed were accompanied by the emergence of the new *Didacna* species, such as *Didacna eulachia*, for instance. The *D. pra-*

voslavlevi, *D. kovalevskii*, *D. lindleyi*, *D. celekenica* and *D. subpyramidata* and others that had emerged at the end of the Bakunian time became developed widely. According to P.Fedorov (1978), B.Vekilov (1969) and T.Yanina (2005), the lower portion of the Urunjik sediments had the characteristic emergence of *Didacna eulachia* and the presence of the Bakunian species *Didacna rudis* and *D. carditoides*. The mollusc fauna similar to the Khazarian one emerged in the second half of the transgression. There are 21 *Didacna* species and subspecies identified in the Urunjik sediments altogether.

The Early Khazarian fauna was rich in species. There are 32 *Didacna* species and subspecies identified; some of them had appeared at the end of the Bakunian time whilst others developed in the Urunjik Basin (Yanina, 2005).

At least three phases are identified within the Early Khazarian transgression; each of them had a corresponding mollusc fauna complex.

The lower complex has the inherent wide spread of *D. subpyramidata* and *D. pallasi* while the Middle Early Khazarian is characterised by the fauna zenith with the trigonoid *Didacna* and the wide-spread catilloid *Didacna*. The Upper Early Khazarian's is the much smaller diversity of species and the extensive development of the crassoid *Didacna* – *D. nalivkini* and *D. delenda*.

The Late Khazarian transgression stands out for the much poorer diversity of species. The faunal associations contain the inherited species as well as the new species *D. surakhanica*, *D. karabugazica* and *D. bogatchevi*. The last two have the limited occurrence areas. The Upper Khazarian complex is different from the Lower Khazarian one with the wide occurrence of the two species that belong to the crassoid *Didacna* – *D. surakhanica*.

The Great Khvalynian transgression was accompanied by the emergence of the completely new *Didacna* species *D. parallellis*, *D. ptotracta*, *D. ebersini*, *D. zhukovi* and *D. praetrigonoides*, *D. trigonoides*, *D. crassa* and *D. pyramidata*, too, emerged in the Khvalynian time

but achieved their development peak in the New Caspian time. The total of 14 *Didacna* species and subspecies are identified in the Khvalynian sediments; only 7 of them have ubiquitous occurrence. Thus, the species composition of the Khvalynian complex is much impoverished. There are practically no crassoid *Didacna* whilst the trigonoid and catilloid ones prevail.

The Early Khvalynian complex is characterised by the dominance of *D. parallella* on the western coast and of *D. zhukovi* and *D. cristata* on the eastern coast of the Caspian Sea. The Upper Khvalynian complex is distinguished by the wide distribution of *D. praetrigonoides*.

The analyses show that the *Didacna* species composition varied substantially across the Pleistocene succession and showed the predominance of the trigonoid, catilloid and crassoid *Didacna* alternately. Evidently, the reasons for that should be sought in the frequent and dramatic changes in the bionomic conditions of the Caspian Pleistocene basins.

The Bionomy of the Pleistocene Basins

The charts of the Sr/Ba distribution in the Pleistocene-Holocene *Didacna* shells found in Azerbaijan show that this value went through considerable variations during the Quaternary (Aliyev, 1990) (Figure 6). It would therefore be

logical to suppose that these variations reflect fluctuations in the salinity of the paleobasins.

According to P.Fedorov (1957), the salinity of the Caspian Sea was slightly less at the beginning of the Bakunian time than it is in the present-day Caspian Sea while it rose somewhat but never exceeded 13–14‰ in the second half of that time. By other estimates, the salinity of the Bakunian Sea equalled 14–15‰ (Sultanov, Khalifa-zade, 1969).

Our data agrees with those opinions. The salinity of the Early Bakunian Sea was much close to that of the Holocene and maybe only exceeded it a little judging by the Sr/Ba ratio (Aliyeva, 1990) (Figure 6).

If we compare the Sr/Ba ratio in the shells of the *Trachyleberis pseudoconvexa* of the Absheronian and of the Bakunian, we can then clearly see the tendency for this ratio to be lower in the Bakunian forms. It equalled 15 on the average in the Absheronian forms and was down to 8 in the Bakunian ones (Figure 7). There are also the smaller variations in this ratio's values. Based on such results, one could conclude that the salinity of the PaleoCaspian decreased considerably in the Bakunian Time in comparison with the Absheronian time and that the salt balance of the Absheron Sea was substantially higher than that of the Caspian in the Holocene.

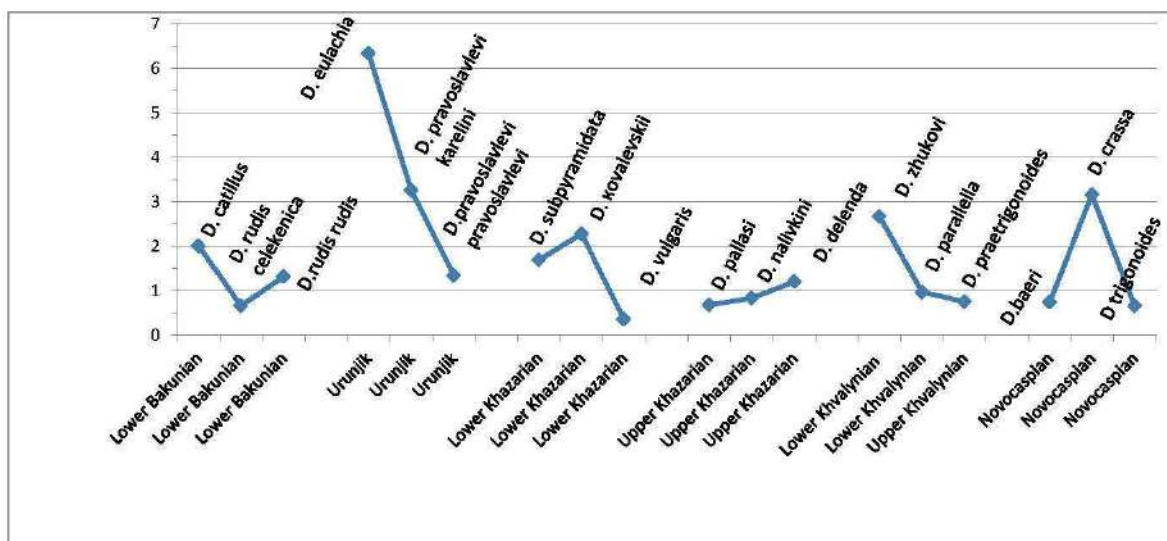


Figure 6. The Sr/Ba ratio values in the shells of the Pleistocene-Holocene *Didacnae* of Azerbaijan



According to A.Svytoch (2013) and Yanina (2005), the dominance of the halophilic *Didacna* of the crassoid group at the beginning of the Urunjik small-scale transgression speaks to the considerably increased salinity of the basin that could reach 16‰ in the Kura Bay. The basin became less saline at the end of the Urunjik transgression as we can see by the appearance of the fresh-water fauna.

The Sr/Ba ratio values show a sharp increase at the beginning of the Urunjik time with the subsequent and gradual reduction to values lower than those of the Bakunian time and of the present-day Caspian lake (Figure 6). So, there is a complete concordance between the paleontological and biogeochemical data.

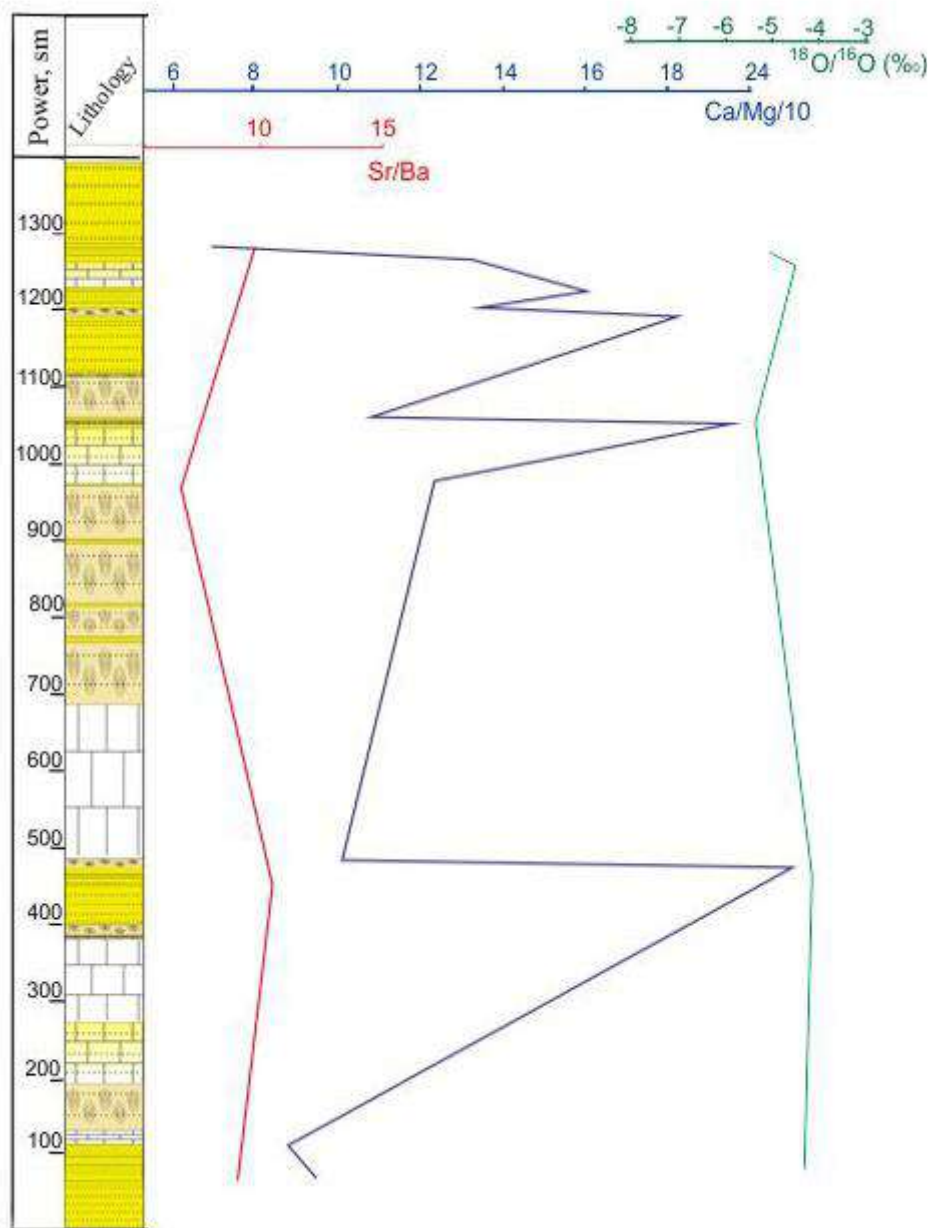


Figure 7. The biogeochemical indicator spread curves for the *Trachyleberis pseudoconvexa* shells across the Bakuvi sedimentary sequence (for legend see Figure 5) (Amirov, 2007; Aliyev, Amirov, 2008)

According to A.Svytoch (1976), again, the wide occurrence of the euryhaline trigonoid *Didacna* at the beginning of the Khazarian time indicates that the salinity of that basin was lower than that of the Bakunian Sea and, most probably, higher (14‰) than that of the present-day Caspian Sea.

The biogeochemical data show that the Sr/Ba ratio values found in the Early Khazarian *Didacna subpyramidata* and *D. kovalevskii* shells varied from 2 to approximately 1.5 whilst they do from 1.6 to 2 in the majority of the Bakunian species and are much less than 1 in the New Caspian species with the exception of the halophilic *Didacna crassa*. Consequently, the paleontological and biogeochemical data may be suggesting the similar salinities of the Lower Khazarian and Bakunian seas and the somewhat higher salinity of the Early Khazarian Sea in comparison with the Holocene basin (in the region of 14‰) the Azeri sector of the Caspian Sea.

The biogeochemical data we found do not confirm the salinity increasing of the Late Khazarian Sea. Such an idea was based on the disappearance of the trigonoid *Didacna* and the wide occurrence of the crassoid ones. The Sr/Ba values we determined as close to those of the Holocene.

Some authors state that the waters of the Khvalynian Sea were greatly desalinated (Федоров, 1957; Квасов, 1966). Other researches hold by the opinion that the salinity of the Khvalynian Sea was somewhat lower than that of the Khazarian Sea but not less than the present-day salinity as well as that it rose as the transgression expanded until it reached its peak (Свиточ, 1991). A.Svytoch attributes the oppression of the Khvalynian *Didacna* to the low temperatures in the sea. The author arrives at such a conclusion upon considering the changes in the faunal complexes and the wide occurrence in the North Caspian of *Didacna protracta* that inhabits the shelves of the Middle/South Caspian until present time at the salinity of 12–13‰.

The Sr/Ba ratio data let us accept this idea. With the exception of *Didacna zhukovi* for

which the Sr/Ba ratio is known to be 2.6 on the average, the other forms have it below 1, which is close to the present-day values.

To sum up the analysis given above, one could arrive at the conclusion that the Caspian Sea did not experience considerable salinity fluctuations in the Pleistocene. The absolute majority of the Pleistocene-Holocene *Didacna* shells with the exception only of *Didacna crassa* have the Sr/Ba ratio varying narrowly from 0 to approximately 2. With the exception of the beginning of the Urunjik transgression during which the salinity was apparently much higher than the present-day one and equalled at least 16‰ along the western coast (Янина, 2005; Svytoch, 2013), in the other Pleistocene basins the salinity varied from 13‰ to 14‰.

As regards the temperature variations in the shallow-water regions of the Lower, Middle, and Upper Pleistocene basins of the Caspian, we could note that, judging by the oxygen isotopic composition data on the shells of the Bakunian *Trachyleberis pseudoconvexa*, the median annual temperatures of the Bakunian Sea exceeded those of the Absheronian Sea. For instance, the median oxygen isotope ratio is -2‰ for the Absheron forms while it is -4.7‰ for the Bakunian forms (Амиров, 2007; Aliyeva, Amirov, 2008) (Figure 7).

Whilst the highest temperatures of water should have been approximately equal in both seas ($\delta^{18}\text{O}$ equals 5.5‰), in the cold seasons the Bakunian Sea had higher temperatures in comparison with the Absheronian Sea. The highest content of the heavy oxygen isotope equals -4.1‰ and +1.5‰ respectively. The variations of the $\delta^{18}\text{O}$ values in the Bakunian shells had been reduced considerably, too, namely, from -5.5‰ to -4.1‰. An analogous regularity is traceable along the Ca/Mg ratio curve as well. Evidently, the temperature regime of the Caspian Bakunian basin was more stable.

According to the same Ca/Mg ratio values found in the shell carbonate of the *Didacna* and *Dreissena* molluscs from the Bakunian outcrops of the Absheron Peninsula, Gobustan and the



Lower Kura Depression, the median annual temperature equalled 10.6°C in the Early Bakunian time (Aliyeva, 2001). The calculations had used the formula $T = 28A/15B$ where T is the ambient temperature, A is the Ca content in the shells, B is the Mg content, and 28 and 15 are the empirical constants (Дорофеева, Хабаков 1980).

The biogeochemical and isotopic data point at a considerable warming in the Late Bakunian and Urunjik times. The oxygen isotopic composition of the shells of *Didacna* of the Absheron Peninsula (Aliyeva, 2001) and of the eastern flank of the South-Caspian basin (Горбаренко и др., 1973) indicates that the heavy isotope content of the Upper Bakunian and Urunjik shells is substantially lower in comparison with that of the Upper Bakunian samples (Figure 8).

It should be remembered also that the enrichment of the Lower Bakunian *Didacna* shells of Azerbaijan with the heavy oxygen isotope might have to do with the low intensity of the alluvial processes along the board of the South Caspian basin in the Early Bakunian time (Федоров, 1978).

Judging by the Ca/Mg ratio data, the median annual water temperatures could be reaching 17°C and 17.1°C in the Late Bakunian and Urunjik times respectively.

The oxygen isotopic composition is notably getting much lighter upwards the sequence in the Lower Khazarian shells on both curves (Figure 8). Apart from this general tendency, $\delta^{18}O$ drops to 9.1‰ in the Turkmen *Didacna* eastwards and on drawing near the Paleo Amu Darya delta. Such a dramatic decrease in the heavy oxygen isotope in the Late Khazarian basin's shells may be due to not only the climate warming but also the effect produced by the inflow of glacial waters in large quantities into the Late Khazarian basin as witnessed by P.Fedorov (1978).

The Late Khazarian transgression was short as we mentioned above; rather, it took course in a warm and dry climate. The isotope data and the Ca/Mg ratio values confirm this. The latter speak to that the median annual water temperature equalled 22.6°C in the Late Khazarian.

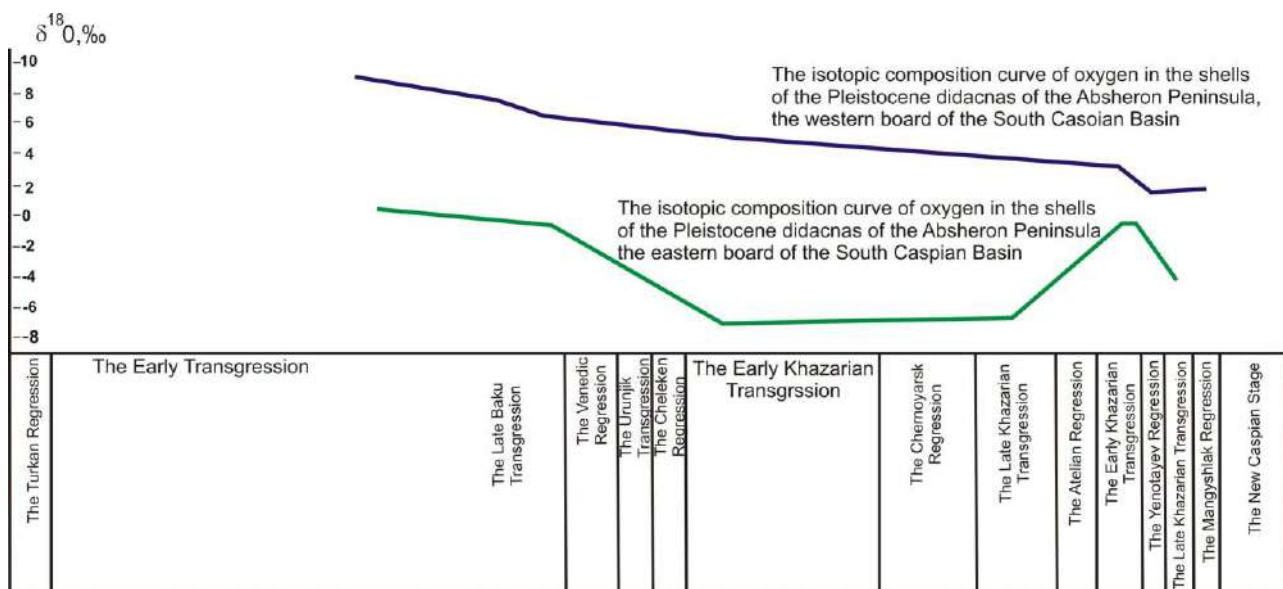


Figure 8. The oxygen isotopic composition curves for the shelly carbonate of the *Didacnae* molluscs from the western and eastern boards of the South Caspian Basin in the Pleistocene (Aliyeva, 2001; Горбаренко и др., 1973)

It follows from the Turkmen sample isotopic data that the oxygen isotopes in the *Didacna* shells became heavier abruptly in the Lower Khvalynianian. In this context, one could agree with A.Svytoch (2013) as he reasons about a cooling in the Early Khvalynianian. At the same time, the reduction of $\delta^{18}\text{O}$ in the Lower Khvalynianian fossils from the Absheron peninsula difficult to explain.

The Conclusions

Thus, the findings from the study of the biogenic conditions in the Pliocene-Pleistocene basins that was carried out using the palaeontological, biogeochemical and isotopic research methods bespeak the multiple variations in the

temperature regime of the Paleocaspian that were accompanied by the substantial biocoenosis composition alterations.

The salt balance of the Caspian Sea did not alter as substantially but remained that akin to brackish-water basins. Apparently, the waters of the Akchagylian Sea had the highest salinity while the sea of the end of the Productive Series' time (the Lower Pliocene) had the lowest salinity. There is a tendency for salinity decrease in the Akchagylian Basin towards the Pleistocene when the waters of the Urunjik Sea had the highest salt content as its characteristic feature. During Pleistocene with the sole exception of the Urunjik Sea. The salinity of the Caspian Sea changes within a narrow range and was close to that of the present-day Caspian Sea.

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PLİOSEN-PLEYSTOSENDƏ CƏNUBİ XƏZƏR HÖVZƏSİNİN BENTİK FAUNASININ VƏ BİONOMİK ŞƏRAİTİNİN TƏKAMÜLÜ

Ak.A. Əli-Zadə, E.H. Əliyeva

Məqalədə pliosen pleystosendə Cənubi Xəzərin bentos faunasının tərkibi və bionomik şəraitinin dəyişməsinə baxılmışdır. Dərc olunan məlumatların ümumiləşdirilməsi nəticəsində müxtəlif yaşlı Xəzər hövzələrinin makrofaunistik və mikrofaunistik kompleksləri, eyni zamanda mühitin abiotik amillərindən asılı olaraq təkamülü göstərilmişdir. Molyusk və ostrakodların qabıq maddələrinin paleontoloji, biogeokimyəvi və izotop göstəricilərinə görə hövzələrin şirin-duzlu, isti-soyuq dövrlərinin formalaşması haqqında müəyyən nəticə əldə olunmuşdur.

Məqalədə əsasən Cənubi Xəzər hövzəsi həmçinin, Xəzər dənizinin başqa hissələrinin fauna tərkibi və bionomiyası haqqında məlumatlar verilmişdir.

ЭВОЛЮЦИЯ БЕНТОСНОЙ ФАУНЫ И БИОНОМИЧЕСКИХ УСЛОВИЙ ЮЖНО-КАСПИЙСКОГО БАСЕЙНА В ПЛИОЦЕН-ПЛЕЙСТОЦЕНЕ

Ак.А. Али-Заде, Э.Г. Алиева

В статье рассмотрены вопросы смены состава бентосной фауны и бионических условий Южного Каспия в плиоцен-плейстоцене. На основе обобщения опубликованных данных приводятся макрофаунистические и микрофаунистические комплексы разновозрастных каспийских бассейнов, показана их эволюция в зависимости от смены абиотических факторов среды. По палеонтологическим, биогеохимическим и изотопным данным раковинного вещества моллюсков и остракод делаются выводы об этапах формирования наиболее опресненных – соленых, холодных – теплых бассейнов.

В статье рассматривается, в основном, Южно-Каспийский бассейн, однако, приводятся также данные фаунистического состава и бионии других частей Каспийского моря.

ESSAYS ON MODERN STRATIGRAPHIC DIVISION OF SEDIMENTARY MATERIAL COMPLEXES OF NAKHCHIVAN FOLDED PROVINCE Chapter I – Proterozoic and Paleozoic

The article based on the findings of the latest research and generalisation in compliance with the modern International Stratigraphic Scale contains the description and palaeontological justification of the local stratigraphic divisions of the Palaeozoic crust structural and compositional complex that has a role in the geological composition of the Nakhchivan Autonomous Republic, the SW region of Azerbaijan.

In addition, the article provides the witness of the impact of the palaeogeodynamic and palaeogeographic factors on the formation of various lithological stratigraphic complexes. The data that are first being presented in the English language can serve as a rich if concise database for members of the international geological community who are interested in the lithology and stratigraphy of the Palaeozoic sediments that outcrop within the boundaries of the South Caucasus.

Keywords: *Palaeozoic, stratigraphy, palaeontology, stratigraphic scale, compositional complex, lithology, local stratigraphic sub-division, suite.*

Problem statement. Being part of Azerbaijan, territory of the Nakhchivan Autonomous Republic is distinguished for a complicated geology-tectonic structure from one side, and the geological section with wide Devonian-Holocene stratigraphic range from another. Over 150 years of researches implemented by both local and foreign geologists had resulted in documented lithological-stratigraphic and paleontological characterization of region's geological profile, development of a breakdown chart of the various stratigraphic units. Latest regional summary was given in a multi-authored monographs (Azərbaycanın geologiyası, 2015; Геология Азербайджана, 1999) dedicated to Azerbaijan's stratigraphy. Along with its' scientific advantages, the monograph also contained a number of gaps related to description of local stratigraphic units and their paleontological characterization. Also the monograph didn't consider rich database developed in result of 30-year geological planning activities implemented within the entire territory of Nakhchivan AR.

In order to fill in the mentioned gaps, authors had carried out a new generalization to

A.B. Mammadov

Institute of Geology and Geophysics,
ANAS
H. Javid ave., 119, AZ1143, Baku, Azerbaijan



T.N. Kangarli

Institute of Geology and Geophysics,
ANAS
H. Javid ave., 119, AZ1143, Baku, Azerbaijan
E-mail: tkangarli@gmail.com



Sh.A. Babayev

Institute of Geology and Geophysics,
ANAS
H. Javid ave., 119, AZ1143, Baku, Azerbaijan
E-mail: shekhababayev@yandex.ru



H.I. Aliyev

Institute of Geology and Geophysics,
ANAS
H. Javid ave., 119, AZ1143, Baku, Azerbaijan



cover the entire range of region's stratigraphic units (Babayev, Kəngərli, Məmmədov, 2015). Being first in the series of scientific articles on Nakhchivan's modern stratigraphy, current paper is dedicated to lithological and stratigraphic patterns of Proterozoic-Paleozoic formations.



Proterozoic

In Azerbaijan, the metamorphic structures of Proterozoic are detected on the northeastern slope of Lesser Caucasus (river-valley of Asrikchay) and in Nakhchivan AR (Azərbaycanın geologiyası, 2015; Геология Азербайджана, 1999). In Asrikchay opening, the Neoproterozoic-Lower Paleozoic metamorphic schists constitute section of the crystalline basement. Bedrock exposures of these schists aren't detected in Nakhchivan but they are present in the geological sections of neighbouring Iranian and Armenian territories, including Nuvadi-Garadagh massif in the river-valley of Araz. Within Nakhchivan AR's territory, Proterozoic metamorphic rocks form buried basement of Phanerozoic material complex. Such rocks are bedded at 600 m depth in the foot of Upper Cretaceous complex, as indicated by boreholes drilled in the region's northeast, left bank of Araz and Kilit village's vicinities. Included in Eocene-Lower Miocene Mighri-Ordubad batholith's structure, the metamorphic rocks of huge occlusion block of Pazmara as well as a number of various block-xenoliths (including the largest Paraghachay block xenolith) are characterized as relicts of the Proterozoic formations that transit young magmatic masses from depth to the upper layers of the earth crust (Azərbaycanın geologiyası, 2015; Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Геология Азербайджана, 1999). *Pazmari occlusion-block* is built by metamorphic rocks distributed among granitoid formations (adamellites, granosyenites, etc.) of the Ganza intrusive massif representing gabbro-granitic formation of Mighri-Ordubad batholith. Represented by apoorthogneiss, amphibolites, metabasites and leucometakeratophyres, the block is situated 1.5–2.0 km to the northeast of the same-named village: it's 0.25–0.37 km wide structure opens towards the river-valley of Vanandchay and extends submeridionally for around 2.1 km. According to its' petrographic composition, the block is similar to pre-Cambrian metamorphic rocks of the Nuvadi-

Garadagh massif revealed on both sides of Araz river to the southeast of Mighri-Ordubad batholith. It corresponds to a huge block pulled out from the ancient basement and elevated together with granitoid magma during the latter's introduction into the earth crust. The massif's surface geological structure is complicated by northwest trending fractures and faults and cleaved by the younger magmatic formations.

Paraghachay block xenolith consists of the metamorphic rocks distributed among subalkaline monzonite phase's formations (quartzite and non-quartz monzonites, monzodiorites, etc.) within the structure of *Misdagh-Gapijig intrusive massif* that represents the Mighri-Ordubad batholith's gabbro-monzonite formation. The xenolith manifests itself as a mass which is constituted by 180x110 m large amphibolized olivine pyroxenites revealed in Paraghachay segment of Aghdara-Paraghachay ore deposit. The xenolith corresponds to a block that was pulled out from its' ancient basement and elevated together with gabbro-monzonite magma during its' introduction into the earth crust.

Paleozoic

Within the territory of Azerbaijan Republic, Paleozoic formations crop out in Nakhchivan AR and partly northeastern slope of the Lesser Caucasus (Asrikchay basin) (Azərbaycanın geologiyası, 2015; Геология Азербайджана, 1999). Within the Nakhchivan's boundaries, Paleozoic terrigenous-carbonate and carbonate complexes (average thickness – 4600 m, maximum cumulative thickness – over 5800 m) constitute main part of the Sharur-Julfa elevation's surface stratigraphy. They are represented by two isolated fragments of the Miocene continental molasses of Nakhchivan superimposed depression (Figure 1). Erathem's complete section is traced in the northwestern Sharur segment of the elevation. In the southeast only its' Permian deposits crop out in the valley of Julfa (Azərbaycanın geologiyası, 2015; Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961;

Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 1999; Мамедов, 1992). Erathem's stratigraphic division is made according to section's lithological characteristics and rich fauna species.

Devonian

Within Nakhchivan AR's territory, Devonian formations protrude at 160 km² large area in the river-basins of Chapanchay, Jahannamdara, Baghyrsagdara and East Arpachay (left bank of Araz) (Azərbaycanın geologiyası, 2015; Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 1999; Геология Азербайджана, 2007). Surface geological section has 2220 m of average and 2960 m of maximal cumulative thickness.

The Devonian system is represented by its' lower, middle and upper stages consisting of carbonate and terrigenous facies with bivalve, brachiopods and corals. Column of a test hole

drilled in 1950's on the southeastern slope of Dahna Mount., had revealed the Lockhovian and Praghian deposits as well.

During Devonian period, the Nakhchivan AR's territory (as a component of Central Iranian massif) used to be part of the southern shelf zone of Paleothetis, corresponded to passive continental margin of Gondwana (Afro-Arabian) continent and was distinguished by a sub-platform tectonic regime. The region was characterized by shallow (200–300 m) marine shelf conditions with normal hydrological regime. Depending on speed of the onshore continuous erosion processes in the south, the basin's carbonation process was periodically replaced by an accumulation of terrigenous material. Various brachiopods, foraminifers, gastropods, pelecypods, ostracods, corals and other thermophilic faunistic forms were widely developed in the basin. Transition period between Devonian and Carboniferous periods was marked by a continuing shallow marine condition of the region.

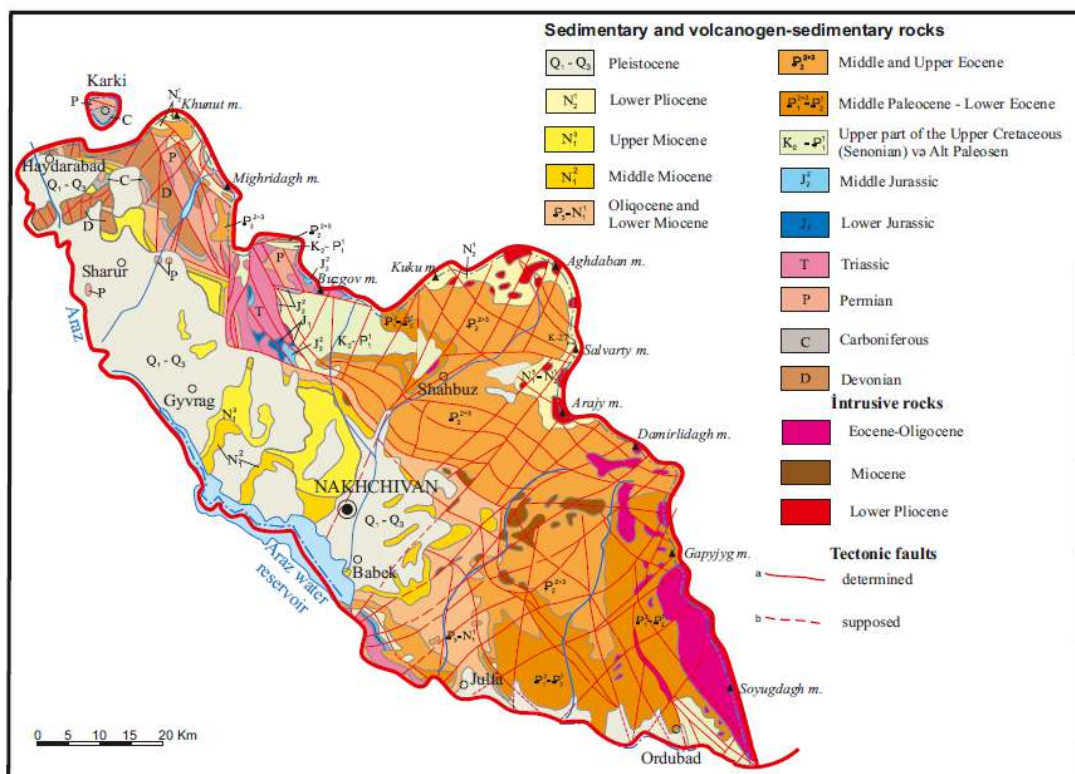


Figure 1. Geological map of Nakhchivan AR. By: T.N. Kangarli



Following scientists had contributed to a long-running studies of the lithology-stratigraphic features and fauna region's Devonian complex: G.V.Abikh, G.Tsulukidze, P.Khalatov, V.Arkipov, Q.Artgaber, F.Frekh, P.Bonne, K.N.Paffenholz, V.F.Zakharov, N.N.Yakovlev, Sh.A.Azizbekov, M.A.Sadykhov, G.P.Korenev, N.V.Pashaly, A.A.Kadirov, E.Kh.Madatov, K.O.Rostovtsev, A.E.Baghyrov, N.A.Balashev, M.B.Zeynalov, T.H.Hajiyev, M.I.Rustamov, M.A.Rjonsnitskaya, A.B.Mammadov, V.A.Aristov, I.A.Grechishnikova, Y.S.Levitskiy, V.P.Feliks, H.I.Aliyev, etc. Collected paleontological material was dated by V.A.Aristov, O.V.Bogoyav-

lenskiy, I.O.Chedia, Y.V.Chibrikova, V.A.Chijova, I.I.Chudinova, V.N.Dubatolov, Y.A.Dubatolova, T.F.Eikhgorn, N.B.Gibshman, V.G.Khalimbaji, A.I.Kim, V.L.Klishevich, G.V.Kotlyar, O.P.Kovalevskiy, G.S.Kropachova, V.F.Kulikova, G.M.Gasiymova, K.Y.Gurevich, Y.S.Levitskiy, Q.L.Lyaschenko, Z.A.Maksimova, A.B.Mammadov, Y.A.Modzolevskaya, A.G.Plamenskaya, Y.A.Reytlinger, M.A.Rjonsnitskaya, N.Y.Spaskiy, Y.N.Spaskiy, L.M.Ulitina, N.G.Verbitskaya, G.P.Vuks, V.I.Yavorskiy, R.S.Yeltisheva, M.V.Yerina and Y.V.Zinevich.

Local stratigraphic units that are present in visible geological section are presented in Table 1.

Table 1

Division of the Devonian system of Nakhchivan AR

Section	Stage and substage	Suites and subsuites
Lower Devonian	Upper Emsian substage	Lower Sarajly subsuite Upper Sarajly subsuite
Middle Devonian	Lower Eifelian substage	Sharur suite
	Middle Eifelian substage	Validagh suite Danzik suite
	Upper Eifelian substage	Lower Gurdgapysy subsuite Middle Gurdgapysy subsuite Upper Gurdgapysy subsuite
	Upper Givetian substage	Sadarak suite
	Upper Givetian substage	Lower Arpachay subsuite Upper Arpachay subsuite
Upper Devonian	Lower Frasnian substage	Kalafaagil suite
	Middle Frasnian substage	Baghysagdara suite
	Upper Frasnian substage	Yayji suite
	Lower Famennian substage	Lower Gabagdagh subsuite Upper Gabagdagh subsuite
	Middle Famennian substage	Lower Payadara subsuite Upper Payadara subsuite
	Upper Famennian substage	Lower Munhbalaoglu subsuite Upper Munhbalaoglu subsuite

Lower Devonian

Within the geological section's surface segment, the Lower Devonian formations are represented by their top successions. However the samples produced from the abovementioned test hole speak for the total thickness of Lockhovian, Praghian and Emsian formations makes up 1414 m.

Lockhovian stage is represented by an alternation of graphitized limestones, quartz sandstones, quartz siltstones and argillites confined to 735.4 m interval of the bottom part of the hole's section.

Praghian stage includes alternation of graphitized limestones and quartz sandstones occupying 274.0 m interval of the middle part of the hole's section.

Emsian stage is represented by a third-from-the-top 404.6 m thick interval of the hole's section, confined to an alternation of limestones, quartzites and argillites. Built by 153 m thick alternation of limestones, siltstones, quartzites and argillites, the stage's outcrops are detected within crest of the Validagh anticline situated on the southern slope of same-named mountain. This ancomplit section was thoroughly studied by A.B.Mammadov (1979) and described as Upper Emsian substage (**Sarajly suite**) distinguished within the *Arduspirifer extensus* and *Uncinulus keltibericus* zones' volume. According to its' lithological features and fauna remains the suite is divided into *Lower* and *Upper Sarajly components*. Brachiopod zones of *Arduspirifer extensus* and *Uncinulus keltibericus* are distinguished within the volume of lower and upper subsuites respectively. Besides brachiopods, the section also contains remnants of bryophytes, crinoids, conodonts, tabulata, stromatoporata, dreadnautilus, ostracods, pelecypods, foraminifers and algae.

Lower Sarajly subsuite is faunistically distinguished within the *Arduspirifer extensu* zone of brachiopods. The subsuite's lower successions are built by grey and dark-grey sandy limestones (25 m), the upper – by an alternation

of siltstones and argillites (40 m). Following remnants were detected in the subsuite's section: brachiopods – *Schizophoria* sp., *Sieberella sieberi rectiformis* Barr., *Atrypa (Rugosatrypa) scharurica* Mat., *Reticulariopsis* cf. *dereimsi* (Oehlert), *Renothyris* cf. *curvatus* (Schloth.), *Arduspirifer extensus* (Solle), etc.; corals – *Parahelolites velidagensis* Dubat., *Striatopora* cf. *ciavis* (Dubat.), *Diganophyllum* ex gr. *bilaterale* Soshk., *Billingsastrea* sp. nov., Spass., etc.; bryophytes – *Atactotoechus magnus* Plam. etc.; crinoids – *Hexacrinites* (?) *humilicarinatus* (Yelt.), etc.; algae – *Solenopora russiensis* Masl.; conodonts – *Latericriodus beckmanni beckmanni* Bischoff. et Ziegl., *Icriodus corniger ancestralis* Weddige, *Spathognatodus carinthiacus* Schulze, etc. (Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 2007).

Upper Sarajly subsuite is faunistically distinguished within the *Uncinulus keltibericus* brachiopod zone's volume. Its' lower segment is built by dark-grey limestones (11 m), and the upper – by an alternation of dark and purple argillites, siltstones, clayey limestones and light-grey quartzites (77 m). Following remnants were detected in the subsuite's section: brachiopods – *Schizophoria* sp. (ex gr. *schnuri* Struve), *Sieberella* ex gr. *sieberi* (Buch), *S.* cf. *volaica* (Gortani), *Ivdelina* cf. *montana* Jux, *I. montana acutecostata* (Spriest.), *Gypidula globosa* (Bronn), *Uncinulus keltibericus* Schumann, *Atrypa (Rugosatrypa) scharurica* Mamedov, sp. nov., *A.* ex gr. *reticularis* Lin., *Spinatrypa* aff. *dorsata* Biernat, *Renothyris* cf. *curvatus* (Schloth.), *Reticulariopsis dereimsi* (Oehlert), *Gryptatrypa* sp., etc.; rugoses – *Digonophyllum* ex gr. *bilaterale* Soshk., *Billingsastraea* sp. nov. Spassk., *Tryplasma aequabilis* L., *Charactophyllum* sp.; tabulatas – *Cladopora cylindrocylularis* Dubat., *Thamnopora elegantula* (Tchud.), *Striatopora* sp., *Crassialveolites pellicularis* Dubat., *Stelliporella* ex gr. *kaplunae* Dubat., *Squameofavosites* aff. *delicatus* Dubat.; stromatoporatas – *Atelodictyon incubonum* (Yavor.); crinoids – *Hexacrinites* (?) cf. *humilicari-*



nates (Yelt.), *H. tuberosus* Yelt., *H. heteroterosus* J.Dubat. et E.Zinev., *Cysloocetocrinus pustulosus* J.Dubat. et E.Zinev., sp. nov., *Cyprinosocrinus* (?) cf. *kakvensis* Millicina and *Tetraptocrinus*, *Mediocrinus*, *Salairocrinus*, *Prebolocrinus*, *Pentanocyclius*, etc.; bryophytes – *Cemicoscinium velidacarinarum* Plamenskaya, sp. nov.; pelecypods – *Paracyclas* (*P.*) *proavia* Goldf. morfotip 2; foraminifers – *Parathuramina* cf. *magna* Antrop., *P. paulis* Byk., *P.* cf. *bykova* Pojark., *P. obnata* Tchuv.; conodonts – *Icriodus corniger ancestralis* Wedd., *I. corniger retrodepressus* Bult., *Polygnathus costatus patulus* Klapper, *Pol.* sp., *Ozarkodina carinthiasa* (Schulze), etc. (Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 2007).

Middle Devonian

Within the territory of Nakhchivan AR, Middle Devonian period is represented by a complete section of Eifelian and Givetian formations, revealed in the Republic's northwest within river-basins of Chapanchay, Baghyrsagdara and East Arpachay. Section's average thickness is around 1100 m and total thickness is more than 1550 m.

Eifelian stage is detected in the river-basin of Chapanchay (Garaburun and Dashburun hills), upper courses (Kalafa Agil area) and lower reaches (Dahna-Validagh area) of Baghyrsagdara, shores of the upper part of Arpachay reservoir (river-basins of Dolanansu and Payadara brooks) and vicinities of Gumushlu settlement. Eifelian formations are represented by limestones, calcareous quartz sandstones, dolomites, clayey and marly schists. Stage's maximum cumulative thickness exceeds 890 m. It is divided into lower (*Sharur suite*), middle (*Validagh and Danzik suites*) and upper (*Gurdgapysy suite*) substages distinguished within the volumes of *Zdimir pseudobaschkiricus velidagensis-Megastrophia yralensis*, *Arduspirifer intermedius*, *Spinospirifer araxicus-Emanuelia takwanensis*, *Arduspirifer interme-*

dius, *Spinatrypa aspera aspera-Undispirifer rzonsnitzkajae*, *Gruenewaldtria latilinguis* and *Devonogypa begljari-Subrensselandia amygdalina* zones of brachiopods. Limestones and sandstones that constitute the upper (317.3 m) interval of a section revealed by Dahna test hole are characterized as Eifelian formations as well. Formerly they used to be distinguished into separate Dahna suite.

Sharur suite was first characterized in 1979 by A.B.Mammadov. Its' stratotype is situated in Dahna-Validagh area confined to a southern slope of Validagh (lower courses of Baghyrsagdara river). Suite's outcrops are also detected along slopes of Dahna and Sarydagh mountains (Figure 2). Its' 197.5 m thick stratotype section is built by an alternation of grey and dark-grey sand-clay and organic limestones with siltstones, quartzites, schists and argillites.



Figure 2. Outcrops of Sharur suite on the slopes of Dahna Mountain (Eifelian stage of Middle Devonian system)

Sharur suite's formations conformably overlie Sarajli suite and get conformably overlapped by Validagh suite's rocks. Faunistically the suite is distinguished within the volume of *Zdimir pseudobaschkiricus velidagensis-Megastrophia yralensis* zone of brachiopods. Besides brachiopods its' section contains remnants of various bryophytes, crinoids, rugoses, conodonts, tabulatas, stromatoporatas and pelecypods. Following remnants were detected in the

suite's section: brachiopods – *Aulacella eifelen-sis* (Vern.), *Kayserella* ex gr. *lepis* (Bronn), *Xystostrophia* ex gr. *umbraculum* (Schloth.), *Megastorpha uralensis* (Vern.), *Schizophoria* aff. *pygmaea* Struve, *Zdimir pseudobaschkiricus velidagensis* Mam., *Z. baschkiricus grandicostatus* Mam., *Z. rossicus* (Karp.), *Z. conspectus* Tjzh., *Z. cf. soswaensis* (Andronov), *Levi-conchidiella calvata* (Khod. et Breiv.), *Pseudocamarophoria* ex gr. *microrhyncha* (C.F.Roemer), *Kransia parallelepipedata* (Bronn), *Beckmannia pentagona pentagona* (Kays.), *Atrypa (Rugostrypa) scharurica* Mam., *Desquamatia velidagensis* Mam., *D. totaensis* (Khod.), *Totia intermediafera* (Khod.), *Spinatrypa (Isospinatrypa) dorsata* Biernat, *Punctatrypa* ex gr. *granulifera* (Barrande), *Howellella aculeata* (Schnur), *Arduspirifer cf. mosellanus* (Solle), *Rhenothyris aequabilis aequabilis* Struve, *Mina-thothyris pachyrhynchoides beta* (Grabau), *Reticulariopsis eifliensis* (Frech), *Cimicinella struvei* And., Boucot, Johnson. etc.; rugoses – *Thamnophyllum* aff. *germanicum* Schlötter, *Tabulophyllum curtoseptatum* Bulv., *T. schandiensis* Bulv., *Dansikophyllum corneolum* (Wdkd.), *D. crassiseptatum* (Tsien), *Lep-toinophyllum spinulosum* (Wdkd.), *Charactophyllum antiquum* Soshk., *Pseudomicroplasma vesiculosum* (Goldf.), *P. assuetum* Ult., *Tryplasma aequabilis* L., *Patridophyllum petermini* Ult., *Pseudozonophyllum halli* (Wdkd.), *Mac-geeia purchisoni* (Pnk), *Zonophyllum parvum* Mark. etc.; tabulatas – *Favosites goldfussi* Orb., *F. schengi* Lin., *Pachyfavosites sphaericus* Tchud., *Heliolites cf. vulgaris* Tchern., *Tham-nopora pulchra* (Tchern.), *Th. parva* Yanet, *Fomitchevia salairica* Dubat., *Crassialveolites pellicularis* Dubat., *Chaetetes* aff. *ninae* Tchern., etc.; stromatoporatas – *Stromatopora ramilosa* Yavor., *Atelodyctyon incubanum* (Ya-vor.), *Plectostroma salairicum* (Yavor.); conodonts – *Latericriodus beckmanni sinuatus* Klapp., Ziegl., Mashk., *Icriodus struvei* Weddige, *I. latericreus* ssp. Klapp. et Ziegl., *I. culicellus* (Bult.), *I. corniger rectirostratus* Bult., *Polygnatus costatus costatus* Klapp., *P.*

ex gr. *linguiformis linguiformis* Hinde, *Eognathodus bipennatus montensis* Weddige, *Belodella devonica* (Stauffer), *Ozarkadina carinthiaca* (Schulze) and etc; pelecypods – *Paracyclas (P.) proavia* (Goldf.), *Conocardium cf. eifelience* Beusch.; crinoids – *Hexacrinites (?) humilicarinatus* Yelt., *H.(?) tuberosus* Yelt., *Cupressocrinites assimilis* J.Dubat., *C. gracilis* Goldf., *Mediocrinus kozlovi* J.Dubat., *Tetraptocrinus erectus* J.Dubat.; bryophytes – *Semicoscinium* aff. *djugarence* Nekh., *Hemitrypa cornea* Nekh., etc. (Азизбеков, 1961; Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 2007).

Dahna suite (named after Dahna Mountain) constitutes upper successions of the section revealed by the same-named test hole. The suite is built by quartz sandstones in the top layers and by the medium-grained organic, sandy, pelitomorphic, sometimes pyritized and graphite limestone containing particles of argillites in the rest of the section. None of the 317.3 m thick suite's formations contains fauna. However, as rocks of the overlying Arazdayan suite (correspond to Sharur and Validagh suites) bear typical remnants of the Eifelian fauna (*Lytrophyllum septatum* Wdkd., *Amplexus multiseptatus* Cürich, *Keriophyllum heiligensteine* Wdkd., etc.) the Dahna suite is dated back to Lower Eifelian stage. In contemporary stratigraphic division it corresponds to the *Sharur suite*.

Validagh suite (named after Validagh Mountain) comprises middle and bottom part of the geological section revealed by Dahna test hole. 1414 m thick suite is conventionally dated as Lower Devonian. The section is built by thinly laminated limestones, schist-like carbonic quartz sandstones and schist-like calcareous argillites. None of the suite's formations contains fauna. Complex's unclear stratigraphic situation made it difficult to use such term. In 1979, A.B.Mammadov had described a stratotype section of limestones overlying the Sharur suite on the southern slope of Validagh (Dahna-Validagh area in the lower courses of small Baghyrsagda-ra River). The section's outcrops are also de-



tected along slopes of Sarydagh, Dahna and Garaburun (parastratotype) mountains, as well as on the left shore of the upper part of Arpachay reservoir (Figure 3). Validagh suite is similar to previously distinguished *Arazdayan suite*. In a stratotype section, it is represented by dark-grey massive organic limestones (63 m). Limestones from the other outcrops also contain layers of quartzites, sandstones, dolomites and siltstones. Within these sections, the suite's thickness varies between 100–210 m. Faunistically the suite is distinguished within volume of *Arduspirifer intermedius* zone of brachiopods. Besides brachiopods its' section contains remnants of rugoses, tabulatas, stromatoporatas, bivalves, crinoids and conodonts. Following remnants were detected in the suite's section: brachiopods – *Arduspirifer intermedius* (Schloth.), *A. supraspeciosus* (Lotze), *Minatothyris concentricus* (Schnur), *Kransia primipilaris* (Buch), *Sep-talaria* cf. *subtetragona* (Schnur), *Atrypa* (*Plan-trypa*) *tirocinia* Copper, *Eifelatrypa plana* (Kays.), *Nucleospira lens* (Kays.), *Schizophoria* ex gr. *striatula* Schloth., *Urella* cf. *asiatica* Rzon., *Athyris* ex gr. *concentrica* Buch. etc.; rugoses – *Acanthophyllum heterophyllum* E. et H., *Atelophyllum multiseptatum* Joh., *Calceola sandalina* (Lam.), *Zonophyllum* (*Neozonophyllum*) *arpaensis* Ult., *Leptoinophyllum hedstroemi* Wdkd, *Lyriellasma halliaforme* (Soshk.), *Tabulophyllum firmatum* Tsien.; tabulatas – *Favosites robustus* Lec., *F. goldfussi* Orb., *F. vagnaransis* Yanet, *Fomitchevia salairica* Dubat., *Caliopora mixta* Deng., *Alveolitella karmakensis* Dubat., *Pachyfavosites* cf. *tumilosus* Yanet, *Crassialveolites* sp., *C. pellicularis* Dubat., *Heliolites* ex gr. *porosus* Goldf., *Thamnopora parva* Yanet in Dubat., *Th. savitschevae* Dubat., *Th. polyforata* (Schl.), *Alveolites* cf. *minitus* Lec., *Cladopora elegans* Dubat.; stromatoporatas – *Atelodictyon amygdaloides* (Lec.); bivalves – *Paracyclas* (*P.*) *proavia* Goldf. morfotip 3; crinoids – *Hexacrinites* (?) *humilicarinatus* Yelt., *H.*(?) *heterotosus* J.Dubat. et E.Zinev., *H.*(?) *tuberosus* Yelt., *Cupressocrinites gracilis* Goldf., *Graptocrinus ulcerosus* J.Dubat. et

E.Zinev., *Cyclocetocrinus pustulosus* J.Dubat. et E.Zinev. etc.; conodonts – *Icriodus corniger corniger* Witt., *I. regularicrescens* Bult., *I. struvei* Wedd., *I. ex gr. latericrescens* Brans. et Mehl., *Polygnathus costatus costatus* Klapper, *P. linguiformis linguiformis* Hinde, *P. aff. robusticostatus* Bischoff et Ziegl., *Eognathodus bipennatus montensis* Wedd., etc. (Азизбеков, 1961; Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 1999; Геология Азербайджана, 2007).



Figure 3. Section of Validagh suite located on slope of the same-named mountain (Eifelian stage of Middle Devonian system)

Arazdayan suite (named after Arazdayan village, currently Yeraskh village in Armenia) was previously dated back to the Upper Eifelian stage. Later it was established that the suite is as old as the Validagh suite, although having different facial and faunistic characteristics. With unrevealed bottom, the suite is conformably overlapped by Gurdgapysy suite. The suite's stratotype (208.7 m) is located on the slope of Garaburun Mountain. Arazdayan suite is built by an alternation of bioclastic, pelitomorph, detritic limestones, sandstones, sandy clay schists and other formations with following remnants of fauna: *Uncinulus goldfussi* Schnur., *U. implexus* Sow., *Atrypa aspera* Schloth., *Euspirifer speciosus* Schloth., *Favosites goldfussi* d'Orb., *Thamnapora tumefacta* Lecompte, *Calceola sandalina* Lam., etc. (Азизбеков, 1961;

Атлас ископаемой фауны Армянской ССР, 1974, Геология Азербайджана, 1999).

Danzik suite (named after Yukhari Danzik village flooded by Arpachay reservoir) was distinguished in 1946 by M.A.Rjonsnitskaya. Its stratotype is located in the headstream of Dolanansu brook flowing on the reservoir's left shore. The suite's outcrops are also detected along slopes of Validagh (parastratotype), Saridagh, Dahna, Garaburun and Dashburun mountains, right shore of the upper part of Arpachay reservoir (north of former Danzik village and southern slope of Gyzylgaya mountain) and the upper courses small Baghyrsaglara river (Kalafa Agil area). 50–140 m thick suite is built by an alternation of dark limestones with brownish-grey sandstones, siltstones, argillites and quartzites. Faunistically the zone is distinguished within volumes of *Spinospirifer araxicus-Emanuella takwanensis* zone of brachiopods. Besides brachiopods its section contains remnants of rugoses, tabulatas, crinoids and conodonts. Following remnants were detected in the suite's section: brachiopods – *Dagnachonetes caucasius* Afan., *Cupularostrum* sp., *C.* ex gr. *hexatoma wetteldorfensis* (H.Schmidt), *Emanuella takwanensis* (Kayser), *Athyris* sp., *A. concentrica* (Buch), *A.* ex gr. *ferronensis* Arch. et Vern., *Schizophoria* cf. *schnuri* Struve, *S.* ex gr. *pygmaea* Struve, *Dagnachonetes caucasius* Afan., *Strophochonetes* ex gr. *tenuicostatus* (Oehlert), *St. tenuicostatus* (Oehlert), *Spinulicosta* ex gr. *spinulicosta* (Hall), *Cupularostrum* ex gr. *hexatoma wetteldorfensis* (H.Schmidt), *Spinospirifer araxicus* (Rzon.), *Emanuella takwanensis* (Kayser), *Stropheodonta* cf. *vicaryi* Davidson, *Xystrotophia* ex gr. *umbraculum* (Schloth.), *Atrypa* ex gr. *reticularis* (Lin.), *Anathyris ezquerraformis* Rzon., *Subrensselandia danzikensis* Mamedov and etc.; tabulatas – *Thamnopora parva* Yanet in Dubat., *Th. pulchra* (Tchern.), *Alveolites* sp., *Coenites* aff. *declivis* Weiss., *C. declivis altaicus* Dubat., *Litophyllum magnificus* Dubat., *Cladopora* sp., *Crassialveolites pellicularis* Dubat., *Cyclochaetetes magnificus* Dubat., *Trachypora di-*

vergens Dubat., *Gephuropora* (?) sp., etc.; conodonts – *Eognathodus bipennatus montensis* Weddige, *Icriodus struvei* Weddige, *I. regularicrescens* Bult., *Icriobus* sp., *E. weddige*, *Icriodus* sp. nov., *I. culicellus* (Bult.), *I.* sp. *E. algae*, *I. corniger corniger* Wittekindt, *I. corniger retrodepressus* Bult., *I. obliquimarginatus* Bischoff. et Ziegler, *I.* sp. nov. Eichgorn, *Ozarkodina bidentata* (Bischoff. et Ziegler), *Polygnathus angusticostatus* Wittekindt, *P. linguiformis* Hinde, *P. costatus costatus* Klapp., *P. linguiformis linguiformis* Hinde., *P. costatus costatus* Klapp., *P. costatus oblongus* Wedd., *P. linguiformis pinguis* Algae., *P. linguiformis alevelandis* Wedd., *Hindeodella* sp., *Tortodus kockleianus* (Jackson), *T. obliquus* Wittekindt and etc.; rugoses – *Caractophyllum* ex gr. *antiquum* Soshk. and etc.; tentaculites – *Podolites* sp. nov. I. etc., crinoids – *Hexacrinites* (?) ex gr. *humilicarinatus* (Yelt.), *Hexacrinites* (?) aff. *tuberosus* Yelt., *Hexacrinites* (?) sp. and etc.; pelecypods – *Paracyclas* (*P.*) *proavia* Goldf. morfotip 3, *Janeia phasseolina* Goldf., *Allorisma* cf. *muenster* (Arch. et Vern.), etc. (Азизбеков, 1961; Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 1999; Геология Азербайджана, 2007).

Gurdgapysy suite (named after the same-named pass located on Dahna-Validagh ridge) was distinguished in 1948 by M.A.Rjonsnitskaya and characterized in 1962 by A.B.Mammadov. The suite's stratotype is located in Gurdgapysy pass (Dahna-Validagh area, lower courses of small Baghyrsaglara river) with the outcrops also detected along slopes of Dahna, Validagh, Garadash, Saradagh, Garaburun and Dashburun mountains, upper shores of Arpachay reservoir (around former Danzik village (parastratotype), Dolanansu and Payadara brooks) and Gumushlu village's vicinities.

The suite is divided into three subsuites: 1 – lower subsuite mainly built by limestones; 2 – middle subsuite built by an alternation of limestones, argillites and siltstones; 3 – upper subsuite built by an alternation of limestones, siltstones and sandstones. In different sections the suite's thick-



ness varies between 85–350 m. Faunistically it is distinguished within the volumes of *Spinatrupa* (*Isospinatrupa*) *aspera aspera*-*Undispirifer rzonsnitzkajae*, *Gruenewaldtia latilinguis* and *Devonogyra begliari-Subresselandia amygdalina* brachiopod zones. Besides brachiopods, the suite's section also includes remnants of various corals, bryophytes, crinoids, rugoses, conodonts, tentaculites, trilobites, tabulatas, stromatoporatas, dreadnautilus, ostracods, gastropods and pelecypods.

Lower Gurdgapysy subsuite is faunistically distinguished within lower part of the *Spinatrupa* (*Isospinatrupa*) *aspera aspera*-*Undispirifer rzonsnitzkajae* zone of brachiopods. Its' stratotype section is built by dark-grey heavy-bedded sandy limestones in the bottom, and clay-sand limestones on the top. The subsuite's thickness varies between 40–50 m with following remnants detected in its' section: corals – *Calceola sandalina* (Lam.), *Acanthophyllum heterophyllum* E. et H., *Heliophyllum longiseptatum* Sytova, *Favosites goldfussi* Orb., *Pachyfavosites sphaericus* Tchud., *Chaeteets* ex gr. *rotundus* Lec., *Alveolittella fugurata caucasica* Dubat., *Stelliporella kaplunae* Dubat., *Fomitchevia salairica* Dubat., *Placocoenites gradatus* (Lec.) and *Cladopora*, *Trachypora*, *Coenites* species; bryophytes – *Hemitrypa devonica* Nekh., *Fistullipora* ex gr. *dugusunica* Nekh., *Alternifenestella pachdarasensis* Plam., sp. nov., *Polypora* aff. *una* Moroz., *Chondraulius arpatschaensis* Plam., sp. nov.; stromatoporatas – *Stromatopora concentrica* Goldf., *Paralleloporella hoeschii* Bargatzky; brachiopods – *Spinatrupa* (*Isospinatrupa*) cf. *aspera* (Schloth.); conodonts – *Tortodus kockelianus australis* (Jackson), *Eognathodus bipennatus montensis* Weddige, *Polygnathus* cf. *pseudofoliatius* Wittekind, *Icriodus* sp.; ostracods – *Selebratina* (?) ex gr. *petaliformis* Rozhd., *Evlanella* sp. indet., etc. (Азизбеков, 1961; Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 1999; Геология Азербайджана, 2007).

Middle Gurdgapysy subsuite is faunistically distinguished within volumes of the upper part of

Spinatrupa (*Isospinatrupa*) *aspera aspera*-*Undispirifer rzonsnitzkajae* and the entire *Gruenewaldtia latilinguis* zones of brachiopods. Its' stratotype section is constitutes by an alternation of dark-grey blackish argillites, siltstones and thin to medium-bedded limestones. The subsuite's thickness varies between 25–200 m.

Built by an alternation of argillites and siltstones with limestones, the lower part of *Spinatrupa* (*Isospinatrupa*) *aspera aspera*-*Undispirifer rzonsnitzkajae* zone contains following remnants: brachiopods – *Aulacella eifelensis* (Vern.), *Radiomena irregularis* (Roem.), *Xystostrophia umbraculum* (Schloth.), *Douvillina* (*Douvillina*) *interstitialis* (Phill.), *Pholidostrophia lepis* (Vern.), *Mesodouvillina birmanica* (Reed), *Leptagonia depressa* (Dalm.), *Devonaria minuta* (Schnur), *Productella varians* Riernat, *Gypidula globosa* (Bronn), *G. brevirostris* (Phill.), *Devonogyra spinulosa spinulosa* Havl., *D. spinulosa lata* Jux, *Nemesa nemesiana* H.Schmidt, *Rzonsnitzkia sadarakensis* Mam., *Kransia parallelepipedata* (Bronn), *K. primipilaris* (Buch), *Beckmannia pentagona* (Kayser), *Pugnax* ex gr. *platyloba* (Sow.), *Glosshypothyridina procuboides* (Kayser), *Camerophorina rafaeli* Mam., *Atrypa* (*Planatrype*) *noraschenensis* Mam., *A. (Planatrype)* *thola* Copper, *A. (Planatrype)* *petasa* Copper, *Desquamatia alinensis* (Vern.), *D. circulareformis* Biernat, *Variatrype prisca* (Schloth.), *V. zonata* (Schnur), *V. subzonata* Biernat, *V. ajugata* Copper, *Synatrype microzonata* Struve, *Atryparia dispersa* (Struve), *Eifelatrype plana* (Kayser), *E. acuticosta* (Havlicek), *Carinatina arimaspa* (Eichwaldt), *Kayseria lens* (Phill.), *Bifida lepida* (Arch. et Vern.), *Spinatrype* (*Isospinatrype*) *aspera aspera* (Schloth.), *Sp. (Is.) aspera meridiana* Copper, *Sp. (Inv.)* aff. *asperoides* Anberson, Boucot, Johnson, *Spinatrype* (*Spinatrype*) *soetenica* (Struve), *Sp. (Sp.) fabaca* Copper, *Spinospirifer diluvianoides* Biernat, *Latiformia* (?) *boucoti* Mam., *Undispirifer rzonsnitzkajae* Mam., *Reticulariopsis eifliensis* (Frech), *R. ex gr. aviceps* (Kayser), *Quadrithyrus* cf. *termierae* Drot, *Q. (?) sinöata*

(Gurich), *Squamularina* cf. *parva* (Gurich), *Cyrtina heteroclita* (Defr.), *Mystrophia areola* (Quenst.), *Nucleospira lens* (Schnur), *Athyris gracilis* Sandb., etc.; rugoses – *Calceola sandalina* (Lam.), *Tabulophyllum* cf. *major* Bulv., *T. nakhichevanensis* Spassky, *Acanthophyllum* ex gr. *tenuiseptatum* Bulv., *Heliophyllum longiseptatum* Sytova, *Aulacophyllum* ex gr. *armenicum* Soshk., *A. vesiculatum* Sloss., *Aulacophyllum* sp. nov. Spassky, *Nordophyllum crassiconium* Ult., *Diplochonesseptatum* sp. nov. Spassky, *Billingsastraea* sp. nov. Spassky, *Mansuyphyllum* ex gr. *soeticum* (Schluter), *Stenophyllum spinulosa* Soshk., *Peneckiella baschkirica* Spassky, *Macgeea* ex gr. *murchisoni* (Pnk.); tabulatas – *Favosites goldfussi* Orb., *F. robustus* Lec., *F. spinosus* (Lec.), *F. saginatus* Lec., *F. maillieuxi* (Salle), *Pachyfavosites* cf. *sphaerica* Tchud., *Alveolites* cf. *straeleni* Lec., *A.* cf. *eximius* Tchern., *A.* ex gr. *nalivkini* Sok., *A. dogdensis* Dubat., *A.* cf. *taenieformis* Schlöter, *Crassialveolites symbioticus* Dubat., *C. crassus* (Lec.), *C.* cf. *krekovensis* Dubat., *Heliolites porosus* Goldf., *H.* ex cf. *krekovensis* Dubat., *H.* cf. *vulgaris* Tchern., *H.* ex gr. *curvitatulatus* Dubat., *Parastriatopora* (?) *relicta* Dubat., sp. nov., *Oculipora tshotschivi* Sok., *Cladopora tenuissima* Dubat., *Coenites bulvankerae* Dubat., *Placocoenites monostricus* Frech, *P.* cf. *medius* (Lec.), *Stelliporella kaplunae* Dubat., *Syringopora* ex gr. *yavorski* Tchern., *Caliapora* cf. *chaetoides* Lec.; stromatoporatas – *Actinostroma clatratum* Nich., *Ateladictyon fallax* Lec., *Paralleloporella höpschii* Bargatzky, *Stromatopora concentrica* Goldf.; bryozoas – *Exfenestella* cf. *dispada* (Hall), *E. danzikensis* Plam., sp. nov., *Alternifenestella pachdarasensis* Plam., sp. nov., *Seminicascunium ubensis* Nekh., *S. angerlyki* Nekh., *Rectifenestella* ex gr. *altschedatensis* Moroz., *R.* ex gr. *mishanensis* Yang., *Chondraulus arpatshaensis* Plam., sp. nov., *Reteporidra* cf. *perundata* (Hall), *R. sadarakensis* Plam., sp. nov., *Polioporella* aff. *circumscrippta* (Froizkaj), *Polypora gjumuschlugensis* Plam., sp. nov.; pelecypods – *Paracyclas* (*P.*) *proavia* (Coldf.), morphotype 3,

Paracyclas (*P.*) cf. *elliptica* Hall, *Lucina rectangularis* Sandb., *Allerisma prisca* Kind.; crinoids – *Hexacrinites*(?) *humilicarinatus* Yelt., *H.*(?) *voltschevorotensis* J.Dubat. et Zinev., sp. nov., *Graptocrinus* aff. *inconditus* (J.Dubat.), *G. spectabilis* J.Dubat. et E.Zinev., sp. nov., *Crenatemes brachyodontus grandijiugatus* J.Dubat. et E.Zinev.; tentaculites – *Novakia* aff. *otomari* Boucek, *Styliolina* ex gr. *nu cleata* Karp., *S. suralica* G.Ljasch., *Uniconus nanus* G.Ljasch., *Guerichina mesodevonica* G.Ljasch.; conodonts – *Icriodus struvei* Weddige, *I. oblongimarginatus* Bischoff. et Ziegl., *I. difficilis* Ziegl. et Klapp., *Polygnathus linguiformis linguiformis* Hinde, *P. linguiformis linguiformis epsilon* Weddige, *P. linguiformis* ssp. Weddige, *P. linguiformis linguiformis* ssp. Weddige, *P. linguiformis pinguis* Weddige, *P. parawebbi* Chatterton, *P.* aff. *robusticostatus* Bischoff. et Ziegl., *P.* ex gr. *angustigostatus* (Wittekindt), *P.* cf. *pseudofaliatus* Wittekindt, *P. costatus oblongus* Wedd., *Eognathodus bipennatus montensis* Wedd., *Tortodus intermedius* (Bult.), *T. kockelianus kockelianus* (Bischoff. et Ziegl.), etc. (Азизбеков, 1961; Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 1999; Геология Азербайджана, 2007).

Upper part of the suite (corresponding to *Gruenewaldtia latilinguis* zone of brachiopods) contains following remnants: brachiopods – *Gruenewaldtia latilinguis* (Schnur), *Aulacella eifelensis* (Vern.), *Schizophoria striatula* (Schloth.), *Mesodouvillina birmanica* (Reed), *Levoconchidiella* cf. *calvata longa* Khod., *Ivdellina* ex gr. *acutolobota* (Sandb.), *Gypidula bibricata* (Schnur), *G. parva* Biernat, *C. (Novozemelia)* ex gr. *olgae* Tcherkesova, *Devonogypa danzikensis* Mamedov, *Devonaria minuta* (Buch.), *Productella varians* Biernat, *Kransia parallelepipedus* (Bronn), *K.* ex gr. *primipilaris* (Buch), *Beckmannia pentagonus* (Kayser), *Fitzroyella angulosa* (Schnur), *Leiorhynchus subplicatus* Biernat, *Camarophorina rafaeli* Mamedov, *Septalaria* ex gr. *brachiptyca* (Schnur), *Atrypa (Planatrypa) noraschenensis* Mamedov, *A. (Pl.) petasa* Copper, *Desquamatia*



frequens Tjzh., *D.* (?) ex gr. *explanata* (Schloth.), *D. scaberbra* Khod., *D. prisca gladbachensis* Jux, *Variatrypa subditiva* Copper, *V. zonata* (Schnur), *V. zonatoides* Biernat, *Synatrypa microzonata* (Struve), *Spinatrypa (Isospinatrypa) aspera aspera* (Schloth.), *S. (Is.) aspera meridiana* Copper, *S. (Invertrypa) contabrica* Struve, *Spinatrypina (Spinatrypina) soetenica* (Struve), *Sp. (Sp.) impolita* M. et I.Breivil, ? *Totia* cf. *intermediafera* (Khod.), *Mimatrypa flabellata* (C.F.Roemer), *M. insquamosa* (Schnur), *Eifelatrypa plana* (Kayser), *E. acuticosta* (Havlicek), *Carinatina* ex gr. *singifera* (Schnur), *Spinospirifer diluvianoides* Biernat, *Urella* ex gr. *asiatica* Rzon., *Reticulariopsis avicers* (Kayser), *Pyramidalia pyramidalis* (Schnur), *Squamularina* cf. *parva* (Görich), *Nucleospira lens* (Schnur), *Athyris concentrica* (Buch) and etc.; rugoses – *Calceola sandalina* (Lam.), *Heliophyllum longiseptatum* Sytova, *Stenophyllum spinulosa* Soshk., *Lep-toinophyllum spinulosum* (Soshk.), *L. hedstroemi* Wdkd, *Thamnophyllum germanicum* Scrutton, *Neospongophyllum variabile* Wdkd, *Peneckiella baschkirica* Spassky, *Tabulophyllum nakhichevanensis* Spassky, *Aulacophyllum* ex gr. *armenicum* Soshk., *A. vesiculatum* Sloss., *Lithophyllum* ex gr. *praecipuum* Wdkd., *Hexagonaria* sp., *Macgeea* sp. and etc.; tabulatas – *Favosites goldfussi* Orb., *F. robustus* Lec., *Pachyfavosites tumulosus* Yanet, *P.* aff. *sphaericus* Tchud, *Syringopora* ex gr. *yavorskyi* Tchern., *Alveolites* cf. *eximius* Tchern., *A. tainioformis* Schlötter, *A.* cf. *straeleni* Lec., *A. dogdensis* Dubat., *Crassialveolites* cf. *krekovensis* Dubat., *C. crassus* (Lec.), *Heliolites* cf. *vulgaris* Tchern., *H. porosus* Goldf., *Coenites bulvankerae* Dubat., *Placocoenites monostrius* (Frech), *Pl. medius* (Lec.), *Pl.* cf. *gradatus* (Lec.), *Stelliporella kaplunae* Dubat., *Caliopora* ex gr. *taltiensis* Yanet, *C.* cf. *chaetetoides* Lec., *Trachypora* sp., *Pseudomicroplasma triplex* Spassky, *Chaetetes* cf. *rotundus* Lec. and etc.; stromatoporatalardan – *Actinostroma clathratum* Nich., *Atelodictyon fallax* Lec., *Parallel-opora höpschii* Barg., *Stromatopora concentri-*

ca Goldf., *Clathrocoilona* sp.; bryophytes – *Chondraululus arpatschaensis* Plamenskaja, sp. nov., *Rectifenestella* ex gr. *altschedatensis* Moroz., *R.* ex gr. *mishanensis* Yang., *Alter-nifenestella* sp., *Semicoscinium* sp., *Reteporidra* cf. *perundata* (Hall), *R. sadarakensis* Plamenskaja, sp. nov., *Orthopora* sp., *Mediopora* sp.; crinoids – *Hexacrinites(?) humilicarinatus* Yelt., *H.(?) voltshevorotensis* J.Dubat. et E.Zinev., sp. nov., *Graptocrinus* aff. *Inconditus* (J.Dubat.), *G. spectabilis* J.Dubat. et E.Zinev., sp. nov.; pelecypods – *Paracyclas (P.)* ex gr. *proavia* (Goldf.); dreadnautilus – *Danzikoceras elavofum* Zhur.; trilobites – *Pacops latifrons* Burm.; conodonts – *Icroodus struvei* Weddige, *I.* cf. *brevis* Stauffer, *Polygnathus linguiformis pinguis* Weddige, *P.* ex gr. *angusticostatus* (Wittekindt), *Belodella* sp., *Hindeodella* sp., *Tortodus intermedius* (Bultynck), *T. kockelianus kockelianus* (Bischoff. et Ziegler), etc. (Азизбеков, 1961; Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 1999; Геология Азербайджана, 2007).

Upper Gurdgapysy subsuite is faunistically distinguished within the volume of *Devonogyra begliari-Subresselandia amygdalina* zone of brachiopods. Its' stratotype section consists of the alternation of siltstones and calcareous limestones with medium-bedded sandy limestones. The subsuite's thickness varies between 15–100 m with following remnants detected in its' section: brachiopods – *Aulacella eifelensis* (Vern.), *Schizophoria* sp., *Radiomena irregularis* (Roemer), *Douvellina interstitialis* Phill., *Mesodouvillina* cf. *birmanica* Reed, *Xystostrophia umbraculum* (Schloth.), *Gypidula biplicata* (Schnur), *Devonogyra begljari* Mamedov, *Chonetes subragibbosa* Sobolev, *Ch. subquadratus* A.F.Roemer, *Helaspis luma* Imbrie, *Productella subaculeata* (Murch.), *Kransia* cf. *primipilaris* (Buch), *Ucinulus* ex gr. *coranatus* (Kayser), *Atrypa (Planatrypa) thola* Copper, *A. (Pl.) petasa* Copper, *Desquamatia prisca gladbachensis* Jux, *Variatrypa* ex gr. *zonata* (Schnur), *V. subzonata* Biernat, *Rugosatrypa* aff. *tenuicostata* Alekseeva, *Atryparia instita* Copper, *Mimatrypa*

flabellata (C.F.Roemer), *M. flabellata kuznetskiensis* Rzon. et Mizens, *M. cf. insquamosa* (Schnur), *Spinatrypa (Isospinatrypa) ex gr. aspera* (Schloth.), *Eifelatrypa cf. acuticosta* (Havlicek), *Kayseria lens* (Phillips), *Spinospirifer cf. diluvianoides* Biernat, *Quadrithyris cf. termierae* Drot, *Reticulariopsis eifliensis* (Frech), *Crurithyris* sp., *Cyrtina cf. heteroclita* (Defrance), *Athyris cingulata* Ficner et Havlicek, *Subrensselandia amygdalina* Stein., *Rensselandia cf. circularis* (Halzapfel); rugoses – *Calceola sandalina* (Lam.), *Heliophyllum halli* E. et H., *Thamnophyllum germanicum* Scrutton, *Leptoinophyllum spinulosum* (Soshk.), *Neospongophyllum longiseptatum* Bulv., *N. variabile* Wdkd., *Dahmophyllum invollutum* Wdkd., *Diganophyllum cf. bilaterale* Soshk., *Macgeea murchisoni* (Pnk.), *Tabulophyllum* sp. and etc.; tabulatas – *Favosites goldfussi* Orb., *Pachyfavosites tumulosus* Yanet, *P. aff. sphaericus* Tchud., *Parastriatopora relictia* Dubat., *Coenites tenella* Görich, *Stelliporella kaplunae* Dubat., *Caliopora chaetoides* Lec., *Alveolites* sp., *Crassialveolites crassus* (Lec.), *Heliolites vulgaris* Tchern.; stromatoporatas – *Actinostroma clathratum* Nich., *Stromatopora concentrica* Goldf., *Simplexodictyon yakovlevi* (Riab.), *Parallelopora höpschii* Barg.; conodonts – *Eognathodus bipennatus montensis* Weddige, *Polygnathus costatus oblongus* Weddige, *P. cf. pseudofoliatus* Wittekindt., etc. (Азизбеков, 1961; Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 1999; Геология Азербайджана, 2007).

Givetian stage is detected in the river basin of Chapanchay (Garaburun, Ujubiz, Dashburun heights), upper (Kalafa Agil area) and lower (Dahna-Validagh area) courses of small Baghyrsagdara river, shores of Arpachay reservoir, river basins of Dolanansu, Payadara, Gumushludara and Yayjydarasi. Its' carbonate facies conformably overlies, sometimes transgressively overlap the Eifelian formations. Givetian formations are represented by heavy-bedded coral limestones alternating with reddish-brown sandy limestones and calcareous

sandstones. With maximal thickness exceeding 500 m, the stage is divided into lower (Sadarak suite) and upper (Arpachay suite) substages distinguished within volumes of *Stringocephalus burtini*, *Crurithyris inflatus*, *Spinocyrtia transcaucasica*, *Undispirifer undiferus-Emanuelia pseudovolhynica* zones of brachiopods.

Sadarak suite (named after Sadarak settlement) was distinguished in 1948 by M.A.Rjonsnitskaya and later studied by A.B.Mammadov (1962). Its' stratotype is located in Sadarak settlement's vicinities in the river basin of Chapanchay, foot of Bulaghbashy ridge. The suite's outcrops are also detected along slopes of Garadagh, Garaburun, Ujubiz and Dashburun mountains, in the upper reaches of small Baghyrsagdara river (Kalafa Agil area), upper shores of Arpachay reservoir (vicinities of former Danzik village (parastratotype), river basins of Dolanansu and Payadara brooks), river sources of Davaolandara, Gumushludara and Yayjydarasi. 110–335 thick suite is represented by dark-grey, massive and heavy-bedded limestones.



Figure 4. Outcrops of Sadarak suite's Middle Devonian, Givetian formations (northwestern slope of Validagh)

Faunistically Sadarak suite is distinguished within volumes of *Stringocephalus burtini* and *Crurithyris inflatus* zones of brachiopods. Besides brachiopods its' section also contains various remnants of bryophytes, crinoids, rugoses, tentaculites, tabulatas, stromatoporata, gastro-



pods, ostracods, foraminifers and pelecypods.

Built by limestones and distinguished within the *Stringocephalus burtini* zone's volume, lower part of the suite contains following remnants in its' section: brachiopods – *Schizophoria* ex gr. *schnuri* Struve, *Gypidula parva* Biernat, *Gypidulina* (?) cf. *globiformis* E.Ivanova, *Devonogypa spinulosa* cf. *lata* Jux, *D. begljari* Mamedov, *Isopoma* ex gr. *brachyptica* (Schnur), *Atrypa* (*Planatrypa*) *petasa* Copper, *Desquamatia alinensis* (Vern.), *Synatrypa microzonata* (Struve), *Reticulariopsis aviceps* (Kayser), *Minatothyris maureri* (Holz.), *Emanuella pachyrincha* (Vern.), *E. pseudopachyrincha* Tschern., *E. norrisi* Mamedov, *Whitfieldella* sp., *Enantiosphen lotzi* Holz., *Rensselandia* ex gr. *circularis* (Holz.), *Stringocephalus burtini* Defr., *Parastringocephalus dorsatus* (Goldf.), etc.; rugoses – *Heliophyllum* sp. nov. Spassky (ex gr. *halli* E. et H.), *Aulacophyllum vesiculatum* Sloss., *Dansikophyllum corneolum* (Wdkd.), *D.* ex gr. *divisum* Wdkd., *Atelophyllum aequivesiculatum* (Ult.), *Digonophyllum* cf. *billaterale* Soshk., *Macgeea murchisoni* Pnk., *Hexagonaria porfirjevi* (Spassky), *H. arctica* (Meeck.), *H.* cf. *darvini* (Frech.); tabulatas – *Favosites tuimazaensis* Sok., *F. goldfussi* Orb., *F. robustus* Lec., *Pachyfavosites sphaericus* Tchud., *Thamnopora* aff. *pulchra* (Tchern.), *Th. savitchevae* Dubat., *Th. polyfarata* (Schloth.), *Th.* aff. *nicholsoni* (Frech), *Trachypora cyrculipora* Keys., *Crassialveolites crassus* (Lec.), *C.* aff. *crassus* (Lec.), *C. polonicus* Nowinskii, *Alveolitella figurata caucasica* Dubat., subsp. nov., *A. polenovi* (Peetz), *Placocoenites* cf. *gradatus* (Lec.), *P. monostichus* (Frech), *Heliolites* aff. *porosus* (Goldf.), *Stelliporella kaplunae* Dubat., *Scolipora* ex gr. *denticulata* (M.Edw. et Haime), *S. denticulata* (M.Edw. et Haime), *Tyranolites eugeni* Tchern., *Roemerolites mamedovi* Dubat., sp. nov., etc.; stromatoporas – *Stromatopora concentrica* Nich., *Actinostroma irregulare* Nich.; bryozoas – *Laxifenestella* aff. *vera* Ulrich, *Semicoscium delicatum* Krans.; crinoids – *Hexacrinites* (?) *humilicarinatus* Yelt., *H.* (?) *tuberosus* Yelt., *H.* (?)

voltschevorotensis J.Dubat. et E.Zinev., sp. nov., *Cupressocrinites grassilis* Goldf., *C.* (?) *ovatus* Schewt., *Anthinocrinus amoenus* J.Dubat. et E.Zinev. sp. nov., *Tetraptocrinus* aff. *nudus* J.Dubat., *T. tetrarimalis* J.Dubat. et E.Zinev., sp. nov., *Tetraxonocrinus optatus* J.Dubat., *Tetraroporocrinus* aff. *lunulatus* J.Dubat., *Anthinocrinus amaeysis* J.Dub. et Zinev., sp. nov., *A. pentatorosus* J.Dub. et Zinev., sp. nov., *Kazachstanocrinus* sp., *Schyschcatocrinus* sp., *Stenocrinus* sp., *Calleocrinus* sp., *Crenatomes brachyodontus grandijugatus* J.Dubat. et E.Zinev., subsp. nov., *Fabali-um* cf. *rudocostatum* J.Dubat., *Cycloocentocrinus* sp.; pelecypods – *Paracyclas* (*P.*) *proavia* (Goldf.) morfotip 4; gastropods – *Euophalus* aff. *goldfussi* Arch. et Vern.; tentaculites – *Dacricoconus mosolevicus* G.Ljasch., *Styliolina* ex gr. *nucleata* Karp.; ostracods – *Aparchites* aff. *tuimasensis* Rozhd., *Aparchitellina agnes* (L.Egorova), *Paraparchites* cf. *bauceki* Prib. et Stainb., *Voronina voronensis* (Pol.), *Reversocypris* aff. *reversus* (Pol.), *Hlyboucekina* (?) sp. indet., *Fabalitypris antiqua* Pok., *Coelbinella* sp., *Coelaenellina* sp. indet.; foraminifers – *Parathuramina* (?) sp., *Parathuramina* (?) – *Visinesphaera*, *Unisinesphaera*; conodonts – *Polygnathus parawebbi* Chatterton, *Icriodus* cf. *lindensis* Weddige, *I.* ex gr. *expansus* Br. et Mehl., *I. brevis* Stauffer, etc. (Азизбеков, 1961; Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 1999; Геология Азербайджана, 2007).

Built by limestones and distinguished within the *Crutithyris inflatus* zone's volume, lower part of the suite contains following remnants: brachiopods – *Crutithyris inflatus*, *Rhipidomella polonica* Sobelev, *Variatrypa subzonata* Biernat, *Spinatrypa subkwangsiensis* (Tien), *Spinatrypa wotanica* (Struve), *Emanuella subumbona* (Hall), *Rhipidomella tetragona* (Vern.), *Schizophoria schnuri schnuri* Struve, *Xystostrophia umbraculum* (Schloth.), *Productella varians* Biernat, *Kransia subcordiformis* (Schnur), *Crurithyris* ex gr. *inflatus* (Schnur), *Spinocyrtia* ex gr. *transcaucasica* Mam., *Cyr-*

tospirifer aperturatus aperturatus (Schholoth.), *C. aperturatus cuspidatus* (Arch. et Vern.), *C. neptunicus* Quiring, *Ambocoelia* aff. *umbonata* Conrad, *Ambothyris infimus* (Whidb.), *Athyris concentrica* (Buch), *Enantiosphen beyrichi* (Holz.), *Stringocephalus burtini* Defr., *Paras-tringocephalus dorsatus* (Goldf.); rugoses – *Hexagonaria amanschauseri* Glinski, *Hexagonaria* sp. (ex gr. *hexagona* Goldf.), *Heliophyllum aiense* Soshk., *Thamnophyllum* ex gr. *germanicum* Scrutton, *Disphyllum paschiense* (Soshk.), *Marisastrum thomasi* (Stainbr.), *Ne-ostringophyllum* ex gr. *waltheri* (Joh), *Cosjuvia rosiformis* (Soshk.), *Aulacophyllum* ex gr. *armenicum* Soshk.; tabulatas – *Thamnopora* cf. *densa* Yanet, *Favosites goldfussi* Orb., *Cras-sialveolites polonicus* Nowinskii, *Tyrganelites eugeni* Tchern., *Roemerolites* sp. nov. Dubat., *Coenites* cf. *tenella* Gurich, *Clatinocoilona* sp. indet.; stromatoporatas – *Stromatoporella sniatkovi* Yavorski, *Actinostroma septatum* Lec., *Stellapora* ex gr. *spisa* Bogoyavl., *Clathroco-ieona abeolna* Yavor., *Parallelopore h pshii* Bargatzky; gastropods – *Euomphalus* aff. *goldfussi* Arch. et Vern.; ostracods – *Selebratina* aff. *ajensis* Bozhd., *Evlanella* sp. indet., *Marginia* cf. *selebratus* Pol., etc. (Азизбеков, 1961; Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 1999; Геология Азербайджана, 2007).

Arpachay suite (named after East Arpachay River) was distinguished and studied in 1962 by A.B.Mammadov. The suite confines with *Gumushlu suite* distinguished and studied in 1948 by M.A.Rjonsnitskaya. Its' stratotype is located in the river valley of Arpachay around Gumushlu settlement (Figure 5), with the outcrops detected also along slopes of Garaburun, Ujubiz, Validagh (parastratotype) and Garadash mountains, upper reaches of Baghyrsagdara river (Kalafa Agil area), upper shores of Arpachay reservoir (river basins of Dolanansu and Payadara brooks), river sources of small Davaolandara, Gumushludara and Yayjydarasi rivers. The suite is represented by dark-grey, sometimes reddish, heavy and medium-bedded, finely

grained, bioclastic, clayey pseudoolite limestones, partly argillites and sandstones. The suite is divided into two subsuites: 1 – lower subsuite mainly built by massive limestones; and 2 – upper subsuite built by an alternation of limestones, argillites, sandstones and siltstones.



Figure 5. East Arpachay valley. Limestones of the Middle Devonian, Givetian Arpachay suite (vicinities of Gumushlu village)

Arpachay suite stands out for the rich brachiopod and coral fauna. Depending on sections, its' thickness varies between 117–200 m. Faunistically the suite is distinguished within volumes of *Spinocyrtia transcaucasia* and *Undispirifer undiferus*-*Emanuella pseudovolhynica* brachiopod zones. Besides brachiopods, its' section also contains various remnants of bryophytes, crinoids, rugoses, conodonts, tabulatas, stromatoporatas, ostracods and pelecypods.

Lower Arpachay subsuite is faunistically distinguished within *Spinocyrtia transcaucasia* zone of brachiopods and built by dark-grey, heavy and medium-bedded, bioclastic, in most cases crystalline and sandy limestones in their alternation with thin layers of argillites, siltstones and sandstones. The subsuite's thickness varies between 49–70 m, with following remnants detected in its' section: brachiopods – *Schizophoria traversensis* Grabau, *Sch. schnuri* Struve, *Rhipidomella polonica* (Sobolev), *Rhipidomella penelope* (Hall), *Schuchertella pelar-*



gonatoides Mamedov, *Douvillina* cf. *distans* Imbrie, *Xystostrophia umbraculum* (Schloth.), *Leptaena sinuata* Rzon., *Chonetes* cf. *ensicosta* Imbrie, *Ch.* ex gr. *bretzii* Schnur, *Devonochonetes coronatus* (Hall), *Productella productoides sinensis* (Kayser), *Devonogypa spinulosa globa* U.Jux, *Kransia parallelepipedata* (Bronn), *K. subcordiformis* (Schnur), *Pugnax pugnax* (Martin, sensu Mansuy), *Hypothyris* aff. *lungtungpeensis* (Kayser), “*Camarotoechia*” *subsignata* Reed, *Desquamatia prisca gladbachensis* U.Jux, *D. desquamata kansuensis* (Grabau), *Variatrypa ventricosa* (Kelus), *Spinatrypa* (*Isospinatrypa*) *aspera subkwangsiensis* (Tien), *Spinatrypa* (*Invertrypa*) *prideri* (Coleman), *Spinatrypa* (*In.*) ex gr. *subnuba* Johnson, *Spinatrypina* (*Spinatrypina*) *dirzenensis* Copper, *Sp.* (*Sp.*) *nana* (Khalfin), *Sp.* (*Sp.*) *sinensis* (Kayser), *Sp.* (*Sp.*) *bodini* (Mansuy), *Sp.* (*Sp.*) *douvillei* (Mansuy), *Sp.* (*Sp.*) *soetenica* (Struve), *Sp.* (*Sp.*) *wotanica* (Struve), *Indospirifer padaukpinensis* (Reed) var. *multicostata* Dagon, *I. pseudowilliamsi* Rzon., *Cyrtospirifer aperturatus aperturatus* (Schloth.), *C. aperturatus cuspidatus* (Arch. et Vern.), *C. aperturatus echinulata* (Arch. et Vern.), *Schizospirifer* (?) *latistriatus* (Frech), *Sch.* cf. *neptunicus* (Quiring), *Spinocyrtia transcaucasica* Mamedov, *Cyrtina* cf. *staufferi* Wright et Wright, *Athyris vittata* (Hall), *A.* (?) *gracilis* Maurer, *A.* (?) *glassii* Davidson, *Dicamara plebeja* (Sow.), *D. prunulum* (Schnur), *Glassia beyrichi* (Kayser), *Cryptonella siehli* Mamedov, *C.* (?) *whidbornei* (Davidson), *Chascothyris barroisi* Holz., *Denckmanella* ex gr. *ovata* M. et I.Breivel, *Rensselandia caiqua* (Arch. et Vern.), *Subrenselandia subpyriformis* Cooper et Phelan., *Rhipidomella vanuxemi* (Hall), *Morovostrophia* cf. *moravica* (Smyvka), *Gypidula parva* Biernat, *Devonogypa spinulosa sinuata* U.Jux, *Kransia primipilaris* (Buch), *Beckmannia* cf. *pentagona* (Kayser), *Variatrypa* ex gr. *zonata* (Schnur), *Spinatrypa* (*Isospinatrypa*) ex gr. *ortoclina* Copper, *Indospirifer orestus* (Hall et Whitfield), *Spinospirifer diluvianoides* Biernat, *Schizospirifer* (?) *cyrtiniformis* (Hall et Whitfield), *Am-*

bocoelia cf. *umbonata* (Conrad), *Reticulariopsis aviceps* (Kayser), *Cyrtina heteroclyta* Defr., *Athyris* ex gr. *concentrica* (Buch), *A.* cf. *ventrosa* (Schnur), *Dicamara scalprum* Gurich, *Whitfieldella tumida* (Dalm.), *Cryptonella planirostra* (Hall), *Enantiosphen torleyi* Halz., *E.* cf. *vicaryi* Davidson, *Stringocephalus burtini* Defr., etc.; conodonts – *Icriodus brevis* Stauffer, *I. obliquimarginatus* Bischoff. et Ziegler, *I. dif- ficilis* Ziegler, Klapper et Johnson; rugoses – *Hexagonaria amanshauseri* Glinski, *H. boloniense* Blainv., *H. primitiva* Sajut., *Dansicophyllum conoideum* Ult., *D. tenuiconicum* Ult., *Neostriophyllum waltheri* (Joh), *N. heterophylloides* (Frech), *Macgeea araxis* (Frech), *M. caucasica* Soshk., *Disphyllum paschiense* (Soshk.), *Heliophyllum halli* E. et H., *Phillipsastraea ibergenseformis* Spassky, *Cosjuvia rosiformis* (Soshk.), *Aulacophyllum armenicum* Soshk., *Prismatophyllum* ex gr. *hexagonum* Joh, *Tabulophyllum* sp. (similar to *T. butovi* Bulv.), *Leptoinophyllum* sp., *Lythophyllum* sp. nov. Spassky, *Zmetnogorsky bublichenkoi* Spassky, etc.; tabulatas – *Thamnopora* ex gr. *reticulata* Blainv., *Th. angusta* Lec., *Th. cervicornis cervicornis* Blainv., *Th. cervicornis obtuspinosa* Dubat., *Th.* ex gr. *alta* (Tchern.), *Th.* aff. *boloniensis* Goss., *Caliapora* ex gr. *battersbyi* Milne Bowards et Haime, *Heliolites porosus* Goldf., *Crassialveolites obtortus* Lec., *Coenites tenella* Gurich, *Placocoenites* cf. *medius* (Lec.), *Alveolitella* ex gr. *figurata* Dubat., *Marisastrum sedgwicki* (E.H.), *Chaetetes tenuis* Frech., etc.; stromatoporatas – *Stromatopora* sp., *Actinostroma* cf. *boreale* Bogoyavl., *Actinostroma fil- litextum* (Lec.); bryosoas – *Hederella* (*Hederel- la*) *filliformis* (Bill.), *Hederella* (*Parahederella*) sp., *Stereotoechus ramosus* Morozova, *Lioclema* aff. *passitabulatum* Duncan, *Rectifenestella mishanensis* Yang., etc.; ostracods – *Eridocon- cha* sp. indet., *Saccarchites berdanae* Rozhd., *Marginia* sp. indet., *Ochascapha* sp. indet., *Ortocypris subparalella* (Pol.), *O.* cf. *parilis* Rozhd., *Cavellina sargaeviensis* Rozhd.; trilo- bites – *Scutellum* cf. *armenicum* Z.Max.; dread- nautilus – *Discosorida*, etc. (Азизбеков, 1961;

Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 1999; Геология Азербайджана, 2007).

Upper Arpachay subsuite is faunistically distinguished within *Undispirifer undiferus-Emanuella pseudovolhynica* zone of brachiopods. It's built by an alternation of grey, dark and greenish grey limestones with argillites, siltstones and sandstones. Depending on section, the subsuite's thickness varies between 68–130 m, with following remnants detected in its' section: brachiopods – *Schizophoria mesocarina* Imbrie, *Rhipidomella vanuxemi* (Hall), *Protoleptostrophia perplana* (Conrad), *Leptaena kwangsiensis* Grabau, *Chonetes* ex gr. *bretzii* Schnur, *Productella productoides productoides* (Murch.), *P. productoides sinensis* Grabau, *Gypidula rectangularioformis* Mam., *Devonogypa granata rossica* Rzon., *Kransia parallelepipedata* (Bronn), *K. subcordiformis* (Schnur), *Beckmannia pentagona* (Kayser), *Isopoma brachyptica* (Schnur), *Septalaria ascendens* (Steininger), *S. phillipsii* (Davidson), *Pugnax acuminatus dillanus* H.Schmidt, *Yunnanella* cf. *custos* H.Schmidt, *Oligoptichoderhynchus hexatoma soetenica* H.Schmidt, *Variatrypa zonata* (Schnur), *V. ventricosa* (Kelus), *Desquamatia hunanensis* (Grabau), *D. auriculata* (Haysaka), *D. circularis* (Leidhold), *Anatrypa colupso* Johnson, *Spinatrypa (Isospinatrypa)* aff. *rockfordensis* (Fenton et Fenton), *Spinatrypa (Invertrypa) nana* (Khalfin), *Spinatrypina (Spinatrypina) girzenensis* Copper, *Sp. (Exatrypa) sinensis* (Kayser), *Indospirifer chaudi* (Grabau), *Spinocyrtia* ex gr. *conjungensis* Torley, *S.* aff. *mediotexta* (Arch. et Vern.), *Mucrospirifer* cf. *cooperi* Wright et Wright, *Cyrtina heteroclita* Defrance, *C. multiplicata* Davidson, *Allanella* ex gr. *allani* Warren, *Warranella* cf. *franclini* (Meek), *Undispirifer undiferus undiferus* (Roemer), *U. undiferus several* (Davidson), *Emanuella pseudovolhynica* Mamedov, *Athyris* (?) *complanatus* (Schloth.), *Dicamara plebeja* (Sow.), *Whitfieldia tumida* (Dalm.), *Rensselandia* cf. *circularis* (Holz.), *Schizophoria traversensis* Grabau, *Mystrorhynchia* cf. *areola* (Quenstedt), *Xystostrophia umbracu-*

lum (Schloth.), *Douvillina* cf. *distans* Imbrie, *Douvillina (Douvillina)* ex gr. *interstitialis* (Phill.), *Radiomena irregularis* (Roemer), *Disquamatia alinensis* (Vern.), *D. gladbachensis* U.Jux, *Spinatrypa (Isospinatrypa) ortoclina* Copper, *Spinatrypa (Invertrypa) subnuba* Johnson, *Cyrtospirifer lansdalii* (Murch.), *Spinospirifer* ex gr. *diluvianoides* Biernat, *Reticulariopsis aviceps* (Kayser), *Ambothyris* ex gr. *infima* (Whidborne), *Crurithyris* ex gr. *inflatus* (Schnur), *Stringocephalus burtini* Defrance; conodonts – *Icriodus difficilis* Ziegler, Klapper et Johnson, *I. obliquimarginatus* Bischoff. et Ziegler, *Icriodus* sp. B (no Weddige), *Icriodus* sp., *Polygnathus* ex gr. *varcus* Stauffer, *P. xylus* Stauffer, *Eognathodus* cf. *bipennatus bipennatus* (Bischoff. et Ziegler), *Ozarcodina* sp.; rugoses – *Neostriangophyllum heterophylloides* Frech, *N. waltheri* (Joh), *Macgeea araxis* Frech, *M. gumushlugense* Spassky, *M.* cf. *caucasica* Soshk., *Dansicophyllum conoideum* (W. et V.), *Ptenophyllum butovi* Bulv., *Gryphophyllum isactis* Frech, *Hexagonaria boloniense* Blainv., *Aulacophyllum armenicum* Soshk., *Aulacophyllum* sp. nov. Spassky, *Peneckiella* ex gr. *darwini* Frech, *Pachyphyllum ibergense* (A.Roemer); tabulatas – *Thamnopora alta* (Tchern.), *Th. Nicholsoni* (Frech), *Th. boloniensis* Goss., *Placocoenites medius medius* (Lec.), *Pl. medius altchedatensis* Dubat., *Caliapora* cf. *battersbyi* (M.Edw. et H.), *Striatopora* sp. nov. Dubat., *Alveolites suborbicularis* Lec., *A.* aff. *tischnoffi* Dubat., *Crassialveolites crassus* (Lec.), *C. crassiformis* Solee, *C. obtortus* Lec.; bryozoas – *Reteporidra sadarakensis* Plam., sp. nov., *Reteporidra* sp.; crinoids – *Hexacrinus* (?) *kartzevae* Yelt. et J.Dubat., *Tassarocrinus* sp., *Calleocrinus* sp. nov. J.Dubat. et E.Zienv., *Cyclocetocrinus* sp., *Hexacrinites* (?) *kartzevae* Yelt. et J. Dubat.; pelecypods – *Paracyclas (P.) rugosa* Goldf. and *Nuculuidea fornicata* (Goldf.), etc. (Азизбеков, 1961; Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 1999; Геология Азербайджана, 2007).

Stratotype of **Gumushlu suite** is located in Gumushlu settlement's vicinities in the river



valley of Arpachay. It's built by 118 m thick layer of heavy and medium-bedded finely grained bioclastic, clayey, pseudoolite limestones. The suite was distinguished in 1948 by M.A.Rjonsnitskaya and dated back to the Upper Givetian substage. Since the *Arpachay suite* was identified in 1989 by A.B.Mammadov, Gumushlu suite's term wasn't used anymore.

Upper Devonian

Upper Devonian formations are revealed by Frasnian and Famennian carbonate-terrigenous facies in the river basins of Chapanchay, Jahannambara, Baghyrsagdara and East Arpachay. Average thickness of the full section is 1040 m, with maximal value of over 1370 m.

Frasnian stage is represented by an alternation of clay schists, micaceous sandstones, crystalline sometimes organic limestones and rarely detected quartzites. With the maximum cumulative thickness reaching 580 m, the stage is divided into lower (Kalafa Agil suite), middle (Baghyrsagdara suite) and upper (Yayji suite) substages distinguished within *Cyrtospirifer disjunctus elegans* and *Cyphoterorhynchus koraghensis-Cyrtospirifer subarchiaci* zones of brachiopods.

Kalafa Agil suite (named after the abandoned village in the sources of small Baghyrsagdara River) was identified in 1981 by A.B.Mammadov and H.I.Aliyev. The suite is confined to a *Charkhana suite* distinguished along border with Armenia. Its' stratotype is located on the left bank of the upper reaches of Baghyrsagdara river. The suite's outcrops are also detected in the vicinities of Danzik village (parastratotype), river basins of small Chapanchay (Ujubiz Mountain), Jahannambara, Baghyrsagdara, Davaolandara, Payadara, Dolanansu, Gumushludara and Yayjydarasi rivers, as well as along shores of Arpachay reservoir. Different sections of this 20–220 m thick suite are built by alternation yellowish-grey limestones, black clay schists, sandstones, siltstones and quartzites. Faunistically the suite is distinguished within the volume of *Cyrtospirifer disjunctus*

elegans zone of brachiopods. Besides brachiopods, it also contains various remnants of crinoids, rugoses, conodonts and tabulatas, with following remnants detected in its' section: brachiopods – *Stropheodonta asella* (Vern.), *S. fischeri* (Vern.), *Productella subaculeata* (Murch.), *Striatoproductus karasikae* Ljasch., *Ripidiorhynchus barroisi* (Rigaux), *R. ex gr. boloniensis* (Orb.), *Hypothyridina calva* Mark., *Spinatrypina (Spinatrypina) comitata* Copp., *Sp. (Sp.) robusta* Copp., *Sp. (Exatrypa) tubae-costata* (Paeck.), *Cyrtospirifer disjunctus elegans* Mam., subsp. nov., *C. ex gr. schelonicus* Nal., *C. lansdalii* (Murch.) var. phi Grabau, *Eodmitria oblivialis* Sartenaer, *Theodossia* aff. *Katavensis* Nal., *Adolfia zickzack* (A. Roemer), *Indospirifer chaudi* Tien, *Apoussiolla dorlodoti* (Rigaux), *A. belliloci* (Rigaux), *Cyrtina demarlii* Dav., *Emanuella ex gr. perlevis* Nal., etc.; rugoses – *Phillipsastraea ibergensis* (Roemer), *Neostrophophyllum modicum* Smith, *N. heterophylloides* (Frech), *Hexagonaria boloniense* (Bleinv.), *Macgeea solitaria* H. et W., etc.; tabulatas – *Crassialveolites obtortus* Lec., *Alveolites* sp., *Clathrocoilona restricta* Gall. et Jean., etc.; crinoids – *Hexacrinites* (?) aff. *biconcavis* Yelt. et J.Dubat., *Stenocrinus* (?) sp., etc.; conodonts – *Icriodus difficilis* Ziegl., Klapp. et Johns., *I. expansus* Brans. et Mehl, *Polygnathus desorosus* Stauff, etc. (Babayev, Kəngərli, Məmmədov, 2015; Miriyeva, 2009; Азизбеков, 1961; Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 1999; Геология Азербайджана, 2007).

Baghyrsagdara suite (named after small Baghyrsagdara River) was named in 1981 by A.B.Mammadov and H.I.Aliyev. It's similar to *Bagarsikh suite* previously distinguished by A.V.Mammadov. With stratotype located in the upper reaches of Baghyrsagdara River, the suite's outcrops are also detected in Danzik village's vicinities, river basins of Chapanchay (Ujubiz Mountain), small Jahannambara, Davaolandara, Payadara, Dolanansu, Gumushludara and Yayjydarasi (parastratotype) rivers, shores of Arpachay reservoir, Ardyj and Gorangalasy areas.

190–205 m thick suite is built by an alternation dark-grey limestones and black clay schists with yellowish-grey sandstones quartzites. Faunistically the suite is distinguished within the volume of *Cyphoterorhynchus koraghensis*-*Cyrtospirifer subarchiaci* zone of brachiopods. Besides brachiopods, it also contains various remnants of rugoses, conodonts, tabulatas, stromatoporatas, tentaculites and algae, with following remnants detected in its' section: brachiopods – *Schizophoria striatula* (Scholth.), *Douvillina dutertrii* (Murch.), *Productella subaculeata* (Murch.), *P. chitralensis* Reed, *Ripidiorhynchus ferquensis* (Goss.), *R. kotelensis* Brice, *Cyphoterorhynchus koraghensis* (Reed), *C. arpaensis* Abr., *C. ajdynica* Rzon., *Leiorhynchus pavlovi marcovskii* Ljasch., *Desquamatia nakhitchevanensis* Mamedov, *D. symmetrica* (Ljasch.), *Spinatrypina* (*Spinatrypina*) *comitata* Copper, *Sp. (Sp.) ertichensis* (Abr.), *Sp. (Sp.) chitralensis* (Reed), *Sp. (Sp.) sinensis* (Kayser), *Sp. (Exatrypa) tubaestata* (Paeck.), *Cyrtospirifer subarchiaci* (Martelli), *C. ex gr. gortani* Pellizari, *C. vicari* Pellizari, *C. ex gr. archeaciformis* (Grabau), *C. wangi* Tien, *C. thalathodoxa* Crickmay, *C. horkellensis* Greiner, *Eodmitria supradisjunctus supradisjunctus* (Obr.), *E. supradisjunctus boloniensis* Brice, *Apousella bouchardi* (Murch.) *A. dorlodoti* (Rigaux), *A. belliloci* (Rigaux), *Emanuella ex gr. perlevis* Nal., *Cryptonella ex gr. seminula* (Belanski), etc.; tabulatas – *Thamnopora aff. cervicornis* (Blainv.), *Th. aff. nicholsoni* (Frech), *Crassialveolites aff. delhayi* (Lec.), *Syringopora sp. nov.* Dubat. (ex gr. *yavorskyi* Tchern.) and etc.; stromatoporatas – *Stromatoporella saginata* (Lec.), *Stachyodes sp. indet.*; tentaculites – *Flabelites rzonnitzkajae* G.Ljasch.; rugoses – *Neostriophyllum heterophylloides* (Frech.), *N. modicum* Smith., *Megaphyllum cylindricum* Soshk., *Peneckiella schucherti* Smith., *P. darwini* Frech, *Pachyphyllum ibergense* Roem., *Schlueteria verrucosa* Soshk.; conodonts – *Icriodus brevis* Stauff., *I. difficilis* Ziegl., Klapp. et Johns., *I. expansus* Brans. et Mehl, *I. expansus* Brans. et Mehl, *I. ex*

gr. nodosus (Hud.), *Polygnathus varcus* Stauff., *P. xylus* Stauff., *P. normalis* Mil. et Young., *P. xylus xylus* Stauff., *P. decorosus* Stauff., *Hindeodella sp.*; microfossil spores – *Archaeozonotriletes vorobjensis* Naum., *A. cf. comptus* Naum. var. *expletivus* Tschibr., *Ar. extensus* Naum., *Acanthotriletes parvispinosus* Naum., etc. (Babayev, Kəngərli, Məmmədov, 2015; Miriyeva, 2009; Азизбеков, 1961; Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 1999; Геология Азербайджана, 2007).

Yayji suite (named after small Yayjydarasi River) was distinguished in 1984 by M.A.Rjonsnitskaya and A.B.Mammadov. Its' section contains almost no fauna remnants. The suite's age is determined according to its' position against faunistically justified Baghyrsagdara and Gabagdagh suites. The suite presumably belongs to *Ancyrognathus triangularis-Palmatolepis gigas* zone of conodonts. Its' lower boundary is established based on disappearance of limestones with *Cyphoterorhynchus koraghensis*-*Cyrtospirifer subarchiaci* brachiopod zone's fauna from Frasnian section. The suite's stratotype is located on the left bank of Yayjydarasi river's source in the northeastern part of Ashaghy Yayji village. Outcrops are also detected in the river basins of small Jahanambara, Baghyrsagdara, Davaolandara, Payadara, Dolanansu and Gumushludara rivers, shores of Arpachay reservoir, Ardyj and Gorangalasy areas. Built by and alternation of dark-grey and grey argillites, quartzites, limestones, sandstones and siltstones, the suite's maximal thickness is 154 m.

Famennian stage is distinguished in the river basins of Baghyrsagdara and East Arpachay, and represented by alternation of clayey schists, sandstones, limestones and quartzites. Maximum cumulative thickness of its' formations reaches 800 m. The stage is divided into lower (*Gabagdagh suite*), middle (*Payadara suite*) and upper (*Munhbalaoglu suite*) substages distinguished within the volumes of *Mesoplica meisteri*, *Cyrtiopsis orbelianus*-*Cyrtiopsis da-*



vidsoni famennianus, *Dmitria semioni*, *Cyrtospirifer pamiricus*-*Enchondrospirifer ghorensis*, *Paurogastroderhinchus nalivkini* and *Spinocariniifera niger*-*Hamilingella goergesi*-*Sphenospira julii* zones of brachiopods.

Gabagdagh suite (named after Gabagdagh Mountain) was identified in 1981 by A.B.Mammadov and H.I.Aliyev. Its' lower boundary is established according to *Cyrtospirifer asiaticus* Brice and its' accompanying typical faunistic remnants. The suite's stratotype is located on slopes of Gabagdagh with parastratotype detected in Ashaghy Yayjy village's vicinities. Outcrops are also revealed in the river basins of Jahannamdara, Baghyrsagdara, Davaolandara, Ardyjlydara, Payadara, Dolanansu, Gumushludara and Yayjydarasi rivers, shores of Arpachay reservoir, Gorangalasy and other areas. With sections representing the alternation of quartzites, limestones, clayey schists and siltstones, the suite is divided into two components: 1 – lower subsuite mainly built by quartzites, clayey schists, partly limestones and siltstones; and 2 – upper subsuite mainly composed of limestones, clayey schists and quartzites. Depending on section, the suite's thickness varies between 130–408 m. Faunistically it is distinguished within volumes of *Mesoplica meisteri* and *Cyrtiopsis orbelianus*-*Cyrtiopsis davidsoni famenniana* brachiopod zones. Besides brachiopods its' section also contains various remnants of foraminifers, conodonts, pelecypods and algae.

Lower Gabagdagh subsuite is faunistically distinguished within the volume of *Mesoplica meisteri* brachiopod zone. It corresponds to *Nohurvank suite* determined in the adjoining district in Armenia. Stratotype is located on the slopes of Gabagdagh Mountain in the vicinities of Ashaghy Yayjy village. 50–152 m thick subsuite is built by an alternation of quartzites containing interlayers of dark-grey sandy limestones and light-blue siltstones with brownish-black clayey schists. Following fauna remnants are detected in the subsuite's section: brachiopods – *Mesoplica meisteri* (Peetz), *Ripidiorhynchus grisica* Nal., *Cyrtospirifer asiaticus* Brice (= *C. archiaci*

Murch., 1840, sensu Vereuil, 1845), *C. ex gr. verneuili* (Murch.), *Athyris globularis* Phill.; foraminifers – *Nanicella tchernyshevae* Lip. (*N. bella* Byk., *N. eugeni* Byk., *N. evoluta* Reitl.; conodonts – *Icriodus subtermicus* Joung., *I. alternatus* Brans. et Mehl, *I. sp. A*, *I. expansus* Brans. et Mehl., *Polygnathus procerus* Brans. et Mehl, *P. streeli* Dressen, Dusar et Grassens, *P. aff. desorosus* Stauff., *P. ex gr. politus* Ovnat., *P. normalis* Mill. et Joung, *P. brevilaminus* Brans. et Mehl., *Palmatolepis triangularis* Sannem.; algae – *Girvanella* sp., *Umbella orbicularis* Berchenko, *Um. sp.*, etc. (Babayev, Kəngərli, Məmmədov, 2015; Miriyeva, 2009; Азизбеков, 1961; Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 1999; Геология Азербайджана, 2007).

Upper Gabagdagh subsuite is faunistically distinguished within the volume of *Cyrtiopsis orbelianus*-*Cyrtiopsis davidsoni famenniana* brachiopod zone. It corresponds to *Ertich suite* determined in the adjoining district in Armenia. Stratotype is located on the slopes of Gabagdagh mountain with parastratotype detected around Ashaghy Yayjy village. 80–256 m thick subsuite is built by an alternation of light-grey limestones and quartzites with black brownish-black clayey schists. Following fauna remnants are detected in the subsuite's section: brachiopods – *Schuchertella chemungensis* (Conrad), *Mesoplica kayseri* (Khalfin), *M. meisteri* (Peetz), *M. tasadyrica* (Nal.), *Productella lachrymosa lachrymosa* Hall, *P. lachrymosa strigma* Hall, *P. herminae* Frech, *P. baitalensis* Reed, *P. pamirica* Reed, *P. chitralensis* Reed, *Praewaagenoconcha speciosa* (Hall), *P. oreliana* Moeller, *Ripidiorhynchus ferquensis* (Goss.), *R. ex gr. kotalensis* Brice, *Centrorhynchus baitalensis* (Reed), *C. baitalensis comitata* (Reed), *C. charakensis* Brice, *Ptychomaletoechia omaliusi* (Goss.), *Cyrtospirifer asiaticus* Brice, *C. whitneyi* (Hall), *C. cf. verneuili* (Murch), *C. verneuili grabau* Paeck., *C. verneuili syringothyriiformis* Paeck., *Cyrtiopsis orbelianus* (Abich), *C. davidsoni famenniana* Paeck., *C. armenicus* (Abr.), *C.(?) tchernyschewi* (Khalf.), *Uchtospirifer ex gr. murchisoni*

anus (Koninck), *Cleiothyridina reticulata* Stainb., *Centrorhynchus letiensis* (Goss.), *Pugnoides nana* Mart., *Leiorhynchus depradi* (Mans.), *Ptychomaletoechia* (?) *turanica* (Rom.), *Eoparophorhynchus triaqualis* (Goss.), *Yunnanella synplicata* Grabau, *Paryphorhynchus* cf. *fatima* Nal., *Cyrtospirifer pellizariformis* (Grabau), *C. triplisinosus* (Grabau), *C. ex gr. wesgensis* Zeiba, *C. ex gr. calcaratus* (Sow.), *Cyrtiopsis celeticus* (Crickmay), *Cleiothyridina gurdoni* (Reed), *C. pseudoglobularis* (Reed), *C. coloradensis* (Girty), *Athyris campomanesiformis* Mamedov; conodonts – *Icriodus cornutus* Sannem, *I. alternatus* Brans. et Mehl, *I. sp. nov.* A. Khalym., *I. expansus* Brans. et Mehl, *I. rectus* Joungq. et Peters, *I. iowaensis* Youngq. et Pet., *Polygnathus* sp., *P. streeli* Dressen, Duser et Grassens, *Polygnathus normalis* Mill. et Joungq, *P. brevilaminus* Brans. et Mehl, *Spathognathodus disparilis* (Brans. et Mehl), *Pelekysgnathus peegavi* Druce; *Acodina curvata* Stauff., *Palmatolepis triangularis* Sann., *P. delicatulus* Brans. et Mehl, *P. minuta* Brans. et Mehl, *P. subperlobata* Brans. et Mehl, *Ancyrognathus sinelaminus* (Brans. et Mehl), *Nothognathella typicalis* Brans. et Mehl; pelecypods – *Leptodesma pamiricus* Reed.; algae – *Umbella pughatchochovensensis* Вук., etc. (Babayev, Kəngərli, Məmmədov, 2015; Miriyeva, 2009; Азизбеков, 1961; Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 1999; Геология Азербайджана, 2007).

Payadara suite (named after Payadara brook) was distinguished in 1981 by A.B.Mammadov and H.I.Aliyev. Its' stratotype is located in the upper reaches of Payadara brook with the outcrops detected also in the river basins of small Jahanambara, Baghyrsagdara, Davaolandara, Ardyjlydara, Dolanansu, Gumushludara and Yayjydarasi (parastratotype) rivers, shores of Arpachay reservoir, Gabagdagh, Gorangalasy and other areas. The suite is built by an alternation of dark-grey limestones, quartzites, argillites, siltstones and sandstones. The suite is divided into two components: 1 – lower subsuite mainly built by limestones, quartzites, argillites and sandstones; and 2 – upper subsuite mainly composed of limestones,

argillites, siltstones, sandstones and quartzites. Depending on section, the suite's thickness varies between 130–170 m. Faunistically it is distinguished within volumes of *Dmitria seminoi* and *Cyrtospirifer pamiricus-Enchondrospirifer ghorensis* brachiopod zones. Besides brachiopods its' section also contains various remnants of corals, conodonts, foraminifers and ostracods.

Lower Payadara subsuite is faunistically distinguished within the volume of *Dmitria seminoi* zone of brachiopods. It corresponds to *Gadirli suite* determined in the adjoining district in Armenia. 100–110 m thick subsuite is mainly built by quartzites and argillites. Following fauna remnants are detected in the subsuite's section: brachiopods – *Schizophoria impressa* (Hall), *Schellwienella* cf. *percha* Stainb., *Mesoplica* ex gr. *praelonga* (Sow.), *M. aff. arctirostratum* (Hall), *Whidbornella caperatifformis* (Abr.), *Productella lachrymosa* (Conrad), *P. cf. bourguignoni* Mansuy, *Ptychomaletoechia* (?) aff. *raricostata* (Nal.), *P. (?) cf. pamirica* (Reed), *P. omaliusi* (Goss.), *Centrorhynchus letiensis* (Goss.), *C. charakensis* Brice, *Eoparophorhynchus* cf. *triaqualis* (Goss.), *Cyrtospirifer verneuili yunnanensis* Mansuy, *C. cf. whitneyi* (Hall), *C. cf. pellizzorii* (Grabau), *C. sinensis* (Grabau) mut. *alfa* (Grabau), *Spirifer distans* (Sow.), *Cyrtiopsis graciosus chakhaensis* Brice, *Dmitria seminoi* (Viq.), *D. mirsa* (Nal.), *Cleiothyridina reticulata* Stainb., *C. (?) pseudoglobularis* Reed; conodonts – *Pelekysgnathus* aff. *nodosus* Thomas, *Polygnathus semicostatus* Brans. et Mehl, *Icriodus cornutus* Sann., *Pelekysgnathus nodosus* Thomas, *Spathognathodus crassidentatus* (Brans. et Mehl), *Sp. aciedentatus* Brans. et Mehl.; foraminifers – *Girvanella* aff. *ducoi* Weth.; corals – *Hexagonaria hexagonia* John and etc. (Babayev, Kəngərli, Məmmədov, 2015; Miriyeva, 2009; Азизбеков, 1961; Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 1999; Геология Азербайджана, 2007).

Upper Payadere subsuite is faunistically distinguished within the volume of *Cyrtospirifer*



pamiricus-Enchondrospirifer ghorensis zone of brachiopods. It corresponds to *Shamamazur suite* determined in the adjoining district in Armenia. 30–60 m thick subsuite is mainly built by an alternation of limestones, argillites, siltstones, sandstones and quartzites. Limestone formations are filled with brachiopods. Following fauna remnants are detected in the subsuite's section: brachiopods – *Aulacella* cf. *interlineata* (Sow.), *Schizophoria impressa* (Hall), *Schuchertella chemungensis* Conrad, *Schewienella* cf. *percha* Stainb., *Mesoplica simplicior* (Whidb.), *M.* aff. *tasadyrica* (Nal.), *Widbornella caperatifformis* Abr., *Sentosia retiformis* (Kr. et Karp.), *Productella baitalensis* Reed, *Leioproductus* ex gr. *pamiricus* Karapetov, *Semiproductus onustus* (Hall), *Planaproductus hillsboroensis* (Kindle), *Ptychomaletoechia omaliusi* (Goss.), *Centrorhynchus letiensis* (Goss.), *Planatoavetrostrum* aff. *planovatum* Nal., *Eoparop horhynchus triaqualis* (Goss.), *Araratella dichotomians dischotomians* Abr., *Paurogastroderhynchus* (?) ex gr. *dumanti* (Goss.), *Parophorhynchus zuleika* Nal., *Syntectirostrum delicatocostatum* (Abr.), *Camarotoechia tenisica* Martynova, *Cam. sobrina* Stainb., *Cyrtospirifer pamiricus* Reed, *C.* aff. *lebedjuanicus* Nal., *C. sulcifer* (Hall et Clarke, sensu Nal., 1937), *C. tarbagataicus* (Vas.), *C. archiaciformis* (Grabau, sensu Paeck., 1942), *C. procumbens* Simorin, *C. crassiplicatus cyrtinaeformis* Brice, *Sphenospira praejulii* Mamedov sp. nov., *Cyrtiopsis hiraethlynae* Crickmay, *Enchondrospirifer ghorensis* Brice, *Athyris sulcifera* Nal., *A. bayeti* Rigaux, *Cleiothyridina reticulata* Stainb.; conodonts – *Pelekysgnathus inclinatus* Thomas, *Pelekysgnathus* sp., *Polygnathus communis communis* Brans. et Mehl, *Pol. collinsoni* Druce, *Pol. streeli* Dressen, Duser et Grossens, *Icriodus cornutus* Sann., *Spathognathodus* aff. *acidentatus* (E.R.Brans.), etc. (Babayev, Kəngərli, Məmmədov, 2015; Miriyeva, 2009; Азизбеков, 1961; Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 1999; Геология Азербайджана, 2007).

Munhbalaoglu suite (named after Munhbalaoglu Mountain) was distinguished in 1981 by A.B.Mammadov and H.I.Aliyev. Its' stratotype is located in the northern and northeastern slopes of Munhbalaoglu mountain with parastratotype detected in Ashaghy Yayjy village's vicinities. The suite's outcrops are also detected in the river basins of small Jahannamdara, Baghyrsagdara, Davaolandara, Ardyjlydara, Dolanansu, Gumushludara and Yayjydarasi (parastratotype) rivers, shores of Arpachay reservoir, Gabagdagh, Gorangalasy and other areas (Figure 6). Being built by an alternation of clayey schists, limestones, sandstones and quartzites, the suite is divided into two components: 1 – lower subsuite mainly composed of clayey schists and siltstones; and 2 – upper subsuite mainly composed of limestones, clayey schists, sandstones and quartzites. Depending on section, the suite's thickness varies between 80–220 m. Faunistically it is distinguished within volumes of *Paurogastroderhynchus nalivkini* and *Shinocarinfiera niger-Hamlingella goergesi-Sphenospira julii* brachiopod zones. Besides brachiopods its' section also contains various remnants of bryophytes, crinoids, rugoses, conodonts, trilobites, ostracods and bivalves.



Figure 6. Left bank of East Arpachay. Geological section of Gorangalasy Mountain. Upper Devonian: D₃fm₃ – Upper Famennian, Munhbalaoglu suite. Lower Carboniferous: C₁t₁ – Lower Tournaisian, Lower Gorangalasy subsuite; C₁t₂ – Upper Tournaisian, Upper Gorangalasy subsuite; C₁v₁ – Lower Viséan, Lower Diza subsuite

Lower Munhbalaoglu subsuite is faunistically distinguished within the volume of *Paurogastroderhynchus nalivkini* zone of brachiopods. It corresponds to *Gortun suite* determined in the adjoining district in Armenia. 20–120 m thick subsuite is mainly built by an alternation of colourful clayey schists and siltstones with brownish-grey, clayey and sandy limestones. Following fauna remnants are detected in the subsuite's section: brachiopods – *Schuchertella chemungensis transversa* Nal., *Schellwienella* cf. *percha* Stainb., *Choenetes* sp., *Mesoplica tasadyrica* Nal., *Buxtonia* ex gr. *scabricula* (Sow.), *Paurogastroderhynchus nalivkini* (Abr.), *Ptychomaletoechia omaliusi* (Goss.), *P.* ex gr. *turanica* (Rom.), *Araratella dichotomians dichotomians* Abr., *A. dichotomians assimulata* Abr., *Pugnax pugnax* (Martin), *Centrorhynchus letiensis* (Goss.), *Syntectirostrum* cf. *delicatocostatum* (Abr.), *Camarotoechia sobrina* Stainb., *Cyrtospirifer latus* Abr., *C. kindlei* Stainb., *C. procumbens* Simorin, *C. insulcifer insulcifer* Vas., *C. krestovnikovi* Nal., *C. crassiplicatus crassiplicatus* Brice, “*Spirifer*” *pseudosuavis* Kr. et Karp., *S.* cf. *distans* (Sow.), *Eobrachythyris strunianus strunianus* (Goss.), *Athyris sulcifera* Nal., *Cleiothyridina* cf. *reticulata* Stainb., *Actinoconchus* aff. *struniensis* (Dehee); bivalves – *Paralelodon* cf. *subcarinatus* (McCoy), *Aviculopecten* sp.; conodonts – *Acodina curvata* Stauff., *A. inornata* (Stauff.), *A.* sp., *Spathognathodus crassidentatus* (Br. et Mehl), *Polygnathus semicostatus* Br. et Mehl, *P. communis communis* Br. et Mehl, *Pelikysgnathus nodosus* Thomas, *Icriodus cornutus* Sann., *Angulodus walrathi* (Hibb.), *A. demissus* Huddle, *Hindeodella* sp., *Ozarkodina* sp., *Hibardella* sp., *Drepanodus* (?) sp., etc. (Вабаяев, Көнгөрлі, Мәммədov, 2015; Miriyeva, 2009; Азизбеков, 1961; Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 1999; Геология Азербайджана, 2007).

Upper Munhbalaoglu subsuite is faunistically distinguished within the volume of *Shinocarinerifera niger-Hamlingella goergesi-Sphenospira*

julii zone of brachiopods. It corresponds to *Arshakiakhbur suite* determined in the adjoining district in Armenia. 60–100 m thick subsuite is built by an alternation of yellowish-grey limestones and black clayey schists with interlayers of quartzites. Following fauna remnants are detected in the subsuite's section: brachiopods – *Aulacella interlineata* (Sow.), *Schuchertella planumbona* (Weller), *Schellwienella kellii* (McCoy), *Mesoplica praelonga* (Sow.), *M. abyshevensis* Sarytcheva, *Spinocarinerifera niger* (Goss.), *S. inflata* (Sokols.), *Hamlingella goergesi* (Paeck.), *Bagrasia chonetiformis* (Kr. et Karp.), *Buxtonia scabricula* (Martin), *Camerotoechia tenisica* Martynova, *C. acutirugata* (Kon.), *C. sobrina* Stainb., *Syntectirostrum delicatocostatum* (Abr.), *Araratella araratica* Abr., *A. dichotomians dichotomians* Abr., *Paryphorhynchus elongatum* Weller, *P. striatocostatum* (Meek et Worthen), *Cyrtospirifer latus* Abr., *C. kindlei* Stainb., *C. procumbens* Simorin, *C. ziganensis* Kr. et Karp., *C. trapezoidalis* Kr. et Karp., *C. crassiplicatus crassiplicatus* Brice, *C. crassiplicatus cyrtinaeformis* Brice, *Unispirifer tornacensis* (Kon., sensu Brice, 1970), *Unispirifer* ex gr. *pentagonus* (Kon.), *Eobrachythyris strunianus* (Goss.), *Sphenospira julii* (Dehee), *Torynifer* cf. *cooperensis* (Swallow), *Dielasma calhounensis* Weller, *Cleiothyridina reticulata* Stainb., *C. coloradensis* Girty, *C. tenuilineata* (Rowley), *Athyris sulcifera intermedia* Nal., *Actinoconchus struniensis* (Dehee), *Composita bellula* Stainb., *Steinhagella kusbassica* Sarytcheva, *Sentosia praecursor* (Stainb.), *S. (?) curtirostris* (Winchell), *Widbornella caperata* (Roeck.), *Camarotoechia* aff. *acutirugata* (Kon.), *C. tuta* (Miller), *C.* ex gr. *panderi* (Sëm. et Möell.), *Araratella dichotomians assimulata* Abr., *Eoparophorynchus tiaequalis* (Goss.), *Shumardella glabraventra* Stainb., *Rhynchopora* (?) *perryensis* Weller, *Pugnoides erugatus* Roberts, *Syringothyris* sp., *Eomartiniopsis* (?) *tscherepeti* Sokols., *Dielasma lenticulare* Kon., *Athyris pseudoconcentrica* Besn.; rugoses – species of *Siphonella* and *Caninia*; trilobites – *Phacops* (*Omegops*) *accipitrinus* (Phill.); conodonts –



Bispathodus aculeatus plumilus Rhodes, Austin, Druce, *B. costatus costatus* (E.R. Brans.), *Polygnathus communis communis* Br. et Mehl, *P. inornatus* E.R.Brans., *P. taxophorus* Cooper, *Icriodus costatus* (Thomas), *Pelekysgnathus* cf. *inclinatus* Thomas, *P. nodosus* Thomas, *P. superstes* Arist., *P. firmus* Arist., *Pseudopolygnathus nodomarginatus* (E. R. Brans.), *Spathognathodus acidentatus* (Br. et Mehl), *S. crassidentatus* (Br. et Mehl), *S. crassidentatus* (Br. et Mehl), *S. regularis* (Br. et Mehl), *Capricornognathus capricornis* (Druce), *Angulodus demissus* Huddle, *Ozarcodina radina* (Cooper), *Acodina* sp., *Hindeodella* sp., *Neoprioniodus* sp., *Hibbardella* sp., *Diplododella* sp., *Drepanodus* (?) sp.; ostracods – *Armenites queasitus* Tschig., *Favorites proprius* Tschig., *Quasiknoxiella reverenda* Tschig., *Knoxiaella reducta* Tschig., *Kn. praeclara* Tschig., *Kloedenellitina* aff. *indinstincta* Tschig., *Cavelina solida* Tschig., *C. munda* Tschig., *Shishaella ferax* Tschig., *Armenella intracta* Tschig., *Bairdia zaninae* Posn., *Acutiangulata* sp., *Coryellina digna* Tschig.; foraminifers – *Tubortina maljavkini* Nich., *Paracaligella antropovi* Lip., *Septatournaella* (*Eoseptatournaella*) *praesegmentata* Bog. et Jut., *Septaglomospiranella nana* Reitl., *Parathurammia cushmani* Sul., *P. suleimanovi* Lip., *Bisphaera malevkensis magna* Drazh., *B. minuta* Bir., *B. malevkensis* Bir.; calcifers – *Visinesphaera squalida* Antr., *Earlandia minima* Bir., *Calcisphaera plavskensis* Reitl., *C. transporanta* Reitl., *Polyderma chovanensis* Reitl., *Radiosphaera basifica* Reitl.; algae – *Girvanella maslovi* Shuysky, *Kamaena delicata* Antr., etc. (Babayev, Kəngərli, Məmmədov, 2015; Miriyeva, 2009; Азизбеков, 1961; Атлас ископаемой фауны Армянской ССР, 1974; Геология Азербайджана, 1999; Геология Азербайджана, 2007).

Lower Carboniferous

Within Nakhchivan AR's territory, Lower Carboniferous formations are represented by Tournaisian, Visean and Serpukhovian terrigenous-carbonate facies (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев,

Омаров, Бурджалиев, Зейналов, и др., 1982; Геология Азербайджана, 1999) accumulated in the river basins of Baghyrsagdara and East Arpachay (Figure 6). Their geological section has 265 m of average and more than 360 m of maximal cumulative thickness.

During Early Carboniferous period (just like in Devonian), the Nakhchivan AR's territory (as a component of Central Iranian massif) used to be part of the southern shelf zone of Paleothetis, corresponded to passive continental margin of Gondwana (Afro-Arabian) continent and was distinguished by a sub-platform tectonic regime. The region was characterized by shallow marine shelf conditions with normal hydrological regime. Continuous land-relief erosion in the south had caused the decline in volumes of imported terrigenous material and the acceleration of basin's carbonation process. During that period the basin was widely populated by thermophilic brachiopods, foraminifers, gastropods and corals. By the end of Early Carboniferous period, Hercynian diastrophism had triggered the region's elevation accompanied by inclined folding processes. Since then and through the end of Carboniferous period terrestrial conditions with flat landscape had established in the region. Late Carboniferous tension processes led to protrusion of gabbrodolerite and dolerite sills and dykes into the upper layers of the earth crust.

Following scientists had contributed to long-running studies of the lithology-stratigraphic features and fauna region's Lower Carboniferous complex: G.V.Abikh, F.Frekh, P.Bonne, V.I.Meller, K.N.Paffenholz, O.L.Einor, Sh.A.Azizbekov, A.M.Sadykhov, K.I.Lisitsin, A.A.Stoyanov, N.N.Yakovlev O.I.Tumanskiy, A.D.Miklukho-Maklay, I.A.Grechishnikova, E.S.Levitskiy, V.T.Felix, A.B.Mammadov, H.I.Aliyev, etc. Collected paleontological material was studied by V.A.Aristov, Y.A.Dubatolova, N.B.Gibshman, V.A.Khalimbaji, A.B.Mammadov, M.A.Rjonsnitskaya, A.M.Sadykhov, D.L.Stepanova and Y.V.Zinevich.

Local stratigraphic units are presented in Table 2.

Table 2

Division of Carboniferous system in Nakhchivan AR

Section	Stage Substage	Suites Subsuites
Lower Carboniferous	Tournaisian	Lower Gorangalasy subsuite Upper Gorangalasy subsuite
	Visean	Upper Diza subsuite Lower Diza subsuite
	Serpukhovian	Bozaghyl suite

Tournaisian stage is represented in mentioned areas and conformably overlies Upper Devonian Famennian formations. Its' 70–165 m thick section is built by an alternation of limestones, quartzites and clayey schists. The stage is represented by *Gorangalasi suite* distinguished within the volumes of *Rhipidomella micheilini-Unispirifer ussiensis* and *Marginatia deruptoides-Marginatia burlingtonensis-Cleiothyridina obmaxima* zones of brachiopods.

Gorangalasy suite (named after Gorangalasy Mountain) was distinguished in 1980 by A.B.Mammadov. Its' stratotype is locate on the northern slope of the same-named mountain (Figure 7). Outcrops are also detected in Munhbalaoglu, Gabagdagh and Bozdagh (Bozaghyl) mountains, as well as in the vicinities of Shahbulag, Gunnut and Karki (parastratotype) villages. In stratotype section, the suite is built by an alternation of coral-containing limestones, clayey schists, argillites, sandstones and quartzites. 70–165 m thick suite conformably overlies Munhbalaoglu suite's Upper Devonian formations and gets overlapped by Diza suite's deposits. Besides brachiopods, its' section also contains various remnants of rugoses, pelecypods, conodonts, ostracods, crinoids and foraminifers. According to lithological and faunistic characteristics the complex is divided into Upper and Lower Gorangalasy subsuites.



Figure 7. Outcrop of Lower Carboniferous (Tournaisian) Gorangalasy suite on the slope of the same-named mountain

Lower Gorangalasi subsuite is faunistically distinguished within the volume of *Rhipidomella micheilini-Unispirifer ussiensis* brachiopod zone. 50–90 m thick suite is built by an alternation of grey finely bedded, clayey and marly, sometimes sandy, limestones with grey, dark-grey clayey schists, argillites, calcareous sandstones and quartzites. Following fauna remnants were detected in the subsuite's section: brachiopods – *Rhipidomella micheilini* (L'Eveille), *Schizophoria chauteauensis* Weller, *Schuchertella planumbona kondomensis* Sokols., *Rugosochonetes hardrensis* (Phill.), *Steinhagella kusbassica* Sarytcheva, *Cama-*



rotoechia panderi (Sëm. et Möell.), *C. conincki* (Tolm.), *C. davidsoni* (Tolm.), *C. quadriplex* (Tolm.), *C. tuta* (Miller), *Unispirifer ussiensis* (Tolm.), *U. tornacensis* (Kon., sensu Tolm., 1931 et Sokols., 1941), *U. taidenensis* (Tolm.), *U. biplicoides* (Well.), *U. praeulbanensis* (Bubl.), *Eobrachythyris* ex gr. *strunianus* (Goss., sensu D. Brice, 1970), *Syringothyris* ex gr. *distans* Sow., *S.* ex gr. *hannibalensis* Swallow, *Punctospirifer partita* (Portlock), *Mucrospirifer sergunkovae* Bubl., *M. pseudoposterus* Bens., *Brachythyris petrenkoi* Nal., *B.* ex gr. *suborbicularis* Hall, *Torynifer cooperensis* (Swallow), *T. evagoratus* Besn., *Martinia bublichencoii* Simorin, *Eomartiniopsis* (?) *tscherepeti* Sokols., *Cleiothyridina royssii* (L'Eveille), *C. tenuillineata* (Rowley), *Dielasma tenerum* Kon., *D. lenticulare* Kon., *Hustedia circularis* (Miller), *Retzia tykhtensis* Bens., *R. nalivkini* Martynova, *Avonia nigra* (Goss.), *Rugauris curtirostris* (Winch.), etc.; rugoses – *Bothrophylum pater* Jvnsky, *Siphonophyllia cylindrica* Scouler; pelecypods – *Conocardium hibernicum* Agassiz; crinoids – *Bicostulatocrinus circumvallatus* Yelt., *Pentagonocyclicus ovoideus* Yelt. et J. Dubat., *Rhysocomax* aff. *cristata* Moore et Jeffords, etc.; conodonts – *Polygnathus inornatus* E.R.Brans., *P. communis communis* Br. et Mehl., *P. longiposticus* Br. et Mehl., etc.; ostracods – *Cavellina* ex gr. *eichwaldi* Posn., *C. solida* Tschig., *Quasiknoxiella revenda* Tschig., *Bairdia* aff. *daedala* Tsching., *B.* aff. *inassueta* Tschig., *Praepilatina* sp., *Coruellina digna* Tschig., etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 1999).

Upper Gorangalasi subsuite is faunistically distinguished within the volume of *Marginatia deruptoides-Marginatia burlingtonensis-Cleiothyridina obmaxima* brachiopod zone. 20–75 m thick suite is built by an alternation of dark-grey finely bedded clayey schists and argillites with quartzites, sandstones and sandy limestones. The subsuite corresponds to *Armash suite* located in neighboring Armenian district.

Following fauna remnants were detected in the subsuite's section: brachiopods – *Rhipidomella burlingtonensis* (Hall), *R. michelini* L'Ev., *Marginatia burlingtonensis* (Hall), *M. deruptoides* Sarytcheva, *M. tenuicostatus* (Hall), *M. vaughani* (Muir-Wood), *Tolmatchoffia elegantulus* (Tolm.), *Dictyoclostus paradoxus* Campbell, *Camarotoechia* ex gr. *panderi* (Tolm.), *Unispirifer striatoconvolutus* (Benson et Dun), *U. tornocensis*, *Palaeochoristites cinctus desinatus* (Lissitzyn), *Neospirifer* ex gr. *attenuatus* Sow., *Syringothyris distans* Sow., *S.* ex gr. *typa* Winchell, *Orulganina* ex gr. *verkhotomica* Sokols, *Brachythyris krapivnensis* Bens., *B. pinguis* (Sow.), *Torynifer pseudolineata pseudolineata* (Hall), *T. pseudolineata asiatica* Bens., *Punctospirifer octoplicatus* (Sow.), *Cleiothyridina obmaxima* (McChesney), *C. incrassata* (Hall), *C. prouti* (Swallow), *C. glenparkensis* Weller, *C. royssii* (L'Eveille), etc.; crinoids – *Bicostulatocrinus* aff. *circumvallatus squamiformis* Yelt. et J. Dubat., *Arenariocrinus arenarius granulosa* (Yelt. et Schewt.), *A. arenarius cingulata* (Yelt. et Schewt.), *Pentagonocyclicus* sp. nov. J.Dubat. et E.Zinev., *Cyclocyclicus* sp., etc., foraminifers – *Earlandia elegans* (Raus. et Reitl.), *E. vulgaris* (Raus. et Reitl.), *E. minima* Bir., *Endothura latispiralla* Lip., *En.* cf. *paracovensis* Lip., *En.* sp. indet., *Endothyranopsis* cf. *convexus* (Raus.), *Latiendothyranopsis* cf. *grandis* Lip., *Tuberendothyra* cf. *tuberculata* Lip., *Laxoendothyra* cf. *paracosvensis* Lip., *Forshia* sp., *Parathurammia* ex gr. *Suleimanovi* Lip., etc., ostracods – *Praepilatina* sp., *Cavellina* ex gr. *eichwaldi* Posner, *Shishaella monospinosa* (Sam. et Sur.), *Shemonaella* ex gr. *procera* N.Ivan., *Shivella longa* (Fachig.), multiple rugoses, pelecypods, etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 1999).

Viscan stage is present in the same areas as the underlying Tournaisian formations. Its' 45–135 m thick section is represented by bituminous, sandy, often fragmental limestones. The stage is distinguished within the volume of

Spirifer striatus-Composita verkhotomica and *Gigantoproductus giganteus* brachiopod zones and represented by *Diza suite*.

Diza suite (named after Diza village) was distinguished in 1988 by A.B.Mammadov. Its' stratotype is located on the northern slope of Gorangalasy mountain with main outcrops detected along slopes of Gorangalasy and Boz-dagh (parastratotype) heights. Other outcrops are also revealed on Munhbalaoglu and Gabag-dagh mountains, as well as in Shahbulag, Gun-nut and Karki villages. The suite's stratotype section is represented by limestones and sandstones. It conformably overlies the Upper Gorangalasy subsuite and gets overlapped by Bozaghyl suite's formations. Depending on section, the suite's thickness varies between 45–135 m. Besides brachiopods, its' section also contains various remnants of rugoses, pelecypods, crinoids, gastropods and foraminifers. According to lithological and faunistic characteristics, the suite is divided into *Lower* and *Upper Diza* subsuites.

Lower Diza subsuite is faunistically distinguished within the volume of *Spirifer striatus-Composita verkhotomica* brachiopod zone. 14–30 m thick suite is built by an alternation of dark-grey to black, partly bituminized, sandy, often fragmental clayey and marly, sometimes sandy, limestones with grey, dark-grey heavy-bedded limestones. It corresponds to *Sarypap suite* distinguished within neighboring Armenian district. Following fauna remnants were detected in the subsuite's section: brachiopods – *Schellwienella crenistria* (Phill.), *Marginatia deruptus* (Rom.), *Dictyoclostus rosonovae* Sarytcheva, *D. semireticulatus* (Martin), *Levitusia hyperborea* (Nal.), *Camarotoechia* ex gr. *biplex* (Tolm.), *Pugnax pugnus* (Martin), *Spirifer striatus* (Martin), *S. crassus* Kon., *S. trigonalis* Martin, *S. aschliariki* Simorin, *Neospirifer* ex gr. *attenuatus* (Sow.), *Paleochoristites cinctus* (Kayslerling), *P. subcinctus* (Kon.), *Syringothris sibiricus* Sokols., *S. cf. afghanica* Plodowski, *Orulganina verkhotomica* (Sokols.), *Punctospirifer octoplicatus* (Sow.), *Tylothyris*

cf. *laminosa* (M'Coy), *Ambocoelia* ex gr. *minuta* White, *Martinothyris salemensis salemensis* (Weller), *M. cf. lineatus* (Martin), *Torynifer pseudolineatus asiaticus* Besn., *Lamellosathyris lamellosus* (L'Eveille), *Cleiothyridina incrassata* (Hall), *C. ex gr. squanigera* (Kon.), *Dielasma sacculus* Martin, *Camposita verkhotomica* Besn., etc.; gastropods – *Natica nexicosta* Phill., *Naticopsis* ex gr. *elliptica* (Phill.); crinoids – *Bicostulatocrinus* aff. *circumvalatus* Yelt., *Pentagonocyclicus* sp., *Cyclocyclicus* sp.; foraminifers – *Earlandia vulgaris* (Raus. et Reitl.), *Ear. vulgaris minor* Raus., *Ammodiscus parvus* Raus., *Archaediscus* cf. *moelleri* (Raus.), *Endothyra similis* Raus. et Reitl., *Endothyranopsis* sp. indet., *Tetratoxis* sp., etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 1999)

Upper Diza subsuite is faunistically distinguished within the volume of *Gigantoproductus giganteus* brachiopod zone. 25–105 m thick subsuite is built by an alternation of yellowish-grey, finely to medium-bedded limestones with dark-grey, fine-grained, calcareous sandstones. partly bituminized, sandy, often fragmental clayey and marly, sometimes sandy, limestones with grey, dark-grey heavy-bedded limestones. Following fauna remnants were detected in the subsuite's section: brachiopods – *Leptagonia analoga* (Phill.), *Schellwienella crenistria* (Phill.), *Schuchertella partlockiana* (Semenov), *Sch. cf. plana* Sokols., *Gigantoproductus giganteus* (Martin), *Spirifer striatus* (Martin), *S. ex gr. spissus* Kon., *Neospirifer* ex gr. *attenuatus* (Sow.), *Palaeochoristites cinctus desinatus* (Lissitzyn), *Syringothris sibiricus* Sokols., *S. cf. subcuspidoides* Plodowski, *Cleiothyridina* sp. nov. Mam.; gastropods – *Ballerophon urii* Fleming, etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 1999).

Spread along the same areas as Visean formations, the **Serpukhovian stage** was distinguished in 1988 by A.B.Mammadov. The



stage is represented by *Bozaghyl suite*. The suite's stratotype is located on the southern slope of Bozdagh (Bozaghyl) mountain (Figure 8) and along slopes of Gorangalasy Mountain. Its' stratotype section includes brachiopod and rugose-containing grey, fine-grained and heavy-bedded limestones. The suite conformably overlies Upper Diza suite and gets transgressively overlapped by Gyzylgaya suite's Upper Permian formations. Depending on section, the suite's thickness varies between 50–65 m. Following faunistic complexes were discovered within the suite's section: brachiopods – *Cliothyridina* aff. *obmaxima* (Mc.Chesny), *Cliothyridina* sp., *Stafella sphaerica* (Abich.), *Echinaria* sp., rugoses – *Dibunopyllum* aff. *Turbinatum* M'Coy.



Figure 8. Bozdagh (Bozaghyl) mountain. Limestones of Bozaghyl suite, Serpukhovian stage of Lower Carboniferous

Upper Permian

Within Nakhchivan AR's territory, Upper Permian complex is represented by terrigenous-carbonate facies (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 1999; Мамедов, 1992) of Kubergandy, Murgab, Midiya, Julfa and Darasham regional stages outcropping in the river basins of East Arpachay and Baghyrsagdara, northern slope of Bozdagh (Bozaghyl) mountain and Julfa valley. The complex has 650

m of average and about 1000 m of maximal cumulative thickness. Its' bottom successions are mainly built by conglomerate and bauxite containing mainly bituminous limestones with occlusions of foraminifers and algae. Upper part of the section is constituted by an alternation of limestones and argillites. Complex's formations transgressively overlie the deeply eroded Upper Devonian and Lower Carboniferous rocks and get unconformably overlapped by Lower Triassic, in some places Upper Cretaceous and Middle Eocene deposits.

Till 1980's, Lower and Upper Permian formations were distinguished among Permian material complex revealed within Nakhchivan AR's territory. Complex basement used to be determined by bottom of the Sakmarian stage. However it was proven by later researches (Babayev, Kəngərli, Məmmədov, 2015; Геология Азербайджана, 1999) that it is only the Upper Permian deposits which are spread in the region.

At the beginning of Permian period (just like in Devonian and Carboniferous), the Nakhchivan AR's territory (as a component of Central Iranian massif) used to be part of the southern shelf zone of Paleothetis, corresponded to passive continental margin of Gondwana (Afro-Arabian) continent and was distinguished by a sub-platform tectonic regime. By the end of Early Permian period, the region's flat terrestrial regime was replaced by shallow marine shelf conditions accompanied by the accumulation of carbonate and terrigenous deposits through the end of described geological period. The basin's normal hydrological regime, presence of shallow shelf with permanent sea currents and hot tropical climate had favoured the development of typical thermophilic fauna, e.g., corals, brachiopods, etc. By the end of Permian period, climate's continuous warming and aridification had speeded up the rates of evaporation, increased the water's degree of salinity and caused deposition of dolomites. Late Permian period was marked by a gradual closure of Paleothetis and opening of Neothetis in the south. During that period, the northeastern mar-

gin of Gondwana became separated from the ocean by a deep rift, formed Cimmerian (Pontian-South Caucasus – Iran) microcontinent and started shifting towards the north. Territory of Nakhchivan used to be a part of that microcontinent represented by Araz block.

Following scientists had contributed to studies of the lithology-stratigraphic features and fauna of the region's Upper Permian material complex: G.V.Abikh, F.Frekh, P.Bonne, G.Artgaber, Y.Moysisovich, K.N.Paffenholz, Sh.A.Azizbekov, N.N.Yakovlev, A.A.Stoyanov, A.M.Sadykhov, A.D.Miklukho-Maklay, O.Einor, G.A.Dutkevich, G.G.Shenk, O.G.Tumanskaya, V.Y.Rujentsov, A.A.Shevirev, T.A.Grunt, T.G.Sarychev, Y.A.Khalilov, K.O.Rostovtsev, M.A.Rjonsnitskaya, F.A.Mustafayev, E.Y.Leven, G.V.Kotlyar, Y.D.Zakharov, G.S.Kropachova, G.P.Pronina, I.O.Chedia, A.B.Mammadov, H.I.Aliyev. Collected paleontological material was dated by G.V.Kotlyar, E.Y.Leven, A.B.Mammadov, V.N.Robinson, D.L.Stepanova and other researchers.

Local stratigraphic units that are represented in the geological section are presented in Table 3.

Kubergandy regional stage is represented by 50–190 m thick lower part of Gyzylgaya suite which overlaps the region's Lower Carboniferous and even Upper Devonian formations. Selected within the volumes of *Arme-*

nina-Misellina (Misellina) ovalis and *Cancellina cutalensis* brachiopod zones the suite is built by foraminifer and algae containing limestones with basal conglomerated and bauxitic limestones in their basement.

Murgab regional stage is represented by 30–100 m thick upper part of Gyzylgaya suite built by limestones and sandstones and outcropped within the volume of Neoschwagerina simplex zone of fusulinids, and 50–200 m thick Shahbulag suite built by algal-detrital limestones and distinguished within the volume of Neoschwagerina craticulifera zone.

Gyzylgaya suite (named after Gyzylgaya Mountain) was distinguished in 1981 by A.B.Mammadov and H.I.Aliyev. It corresponds to *Asni suite* situated in the neighboring district of Armenia. The suite's stratotype is located on Gyzylgaya mountain and its' outcrops are also detected in the areas of Bozdagh (Bozaghyl), Baghyrsagdara, Ardyj, Zarlidara, Danzik, Mighridarasi, Dolanan, Gumushludara, Davaolandara, Munhbalaoglu, Hoja Ahmad, Gorangalasy, Yayjydarsasi, Diza, Hamzali, Khyrmanjyg, Baysal, etc. The suite unconformably overlies the Upper Devonian and Lower Carboniferous formations and gets conformably overlapped by Shahbulag suite's deposits. Its' stratotype section is constituted by an alternation of black and dark-grey medium-to-heavy bedded foraminifer-algal limestones, their brecciated forms and partly dolomites.

Table 3

Division of Permian system in Nakhchivan AR

Section	Stage, substage	Suite, subsuite
Upper Permian	Kubergandy stage	Gyzylgaya suite
	Lower Murgab substage	
	Upper Murgab substage	Shahbulag suite
	Lower Midiya substage	Davaolan suite
	Upper Midiya substage	Lower Baysal subsuite
	Julfa stage	Julfa suite
	Lower Julfa substage	Upper Baysal subsuite
	Upper Julfa substage	Lower Akhura subsuite
Darasham stage	Darasham suite / Upper Akhura subsuite	



Sometimes the bottom successions contain basal conglomerates and bauxitic limestones as well. 80–290 m thick suite is faunistically distinguished within the volumes of *Armenina-Misellina* (*Misellina*) *ovalis*, *Cancellina cutalensis* and *Neoschwagerina simplex* zones of fusulinids. Besides fusulinids, its' section also contains the remnants of various tetracorals, conodonts, foraminifers and cancellinas, including: fusulinids – *Armenina salgirica* V.-Macl., *A. cf. asiatica* Lev., *A. spp.*, *Yangchienia hainanica* Sheng, *Neofusulinella* sp., *Parafusulina* ex gr. *dzaman-talensis* Lev., *P. sapperi* (Staff.), *P. subrectangularis* Kling., *P. guatemalensis* Dunb., *Prae-sumatrana neoschwagerinoides* (Depr.), *Misellina* ex gr. *claudia* (Depr.), *Verbeekina* sp., *Pseudodoliolina* cf. *ozawai* Yabe et Hanz., *Ps. vulgaris* (Sch. Et Dyrh.), *Ps. exigua* (Sch. Et Dyrh.), *Stafella* sp., *Nankinella* sp.; conodonts – *Mesogondolella idahoensis* (Young, Haw. et Mill.); tetracorals – *Waagenophyllum indicum* (Waag. et Wentz.), *Wentzellophyllum asniense* Kropatcheva; cancellinas – *Cancellina armenica* Lev., *C. armashaensis* Lev.; small foraminifers – *Glomospira* ex gr. *elegans* Lip., *Globivalvulina cyprica* Reichel, *G. bristolensis* Reichel, *Dagmarita* sp., *Neoendothyra* sp., *Nodosaria* ex gr. *ochotica* M.-Macl., *Pachyphloia* ex gr. *ovata* Lange, *Langella* sp., etc. (Babayev, Kəngərli, Məmmədov, 2015, Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 1999).

Shahbulag suite (named after Shahbulag village) was distinguished in 1981 by A.B.Mammadov and H.I.Aliyev. It corresponds to *Gnishik suite* situated in the neighboring district of Armenia. The suite's stratotype is located in Shahbulag village's vicinities, while the outcrops are also detected in the areas of Baghyrsagdara (upper reaches of the river), Ardyj, Zarlidara, Mighridarasi, Dolanan, Davaolandara, Hoja Ahmad, Gorangalasy, Yayjydarasi, Gabagyal (Figure 9), Baysal, Diza, Hamzali, Kechaltapa, etc. 50–200 m thick suite is built by an alternation of black, dark-grey and grey medium-to-heavy bedded siliceous-

bituminized, sometimes schist-like algal-detrital limestones with their heavy-bedded sandy variations. The suite's formations conformably overlie the Gyzylgaya suite's deposits and get overlapped by the Deveolen suite's rocks. Shahbulag suite is faunistically distinguished within the volumes of *Neoschwagerina craticulifera* zone or *Eopolydixodina persica* and *Pseudofusulina padangensis-Chusenella shengi* local zones of fusulinids. Besides fusulinids, the complex's section also contains remnants of various tetracorals, brachiopods and small foraminifers, including: fusulinids – *Eopolydixodina persica* Kahler, *E. vediensis* (Toum.), *E. chekiangensis* (Sheng), *E. megasphaerica* (Leven), *E. afghanensis* (Thomp.), *E. douglasi* Lloyd., *Pseudofusulina padangensis* Lange, *Ps. shishiaensis* (Lee), *Ps. quasiregularis* (Sheng), *Ps. parachihsiensis* Scherb., *Ps. tienchiensis* (Chen), *Ps. cf. otai* (Nogami), *Chusenella shengi* Tor. et Kanm., *Ch. sofja* Ched., *Ch. intermedia* Skin. et Wilde, *Ch. cybolensis* Stewart, *Ch. rabatei* Skin. et Wilde, *Verbeekina* sp., *Sumatrana annae* Volz., *Staffella sphaerica* (Abich), *S. elegantula* K.-Dev., *Sphaerulina ellipsoidalis* K.-Dev., *Pisolina abichi* Dutk., *Nankinella caucasica* Dutk., *Neoschwagerina* ex gr. *cheni* Sheng., *Chusenella shengi* Tor. et Kanm., *Pseudofusulina* ex gr. *padangensis* Lange. etc.; brachiopods – *Edriostegos poyangensis* (Kays), *Vediproductus vediensis* Sar., *Linoproductus transcausicus* Kotlyar, *Septospirigerella matasanica* Kotl., *Orthotichia avushensis* Sok., *Neochonetes armenicus* Sok., *Marginifera magniplicata* (Huang), *Haydenella kiangsiensis* (Kays.), *Septospirigerella aplanata* Grunt., *S. baissalensis* Grunt.; tetracorals – *Wentzellophyllum kueichowense*, *Wentzellophyllum* ex gr. *gravi* (Douglas), *Yatsengia asiatica kiangsuense* Yoh, *Ipciphyllum anatolicum* Flugel, *Ipc. flexuosum* (Huang), *Ipc. armenicum* (Dobr.), *Ipc. irregulare* Wu, *Ipc. subelegans* Minato et Kato, *Wentzellophyllum* (W.) ex gr. *intermedium* (Huang), *W. (W.)* ex gr. *gelikhaense* Minato et Kato, *Wentzellophyllum* (*Armeniaphyllum*) *densicolumnatum* (Iljina), *Pseudohuangia minima*

(Douglas), *Yatsengia* ex gr. *asiatica* *kiang-suense* Yoh, *Ipciphyllum flexuosum* (Huang), *Ipc.* ex gr. *ipci* Hudson, *Ipc. subtimoricum* (Huang), *Ipc. simplex* Wu, *Ipc. persicum* (Douglas), *Ipc.* ex gr. *restriseptatum* Zhao, *Ipc. subelegans* Minato et Kato, *Ipc. armenicum* (Dobr.), *Paraipcyphyllum hudsoni* Minato et Kato, *Wentzelella* sp., *Wentzelophyllum intermedium* (Huang), *Wentzelophyllum (Armeniaphyllum) armenicum* Kropatcheva, *Wentzelophyllum (Ar.) densicolumnatum* (Ијина), *Lophophyllidum pendulum simplex* Huang, *L. sp.*, *Lophocarinophyllum pulchrum* Kropatcheva, *Ufimia* ex gr. *elongata* (Grabau); small foraminifers – *Pseudoglomospira* ex gr. *elegans* (Lip.), *Climacammina valvulinoides* Lange, *Globivalvulina bristolensis* Reich., *G. graeca* Reich., *Dagmarita chanakchiansis* Reitl., *Pseudoammodiscus* sp., *Ps. aff. microsphaericus* (K.M.-Macl.), *Hemigordius* sp., *Multidiscus maopingensis* (Wang et Sun), *Neodiscus milioloides* M.-Macl., *Agathammina* ex gr. *pusilla* (Geinitz), *Nodosaria* ex gr. *cucumis* Karav., *N. globosocamerata* Karav., *Pachyphloia* aff. *ovata* Lange, *P. triangula* K.M.Macl., *Fronidina* sp., *Neoendothyra minuta* Hung, *Climacammina lagenalis* Lange, *Globivalvulina graeca* Reich., *G. decrouzeae* Koy. et Alt., *Pseudovidalina involuta* Zan., Alt. et Cat., *Angelina magna* G.Pron., *Geinitzina longa* Sul., *G. chapmani* Schub., *G. aff. flabellata* K.M.-Macl., *Ichtyofronidina latilimbata* (Civr. et Dess.), *Lingulonodosaria* aff. *quasiconcinna* K.M.-Macl., etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 1999).

Midiya regional stage is represented by over 450 m thick *Davaolan suite* and bottom part of *Baysal suite* built by clayey-siliceous, bituminized and algal-detrital limestones and distinguished within the volumes of *Neoschwagerina margaritae* and *Yabeina-Lepidolina* fusulinid zones.



Figure 9. Northern slopes of Gabaglychay valley. Limestones of Shahbulag suite (Upper Murgab substage of Upper Permian)

Davaolan suite (named after Davaolan valley) was distinguished in 1981 by A.B.Mammadov and H.I.Aliyev. It corresponds to *Arpachay suite* situated in the neighboring district of Armenia. The suite's stratotype is located at the beginning (northeastern slope) of Deveolen valley with outcrops also detected in the areas of Ardyj, Zarlidara, Mighridarasi, Gumushludara, Munhbalaoglu, Hoja Ahmad, Yayjydarasi, Khyrmanjyg, Gabagyal (Figure 10), Baysal, Hamzali, Kechaltapa, Gabaglychay, etc., 70–240 m thick suite is built by an alternation of grey and dark-grey massive and heavy-bedded clayey-siliceous, algal-detrital limestones. The suite conformably overlies Shahbulag suite's deposits and is overlapped by the Baysal suite. Davaolan suite is faunistically distinguished within the volumes of *Neoschwagerina margaritae* and *Yabeina-Lepidolina* fusulinid zones or *Yangchienia thompsoni* and *Chusenelia abichi* local fusulinid zones. Besides fusulinids, its' section also contains remnants of various foraminifers, tetracorals and brachiopods. Following remnants are detected within the suite's section: fusulinids – *Yangchienia thompsoni* Skin. et Wilde, *Chusenella alpina* (Koch.-Dev.), *Ch. ex gr. tingi* Chen, *Ch. soffja* Ched., *Ch. cheni* Skinner et Wilde, *Ch. dorashamensis* Rozov., *Ch. ellipsoidalis* (Wang, Sheng et Zhang), *Ch. referta* Skin. et Wilde, *Ch.*



ex gr. *caucasica* Ched., *Ch. abichi* M.-Macl., *Ch. sinensis* Sheng, *Ch. cf. ishanensis* Hsu, *Ch. longa* Rozov., *Ch. ventricosa* Rozovsk., *Ch. nana* Sheng, *Ch. gubleri* Stewart, *Ch. ex gr. glenisteri* Skin. et Wilde, *Ch. brevis* Rozov., *Ch. caucasica* Ched., *Pseudofusulina* sp., *Rugosofusulina* spp., etc.; brachiopods – *Chonostegoides armenicus* Sar., *Ch. ogbinensis* Sar., *Krotovia jisuensiformis* Sar., *Ogbinia dzhagrensis* Sar., *Richtofenia lawrenciana* (Kon.), *Orthotetina vediensis* Sok., *Orthotichia avushensis* Sok., *Marginifera magniplicata* (Huang), *Lepetodus nobilis* (Waag.), *Septospirigerella baissalensis* Grunt, *S. aplanata* Grunt, *Phricodothyris asiatica* (Chao), *Permorphricodothyris ovata* Pavl., etc.; tetracorals – *Ufimia elongata* (Huang), *Uf. elongata* (Grabau), *Uf. alternata* (Huang), *Uf. ex gr. rectum* Zhao, *Pseudohuangia* (?) sp., *Ipciphyllum persicum* (Douglas), *Ipc. flexuosum* (Huang), *Ipc. armenicum* (Dobr.), *Ipc. grandicolumnarium* Kropatcheva, *Ipc. subtimoricum* (Huang), *Ipc. ex gr. subtimoricum* (Huang), *Ipc. subelegans* Minato et Kato, *Ipc. ex gr. stabilis* Zhao, *Ipc. persicum* (Douglas), *Ipc. flexuosum* (Huang), *Ipc. subelegans* Minato et Kato, *Ipc. armenicum* (Dobr.), *Ipc. grande* Kropatcheva, *Wentzellophyllum (Armeniaphyllum) armenicum* Kropatcheva, *W. densicolumnatum* (Iljina), *W. (?) ex gr. jenningsi* (Douglas), *W. vediense* Kropatcheva, *W. geranosense* Kropatcheva, *Polythecalis ex gr. variabilis* Gerth, *P. ex gr. jangtzeensis* Huang, *Szechuanophyllum armenicum* Kropatcheva, *Chusenella abichi*, *Lasmophyllum giganteum* Kropatcheva, *Szechuanophyllum transcaasicum* Kropatcheva, *Sz. armenicum* Kropatcheva, etc.; small foraminifers – *Lasiotaxularia thorax* (Lange), *Climacammina plurilocellata* A.Nikit., *C. tudicla* Lange, *C. valvulinoides* Lange, *Endothyra minima* Lange, *Neoendothyra bronnimanni* Boz., *N. compressa* Sosn., *N. dzuongi* Hung, *N. ornata* Sosn., *N. langsonensis* Hung, *N. caobangensis* Hung, *Postendothyra micula* (Sosn.), *P. novizkiana* (Sosn.), *Globivalvulina vonderschmitti* Reich., *G. graeca* Reich., *Para-*

globivalvulina mira Reitl., *Tetrataxis* sp., *Abadehella biconvexa* Okim. et Ishii, *Pseudomodiscus baissalensis* (G.Pron.), *Multidiscus padangensis* (Lange), *M. arpaensis* G.Pron., *Nodosaria ustritskii* Soss., *Geinitzina gigantea* K.M.-Maclay, *G. richteri* K.M.-Macl., *Pachyphloia stricta* Sosn., *P. minutissima* Sosn., *P. gracilis* Sosn., *Rectoglandulina ex gr. guttula* Karav., *Reitlingeria vediensis* G.Pron., *Ichtyofrondina cuneata* (Sosn.), *Pseudolangella pulchra* G.Pron., *P. filumiformis* G.Pron., *P. dzhagadzurenensis* G.Pron., *P. Geranos-sensis* G.Pron., *Partisania* sp., etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 1999).



Figure 10. Southern slopes of Gabagyal Mountain. Limestones of Deveolen suite (Lower Midiya stage, Upper Permian)

Julfa regional stage is represented by the upper part of *Baysal* suite, *Julfa* suite and lower part of *Akhura* suite. Cites suites are built by an alternation of argillites with limestones and distinguished within the volumes of *Araxoceras latum* and *Vedioceras ventroplanum* ammonoidea zones.

Darasham regional stage is represented by the upper part of *Akhura* suite and the *Darasham* suite, both built by argillites with scattered interlayers of concretionary limestones, and distinguished within the volumes of *Phisonites triangulus*, *Iranites transcaucasus*, *Dzhulfites spinosus*, *Shevyrevites shevyrevi*,

Paratirolites kitti and *Pleuronodoceras occidentale* lones of ammonoideas.

Baysal suite (named after Baysal Mountain) was distinguished in 1981 by A.B.Mammadov and H.I.Aliyev. It corresponds to *Khachik suite* located in the neighboring district of Armenia. The suite's stratotype is confined to the southwestern slope of Baysal Mountain. Outcrops are also detected along slopes of Gabagyal, Khyrmanjyg, Ardyj and Kechaltapa mountains, Shahbulag village's vicinities, Deveolen and Gabaglychay valleys (Figure 11). Complex conformably overlies the Davaolan suite's formations and gets conformably overlapped by the Akhura suite's deposits. It also forms basement of the Julfa valley's Permian section. The suite's stratotype section is built by an alternation of grey, dark-grey and black, heavily bituminized, algal-foraminiferal and detrital limestones with the interlayers of grey and yellowish-brown argillites, sandstones and siltstones. Middle successions of up to 200 m thick suite are predominantly built by argillites, while the top layer is composed of limestones. In Julfa valley, the suite's bottom is covered by deluvial deposits.



Figure 11. Northern slopes of Gabaglychay valley. Outcrop of Baysal suite (Upper Midiya and Lower Julfa regional stages of Upper Permian)

Baysal suite is faunistically distinguished within volume of the upper part of *Yabeina-Lepidolina* fusulinid zone. Lower successions

are confined to *Baisalina puichra* and *Hemigordiopsis orientalis*, the upper ones – to *Midiella irregulariformis-Orthotetina azarjani* and *Pseudodunbarula arpaensis-Araxilevis intermedius* local foraminifer lones. Besides foraminifers, the suite's section also contains various remnants of fusulinids, tetracorals, brachiopods and conodonts. According to lithological and faunistic characteristics the suite is divided into *Lower* and *Upper Baysal subsuites*.

Lower Baysal subsuite is faunistically distinguished within the volumes of *Baisalina puichra* and *Hemigordiopsis orientalis* local foraminifer lones. 90–140 m thick subsuite is built by an alternation of dark-grey and black, heavily bituminized, algal-foraminiferal and detrital limestones with grey and yellowish-brown argillites. Fusions of flint are detected in limestones. Middle successions are predominantly built by argillites while the lower part of the section contains interlayers of sandstone and siltstone. Following remnants are detected in the subsuite's formations: small foraminifers – *Globivalvulina vonderschmitti* Reich., *G. graeca* Reic., *G. decrouezae* Koy. et Alt., *G. cyprica* Reich., *Paraglobivalvulina mira* Reitl., *P. gracilis* Zan., Alt. et Cat., *Abadehella* sp., *Pseudoammodiscus* ex gr. *kinkelini* (Spand.), *Okimuraites planus* (G.Pron.), *Baisalina pulchra* Reitl., *B. globosa* Wang, *Pseudobaisalina mirifica* Sosn., *Kamurana broennimanni* Alt. et Zan., *Agathammina pusilla* (Geinitz), *A. bella* G.Pron., *A. multa* G.Pron., *Pachyphloia gracilis* Sosn., *P. ex gr. prolifica* Sosn., *Ichtyolaria permotaurica* Civr. et Dess., *Fronidina permica* Civr. et Dess., *F. turris* G.Pron. *Langella conica* Civr. et Dess., *Pseudolangella fabaeformis* G.Pron., *Rectoglandulina pygmaeformis* M.-Macl., *R. gerkei* Sosn., *Dentalina* sp., *Robuloides lens* Reich., *R. elegans* G.Pron., *Eomarginulinella cubiformis* Sosn., *Partisania* sp., *Olympina* (?) sp., *Deckerella* sp., *Endothyra minima* Lange, *Neoendothyra broennimanni* Boz., *Hemigordiopsis orientalis* (Wang et Sun), *H. irregularis* (Wang et Sun), *Neodiscus* sp., etc.; fusulinids – *Pseudofusulina solita* Skin. et Wilde, *P. aff. mo-*



toyochiensis Mor., *Neoschwagerina pinguis* Skin., *Chusenella schwagerinaeformis* Sheng, *Ch. tingi* Chen, *Ch. dorashamensis* Rozov., *Ch. referta* Skin. et Wilde, *Ch. liangshanensis* Sheng, *Ch. ex gr. tingi* Chen, *Kahlerina* ex gr. *africana* Skin., *K. ex gr. sinensis* Sheng, *K. sp.*, *Reichelina* sp., *Nankinella* sp., *Staffella* sp., *Leella* sp., *Sphaerulina* sp., etc.; tetracorals – *Waagenophyllum indicum* (Waag. et Wontz.); brachiopods – *Rhipidomella (Rhipidomella) veldensis* Bok., *Orthotetina arakeljani* Sok., *Chonostegoides baissalensis* Sok., *Spirigerella* ex gr. *derbyi* Waag., *Septospirigerella megridagica* Grunt, *S. aplanata* Grunt, *S. baissalensis* Grunt., etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 1999).

Upper Baysal subsuite is faunistically distinguished within the volumes of *Midiella irregulariformis-Orthotetina azarjani* and *Pseudodunbarula arpaensis-Araxilevis intermedius* local foraminifer zones. 15–60 m thick suite is built by light-grey, grey, dark-grey and black medium-to-heavy bedded (massive) algal-foraminiferal and detrital limestones with the interlayers of argillites. Following remnants are detected: small foraminifers – *Paraglobivalvulina gracilis* Alt. et Zan., *P. mira* Reitl., *Dagmarita chanakchiensis* Reitl., *Midiella irregulariformis* (Zan., Alt. et Cat.), *M. zaninettiae* (Alt.), *M. sigmoidalis* (Wang), *M. broennimanni* (Alt.), *Hemigorduis* ex gr. *reicheli* Lys, *H. spp.*, *Kamurana broennimanni* Alt. et Zan., *Froncina permica* Civr. et Dess., *F. appressaria* Sosn., *Rectoglandulina pygmaeformis* M.-Macl., *Langella pulchra* (Lange), *Colaniella* cf. *minima* Wang, *Robuloides acuminatus* Sosn., etc., rarely *Calvezina* aff. *ottomana* Civr. et Dess., *Astacolus* sp. 2, *Abadehella coniformis* Okim. et Ishii, *Nodosaria mirabilis caucasica* K.M.-Macl., *N. longissima camerata* K.M.-Macl., *N. planocamerata* Sosn., *Pseudotristix solida* Reitl., *Cryptoseptida anatoliensis* Civr. et Dess., *Froncina parvula* G.Pron., *Langella ocarina* Civr. et Dess., etc.; fusulinids - *Schubertella* sp.,

Codonofusiella kueichowensis Sheng, *C. kwangsiana* Sheng, *C. ex gr. kwangsiana* Sheng, *C. tenuissima* Sheng, *C. schubertelloides* Sheng, *C. ussuriensis* Toum., *C. golubinensis* Sosn., *C. lipovensis* Sosn., *C. parva* Sosn., *C. dzhulfensis* Rauser, *C. erki* Rauser, *C. aksuensis* Ched., *C. iniqua* Ched., *C. dzhagrensis* Ched., *C. nana* Erk, *C. explicata* Kawano, *C. paradoxica* Dunb. et Skin., *C. aff. sphaerica* Sosn., *C. cf. lui* Sheng, *C. aff. japonica* Morik., *C. ex gr. golubinensis* Sosn., *C. (?) sp.*, *Ogbinella ogbinensis* Ched., *O. avushensis* Ched., *O. ardaglensis* Ched., *Boultonia* ex gr. *willsi* Lee, *B. sp.*, *Pseudodunbarula arpaensis* Ched., *Ps. dzhagadzurenensis* Ched., *Ps. minima* (Sheng), *Ps. sp.*, *Nanlingella* aff. *palaeofusulinaeformis* Sheng, *Reichelina* ex gr. *minuta* Erk, *R. aff. changshingensis* Sheng et Chang, *R. tenuissima* K.M.-Macl., *R. sp.*, *Nankinella* sp., *Staffella* sp., *Codonofusiella schubertelloides* Sheng, *C. dzhulfensis* Rauser, *C. erki* Rauser, *C. kwangsiana* Sheng., etc.; tetracorals – *Waagenophyllum indicum* (Waag. et Wontz.), *Pentaphyllum dzhulfense* (Iljina), *Pentamplexus leptonicus* (Abich); brachiopods – *Enteletina ruzhencevi* (Sok.), *Orthotetina peregrina* (Abich), *O. dzhulfensis* (Sok.), *Tschernyschewia typica* (Stoy.), *Araxilevis intermedius* (Abich), *Spinomarginifera helica* (Abich), *Araxathyris araxensis* Grunt, *Compressoproductus djulfensis* (Stoy.); conodonts – *Clarkina bitteri* (Koz.), *C. leveni* (Koz., Mostl. et Pjat.), *Merrillina divergens* (Rend. et Stopp.), *Stepanovites dobruskiniae* Koz. et Pjat., etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др. 1982; Геология Азербайджана, 1999).

Akhura suite (named after Akhura village) was distinguished in 1975 by E.Y. Leven. Its stratotype is located 1.5 km to the north of Akhura village on the southern slope of Baysal mountain. Suite's outcrops are also detected in Havush village's vicinities and along the slopes of Gabagyal, Khyrmanjyg, Ardyj and Kechaldagh heights. Parastratotype (Julfa suite) is located in Julfa valley, having slightly different lithological composition and faunistic complex.

The suite's stratotype section is built by an alternation of colourful argillites and limestones. Depending on section, the complex's thickness varies between 20–50 m. Akhura suite's formations conformably overly the Baysal suite and are overlapped by Garabaghlar suite's deposits.

Faunistically Akhura suite is distinguished within the volumes of *Araxoceras latissimum* and *Vedioceras ventrosulcatum* local ammonoidea zones in the lower part, and *Phisonites triangulus*, *Iranites transcaucasus*, *Dzhulfites spinosus*, *Shevyrevites shevyrevi*, *Paratirolites kitti* local ammonoidea zones in the top. Besides ammonoideas, the suite's section also contains remnants of various foraminifers, brachiopods and conodonts. According to lithological and faunistic characteristics the suite is divided into *Lower* and *Upper Akhura* components.

Lower Akhura subsuite is faunistically distinguished within the volumes of *Araxoceras latissimum* and *Vedioceras ventrosulcatum* local ammonoidea zones. 10–30 m thick complex is built by grey, light-grey and brick-red, finely and medium-bedded marly limestones with the interlayers of brick-red and brick-brown argillites. Following remnants are detected in the subsuite's section: ammonoideas – *Kingoceras achurense* Yu.Zakh., *Araxoceras* sp., *Avushoceras jakowlewii* Ruzh., *Vescotoceras* sp., *Vedioceras umbonovarum* Ruzh., *V. ventrosulcatum* Ruzh., *Prototoceras tropitum* (Abich), *Pseudogastrioceras abichianum* (Moell.), *Avushoceras jakowlewii* Ruzh., *Pseudotoceras admirabile* Rost. et Azar.; brachiopods – *Araxathyris araxensis* Grunt, *Ar. minor* Grunt, *Orthotetina peregrina* (Abich), *Spinomarginifera spinosocostata* (Abich), *Compressoproductus djulfensis* (Stoy.), *Leptodus nobilis* Waag.; conodonts – *Neogondolella leveni* Koz., Most. et Pjat., *N. planate* Clark, *N. orientalis* Barsk. et Kor. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Геология Азербайджана, 1999).

Upper Akhura subsuite is faunistically distinguished within the volumes of *Phisonites tri-*

angulus, *Iranites transcaucasus*, *Dzhulfites spinosus*, *Shevyrevites shevyrevi*, *Paratirolites kitti* local ammonoidea zones. Its' 10–20 m thick section is constituted by coffee-coloured, brown, brick-red and brick-brown clays and argillites with the interlayers of grey and brownish-red limestones. Following remnants are detected: ammonoideas – *Xenodiscus* sp., *X. dorashamensis* Shev., *Iranites* sp., *Phisonites* (?) sp., *Shevyrevites shevyreviteich* et Kumm., *Abichites* sp., *A. stoyanowi* (Kip.), *A. mojsisovicsi* (Stoy.), *Pseudogastrioceras abichianum* (Moell.), *Paratirolites waageni* (Stoy.), *P. vendiensis* Shev., *P. trapezoidalis* Shev., *P. dieneri* Stoy., *Synoceltites* (?) *minutus* Yu.Zakh.; brachiopods – *Araxathyris minor* Grunt; conodonts – *Neogondolella planate* Clark, *N. orientalis* Barsk. et Kor., *N. subcarinata* Sweet, *Hindeodus parvus* Koz. et Pjat., *Lopingoceras* sp., etc.; foraminifers – *Neoendothyra* sp. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Геология Азербайджана, 1999).

Julfa suite (named after Julfa valley) was distinguished in 1963 by A.D.Miklukho-Maklay. Its' stratotype is located in Julfa valley to the north of Darasham-II railway station. Outcrops are detected only in Darasham-I and Darasham-II stations. The suite corresponds to *Akhura suite* located in the northwest of Nakhchivan AR, but has different lithological and faunistic characteristics. Its' 40–50 m thick stratotype section is built by greenish and dark-grey schist-like argillites with the interlayers of yellowish pelitomorphic limestones. Julfa suite conformably overlies Baysal suite's limestones and is overlapped by Darasham suite's formations.

Julfa suite is faunistically distinguished within the volume *Pseudodunbarula arpaensis-Araxilevis intermedius* (foraminifers) local zone in the bottom, *Araxoceras latissimum* (ammonoideas) local zone in the middle, and *Vedioceras ventrosulcatum* (ammonoideas) local zone on the top. Besides foraminifers and ammonoideas, the suite's section also contains remnants of various tetracorals, brachiopods, ostracods, fusu-



linids, conodonts and crinoids, including: small foraminifers – *Eotuberitina reitlingerae* M.Macl., *Abadehella* (?) sp., *Robuloides* aff. *acutus* Reich., *R. lens* Reich., *R. aff. aequalis* Sosn., *Hemigordius admirabilis* G.Pron., *Nodosaria armeniensis* Efim., *N. transcaucasica* G.Vuks, *N. piricamerata* Efim., *N. mirabilis caucasica* K.M.-Macl., *N. chivatshensis* Karav., *Geinitzinita* sp., *G. sosninae* G.Vuks, *Neoendothyra* sp., *N. stricta* G.Vuks, *Paradagmarita flabelliformis* Zan. et Alt., *Pachyphloia cukurkoyi* Civr. et Dess., *Pseudolangella* sp., *Pseudotristix* sp., *Froncina palmata* (Wang), *Rectoglandulina* aff. *subsphaerica* Sosn., *Frondicularia* (?) *composita* Karav., etc.; fusulinids – *Codonofusiella* sp., *Pseudodunbarula* sp., *Reichelina* sp.; *R. media* M.Macl., *R. tenuissima* M.Macl., etc.; ammonoideas – *Pseudogastrioceras abichianum* (Moell.), *Vescotoceras parallelum* Ruzh., *V. acutum* Ruzh., *V. possoides* (Abich), *Araxoceras latum* Ruzh., *A. latissimum* Ruzh., *A. trochoides* (Abich), *Urartoceras abichianum* Ruzh., *Prototoceras tropitum* (Abich), *P. discoidale* Ruzh., *P. djulfense* (Abich), *P. admirabile* Rost. et Azar., *Vedioceras umbonovarum* Ruzh., *V. cf. ogbinensis* Ruzh., *V. ventrosulcatum* Ruzh., etc.; brachiopods – *Orthotichiaminuta* Sok., *Orthotetina peregrina* (Abich), *O. dzhulfensis* Sok., *Orthotichia dorashamensis* Sok., *Or. minuta* (Abich), *Or. dorashamensis* Sok., *Oldhamina transcaucasica* (Stoy.), *Tschernyschewia typica* Stoy., *araxilevis intermedius* (Abich), *Spinomarginifera spinosocostata* (Abich), *S. helica* (Abich), *S. ciliata* (Abich), *Compressoproductus djulfensis* Sar., *Permophricodothyris ovata* Pavl., *Araxathyris araxensis* Grunt, *A. intermedius* (Abich), *A. protea* (Abich), *A. lata* Grunt, *Notothyris djoulfensis* (Abich), *Wellerella arthaberi* Tschern., *W. arthaberi* Tschern., *W. dorashamensis* Sok., *Notothyris djoulfensis* (Abich), *Haydenella minuta* Sar., *Haydenella minuta* Sar., *Leptodus nobilis* Waag., *L. cf. nobilis* Waag., etc.; ostracods – *Amphissites notabilis* Bel., *Bairdia hassi* Sohn., *B. araxensis* Bel., *B. diffusa* Bel., *B. anbeedei* Bel., *Hol-*

linella tuberculata Bel., *Orthobairdia?* cf. *gualupiana* Hamil., *Fabalicypriis* cf. *geinitziana* (Jon.), *F. cf. permica* Bel., *F. hexabarensis* Harl., *Microcheilinella* aff. *speciosa* Chen., etc.; tetracorals – *Pentaphyllum dzhulfense* (Iljina), *P. ex gr. excentricum* (Iljina), *P. araxense* Krop., *P. dzhulfense* (Iljina), *P. excentricum* (Iljina), *P. brevisseptum* (Iljina), *P. araxense* Krop., *P. clavatum* (Iljina), *P. ex gr. antractum* (Iljina), *Pentamplexus leptoconicus* (Abich), *P. minimus* (Iljina), *Ufimia* sp., *U. stepanovi* (Flug), *U. iljinae* (Flug.), etc.; conodonts – *Clarkina bitteri* (Koz.), *Cl. leveni* (Koz., Most. et Plat.), *Cl. planata* Clark, *Cl. aristovi* (Pjat.), *Cl. orientalis* (Bars. et Kor.), *Cl. carinata* (Sweet), *Hindeodus typicalis* (Sweet), *H. minutus* (Ellis.), *H. julfensis* (Sweet), *Stepanovites obruskinae* Koz. et Pjat., *Amphissites notabilis* Bel., *Bairdia hassi* Sohn., *B. diffusa* Bel., *B. cf. araxensis* Bel., *Diplognathodus movschovitschi* Koz., *Iranognathus tarazi* Koz., Most. et Pjat., etc.; crinoids – *Erisocrinus araxensis* Yakovlev, etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Геология Азербайджана, 1999).

Darasham suite (named after Darasham railway station) was distinguished in 1983 by G.V.Kotlyar. Its' stratotype is located in Julfa valley to the north of Darasham-II railway station. Outcrops are detected only in Darasham-I and Darasham-II stations. Its' 30–35 m thick stratotype section is built by colourful argillites with the interlayers of concretionary limestones. Darasham suite conformably overlies Julfa suite's argillites and is overlapped by Lower Triassic Garabaghlar suite.

Darasham suite is faunistically distinguished within the volumes of *Phisonites triangulus*, *Iranites transcaucasus*, *Dzhulfites spinosus*, *Shevyrevites shevyrevi*, *Paratirolites kitti*, *Pleuronodoceras occidentale* local ammonoidea zones. Besides ammonoideas, its' section contains remnants of various foraminifers, brachiopods, conodonts, ostracods, tetracorals, partly trabulatas and gastropods. Following remnants are detected in the suite's section: ammonoideas – *Pseudogastrioceras abichianum* (Moell.),

Xenodiscus araxensis Shev., *X. dorashamensis* Shev., *Phisonitstriangulus* Shev., *Iranites transcaucasius* (Shev.), *Dzhulfites* sp.?, *D. spinosus* Shev., *D. nodosus* Shev., *Shevyrevites shevyrevi* Teichert et Kummel, *Sh. sp.*, *Paratrolites waageni* (Stoy.), *P. kittli* Stoy., *P. waageni* (Stoy.), *P. vediensis* Shev., *P. trapezoides* Shev., *P. dieneri* Stoy., *Abichites stoyanowi* (Kipar.), *A. mojsisovicshi* (Stoy.), etc.; ostracods – *Bairdia anbeedei* Bel., *Fabalicypriis hoxabarensis* Harlton, *F. obunca* Bel., *F. hoxabarensis* Harlton, *F.?* *subgeinitziana* Bel., *Moorites* sp., *Hollinella cushmani* Kell., *Polycoppe* aff. *perminuta* Kell., *P. aff. ornata* Kotsch., *Healdianella dorashamensis* Bel., *H. splendida* Bel., etc.; conodonts – *Clarkina subcarinata* (Sweet), *Cl. orientalis* (Barsk. et Kor.), *Cl. planata* (Clark), *Hindeodus julfensis* Sweet., *H. minutus* (Ellis), *H. tyricalis* (Sweet), *H. cf. turgidus* Koz., Mostl. Et Rah.-Yazd, *H. cf. parvus* Koz. et Pjat., *H. sp.*, *Neogondolella subcarinata* Sweet, *N. orientalis* Barsk. et Kor., *N. deflecta* (Wang et Wang), *N. aristovi* Pjat., *N. aff. changxingensis* (Wang et Wang), *Xenodiscus* sp. nov., *Spinomarginifera* cf. *pygmeea* Sar., *Claraia* sp., etc.; foraminifers – *Glomospira* sp., *Nodosaria* sp., *N. ex gr. hoi* (Trif.), *Geinitzina* sp., *Lingulonodosaria* sp., *Lingulina* sp., *Rectoglandulina* sp., *R. micula* G.Pron., *Neoendothyra parva* (Lange), *Hemigordius changxingensis* Wang, *Streblospira minima* G.Vuks, etc.; tetracorals – *Pentaphyllum* sp., *Ufimia* cf. *differentiata* (Iljina), *Pentamplexus* sp., *P. leptoconicus* (Abich), *P. minimus* (Iljina), *Ufimia differentiata* (Iljina); brachiopods – *Comelicania triangularis* Grunt, *Janiceps janiceps* (Stache), *Araxathyris minor* Grunt., *Haydenella minuta* Sar.; tabulatas – *Michelinia vaga* Tchud., *M. parva* Tchud.; gastropods – *Bellerophon?*, *Hindeodus turgidus* Koz., Most. et Rah.-Yazd, *H. cf. parvus* Koz. et Pjat. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Геология Азербайджана, 1999).

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NAXÇIVAN QIRIŞIQLIQ VİLAYƏTİNİN ÇÖKMƏ MADDİ KOMPLEKSLƏRİNİN MÜASİR STRATIQRAFİK BÖLGÜSÜ ÜZRƏ OÇERKLƏRİ OÇERK I – PROTEROZOY VƏ PALEOZOY

A.B. Məmmədov, T.N. Kəngərli, Ş.Ə. Babayev, H.İ. Əliyev

Məqalədə Azərbaycanın cənub-qərb regionu olan Naxçıvan Muxtar Respublikasının geoloji quruluşunda iştirak edən Paleozoy struktur-maddi kompleksinin son tədqiqat və ümumiləşdir-mələr nəticəsi kimi müasir Beynəlxalq Stratiqrafik Cədvəl əsasında yerli bölgüsü, ayrılan stratiqrafik vahidlərinin təsviri və paleontoloji əsaslandırılması verilmişdir. Həmçinin müxtəlif litoloji-stratiqrafik komplekslərin əmələgəlməsində paleogeodinamik və paleocoğrafi faktorların təsiri qısa şəkildə işıqlandırılmışdır. Bu məlumatlar ilk dəfə olaraq ingilis dilində təqdim edilir və Cənubi Qafqazda yerin səthinə çıxan Paleozoy çöküntülərinin litologiya və stratiqrafiyası ilə maraqlanan beynəlxalq geologiya ictimaiyyətinin nümayəndələri üçün yığcam və dolğun məlumat bazası kimi qəbul edilə bilər.

ОЧЕРКИ ПО СОВРЕМЕННОМУ СТРАТИГРАФИЧЕСКОМУ РАСЧЛЕНЕНИЮ ОСАДОЧНО-МАТЕРИАЛЬНЫХ КОМПЛЕКСОВ НАХЧЫВАНСКОЙ СКЛАДЧАТОЙ ОБЛАСТИ ОЧЕРК I – ПРОТЕРОЗОЙ И ПАЛЕОЗОЙ

А.Б. Маммедов, Т.Н. Кенгерли, Ш.А. Бабаев, Г.И. Алиев

В статье по материалам последних исследований и обобщений на базе современной Международной Стратиграфической Шкалы дается описание и палеонтологическое обоснование местных стратиграфических подразделений палеозойского структурно-вещественного комплекса, участвующего в геологическом строении Нахчыванской Автономной Республики – юго-западного региона Азербайджана. Помимо этого, приводятся краткие сведения о воздействии палеогеодинамических и палеогеографических факторов на формирование различных литолого-стратиграфических комплексов. Эти данные, впервые представляемые на английском языке, могут послужить сжатой, но насыщенной базой данных для представителей международной геологической общественности, интересующихся литологией и стратиграфией палеозойских отложений, обнажающихся в пределах Южного Кавказа.

ESSAYS ON MODERN STRATIGRAPHIC DIVISION OF SEDIMENTARY MATERIAL COMPLEXES OF NAKHCHIVAN OROGENESIS REGION Chapter II – Mesozoic

This article is the second one of the series of publications on the stratigraphy of the Nakhchivan Autonomous Republic. The work that is based on the modern International Chronostratigraphic Chart concisely differentiates and describes local sequences and grounds palaeontologically the local stratigraphic sub-divisions. It also offers the palaeogeodynamic and palaeogeographic factors that had stood behind the formation of the various Mesozoic structural substance complexes that contribute to the geological constitution of the area covered. Those data, published in English for the first time ever, add up to a rich lithology and stratigraphy database on the Triassic, Jurassic and Cretaceous pericontinental sediments of the Araz Structural Megazone, that is, the NW Block of the South Azeri Segment of the Central-Iranian Microcontinent. Such data as contained in this work can safely be used by overseas geologists interested in the South Caucasian geology and stratigraphy to underpin regional generalisations and stratigraphic correlations of the Mesozoic sequences.

Keywords: *Mesozoic, stratigraphy, palaeontology, a stratigraphic chart, a substance complex, lithology, a local stratigraphic sub-division, a sequence.*

Introduction

Problem statement. Presented article is the second in a series of articles devoted to the modern stratigraphy of the territory of Nakhchivan Autonomous Republic and is dedicated to lithologic and stratigraphic features of the Mesozoic deposits. Mesozoic material complexes which have relatively less developed on surficial geology aspect are spread in Arpachay and Jahrichay basins in Daralayaz range in the northwest, and in Daghustu (Daridagh) ridge and Kilit-Kotam area in Julfa canyon along the left bank of the Araz River in the south-east (Figure 1). They are represented by deposits of the Triassic, Jurassic (the lower and middle series) and Cretaceous (the upper series) systems. Lithological and paleontological features of these sediments have been revised by the authors, and taking into account rich data of the geological planning work and targeted research of the last 30 years, their new summaries have been carried out which covered stratigraphic units of both modern International stratigraphic

Sh.A. Babayev

Azerbaijan National Academy of Sciences,
Geology and Geophysics Institute,
H.Javid ave., 119, Az 1143, Baku, Azerbaijan
E-mail: shekhababayev@yandex.ru



T.N. Kangarli

Azerbaijan National Academy of Sciences,
Geology and Geophysics Institute,
H.Javid ave., 119, Az 1143, Baku, Azerbaijan
E-mail: gia@azdata.net



H.I. Aliyev

Azerbaijan National Academy of Sciences,
Geology and Geophysics Institute,
H.Javid ave., 119, Az 1143, Baku, Azerbaijan



table and the local division (Babayev, Kəngərli, Məmmədov, 2015). The materials reflected in this article are based on information of this summary.

Triassic

Within the geology aspects of the territory of the AR, the Triassic system is represented by its



carbonate- and partly terrigenous-facies lower, middle and upper series (average thickness is 1040 m, generalized maximum thickness is 1370 m) and is separated in the Arpachay and Jahrichay basins in the Daralayaz range in the north-west (in the south-east depression area of Sharur uplift) and in the Julfa canyon in the south-east (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др.; Аллахвердиев, Тарасова и др.; Геология Азербайджана, 2007; Халилов, 1978).

During the Triassic Era the territory of Nakhchivan AR situated between the Paleothetis, and the Neothetis that opened in the south-west. It was referred to the north-west edge of the South Azerbaijan segment (to Araz block) of the Central Iranian Plate within Kimmer (or Pont-South Caucasus-Iran) microcontinent distinguished by its subplatform tectonic regime and located in the southern shelf zone of the Paleo-

thetis. As in the Early and Middle Triassic here prevailed shallow sea conditions, mainly carbonate and partly terrigenous facies gathered here. As a result of the general rise in the closing process of the Paleothetis, sea gradually became shallow in the Anisian age of the Middle Triassic and was entirely drawn from the area at the end of the age. New transgression took place in the Carnian age of the Late Triassic and a thick dolomite and dolomitic limestone layer was formed in the occurred shallow salty basin. Finally, in the Early Kimmer phase of the tectogenesis, as a result of the gradual approach of the Kimmer and Eurasian continents to each other and of their collision, ocean waters were drawn from the north-west side of the Kimmer microcontinent at the end of the Triassic Era (end of the Norian age, and the Rhaetian ages) and the continental regime was established for a long time – until the Early Jurassic.

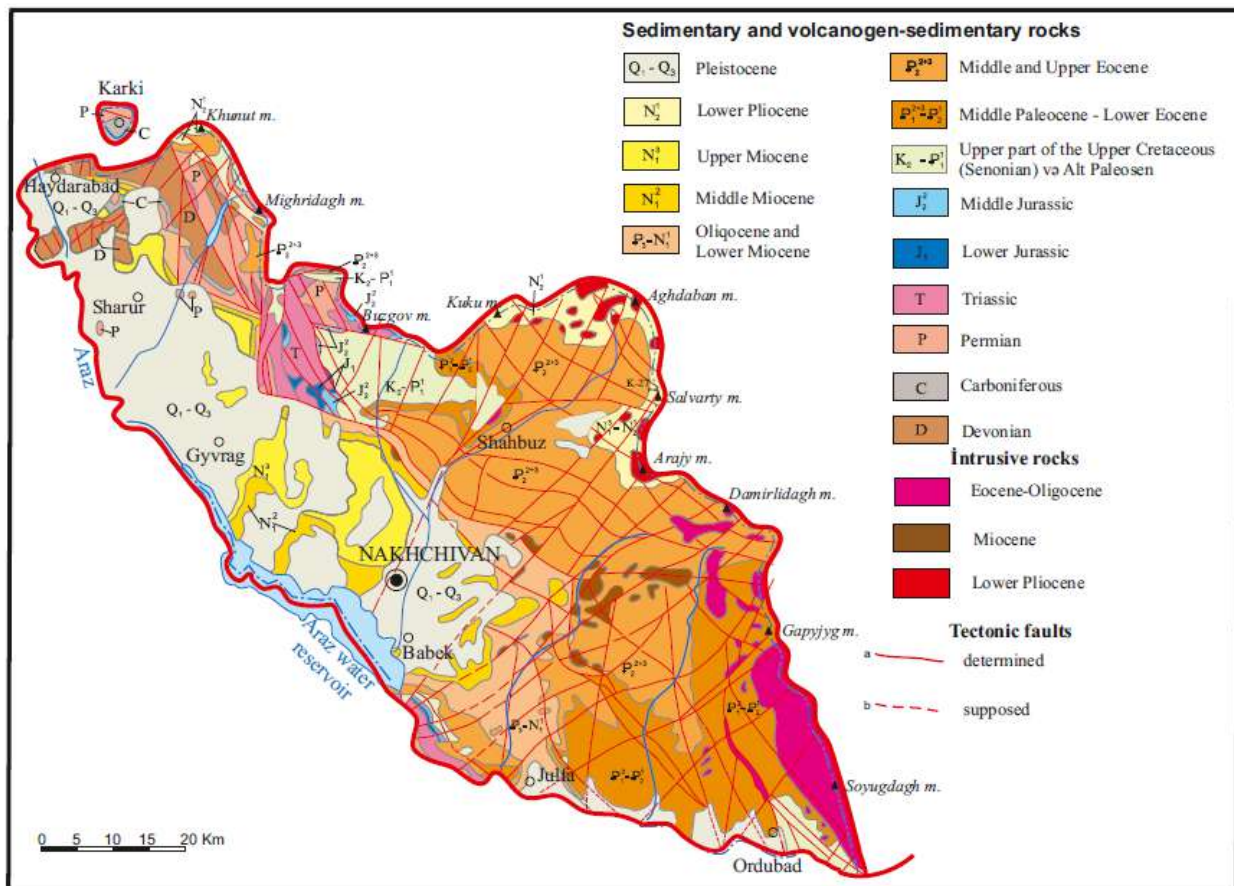


Figure 1. Geological map of the Nakhchivan Autonomous Republic. The person who compiled – T.N.Kangarli

Lithologic and stratigraphic features and fauna of the Triassic material system were studied and described in detail by G.Abikh, E.Moysisovich, F.Frekh, Q.Artqaber, P.Bonne, A.A.Stoyanov, K.N.Paffenholts, L.D.Kiparisova, A.M.Sadikov, K.O.Rostovtsev, Sh.A.Azizbayov, A.A.Shevirev, T.A.Qrunt, T.Q.Saricheva, V.N.Shimanski, T.A.Hasanov, M.İ.Rustamov, F.A.Mustafayev, H.I.Aliyev, Q.I.Allahverdiyev in different years. Collected paleontological materials were defined by L.D.Kiparisova, A.N.Krishtofovich, V.D.Prinada, V.N.Robinson, K.O.Rostovtsev in different years.

Lower Triassic

Within the geology aspects of the territory of Nakhchivan AR, the Lower Triassic period is presented through its both stages (Induan and Olenekian) and is represented by carbonate-facies *Garabahglar suite* which has maximum thickness of more than 400 m. **The Induan stage** is composed of colorful limestones (65–170 m) located at the base of the suite and the **Olenekian stage** is composed of grey, light-grey, partly dolomitized limestones (195–250 m) that form the rest of its section.

Garabahglar suite (according to the Garabahglar village) was named in 1973 by K.O.Rostovtsev. Stratotype is situated 3 km to the northeast of the Garabahglar village in the south-western slope of Bazakli Mountain (Figure 2). Its major outcrops are tracked in the Gabaglychay River basin (in vicinities of Akhura və Havush villages), in Mt. Kechaltapa and in Subuzdagh (Buzgov) ridge separating from it towards the east, in the part of Daralayaz range between Tananam and Garabahglar villages. Minor outcrops are detected on the western and south-western slopes of Mt. Gabagyal and Mt. Baysal, in the upper reaches of the small Davaolandara Brook (to the south of Mt. Ardyj) and in the Mehridarasi area. Also is opened in the north-east wing of the cognominal uplift in the Julfa canyon in the south-east (parastratotypic section). The suite with nonevident unconformities overlies the Upper Permian

formations of the Akhura and Darasham suites and gets conformably overlapped by the Ardaghy suite of the Middle Triassic. The Garabahglar suite is divided into three components: 1 – the lower subsuite confined to the Induan and Lower Olenekian substages and represented by mainly thin-bedded fucoid limestone; 2 – the middle subsuite confined to a lower segment of the Upper Olenekian substage and built by heavy-bedded massive limestone; 3 – the upper subsuite confined to the upper part of the Upper Olenekian substage and mainly represented by dolomitized limestone. Depending on the sections, the suite's thickness varies between 260 and 420 m. This section stands out for its fauna of bivalves, ammonoideas and conodonts.



Figure 2. Northern vicinity of the Garabahglar village. Outcrop of the Lower Triassic aged Garabahglar suite

Lower Garabahglar subsuite is comprised of the alternation of reddish, pink, yellowish, grey and light-grey thin-bedded fucoidal, sometimes clayey and pisolitic limestones with sparse layers of sandy and dolimitic limestone, dolomite, chalky clay and shale clay. Depending on the sections, the suite's thickness varies between 75 and 190 m. The following fauna remains were found in this section: bivalves – *Glaraia clarai* Emm., *Cl. wangi* Patte, *Cl. stachei* Bitt., *Cl. aurita* Hauer, *Cl. cf. exclamata* Spath., *Cl. cf. dalpiasi* Leon., *Cl. intermedia* Bitt., *Cl. orbicularis* Pichth., *Cl. tredintina* Bittn., *Cl. stachei* Bittn.; ammonoidea – *Proptychites discoides* Waag., *Ophiceras* (*Lyth-*



ophioeras) facuntala Diener, *O. medium* Griesd., *O. sp. indet.*, *Anchignathodus parvus* Koz. et Bjat., *Guronites sp.* and etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 2007).

Middle Garabaghlar subsuite is represented by grey and light-grey massive, oolite limestones (35–60 m). This section stands out for the remains of bivalves: *Eumorphotis venetiana* Hauer., *E. reticulata* (Richth.), *E. spinicostata* Witt., *E. cf. inaequicostata* (Ben.), *E. cf. multiphormis* (Bittn.), *Anadontophora fassaensis* (Wissm.), *A. canalensis* Catulo, *Entolium microtis* Bittn., *Neoschizodus laevigatus* (Ziet.), *N. ovatus* (Goldf.), *Pseudocorbula cf. nuculiformis* (Zenk.), *Myophoria cf. ovata* Goldf., *Worthenia sp.*, *Omphaloptycha sp.* and etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 2007).

Upper Garabaghlar subsuite is comprised of the alternation of colorful clayey and pisolitic limestones with sparse layers of dolomitized limestone and dolomites. Depending on the sections, the suite's thickness varies between 150 and 170 m. Remains of bivalves were found in its section: *Eumorphotis cf. hinnitidae* (Bittn.), *E. venetiana* Hauer, *E. multiphormis* (Bittn.), *E. costata* (Witt.), *E. aff. granulatus* (Assm.), *Pseudocorbula cf. nuculiformis* (Zenk.), *P. cf. plana* (Hoh.), *Neoschizodus cf. ovatus* (Goldf.), *Anadontophora aff. isocardiodes* Frech., *A. canalensis* Catulo, *A. fassaensis*, *Omphaloptychia sp.*, *Worthenia sp.* and etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 2007).

Middle Triassic

Within the geology aspects of the territory of Nakhchivan AR, the Middle Triassic is only presented through its **Anisian stage** and is represented by terrigenous-carbonate facies *Ardaghy suite* which has maximum thickness of up to 150 m.

Ardaghy suite (according to the Ardaghy upland) was named in 1981 by H.I. Aliyev. Stratotype is situated on the northern slope of the Ardaghy high. Its outcrops are found in the north-west and western slopes of the Ardaghy, south-western slopes of the Hinadali, Garovultapa and Bazakli mountains, Gabaglychay basin (in vicinities of the Akhura və Havush villages), in the Subuzdagh (Buzgov) ridge, in the part of the Daralayaz range between Tananam and Garabaghlar villages, also in the upper reach of the small Davaolandara river (in the south from the Ardyj mountain). Parastratotypic outcrop is opened in the north-east wing of the Julfa uplift in the south-east of the Autonomous Republic (Figure 3).



Figure 3. Dolomites of the Upper Triassic aged Tananam suite which is opened in the slopes of Nehram valley in the north-east wing of the Julfa uplift. In the foreground – “Sphinx” rock consisting of eroded dolomites of the Ardaghy suite of the Middle Triassic

Stratotype and other sections are built by an alternation of dark- and greenish-grey, heavy-bedded, brecciate dolomitic limestone and silicic dolomites with clayey sandstones and layers of calcareous clay. Conformably overlies the Lower Triassic formations (Garabaghlar suite) and is transgressively covered with rocks of the Upper Triassic (Tananam suite). Depending on the sections, the suite's thickness varies between 50 and 150 m. Its section contains fauna of bivalves, ammonoideas and conodonts, including the following: *Undularia cf. scalata* Schloth., *Omphaloptychia sp.*, *Pleuromya sp.*, *Pleuromia*

sp., *Megalodon* aff. *rimosus* Münst., *Myophoropsis* cf. *nuculaeformis* Zenk., *Eumorphotis inaeguicostata* Ben., *E. venetiana* Hauer, *E. cf. hinnitidea* Ditt., *Anadontophora* aff. *brevieformis* Spath., *A. canalensis* Cat. and etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 2007).

Upper Triassic

Within the geological aspects of the Autonomous Republic, the Upper Triassic is presented through its Lower Carnian and (presumably) Middle (Norian) stages, represented by the carbonate-facies *Tananam suite* which has maximum thickness of up to 800 m. Rocks of **the Carnian stage** are the main part of the suite and **the Norian (?) stage** is represented by the upper part of the section.

The Tananam suite (according to Tananam village) was named in 1973 by K.O.Rostovtsev. Its stratotype is situated to the northeast of the Tananam village (Figure 4) and parastratotype in the Nehram valley (see Figure 3). The suite's major outcrops in the north-west are widely developed in the Gabaglychay and Jahrichay river basins, as well as in the vicinities of the Chalkhangala, Garabaghlar, Tananam, Akhura and Havush villages. The outcrops are also detected on the peaks and slopes of the Ardaghy, Hinadali, Remlar, Garovultapa, Anabad-Gadik, Garagush and Bazakli mountains. Minor outcrops are detected in the source of the Lizbirtchay (Salakhanbulag area) and in the upper reach of the small Davaolandara river (in the south from the Ardyj mountain). It also takes part in the geological section of the north-east wing of the cognominal uplift in the Julfa in the south-east. Is represented by grey and dark-grey, sometimes brownish-grey, heavy-bedded and massive, fractured, ferruginous, lightly siliceous hollow-bored dolomites and dolomitic limestones. The suite transgressively overlies the Lower (Garabaghlar suite) və Middle (Ardaghy suite) Triassic formations, with its eroded roof unconformably overlapped by various layers of Jurassic and Cretaceous formations. Depending on

the sections, the suite's overall thickness varies between 400 and 800 m. In the heel of its section includes remnants of rare *Undularia* cf. *scalata*, *Omphaloptycha* sp., *Pleuromya* sp. fauna and discovery of these remnants allows the suite to belong to the Upper Triassic.



Figure 4. North-east vicinity of the Tananam village. Dolomites of the Upper Triassic aged Tananam suite

Jurassic

Within the geological aspects of the Autonomous Republic, the Jurassic period is presented through its volcanic-origin lower and carbonate-terrigenous facies middle series (average thickness is 485 m, generalized maximum thickness is 775 m) and is separated in the Daralayaz range (in the area between Gabaglychay-Jahrichay) in the north-west and in the Julfa canyon in the south-east (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 2007; Геология Азербайджана, 2007).

Dry conditions prevailed between the Triassic and Jurassic systems in the territory of Nakhchivan AR. As a result of the stress and rifting occurred in the north at the beginning of the Jurassic period, the Mesotethys was founded. In the Early Jurassic epoch the Kimmer microcontinent separated into two parts with a deep rift and was divided into South Caucasus and Central Iranian Plates. This time the Iranian Plate which included Araz block where



the Nakhchivan AR territory belonged to separated from the South Caucasus Plate joined to the southern edge of Eurasia and as a result of the commissioning of the spreading process the Lesser Caucasus arm of the Mesotethys opened and consistently expanded. Compensating this expansion process, at the end of the Aalenian age along the northern edge of the basin (in the contact strip of the newly formed ocean and more ancient continental crust) began convergence and subduction process of the oceanic crust northward and lasted 90 million years until the Early Senonian age. At the same time, during the Jurassic-Neocomian epoch a series of effusive-radiolarite sediment of ophiolite association accumulated in the chair of ocean and subalkaline olivine tholeiite magmatism formations, which were the product of the continental rifting in the Early Jurassic, appeared within the Araz block of the South Caucasus segment of the Central Iranian Plate that corresponded to the southern coast of the basin. Afterwards – in the Middle Jurassic epoch here gathered smoothing sandy-clay sediments in shallow sea conditions but as a result of the rise and sea regression at the end of the Callovian era, dry conditions were established there until the Late Cretaceous period.

Lithologic and stratigraphic features and fauna of the Jurassic formations were thoroughly studied and described by P.Bonne, K.N.Paffenholts, B.P.Juze, Sh.A.Azizbayov, K.O.Rostovtsev, M.I.Rustamov, T.A.Hasanov, F.A.Mustafayev, Ch.G.Aliyeva, H.I.Aliyev, G.I.Allahverdiyev, Y.V.Karyakin and others in different years. Collected palaeontological materials in different years were determined by Sh.A.Azizbayov, D.Q.Aliyeva, T.A.Hasanov, I.R.Kakhadze, G.Y.Krimhols, K.O.Rostovtsev and others.

Lower Jurassic

Within the geological aspects of Nakhchivan Autonomous Republic, the Lower Jurassic epoch is presented through basalt formations and is represented by *Nehram suite* (according to

the Nehram railway station). It was called in 1986 by T.A.Hasanov. Spreading limited, these formations are opened in the eastern and north-eastern slopes of the Mt. Hinadali and Anabad-Gadik, Bazaklidara area and in vicinity of the Chalkhangala village in the north-west (Figure 5) and in the Julfa canyon, in the north-east wing of the cognominal uplift in the south-east. Its stratotype is situated in the Julfa canyon (Nehram ravine) and the parastratotype is situated in vicinity of the Chalkhangala village. In the stratotypic section it is comprised of sandstone and gravelites in the base part (10–16 m) and of plagioclase pyroxene, olivine, partly mandelstone basalts and diabase porphyrites stratified with tuff, tuff sandstone, tuff aleurolite, tuff gravelite, tuff breccia and tuff glomeration in the upper part. In the parastratotypic section picrite-dolerite, picrite-basalt, picrite-diabase, gabbro-diabase, diabase and diabase porphyrites in the lower part are gradually replaced with basalt porphyrite, andesit-basalt porphyrite, andesit prophyrite and siliceous rocks in the upper part. In the stratotypic section prevail lava-facies and in the parastratotypic section prevail piroclastic-facies rocks. Depending on the sections, the suite's overall thickness varies between 40 and 270 m.



Figure 5. Outcrop of the Lower Jurassic aged Nehram suite in the north-west edge of the Chalkhangala village

Middle Jurassic

Within the geological aspects of the Autonomous Republic, the Middle Jurassic is presented through its all series and is represented

by carbonate-terrigenous facies formations which have thickness of up to 800 m. Limitedly spreading, it is separated in the eastern and north-eastern slopes of the Mt. Hinadali, Garagush and Anabad-Gadik, in vicinity of the Chalkhangala village, in Bazaklidara, Salakhanbulag and Gazanyayla areas and eastern end of the Subuzdagh (Buzgov) ridge in the north-west and in the Julfa canyon, in the north-east wing of the cognominal uplift in the south-east.

The Aalenian stage is separated in the eastern and north-eastern vicinity of the Chalkhangala village, also in the Bazaklidara, Salakhanbulag and Gazanyayla areas in the north-west and in the Julfa canyon, in the north-east wing of the cognominal uplift in the south-east and is represented by the less-thick *Chalkhangala suite* which unconformably overlies the Triassic or Lower Jurassic formations, as well as which has tectonically brought into contact with them.

The Chalkhangala suite (according to the Chalkhangala village) was named in 1981 by H.I.Aliyev. Corresponds to the upper part of the Aalenian stage. Stratotype is situated in the north and north-east edge of the Chalkhangala village (Figure 6) and the parastratotype around the Nehram railway station in the Julfa canyon. In the stratotypical section it is comprised of the alternation of grey, yellowish-grey middle- and thick-layer coarse-grained quartz sandstone and lime-containing gravelites with layers of sparse sandy limestones (10–15 m). In the parastratotypic section it is represented by grey and greenish-grey medium-grained, micaceous and quartz sandstone and aleurolite in the lower part (12 m) and by greenish-grey tuff and tuff-sandstones in the upper part (12 m). Is conformably overlapped by the rocks of Babak suite of the Middle Jurassic. Depending on the sections, the suite's overall thickness varies between 10 and 35 m. The following fauna remnants were found in its section: pelecypoda – *Pholadomya*, *Ostrea*, *Mytiloides cinctus* (Goldf.), *Mytiloceramus amygdaloides* (Goldf.), *Syncyclonema spathulata* (Roem.), *Entolium* cf. *cingulatum* (Goldf.),

E. singulatum (Goldf.), *Ludwigia* sp.; foraminifers – *Lenticulina* cf. *toarcense* Payard., *L.* cf. *subculturata* (Mamont.), *Hypertamina* sp., *Conorboides* sp.; bivalves – *Chlamus ambigua* Münst., *Ctenostreon pectiniforme* Schloth., *Mytiloides cinctes* Goldf., *Ostrea*, *Pholadomya* fractures and etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 2007).



Figure 6. Outcrop of the Middle Jurassic aged Chalkhangala suite (Aalenian stage) in the north-east edge on the Chalkhangala village

Bajocian stage is separated in vicinity of the Chalkhangala village, in the eastern and north-eastern slopes of the Mt. Hinadali and Garagush, in the Salakhanbulag and Gazanyayla areas and in the eastern end of the Subuzdagh (Buzgov) ridge in the north-west and in the Julfa canyon, in the north-east wing of the cognominal uplift in the south-east. Is represented by lower and middle parts of *the Babek suite* which is conformably situated on the Chalkhangala suite.

Bathonian stage (lower substage) is separated in the areas mentioned together with the previous stage and is represented by the upper part of the *the Babek suite*.

The Babek suite (according to the Babek settlement) was named by T.A.Hasanov in 1986. Its stratotype is situated in vicinity of the Nehram railway station to the south from the



Babek settlement and the parastratotype is situated in the Gazanyayla area. In the stratotypical section it is comprised of the alternation of grey, greenish-, yellowish- and blue-grey clay, thin-layer clayey sandstone and grey chalky clays with sparse marlstone layers. In the parastratotypic section is represented by grey colored clays and also by chalky clays in the upper part of the section. It retains typical ammonite, pelecypod, brachiopod and foraminifer fauna complex. Is unconformably covered by the rocks of the Anabadgadik suite of the Callovian stage. Depending on the sections, the suite's overall thickness varies between 120 and 270 m. Formations of the Bajocian and Bathonian parts of the section are lithologically similar to each other but in terms of location of the typical fauna remnants, the suite is divided into the Lower, Middle and Upper Babek subsuites.

Lower Babek subsuite in the stratotypic section is comprised of greenish-grey clays (23 m) that keep grey, yellowish-grey sandstone and gravelites (22 m) in its heel. In the parastratotypic section limestones are situated in the basal part (12–15 m). Depending on sections, thickness varies between 20 and 150 m. The following fauna remnants were found in its section: ammonites – *Sonninia sowerbyi* Mill., *Otoites sauzei* d'Orb., *O. contractus* Sow., *Stephanoceras humphriesianum*, *St. macrum* (Quenst.), *St. zieteni* (Quenst.), *St. humphriesianum* (Sow.), *Ophthalmidium infraoolithicum* (Terg.), *Oppelia flexa* (Bucum.), *Chondroceras gervillia* (Sow.), *Cadomites rectolobatus* (Hauer), *C. rectelobatus* (Hau.), *C. richei* (Liss.), *Phylloceras* (*Calliphylloceras*) cf. *disputabile* (Zitt.), *Ph. mediterraneum* (Neum.), *Lissoceras* cf. *psilodiscus* (Schloenb.), *Lytoceras* cf. *crimea* (Strem.), *Perisphinctes subtilis* (Neum) and etc.; pelecypoda – *Pecten silenus* d'Orb., *Entolium demission* Phill. and etc.; foraminifers – *Huperammia ligula* (Mak.), *Glomospira gordialis* (Par. et Jon.), *Homospirella gordialis chodzica* (Ant), *Ophthalmidium infraoolithicum* (Terq.), *Quinqueloculina ac-culta*, *Lenticulina cordiformis* Terq., *Dentalina communis* Orb., *Nodos aria fontinensis* Terq.,

Vaginulina flabelloides Terq. and etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 2007).

Middle Babek subsuite is represented by grey, bluish-, brown- and greenish-grey colored sandy and calcareous clays stratified with aleurolites in the stratotypic and other sections; sometimes stratification of the clays with marlstones is observed in the upper part of the section. Depending on sections, thickness varies between 12 and 100 m. Its section is characterized with the following fauna remnants: ammonites – *Leptosphinctes* sp., *L. vermiformis* (Buckm.), *Lytoceras* cf. *polyhelictum* (Böck.), *L. tripartitus* (Rasp.), *Entolium cingulatum* (Goldf.), *Nannolytoceras* sp., *N. ilanense* (Strem.), *N. tripartitum* (Rasp.), *Spiroceras azariani* (Rost.), *Sp. bifurcatum*, *Garantiana garantiana* Sow., *Strenoceras subfurcatum* (Schloth.), *Strenoceras* sp., *Sphaeroceras brongniarti* (Sow.), *Strigoceras truelli* (Orb.), *Oppelia subradiata* (Sow.), *Oecotraustes genicularis* (Waag.), *Garantiana baculata* (Quenst.), *G. filicosta* Bentz., *G. subgaranti* (Wetz.), *Cadomites* sp., *Pseudogarantiana dichotoma* Bentz., *Calliphylloseras asisbekovi* (Kakh.), *C. disputabile* (Zitt.), *C. flabellum* (Neum.), *C. zignodianum* (Orb.), *Oppelia subradiata* (Sow.), *Partschiceras abichi* (Uh.), *Parkinsonia parkinsoni* (Sow.), *P. depressiya* (Quenst.), *P. rarecostata* Buckm., *Perisphinctes martinsi* (d'Orb.), *Phylloceras mediterraneum* (Neum.), and etc.; foraminifers – *Leptodermalla conica* (Mak.), *Huperammia ligula* (Mak.), *Glomospira gordialis* (Par. et Jon.), *Haplophragmoides convexus* (Ant.), *Textularia jurassica* Gumb., *Glomospirella gordialis chodzica* (Ant.), *Ophthalmidium caucasicum* (Ant.), *O. negramensis* and etc., brachiopods – *Rhynchonelloidella mesoloba* (M.-W.), *Negramithyris negramensis* (Pros.), *Loboidothyris* (?) *jabaensis* (Weir.) and etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 2007).

Upper Babek subsuite is comprised of stratification of grey clays with marlstones in the lower part and the blue-grey clays in the upper part in the stratotypic section (115 m). In the parastratotypic and other sections consists of the alternation of grey, yellowish- and dark-grey clay and chalky clays (30–50 m). Retains typical fauna remnants: ammonites – *Strigoceras truellei* (Orb.), *Lissoceras psilodiscus* (Schloen.), *Dimorphinites dimorphus* (Orb.), *Planisphinctes tenuissimus* (Siem.), *Oecotraustes fusca* Quenst., *O. formosus* Ark., *O. genicularis* (Waag.), *Oppelia limosa* (Buckm.), *O. fusca* Quenst., *O. subradiata* (Sow.), *O. aspidoides* Opp., *O. subradiata* (Sow.), *Parkinsonia depressa* Quenst., *P. ferruginea* Opp., *P. parkinsoni* (Sow.), *P. subarrietes* (Wetz.), *Perisphinctes martinsi* d'Orb., *Phylloceras mediterraneum* Neum., *Ph. azizbekovi* Kakh., *Nannolytoeoras atronosulcutus* Boc., *Partachicoras abichi* (Vnlig.), *Cadomites rectolobatus* (Hauer), *C. linguiferus* (Orb.), *C. orbigny* (Gross.), *Leptosphinctes vermiformis* (Buckm.) and etc.; pelecypoda – *Inoceramus acoundus* (Mec.) and etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 2007).

The Callovian stage is separated only in the north-west of the Autonomous Republic, in vicinity of the Chalkhangala village, in the eastern and north-eastern slopes of the Mt. Garagush and Anabad-Gadik, in the Salakhanbulag and Gazanyayla areas and in the eastern edge of the Subuzdagh (Buzgov) ridge. Is represented by *Anabadgadik suite* unconformably overlying the Babek suite.

The Anabadgadik suite (according to the Anabadgadik mountain) was named by H.I.Aliyev in 1981. Stratotype is opened as tectonic wedge between the formations of the Lower and Upper Jurassic in the northern slope of the Mt. Anabadgadik. Here the suite is comprised of alternation of yellowish-grey, middle- and thick-layer, different-grained calcareous sandstone and sandy limestones with thin layers of coarse-grained quartz sandstone and gravelites. In the parastratotypic section the suite is comprised of

yellowish- and greenish-grey colored calcareous sandstones stratified with sparse layers of clay (Figure 7) in the north-east of the Chalkhangala village. Basal glomerations are opened at its base in the north from the Ashagi Buzgov village in the Subuzdagh ridge. Unconformably overlies the Upper Babek subsuite and is covered with the formations of the Upper Cretaceous in the top. Depending on sections, thickness varies between 25 and 200 m. It retains characteristic fauna complex, including: ammonites – *Procerites funatus* (Opp.), *Hecticoceras lumiloides* (Kil.), *Phylloceras mediterraneum* (Neum.), *Ph. viator* (d'Orb.), *Rhynchonella alemanica*, *Entolium angulatum* (Goldf.), *En. spathulatum* (Roem.), *E. cingulatum* (Goldf.), *Posidonia buchi* (Roem.), *Pholadomya* cf. *murchisoni* (Sow.) and etc.; foraminifers – *Ophthalmidium monstraesum*, *O. antonovae* (Mak.), *Ligmoilina moldaviense* (Danitch.), *Flondicularia exilis* (Kapt.), *Lenticulina uhligi* (Wich.), *L. pseudocrassa* (Mjatt.), *L. desipiens* (Wich.) and etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 2007).



Figure 7. Outcrop of the Middle Jurassic aged Anabadgadik suite (the Callovian stage) in the eastern edge of the Chalkhangala village

Upper Cretaceous

Within the geological aspects of the Nakhchivan Autonomous Republic, the Cretaceous system is presented through its upper series and is separated in the Arpachay and Jahrichay ba-



sins, in the eastern vicinity of the Chalkhangala village in the north-west and along the left bank of the Araz River in the Julfa canyon in the north-east wing of the cognominal uplift, in the Daghestu (Daridagh) ridge and in the Kilit-Kolam anticlinal uplift area of Zangazur uplift in the south-east (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Алиюлла, Бабаев, Шихлинский, Алиев, Рагимли, Азизбекова, 1980; Аллахвердиев, Тарасова и др. 1973; Геология Азербайджана, 2007; Меловая фауна Азербайджана, 1988; Мустафаев, Алиев, Алиев и др., 1973; Халафова, 1969; Халилов, 1978). In the geological section the system is presented through its all stages besides the Cenomanian stage and is represented by vulcanogenic facies in the lower part and with the terrigenous-carbonate facies in the middle and upper parts. Generalized average thickness is 1550 m and the maximum thickness is more than 2430 m.

In the early Cretaceous period territory of the Nakhchivan AR fitted to the raised Araz block that belonged to the South Azerbaijan segment of the Central Iranian Plate which corresponded to the southern coast the Lesser Caucasus of the Mesotethys as in the Late Jurassic epoch and here dominated dry conditions. This time other areas of the Central Iranian Plate were covered with epicontinental sea water and in the north – in the Mesotethys basin continued expansion (spreading) and northern subduction processes. In the Austrian phase of the tectogenesis coinciding with the late transition period from the Early Cretaceous to the Late Cretaceous the spreading in the oceanic basin territory of the Lesser Caucasus ended and common compression process which indicated the beginning of the collision era began. Initial signs of the compression appeared in the Middle Albian stage and by gradually increasing, it resulted with the mutual rapprochement of north (South Caucasus Plate) and south (Central Iranian Plate) coasts in the Early Senonian, with the closing of the South Caucasus arm of the Mesotethys

and with bipolar obduction of ophiolite association which ended in the Early Senonian in the boundaries of both continental plateau from the axis part of the oceanic basin. In the same sequence but somewhat delayed events took place also in the Neotethys basin and coating formation phase here ended at the end of the Santonian. But Miocene sediments within the ophiolite melange in the territory of Iran suggests that the collision between the Arabian and Central Iranian Plates continued till the end of the Miocene. These processes that occurred in both riverbeds were accompanied by the straining of the coastal blocks of the Central Iranian Platform, the downwarping of layers lengthwise and the gradual advance of marine waters. Sea transgression reached to the territory of Nakhchivan AR only in the Turonian age of the Late Cretaceous. As in the Early Jurassic, stress and transgression processes here were accompanied by continental rifting and effusive magmatism and resulted in the accumulation of basaltic lava and lava breccia, tuff and tuff-breccia. All of these are explained by occurrence of the new rift-related stress in the residue basin of the Lesser Caucasus of the Mesotethys. As a result of the compressing, the rifting process happened in the subduction of the oceanic chair of the Neotethys to the north – under the Central Iranian Plate and as a result of it behind a magmatic island arc sprung up along the southern edge of the Plate. Later on, until the end of the Late Cretaceous mainly carbonate and partly terrigenous facies sediments accumulated in shallow sea conditions within the territory of Nakhchivan AR.

Lithologic and stratigraphic features and fauna of the Upper Cretaceous material complex were studied and described in detail by P.Bonne, K.N.Paffenholts, Sh.A.Azizbayov, R.N.Abdullayev, Kh.Aliyulla, A.R.Azizbayova, T.H.Hajiyev, R.N.Mammadzada, M.İ.Rustamov, Y.V.Karyakin, F.A.Mustafayev, H.I.Aliyev, Q.I.Allahverdiyev and others in different years. Collected paleontological materials were determined in different years by N.N.Bobkova, P.Bonne, Kh.Aliyulla, A.R.Azizbayova, V.M.Kharitonova, R.A.Khalafova, D.M.Khalilov, I.E.Karstens,

M.I.Moskvina, V.F.Pchelinsev, V.P.Rengarten, Q.Sulukidze, O.I.Shmidt and others.

Local stratigraphic units participating in the geological section are given in the Table 4.

The Turonian stage is separated in the Jahrichay valley and eastern vicinity of the Chalkhangala village in the north-west and in the north-east wing of the cognominal uplift in the slope of the Julfa canyon along the bank of the Araz River and in the core of Kilit-Kotam anticlinal uplift in the south-east. Is represented by its substages of lower volcanogenic and upper sedimentary and partly volcanogenic-sedimentary origin that have middle thickness of 570 m and generalized maximal thickness of up to 800 m. Is characterized by rich bivalve, foraminifer, ostracod and coccolithophorid fauna complex.

Arkhaj suite (according to Arkhaj Mountain) was named in 1981 by M.I.Rustamov. Stratotype is situated in the steep south-west slope of the Arkhaj mountain in the area of Julfa uplift (in the source part of the Nehram ravine) and other outcrops are observed in eastern suburbs of the Chalkhangala village and in the right bank of the Jahrichay on the border with Armenia in the north-west. Is comprised of effusive-pyroclastic formations or deposits of basalt-rhyolite formations. In the stratotypic section the base part is comprised of basal conglomerates (25–117 m) and the upper part is comprised of pyroclastolites (280–500 m). The latter are comprised of an un-

even alternation of grey, purple-grey andesite, rhyolite, basalt, andesite-basalt and andesite-dacitic tuffs, tuff breccia and brecciated porphyries. Thickness in vicinities of the Chalkhangala and Ashagı Buzgov villages varies between 70 and 80 m. Overlies washed surfaces of sediments of the Anabadgadik suite in the Jahrichay basin (the Callovian stage of the Middle Jurassic) and of the Upper Babek suite in the Arkhaj area (the Bathonian stage of the Middle Jurassic) and in its turn is unconformably covered by conglomerate, gravelite and sandstones of the Jahrichay suite. Typical fauna complex was found by M.I.Rustamov in the clayey sandstone horizon opened between pyroclastolites in the section of top part of the suite, including: macrofauna – *Gimmertome renauxiana* (d'Orb.), *Araratella pulchra* Hacob., *Tylostoma* sp., microfauna – *Globorotalites hangensis* Vassilenko, *Guroidinoidea nitidus* (Reuss), *Helvetoglobotruncana helvetica* (Bolli), *Globotruncana renzi* Gandolfi, *Gl. imbricata imbricata* Mornod, *Gl. andusticarinata* Gandolfi, *Gl. linneiana* (d'Orbigny), *Valvulineria lenticula* (Reuss) and etc. Also thick volcanic layer was opened in the heel of the Cretaceous sediments in the geological section of a drilled borehole in vicinity of Cheshmabasar village in the north-east from the Arkhaj mountain and according to microfauna its age was defined as Turonian.

Table 4

Division of the Upper Cretaceous series in the territory of Nakhchivan AR

Stage and substage	Suites and subsuites
Lower Turonian	Arkhaj suite Lower Jahrichay subsuite
Upper Turonian	Upper Jahrichay subsuite
Coniacian	Lower Buzgov subsuite Upper Buzgov subsuite
Santonian	Lower Kotam subsuite Upper Kotam subsuite
Campanian	Garmachatag suite
Maastrichtian	Lower Pirchay subsuite Upper Pirchay subsuite



Jahrichay suite (according to the Jahrichay river) was named in 1981 by H.I. Aliyev. Stratotype is situated in 2 km north-east from the Ashagi Buzgov village in the upstream of the Jahrichay. The suite is opened in vicinities of Payız, Chalkhangala and previous Bilava villages (Figure 8), in Akhura, Mehridarasi and Zarlidara areas in the Arpachay basin and in the upstream of the Gabaglychay in the north-west and in the left bank of the Araz River in the area of Julfa uplift in the south-west slope of the Mt. Arkhaj and Kurnizar and in Kilit-Kotam area (parastratotypic section) in the south-east. Unconformably overlies the Upper Cretaceous dolomites in the Bilava and Akhura areas and incompatibly covers washed surface of the Permian and Triassic sediments in the Mehridarasi, Zarlidara areas and upstream of the Gabaglychay river. Also incompatibly overlies volcanogenic layer of the Arkhaj suite in the stratotypic section in the Jahrichay basin and in the section of the Julfa canyon. But in Kilit-Kotam area heel of the section is not opened. According to the lithologic and faunistic features, the suite is divided into lower (upper part of the Lower Turonian substage) and upper (the Upper Turonian substage) subsuites in the Jahrichay basin. The suite presents through indivisible section in other outcrops and maybe is represented by only upper subsuite. Depending on sections, thickness varies between 45 and 185 m. Is distinguished by typical fauna complex of bivalve, foraminifer, ostracod, gastropod, pelecypoda and coccolithophorid. Mostly is formed of clay, sandstone and limestones in the Jahrichay basin. Along with these, conglomerate and gravelites occupy significant, even important place in the section in the Arpachay basin and Bilava sections, and an alternation of sandstone and clays with sparse layers of gravelite and conglomerate is observed in the Julfa-Ordubad area. Eventually, the suite presents through volcanogenic sedimentary facies in the parastratotypic section in the Kilit-Kotam area, and consisting of calcareous and siliceous sandstone and partly siliceous limestones stratified with argillite layers, the suite retains fi-

ne-grained calcareous and siliceous tuff sandstones in the base and ceiling parts.

Lower Jahrichay subsuite is composed of alternation of grey and dark-grey finegrained clayey sandstone and sandy clays with grey sandy, dolomitic, brecciated limestones (33,6 m). Depending on sections, thickness varies between 30 and 65 m. Typical fauna complexes was found in the stratotypic and other sections: foraminifers – *Gavelinella vesca* (N.Byk.), *G. aktagi* (N.Byk.), *G. globosa* (Brotz.), *Bolivinopsis praelonga* (Reuss), *Rotalipora cushmani* (Morr.), *Guembelitria cenomana* (Kell.), *Praeglobotruncana stephani* (Gand.), *Helvetoglobotruncana helvetica* (Bolli), *Tesseraella boliviniformis* (Agal.) and etc.; ostracods – *Cytherella* sp., *C. latiuscula* Andr., *C. elegans* Andr., *C. kemischdagica* Z.Kuzn., *C. testata* Z.Kuzn., *C. complanata* Reuss, *Bairdoppielata roemeri* Deroo, *Ovocytheridea faisabadensis* Andr., *Ov. faisabadensis* Andr., *Schuleridea* sp., *Schuleridea profunda* (Mandel.) and etc.; molluscs – *Actaeonella ovata* (Pcel.), *A. supernata* (Pcel.), *Pleisioptygmatis olisiponensis* (Scharpe), *Ampulospira punctata* (Scharpe), *Haustator subnodosus* (Pcel.), *Aptyxiella posthuma* (Pcel.), *Glauconia subrauxi* (Pcel.), *Radiolites peroni* (Choff.), *Durania martoni* (Mant.), *Inoceramus labiatus* (Schloth.), *In. labiatus* Schloth., *In. hercynicus* Petz., *Radiolites peroni* Choff. and etc.; nanoplankton – *Micula staurophora* (Gard.), *M. staurophora* (Gard.), *Tetralithus pyramidus* (Gard.), *T. obscurus* (Defl.), *Discorhabdus ignotus* (Gorka), *Manivitella pemmatoida* (Defl.), *Zygodiscus diplogrammus* (Defl.), *Chiastozygus amphipons* (Braml. et Mart.), *Corollithion exiguum* Str. and etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Азизбекова, 1974; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Алиюлла, Бабаев, Шихлинский, Алиев, Рагимли, Азизбекова, 1980; Аллахвердиев, Тарасова и др., 1973; Геология Азербайджана, 2007; Меловая фауна Азербайджана, 1988; Мустафаев, Алиев, Алиев и др., 1973; Халафова, 1969).



Figure 8. Vicinity of the previous Bilava village. Outcrop of the Jahrichay suite belonging to the Turonian stage of the Upper Cretaceous

Upper Jahrichay subsuite is composed of the alternation of reddish brown, grey, dark grey, brown and greenish-grey tuff sandstone, sandstone, argillite and clays in the lower part in the stratotypic section (106,6 m). Basal (?) conglomerate layer (1,5 m) is observed in a rough surface of limestones belonging to the lower subgroup in the base part of the layer. Depending on sections, thickness varies between 15 and 110 m. Typical fauna complex was found in the stratotypic and other sections: gastropods – *Pseudomesalia bicarinata* (Pchel.), *P. andustata* (Pcel.), *P. regularis* (Pcel.), *Oligoptuxis turricula* (Pcel.), *Actaeonella supernata* (Pcel.), *A. ovata* (Pcel.), *A. posthuma* (Pcel.), *A. caucasica* (Zek.), *Frachactaeon biconicus* (Pcel.), *Itruvia gigantata* (Pcel.); foraminifers – *Globotruncana imbricata* (Morn.), *Gl. imbricata* (Morn.), *Gl. globogerinoides* (Brotz.), *Gl. bulloides* (Vogl.), *Ammodiscus* sp., *Dentalina* sp., *Bolivinopsis praelonga* (Reuss), *Gaudryina boliviniformis* N.Byr. and etc.; ostracods – *Ovocytheridea* sp., *Fabanella* sp., nanoplankton – *Zygodiscus erectus* (Defl.), *Eiffelithus turriseiffeli* (Defl.), *Tetralithus pyramidus* Gard.; molluscs – *Pseudomesalia subcarinata* Pcel., *Plesioptigmatis armenica* Pcel., *P. bicincta* Bronn., *Ampullospira punctata* Scharp., *Haustator subnodosus* Pcel., *Inoceramus labiatus* Schloth., *In. hercynicus* Petz., *In. latus rotundus* Chal., *In. problemati-*

cus aviculinooides Meek., *In. cuvieri* Sow., *In. woodsi* Boehm, *In. frechi* And., *Conulus subrotundus* Mant. and etc.; nanofossils – *Broinsonia enormis* (Shum.), *Cretarhabdus decorus* (Defl.), *Lithastrinus grilli* Str., *Zygodiscus acanthus* (Reinh.). From moire algae *Atopochara multivolvus* Peck., *A. submultivolvus* Romasch., *A. elognata* Romasch., *Raskyella caucasica* Romasch., etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Азизбекова, 1974; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Алиюлла, Бабаев, Шихлинский, Алиев, Рагимли, Азизбекова, 1980; Аллаhverдиев, Тарасова и др., 1973; Геология Азербайджана, 2007; Меловая фауна Азербайджана, 1988; Мустафаев, Алиев, Алиев и др., 1973; Халафова, 1969).

The Coniacian stage is separated in the Arpachay and Jahrichay basins in the north-west and in north-west wing of the Julfa uplift along the left bank of Araz River and in Kilit-Kotam anticlinal strip in the south-east. Is represented by *the Buzgov suite* consisting of alternation of clay, sandstone, chalky clay and limestones that conformably overlies formations of the Turonian stage.

The Buzgov suite (according to the Ashagi Buzgov village) was named in 1981 by H.I.Aliyev. Stratotype is opened in Buzgov anticlinal arch in vicinity of the Ashagi Buzgov village (Figure 9). Outcrops are also observed in vicinities of the Chalkhangala and Payiz villages in the Jahrichay basin, in the north from the ruins of the previous Binava village (Figure 10), in Bilava-Akhura and Mehridarasi areas in the Arpachay basin, in Kilit-Kotam area (parastratotypic section) and in the north-west wing of the Julfa uplift (in the south-west slope of the Mt. Arkhaj and Kurnizar) in the left bank of the Araz River. Mostly is comprised of clay, argillite and sandstones in the north-west and limestone, chalky clay and argillites in the south-east. Depending on sections, thickness varies between 80 and 640 m. According to the lithologic and faunistic features, is divided into two subsuites. Conformably overlies the Jahrichay suite and in its turn, is covered (in some areas incom-



patibly) with limestones of the Kotam suite (Santonian stage). Sometimes is incompatibly situated on the surface of the Permian and Triassic formations in the north-west outcrops (in the Arpachay basin). Typical fauna complex of mollusc, coral, foraminifer, nanoplankton, ostracod, inoceramus, ammonite, spherical radiolaria was found in the section.

The Lower Buzgov Group of semi-layers consists of the alternate chipped and lumpy, low-sand grey, dark-grey and greenish-grey clays, argillites and finely-grained and sometimes clayey rocks with scarce limestone and gravelstone layers (125.8 m). In the parastratotypic section consists of grey, bluish-grey and dark grey chalky clay, argillite, clay, calcareous sandstone and limestones (238 m). Depending on outcrops, thickness varies between 40 and 250 m. Typical fauna complex was found in stratotypic and other sections: molluscs – *Rostellinda fusaidea* Pcel., *Plicatula batnensis* Coq., *Pl. auressensis* Coq., *Pl. instabilis* Stol., *Pl. aspera* Sow., *Pl. multicostata* Forl., *Pl. turkestanensis* Arkh., *Pl. guelistanensis* Chal., *Pl. alizadei* Chal., *Haustator subnodous* Pcel., *H. differensialis* Pcel., *H. subnodous* Pcel., *Tectaplica* cf. *armenica* Pcel., *Inoceramus renngarteni* Bod., *Rimella convexa* Pchel.; ostracods – *Cytherella latiuscula* Andr., *Schuleridea profunda* (Mandel.), *Cytherella latiuscula* Andr., *C. latissima* Andr., *Tetisocypris proceriformis* (Mandel.); foraminifers – *Gaudryina subserrata* Vass., *Valvulineria lenticula* (Reuss), *Gavelinella vesca* (N.Byk.), *G. moniliformis* (Reuss), *Heterohelix turonica* (Agal.), *Gyroidinoides* sp., *G. nitidus* (Reuss), *Globorotalites* sp., *Rugoglobigerina ordinaria* (Subb.), *Globotruncana schneegansi* (Sigal), *Gl. renzi* (Thalm.), *Lenticulina subalata* (Reuss), *Bifarina regularia* Kell., *Heterohelix globifera* (Reuss) and etc.; nanoplankton – *Eiffelithus eximus* (Stov), *Ahmullerella octoradiata* (Gorka), *Corolithion signum* (Str.), *Rucinolithus hayi* Stov., *Chiastozygus trabeculatus* (Gorka), *C. propagulis* Bukry, *Broinsonia enormis* (Shum.), *Tetralithus obscurus* Defl., *Watznaueria barnesae* (Black),

Microrhabdulus decoratus Defl., *Marthasterites furcatus* (Defl.), *Cretarhabdus actinosus* (Stov.) and etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Азизбекова, 1974; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Алиюлла, Бабаев, Шихлинский, Алиев, Рагимли, Азизбекова, 1980; Аллахвердиев, Тарасова и др., 1973; Геология Азербайджана, 2007; Меловая фауна Азербайджана, 1988; Мустафаев, Алиев, Алиев и др., 1973; Халафова, 1969).



Figure 10. Northern vicinity of the previous Bilava village. Outcrop of the Buzgov suite of the Coniacian stage of the Upper Cretaceous



Figure 9. Left bank of the Jahrichay, vicinity of the Ashagi Buzgov village. Contact of carbonate-terrigenous rocks of the Buzgov suite of the Upper Cretaceous (the Coniacian stage – K₂k) with limestones of the Kotam suite (the Santonian stage – K₂st)

Upper Buzgov subsuite is comprised of the alternation of grey, greenish-, reddish brown, brown and dark grey, different grained, clayey and calcareous sandstone, clay, argillite, occasionally limestone and tuff sandstones in the stratotypic section (381 m). An interval consisting of tuff sandstone, gravelite and conglomerates is observed in the middle part of the section (72 m). The subsuite consists of yellowish-grey limestones that retain typical *Inoceramus lusatie* and *In. percostata* Müll. mollusc remnants in the parastratotypic section (65 m). Depending on sections, thickness varies between 40 and 390 m. Typical fauna complex was found in the stratotypic and other sections: molluscs – *Inoceramus involutus* Sow., *In. lobatulus* Muens., *In. frechi* Andr., *In. weisei* Andr., *In. keoneni* Muell., *In. lusatie* Andr., *In. striatus* d'Orb., *In. subquadratus* Schloet., *In. subquadratus curvatus* Heinz, *In. supercostatus* Andert., *Micraster cortestudinarius* Goldf. and etc.; foraminifers – *Rugoglobigerina ordinaria* (Subb.), *Globotruncana* cf. *sigaki* Reich., *Gl. linneiana* (d'Orb.), *Gl. bulloides* Vogl., *Gl. lapparenti* Brotz., *Gl. globigerinoides* Brotz., *Gl. tricarinata* (Quer.), *Gl. renzi* Gand., *Gl. angusticarinata* (Gand.), *Gl. coronata* Bolli, *Heterohelix* cf. *obtusata* (Agal.), *Gavelinella* cf. *kelleri* (Mjatl.), *H. globulosa* (Ehrenb.), *Lenticulina agdavanensis* Alij., *Verneuilina muensteri* Reuss, *Gaudryina avuschensis* Aziz., *Pasternakia senonica* (Mjatl), *Braarudosphaera bigelowi* Gran. et Braarud. and etc.; nanoplankton – *Prediscosphaera intereisa* (Defl.), *Cretarhabdus actinosus* (Stov.), *Chiastozygus propagulis* Bukry, *Rucinolithus hayi* Stov., *Tesseraella pseudotessera* (Cushm.), *Eiffellithus turriseiffeli* (Defl.), *Lithastrinus grilli* Str. and etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Азизбекова, 1974; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Алиюлла, Бабаев, Шихлинский, Алиев, Рагимли, Азизбекова, 1980; Аллахвердиев, Тарасова и др., 1973; Геология Азербайджана, 2007; Меловая фауна Азербайджана, 1988; Мустафаев, Алиев, Алиев и др., 1973; Халафова, 1969).

The Santonian stage is separated in the Arpachay and Jahrichay basins, as well as in the left bank of the Araz River in the areas where formations of the Coniacian stage are spread and is represented by *Kotam suite* consisting of the alternation of limestone, clay and chalky clays that compatibly overlies them.

The Kotam suite (according to the Kotam village) was named in 1985 by Q.I. Allahverdiyev. Stratotype is situated in vicinity of Kotam village in the south-east of the Autonomous Republic and parastratotype is situated in the Jahrichay valley (see Figure 8). Outcrops are observed also in the north-east wing of the Julfa uplift (in the south-west slope of the Mt. Arkhaj and Kurnizar) and in the Jahrichay basin – in vicinities of Yukhari Buzgov, Ashagi Buzgov and previous Lizbirt villages, as well as in the north-west from the Payız village, in the north from the ruins of the previous Bilava village (Figure 11), in the Arpachay basin – Bilava, Akhura, Havush, Mehridarasi, Zarlidara, Gumushludara and Yayjidarasi areas, as well as in the source part of the small Bagırsagdara river in the north-west. Incompatibly covers the Buzgov suite in the Jahrichay and Arpachay basins, as well as transgressively overlies directly the Jahrichay suite in the source part of the Gabaglychay in the east from the Havush village. Is clearly divided into a lower part of volcanogenic-sedimentary facies, and an upper part of carbonate content in the Kilit-Kotam area and is usually formed of stratification of limestones with terrigenous rocks in other outcrops. According to the lithologic and faunistic features, the suite is divided into lower and upper subsuites the overall thickness of which varies between 70 and 430 m. Typical fauna complex of mollusc, foraminifer, nanoplankton, sea urchin and ammonite was found in the section.

Lower Kotam subsuite is formed of the alternation of greenish- and dark-grey tuff conglomerate, tuff gravelite and tuff sandstones stratified with argillite layers in the stratotypic section (198 m); argillites prevail in the upper part of the section. Is represented by stratification of grey calcareous clays with thin layer limestones in the wing of the Julfa uplift (59 m). In the parastrato-



typic section mostly consists of pelitomorphous and calcareous limestones (35 m). Depending on sections, thickness varies between 30 and 200 m. Typical fauna complex was found in different sections: foraminifers – *Globotruncana subbotinae* (Alij.), *Gl. linneiana* (d'Orb.), *Gl. lapparenti* (Brotz.), *Gl. tricarinata* (Quer.), *Gl. fornicata* (Plumm.), *Gl. cf. coronata* (Bolli.), *Gl. cf. arca* (Cushm.), *Gl. cf. subarca* (Alij.), *Gl. cf. ventricosa* (White), *Arenobulimina brotzeni* (Wolosch.), *Ammodiscus glabratus* Cushm. et Jarv., *A. cretaceus* (Reuss), *Pasternakia senonica* (Mjat.), *Striataella striata* (Ehrenb.), *Cribrosphaerella arkhangeliskii* (Shum.), *Rotundina cf. ordinaria* (Subb.), *Pseudovulineris cf. dainae* (Mjat.); molluscs – *Inoceramus striatus* (Chal.), *In. opetensis* Bose., *In. labiatus* Schloth., *In. hercunicus* Petz., *In. undulatoplicatus* (Heinz.), *In. subquadratus* (Schloth.), *In. dariensis* (Moskv.), *In. lobatus* (Müll.), *In. cf. undulatoplicatus* Roem., *In. involutus* Sow., *In. balticus* Boehm, *In. buguntaensis* d'Orb.; sea urchins – *Echinocorus vulgaris* (Breyn.), *Micraster cortestudinarium* Goldf. and etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Азизбекова, 1974; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Алиюлла, Бабаев, Шихлинский, Алиев, Рагимли, Азизбекова, 1980; Аллахвердиев, Тарасова и др., 1973; Геология Азербайджана, 2007; Меловая фауна Азербайджана, 1988; Мустафаев, Алиев, Алиев и др., 1973; Халафова, 1969).



Figure 11. Northern vicinity of the previous Bilava village. Outcrop of the Kotam suite that belongs to the Santonian stage of the Upper Cretaceous

Upper Kotam subsuite is formed of grey, light-, whitish- and yellowish-grey, thin-, middle- and thick-layer close pelitomorphous limestones in the stratotypic section (85 m). In the parastratotypic section participate pelitomorphous and sandy limestones (43,7 m). Depending on sections, thickness varies between 40 and 120 m. Typical foraminifer complex was found in the stratotypic and other sections: *Globotruncana linneiana* (d'Orb.), *Gl. lapparenti* (Brotz.), *Tesseraella pseudotessera* (Cushm.), *Ammodiscus cretaceus* (Reuss), *Arenobulimina brotzeni* (Wolosch.), *Pasternakia senonica* (Mjat.) and etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Азизбекова, 1974; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Алиюлла, Бабаев, Шихлинский, Алиев, Рагимли, Азизбекова, 1980; Аллахвердиев, Тарасова и др., 1973; Геология Азербайджана, 2007; Меловая фауна Азербайджана, 1988; Мустафаев, Алиев, Алиев и др., 1973; Халафова, 1969).

The Campanian stage is separated in the territory of the Autonomous Republic in areas where formations of the Santonian stage are spread and is represented by *Garmachatag suite* comprising of the alternation of limestone, chalky clay and sandstones rich in fauna which conformably overlie them.



Figure 12. Vicinity of the Garmachatag village. Alternation of limestone, chalky clay and clays that form the Garmachatag suite of the Campanian stage of the Upper Cretaceous

Garmachatag suite (according to Garmachatag village) was named in 1981 by H.I.Aliyev. Stratotype is situated in vicinity of the Garmachatag village (Figure 12) and in the average flow of the cognominal river. Outcrops are observed also in the Lizbirtchay and Jahrichay (Figure 13) valleys, in vicinities of Yukhari and Ashagi Buzgov, Turkesh, Payız villages, around the Gizilgaya, Yahargardik and Agsal mountains in the Arpachay basin, in the southwest from Shada village in Nakhchivanchay basin (Figure 14), and in the north-east wing of the Julfa uplift in the left bank of Araz River (between the Mt. Arkhaj and Kurnizar) and Kilit-Kotam area (parastratotypic section) in the south-east. Is formed of the alternation of light-grey, medium- and thick-layer, sandy and clayey pelitomorphitic limestones conformably overlying the Kotam suite with chalky clay and clay layers. Transgressively covered by conglomerates of the Middle Eocene epoch in the Julfa area. Depending on sections, thickness varies between 80 and 260 m. Typical fauna complex of ammonite, inoceramus, foraminifer and sea urchins was found in the section, including: molluscs – *Inoceramus azerbaijanensis* (Aliiev), *In. ex. gr. mantolli* (Nero.), *In. angensis* (Owen.), *In. buguntaonsis* (Dobr.), *In. gandraensis* (Aliiev), *In. tausensis* (Aliiev), *In. balticus* (Boehm.), *In. regularis* (d'Orb.), *In. sarumensis* (Woods), *In. alaeformis* (Zek.), *In. barabini* (Mort.); sea urchins – *Gatopygus willamsi* (Ghark.), *Micraster nohroederi* (Stoll.), *Micraster schroederi* (Stoll.), *Pseudoffaster caucasicus* (L.Dru.), *Echinocorys vulgaris* Breyn., *Physaster abichi* Ant., *Ornituaster alaplensis* (Damb.); ammonites – *Eupachydiscus levyi* (Gross.), *Echinocorys ovatus* (Leske), *Cardiotaxis heberti* Cott, *Physaster abichi* Ant.; foraminifers – *Rugoglobigerina rugosa* (Plumm.), *Marssonella oxycona* (Reuss), *Verneuilina bronni* Reuss, *Tritaxia tricarinata* Reuss, *Rugoglobigerina rugosa* (Plumm.), *Globotruncana arca* (Cushm.), *Gl. lapparenti* Brotz., *Gl. charchaputensis* Alij., *Gl. morozovae* Vass., *Gl. rossetta* (d'Orb.), *Gl. cf. fornicata*

Plumm., *Globotruncanita cf. struarti* (Zapp.), *Striataella striata* (Ehrenb.), *Arenobulimina arca* Volosch., *Ataxophragmium concavum* (Marie), *Heterohelix planeobtusa* Alij., *Pseudotextularia plummerae* (Loett.) and etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Азизбекова, 1974; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Алиюлла, Бабаев, Шихлинский, Алиев, Рагимли, Азизбекова, 1980; Аллаhverдиев, Тарасова и др., 1973; Геология Азербайджана, 2007; Меловая фауна Азербайджана, 1988; Мустафаев, Алиев, Алиев и др., 1973; Халафова, 1969).



Figure 13. Jahrichay valley, northern vicinity of the Payız village. Alternation of limestone and sandstones that form the Garmachatag suite that belongs to the Campanian stage of the Upper Cretaceous

Maastrichtian stage is separated in the territory of the Autonomous Republic in areas where formations of the Campanian stage are spread and is represented by *Pirchay suite* comprising of alternation of limestone, clay and chalky clays that conformably overlies them.

The Pirchay suite (according to the Pirchay) was named in 1981 by H.I.Aliyev. Stratotype is situated in the average flow of Salasuzchay which is the right arm of Nakhchivanchay and conformably overlies the sediments of the Garmachatag suite. Other outcrops are tracked in the Jahrichay basin along the right bank of the Lizbirtchay and Girdasar ridge eastwards till the area of Badamlı mineral springs and from there are



tracked to the north in the direction of the Shada and Garmachatag villages (see Figure 14), as well as is observed in the Zarlidara and Mehridarasi areas in the Arpachay basin. In the south-east the suite is opened in the Daghestu (Darıdagh) ridge and Kilit-Kotam area in the left bank of Araz River (parastratotypic section). Participating in carbonate-terrigenous facies, the suite is divided into lower and upper subsuites according to the lithologic and faunistic features. Depending on outcrops, thickness varies between 105 and 310 m. Typical fauna complex of ammonite, inoceramus, foraminifer, nanoplankton and sea urchins was found in the section.

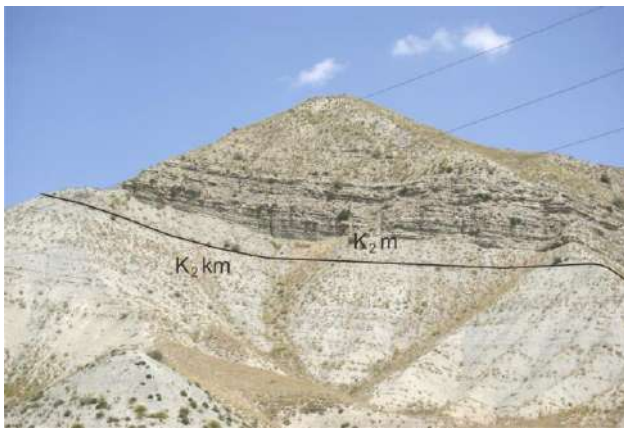


Figure 14. South-western vicinity of the Shada village. Contact of the Garmachatag (the Campanian stage – K₂km) and the Pirchay (the Maastrichtian stage – K₂m) suites of the Upper Cretaceous

Lower Pirchay subsuite is formed of the alternation of grey, yellowish-grey, medium- and thick-layer calcareous sandstones, purple-grey, thin-layer sandy clay, yellowish-grey, medium- and coarse-grained sandstone and chalky clays with sparse layers of calcareous gravelite and limestones in the stratotypic section. In the sections opening in the Kilit-Kotam area prevail sandstone and clays and in some sections prevail limestones. Depending on sections, thickness varies between 35 and 160 m. Typical fauna complex of ammonite, inoceramus, foraminifer, nanoplankton and sea urchins was found in the section, including: foraminifers and nano-

plankton – *Rugoglobogerina rugosa* (Plumm.), *Globotruncana arca* (Cushm.), *Gl. paraventricosa* (Hofk.), *Gl. caliciformis* (Lapp.), *Gl. contusa* (Cushm.), *Gl. conica* White, *Gl. stuarti* (Lapp.), *Globotruncanita stuarti* (Lapp.), *Bolivina incrassata crassa* Vass., *Matanzia varians* (Glaessn.), *Stensioina stellaria* (Vass.), *Racemiguembelina fructicosa* (Egger), *Lithraphidites quadratus* Braml. et Mart., *Arkhangelskiella cymbiformis* Vesk., *Cretarhabdus surirellus* (Defl. et Fert.), *Micula staurophora* (Gard.), *Spiroplectamina baudouiniana* (d'Orb.), *S. dentata* (Alth), *Verneuilina bronni* Reuss, *Stensioina stellaria* (Vass.), *St. pommerana* Brotz., *Rugoglobigerina rugosa* (Plumm.), *Pseugembelina postsemicostata* (Vass.), *Tetralithus copulatus* Defl., *T. obscurus* Defl., *Marssonella oxycona* (Reuss), *Arkhangelskiella specillata* Vers., *Zygodiscus bussoni* (Noel), *Z. diplomogrammus* (Defl.), *Dorothia retusa* (Cushm.), *Ataxophragmium incognitum* Wolosch., *Cibicides excavatus* Brotz., *Cribrosphaerella ehrenbergi* (Ark.) and etc.; sea urchins – *Pseudoffaster* cf. *renngarteni* Schmidt, *Seunaster* cf. *lamberti* Charl., *Cyclaster integer* Seun., *Ornithaster alaplensis* Lamb. and etc.; inoceramus – *Inoceramus balticus* Boehm., *In. cf. abichi* Tsag., *In. cf. decipiens* Zitt., *In. cf. tenuilinentus* Meek.; ammonites – *Diplomoceras* cf. *cylindroceum* (Defl.) and etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Азизбекова, 1974; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Алиюлла, Бабаев, Шихлинский, Алиев, Рагимли, Азизбекова, 1980; Аллахвердиев, Тарасова и др., 1973; Геология Азербайджана, 2007; Меловая фауна Азербайджана, 1988; Мустафаев, Алиев, Алиев и др., 1973; Халафова, 1969).

Upper Pirchay subsuite is formed of the alternation of limestone, chalky clay and clays, thick- and rough-layer, medium- and crumb conglomerates with coarse-grained sandstone and thick-layer calcareous gravelite layers in the stratotypic section. Is comprised of calcareous argillite and fine-grained sandstones in the Kilit-Kotam area. Depending on sections, thickness

varies between 70 and 150 m. Typical fauna complex of ammonite, inoceramus, foraminifer, nanoplankton and sea urchins was found in the section, including: foraminifers and nanoplankton – *Verneuilina bronni* Reuss, *Gaudryina laevigata* Franke, *Globotruncana contusa* (Cushm.), *Globotruncanita andori* (Klasz), *Gl. stuarti* (Lapp.), *Cl. conica* (White), *Tesseraella pseudotessera* (Cushm.), *Racemiguembelina fruticosa* (Egger), *Marssonella indentata* (Cushm. et Jarv.), *Stensioina pommerana* Brotz., *Cibicides bembix* (Marss.), *Globotruncana lapparenti* Brotz., *Pseudotextularia plummerae* (Loett.), *P. elegans* (Rzeh.), *Planoglobulina acervulinoides* (Egger), *Ceratolithoides kamptneri* Braml. et Mart., *Arkhangelskiella cymbiformis* Veks., *Ataxophragmium*

compactum Brotz., *Bolivina incrassata* Reuss, *Tetralithus murus* Mart., *Lithraphidites quadratus* Braml. et Mart., *Watznaueria barnasae* (Black), ammonites – *Diplomoceras* cf. *cyliandroceum* (Defr.), *D. cyliandroceum regularis* (Defr.); sea urchins – *Coraster minieri* (Seun.), *Stregaster chalmasi* (Seun.), *Seunaster* sp., *Echinocorya pyramidatus* (Portlock), *Ech.* cf. *cypliensis* (Lambert.) and etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Азизбекова, 1974; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Алиюлла, Бабаев, Шихлинский, Алиев, Рагимли, Азизбекова, 1980; Аллахвердиев, Тарасова и др., 1973; Геология Азербайджана, 2007; Меловая фауна Азербайджана, 1988; Мустафаев, Алиев, Алиев и др., 1973; Халафова, 1969).

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NAXÇIVAN QIRIŞIQLIQ VİLAYƏTİNİN ÇÖKMƏ MADDİ KOMPLEKSLƏRİNİN MÜASİR STRATIQRAFİK BÖLGÜSÜ ÜZRƏ OÇERKLƏRİ Oçerk II – Mezozoy

Ş.Ə. Babayev, T.N. Kəngərli, H.I. Əliyev

Məqalədə Naxçıvan Muxtar Respublikasının stratigrafiyasına həsr edilmiş silsilə məqalələrdən ikincisi olmaqla ərazinin geoloji quruluşunda geniş iştirak edən Mezozoy struktur-maddi kompleksinin Beynəlxalq Stratigrafiik Cədvəl əsasında yerli bölgüsünü, ayrılan stratigrafiik vahidlərin kəsilişini və paleontoloji xüsusiyyətlərini, litoloji-stratigrafiik komplekslərin əmələgəlməsində paleogeodinamik və paleocoğrafi faktorları yığcam şəkildə işıqlandırır. İlk dəfə olaraq ingilis dilində dərc edilən məlumatlar Qondvana mənşəli Mərkəzi İran mikroqitəsinin Cənubi Azərbaycan seqmentinin şimal-qərb parçası olan Araz struktur meqazonasının qitəkənarı Trias, Yura və Üst Təbaşir çöküntülərinin litologiya və stratigrafiyası barədə dolğun məlumat bazasıdır və Cənubi Qafqazın geologiyası və stratigrafiyası ilə maraqlanan əcnəbi geoloqlar tərəfindən regional ümumiləşdirmə və stratigrafiik korrelyasiya işlərində inamla istifadə edilə bilər.

ОЧЕРКИ ПО СОВРЕМЕННОМУ СТРАТИГРАФИЧЕСКОМУ РАСЧЛЕНЕНИЮ ОСАДОЧНО-МАТЕРИАЛЬНЫХ КОМПЛЕКСОВ НАХЧЫВАНСКОЙ СКЛАДЧАТОЙ ОБЛАСТИ Очерк II – Мезозой

Ш.А. Бабаев, Т.Н. Кенгерли, Г.И. Алиев

Статья является второй из серии публикаций, посвященных стратиграфии Нахчыванской Автономной Республики. В работе на базе современной Международной Стратиграфической Шкалы в сжатой форме даются расчленение, описание разрезов и палеонтологическое обоснование местных стратиграфических подразделений, а также палеогеодинамические и палеогеографические факторы формирования различных литолого-стратиграфических комплексов мезозойского структурно-вещественного комплекса, участвующего в геологическом строении описываемой территории. Эти данные, впервые публикуемые на английском языке, представляют собой насыщенную базу данных по литологии и стратиграфии триасовых, юрских и меловых окраинно-континентальных отложений Аразской структурной мегазоны – северо-западного блока Южно-Азербайджанского сегмента Центрально-Иранского микроконтинента. Они могут быть с уверенностью использованы при проведении региональных обобщений и стратиграфической корреляции разрезов мезозоя со стороны зарубежных геологов, интересующихся геологией и стратиграфией Южного Кавказа.

MINERAL STRATIGRAPHY OF THE CRETACEOUS DEPOSITS OF AZERBAIJAN

The article gives a detailed lithological and petrographic analysis of a number of sections of Cretaceous deposits in some oil and gas regions of Azerbaijan-PreCaspian-Guba, Shamakhi-Gobustan, Ganja, Yevlakh-Agjabedi, interfluves of Kura and Gabyrry.

It is shown a similarity of provenance areas of Cretaceous sediments in the PreCaspian-Guba and Shamakhi-Gobustan regions. A stratigraphy of the studied sections based on their mineralogical composition is already presented in the paper. The results also show the difference in the geodynamic and palaeogeographic settings of the Eastern and Western Azerbaijan. It can be argued that in the Western Azerbaijan there existed forearc and back arc basins, characterized by the accumulation of volcanic-sedimentary strata.

Keywords: *mineral stratigraphy, Cretaceous, Eastern, Western Azerbaijan, sedimentary basins, volcanic-sedimentary series.*

Introduction

PreCaspian – Guba oil-gas region

Geological background

The Cretaceous deposits of East Azerbaijan have the long history of their study and yet, the works on the petrography of those deposits and their litho-, mineral stratigraphy are few. The more complete research of the subject can be found in the works by A.G.Aliyev, E.A.Dahidbekova (1955), G.A.Ahmedov (1957), M.B.Kheyirov (1961) and A.A.Alizade, et al. (1972). Whilst those research works have not lost their significance over many years, the material that has been accumulated during last years needs to be interpreted and summarised.

The Cretaceous sediments have the most occurrences in the Precaspian-Guba oil-gas bearing region. Here are cropping out and opened by drilling both series of the Cretaceous system. The occurrence depths of the Cretaceous deposits' top vary considerably given the complex tectonic structure of the region – from the exposing sediments in the region of the Tenghin-Beshbarmak anticlinorium to the depths below 6 km in the most subsided part of the Gusar-Devechi trough that corresponds to abyssal faults (Figures 1, 2). The subsidence of the Mesozoic complex is also recorded toward the Caspian Sea.

E.H. Aliyeva

The Petroleum R&D Institute, Socar
H. Zardabi, 88^a, AZ1012, Baku, Azerbaijan
E-mail: e_aliyeva@gia.ab.az



A.J. Imanov

The Petroleum R&D Institute, Socar
H. Zardabi, 88^a, AZ1012, Baku, Azerbaijan



K.H. Safarli

The Petroleum R&D Institute, Socar
H. Zardabi, 88^a, AZ1012, Baku, Azerbaijan



S.M. Ismaylova

The Petroleum R&D Institute, Socar
H. Zardabi, 88^a, AZ1012, Baku, Azerbaijan



A.T. Khakimova

The Petroleum R&D Institute, Socar



A.N. Nasirov

The Petroleum R&D Institute, Socar
H. Zardabi, 88^a, AZ1012, Baku, Azerbaijan



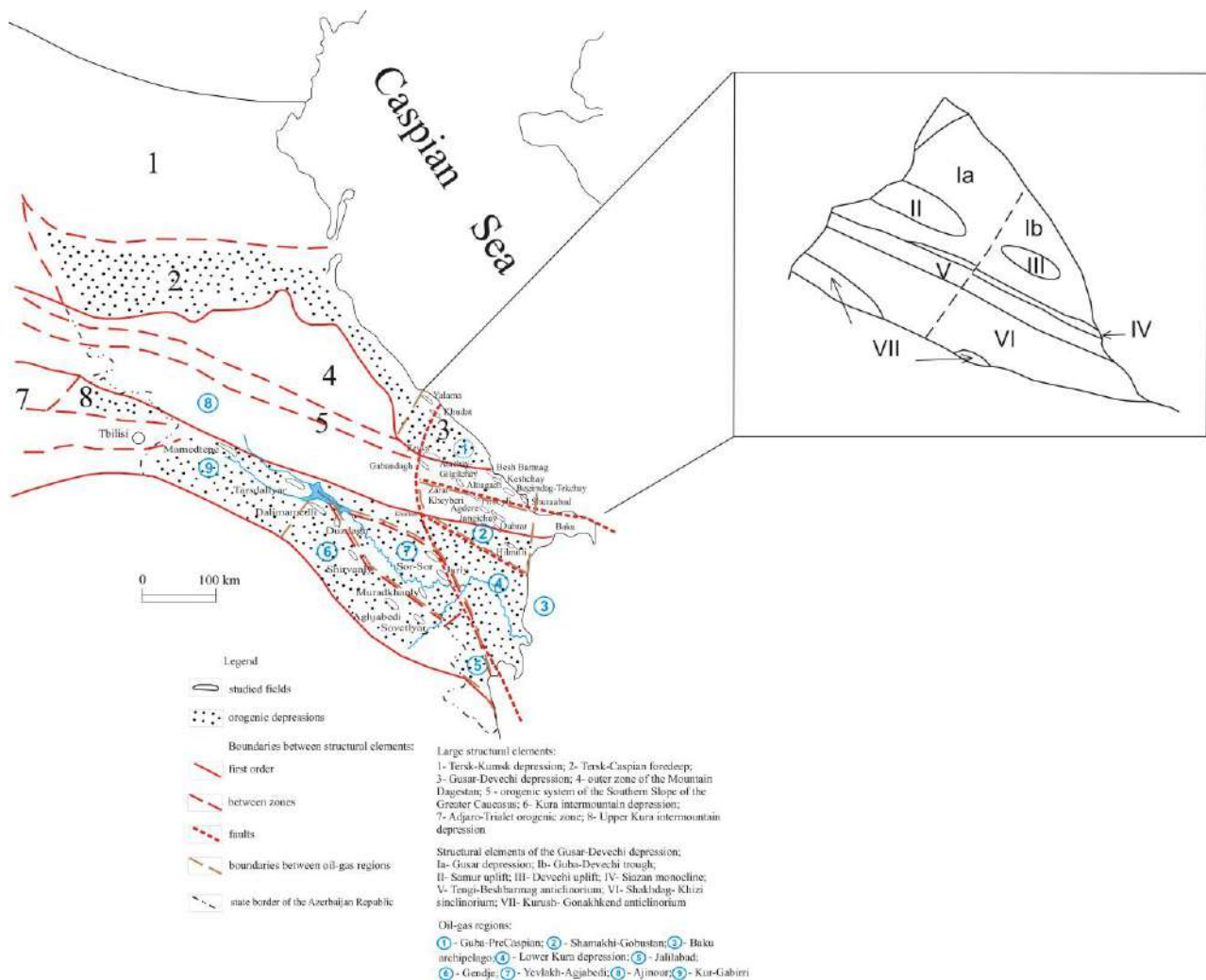


Figure 1. Tectonic structure of the studied area and location of the studied fields (tectonic scheme is from Gamkrelidze I.P., 1988)

The lithological composition of the Cretaceous deposits is very heterogenous in the Pre-Caspian-Guba Region. The Valanginian stage is represented in the PreCaspian-Guba Region by the flysch series of tight calcareous sandstones, limestones, marls and shales. The deposits consist of the coarse flysch facies composed of conglomerates, sandstones, shales, marls and limestones in the Beshbarmak uplift (Figure 1). The Valanginian Stage is dominated by gravelstone and conglomerates in the Khaltan region. In Dubrar (Figure), there is the normal flysch alternation of calcareous sandstones, limestones, marls and shales.

The Valanginian deposits of the southern slopes of the SE Caucasus are represented by the

rhythmic alteration of calcareous sandstones, pelitomorphic limestones, marls and shales. The thickness of those sediments reaches 1,000 m.

The Hauterivian Stage is represented by the shale lithofacies with the rare interbeds of marls and limestones. In some regions, such as in Dubrar, for instance, gravelstone, muddy conglomerates and siltstones are encountered as forming interbeds, too. The thickness of the deposits of this stage varies between 100 m and 500 m.

The Barremian Stage is represented by the shale series with interbeds of marls with the total thickness of 700 m in the Khizi Region (Figure 1).

In the Shahdag region, these sediments are composed of limestones with shale interbeds and infrequent sandy layers.

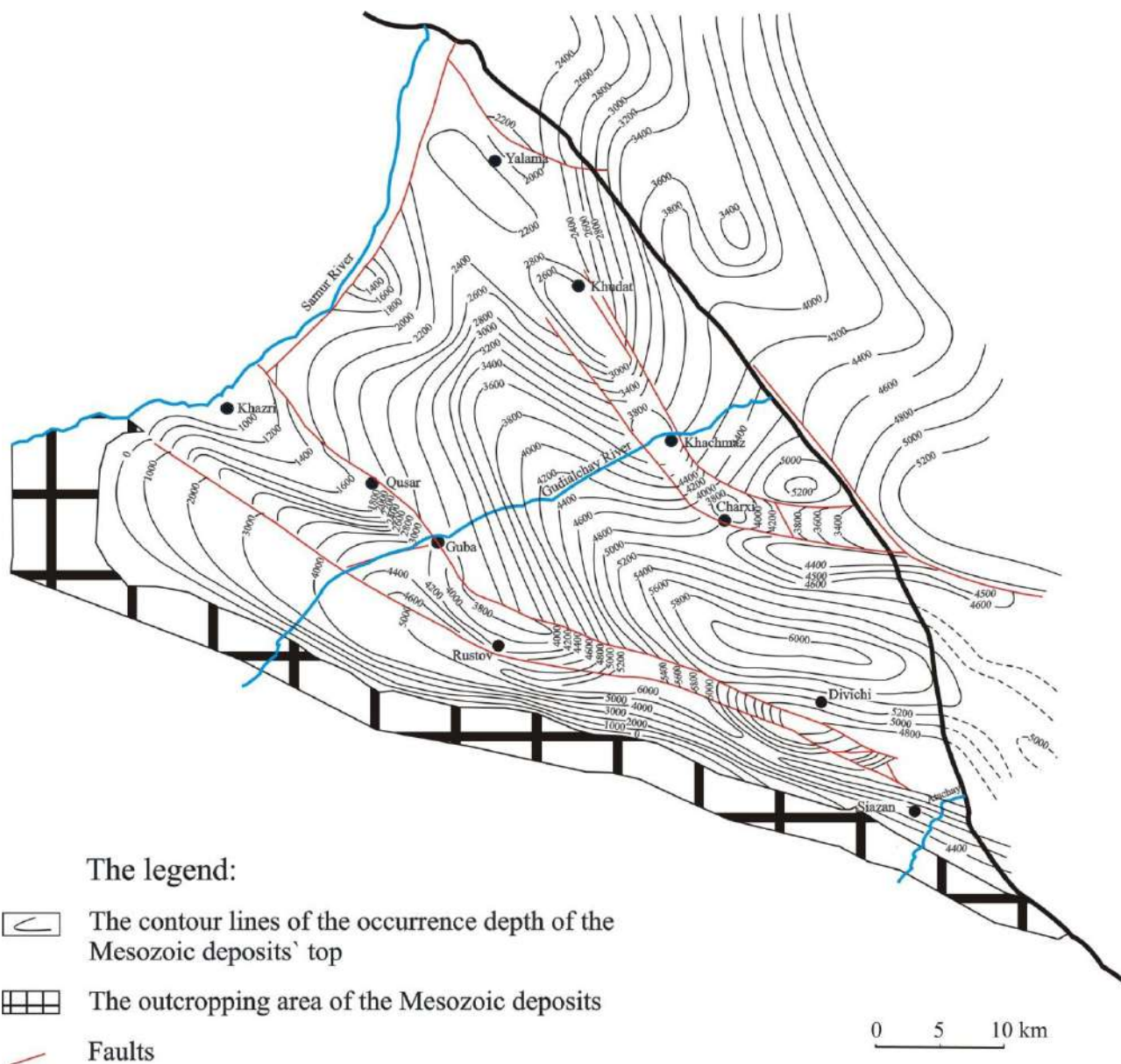


Figure 2. The structural map on the top of the Mesozoic succession of the PreCaspian-Guba Region (The Stage and Deposition Conditions...., 1985)

The Barremian deposits consist of shale rocks by more than 90% in the Shuraabad field (Figure 1). There are also individual interbeds of siltstones and marls. The thickness of the Barremian deposits reaches 800 m.

The lower portion of the Aptian stage is composed of shales with the rare interbeds of sandstones and siltstones. The overall thickness does not exceed 40 m. The thickness of the deposits of the upper portion of the Aptian stage reaches 140 m. The Aptian stage is represented by shales

with interbeds of marls in the region of Altiagach. The succession of the Aptian succession in Shuraabad locality is completely composed of terrigenous sediments. The share of siltstones grows up and they comprise almost a half of the section. However, the thickness of the Aptian sediments is not great and does not exceed 100 m.

The lower and middle portions of the Albian stage are represented by calcareous shales and marls with thin interbeds of fine sandstones. The Upper Albian has the 40-metre-thick series



of reservoir Kululu sandstones overlaid by the series of alternating sandstones, siltstones, argillites and shales, 50 m in thickness.

The deposits of the Upper Cenomanian are composed of shales with the frequent interbeds of sandstones reaching 7 m in thickness, and the lenses of gravelstones. The thickness of these deposits equals 130 m. The Cenomanian deposits in the Khudat-Yalama field are represented by sandy limestones and marls. Their thickness is 45–50 m.

The Lower Turonian is represented by the alternating interbeds of shales, marls and sandstones; the thickness is up to 1.5 m. The share of sandy rocks increases in the southern and south-eastern directions.

The Upper Turonian succession differs from the lower one by the appearance of conglomerates and sandy limestones as well as marls.

The Coniacian stage of the Dubrar-Yalama field is composed of the shale series with the sand interbeds of up to 0.5 m in thickness. Those deposits consist of marls and calcareous shales with the overall thickness of 50–75 m in the Yalama-Khudat region (Figure 1).

The Santonian deposits consist of shales and calcareous sandstones. The succession of those deposits in the Khudat-Yalama region is represented by the alteration of calcareous shales, sandstones, limestones and marls.

The Santonian-Danian deposits are not separated but manifest themselves as a whole complex at least 80 m in thickness in the Shuraabad section. Thus, the Upper Cretaceous deposits in this locality are characterised by the greatly reduced thickness.

The Campanian deposits consist of the shale-marl lithofacies. There are the infrequently encountered interbeds of calcareous sandstones and conglomerates.

The Upper Campanian succession in NW PreCaspian-Guba Region is dominated by marls and shale marls.

The dominance of carbonate rocks represented by limestones and marls with interbeds of shales and rare interbeds of gravelstones is common in the Maastrichtian succession.

To describe briefly the Cretaceous sediments' lithology within the limits of the PreCaspian-Guba oil-gas bearing region, we can note that the thicknesses of certain stratigraphic complexes decrease while the share of carbonate deposits grows up going northwards. For instance, the thicknesses of individual Cretaceous units are smaller in the Yalama field rather in the Tekchay-Keshchay succession. The percentage of carbonate sediments increases substantially; they form the upper portion of the Albian succession (marls) and practically the whole Upper Cretaceous succession (limestones with interbeds of marls). The Santonian and Lower Turonian deposits are not recorded in the section.

Mineralogy, mineral stratigraphy, provenance

The lithological-mineralogical descriptions of the Cretaceous sediments within the individual fields in the PreCaspian-Guba Region are shown below.

The succession of the Cretaceous deposits is represented with sufficient completeness in the Tekchay-Keshchay field (Figure 3). The thickness of the Hauterivian deposits here equals approximately 500 m. This succession composed of the terrigenous-carbonate series with the dominant clastic sediments. Terrigenous rocks are represented by the clay fraction as well as siltstones, sandstones and gravelstones. Carbonate rocks are represented by limestones and marls.

The Barremian succession is almost wholly comprised of detrital rocks with the exception of the singular interbeds of sandy limestones and marls. It is only in the lowermost portion of the succession that there are the individual interbeds of sandstones and conglomerates. The thickness is 600 m.

The Aptian deposits are well divided in the lower and upper ones by the occurrence of pelitomorphic limestones and marls in the Upper Aptian. The Lower Aptian is wholly comprised of terrigenous rocks with predominance of shales. The aggregate thickness equals 135 m.

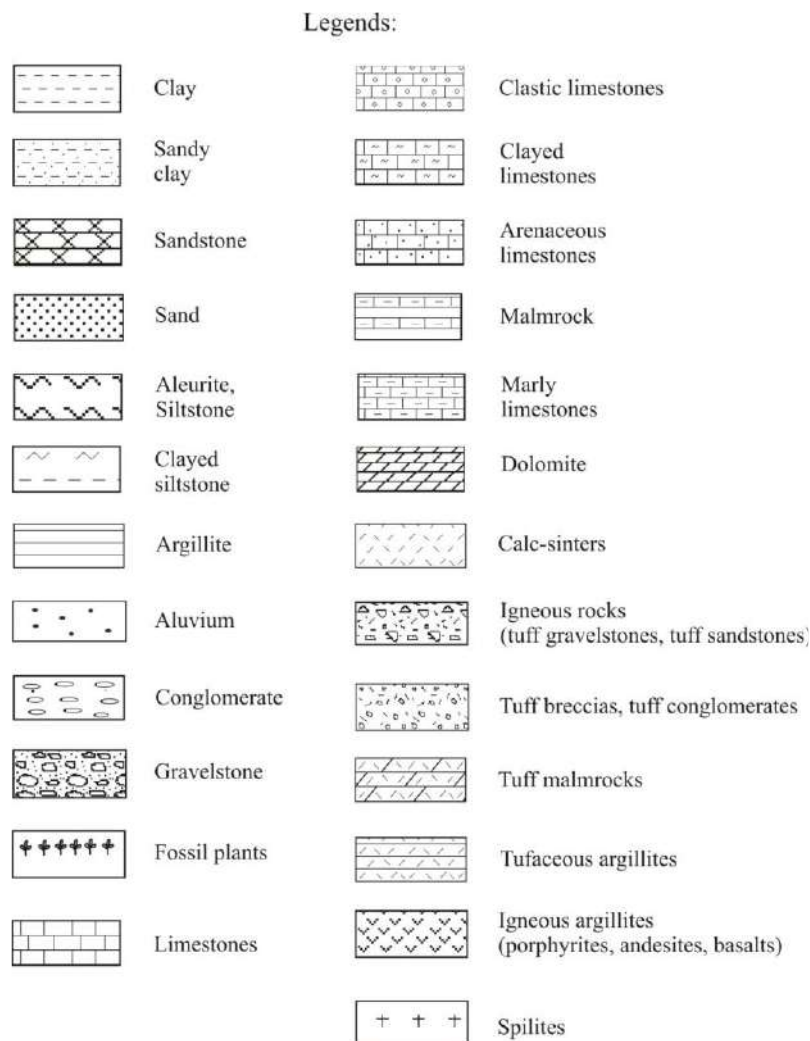


Figure 3. The lithological-mineralogical characteristic of the Cretaceous deposits in the Tekchay-Keshchay field of the PreCaspian-Guba oil-gas bearing region

The Albian deposits have the least thickness in the Lower Cretaceous succession; it equals 95 m; the deposits have the characteristic coarse grain of composition. Sandstones and sandy siltstones prevail. Limestones are only noted as sporadic thin interbeds.

The Upper Cretaceous succession strats with the Kemishdag Suite that pertains to the Cenomanian. Its succession has both terrigenous rocks (sandstones, gravelstones and, less commonly, shales and siltstones) and carbonate rocks – limestones and marls. The thickness is 130 m.

The Turonian-Coniacian deposits are not recorded in the Upper Cretaceous section. The

role of carbonate rocks significantly increases in the subsequent Yunusdag Suite (the Santonian – the Lower Campanian), which especially true of the uppermost portion of the suite. The thickness of these deposits equals 160 m.

Carbonate rocks are absolutely predominant in the Upper Campanian-Maastrichtian (the Agburun Suite). The thickness of these deposits equals 90 m; they are comprised of limestones and marls.

The mineralogical characteristics of the Cretaceous deposits in the Tekchay-Keshchay field testifies to inconstancy of provenance area.

The interval of the Yunusdag Suite (the Santonian-the Lower Campanian) stands out for the increase in the garnet, rutile, tourmaline, biotite, muscovite as well as staurolite and titanite contents.

All those minerals point to the metamorphic nature of the source area (gneisses and crystalline schists). The rather high quartz content confirms this conclusion. At the same time, the high presence of magnetite, ilmenite is also evidence of the occurrence of mafic, ultramafic rocks in the provenance area.

The Albian is the second interval characterised by the high contents of quartz, feldspars, garnet, rutile, tourmaline, zircon, staurolite, titanite, magnetite and ilmenite. Probably, the same rocks as above mentioned compose the provenance area for these sediments.

The succession's distinguishing feature is also that it has the high content of pyrites in the Aptian, Albian successions and Kemishdag Suite (the Cenomanian) as well as in the individual Barremian and Hauterivian intervals whilst the glauconite is absent with the exception of the Albian.

The Cretaceous succession in Tekchay-Keshchay field can be divided in two parts by the glauconite content: the lower one that incorporates the Neocomian deposits in which this mineral absent and the upper one that combines the Aptian - Maastrichtian deposits and is characterised by the mineral's appearance in considerable quantities and more regularly in the Cenomanian rocks and upper stratigraphic intervals.

Thus, if we were to subdivide the succession by its mineralogical composition, we would see the clear stratigraphy of those deposits into the lower portion from the Hauterivian stage to the Cenomanian stage inclusively enriched with the pyrite, and the upper portion, which is distinguished by high content of glauconite and absence of pyrite. As is known, the formation of pyrite is associated with microbial processes caused decomposition of organic matter and hydrogen sulphide formation in the reducing geo-

chemical conditions while formation of glauconite requires the presence of oxygen in the depositional environment.

These facts testify to the geochemical environment change in the basin of sedimentation from the reducing ones in the lower portion of the Tekchay-Keshchay succession to the more oxidising ones in its upper portion.

The muscovite and chlorite contents are substantially higher also in the Neocomian deposits while the content of staurolite, picotite, titanite, anatase, magnetite and ilmenite is considerably higher in the Aptian-Maastrichtian sediment, and those minerals' content grows more steadily in the Cenomanian-Maastrichtian deposits.

On the whole, it can be said that the provenance areas of the upper portion of the succession from the Aptian to the Maastrichtian and of the lower portion (the Hauterivian and the Barremian) were different.

It is important while providing the lithological description of the Cretaceous deposits in the Meshrif-Zeyva field (well #1) (Figure 4) to note, firstly, the reduced thickness of the sediments comparing with the Tekchay-Keshchay field, and, secondly, large hiatuses in sedimentation. A number of stratigraphic units - the Lower Aptian, the Upper Turonian, the Coniacian and the Santonian, fall out of the section. On a whole, the distribution regularities of certain minerals are matching along the Cretaceous section in the Tekchay, Keshchay and Meshrif-Zeyva fields.

For instance, glauconite appears and its content grows steadily upward the section from the Cenomanian to the Maastrichtian. It is absent in almost all the Lower Cretaceous deposits with the exception of the singular Barremian samples. Also, the content of muscovite and chlorite in the Meshrif-Zeyva field is significantly higher in the Barremian sediments than it is in the overlying rocks, while the quantity of titanite, picotite and anatase is higher in the Cenomanian-Maastrichtian deposits similarly to the Tekchay-Keshchay field.

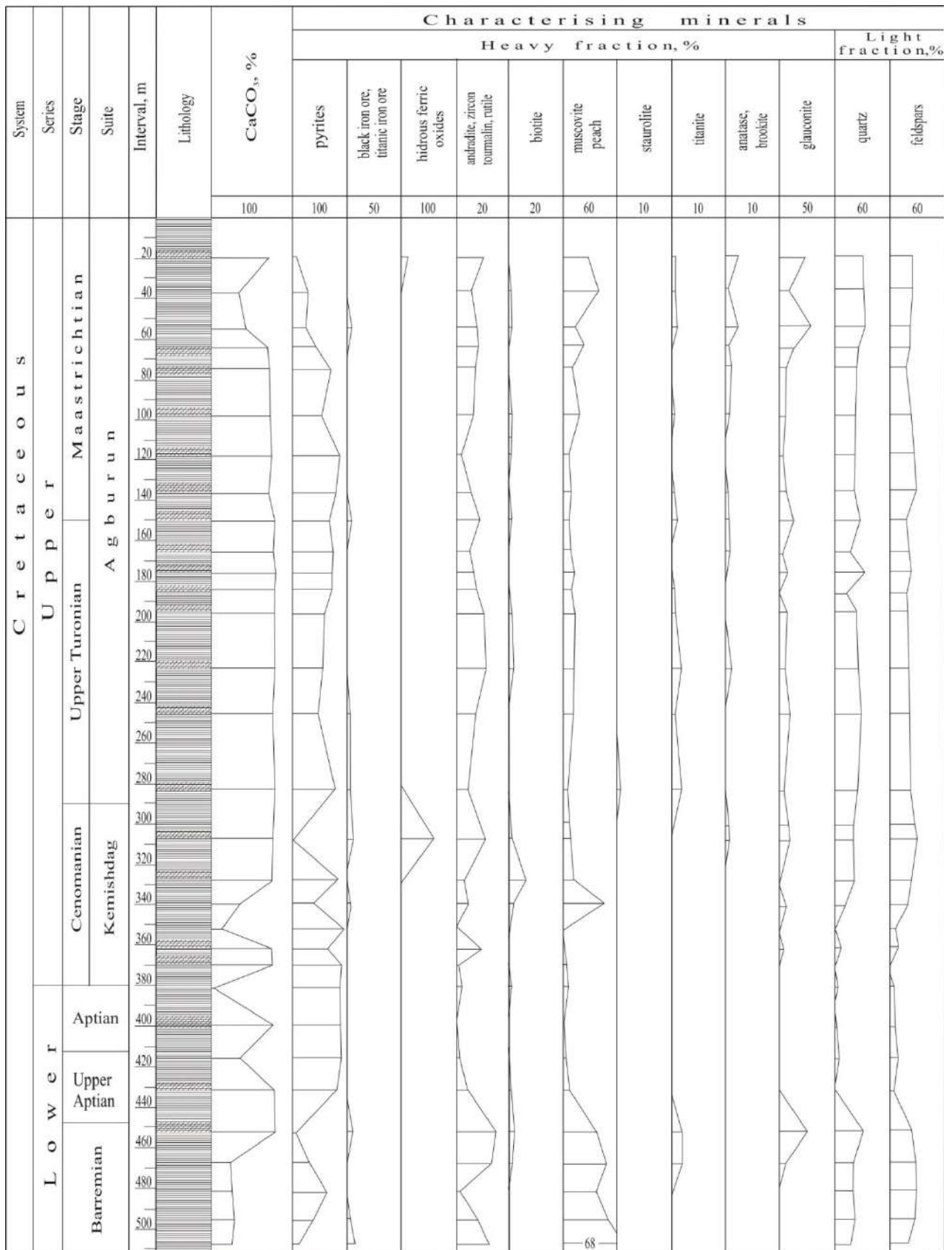


Figure 4. The lithological-mineralogical description of the Cretaceous deposits in the Meshrif-Zeyva field of the PreCaspian-Guba oil-gas bearing region, well 1 (see the legend in Figure 3)

For instance, glauconite appears and its content grows steadily upward the section from the Cenomanian to the Maastrichtian. It is absent in almost all the Lower Cretaceous deposits with the exception of the singular Barremian samples. Also, the content of muscovite and chlorite in the Meshrif-Zeyva field is significantly higher in the Barremian sediments than it is in the overlying rocks, while the quantity of titanite, picotite and anatase is higher in the Cenomanian-Maastrichtian deposits similarly to the Tekchay-Keshchay field.

The difference between the two successions consists in the behaviour magnetite, ilmenite and pyrite; no stratigraphic regularity is observable in the Meshrif-Zeyva succession.

Also, there is a difference between the distribution of quartz and feldspars, which reach the highest values in the Albian rocks in Tekchay-Keshchay field, and the lowest ones in Meshrif-Zeyva field. As regards the distribution of pyrite, the high contents of the mineral are encountered all along the succession of the Cretaceous deposits in the Meshrif-Zeyva field including also its upper series. This fact signifies the more reducing conditions that had taken place in the Meshrif-Zeyva field in the Cretaceous period in comparison with Tekchay-Keshchay field.

It could be said that the both fields have the same provenance area. According to the earlier studies (Suleymanov, 1969), those structures were located in the shallow-water zone in the Barremian-Aptian time, where the sandy, carbonate and silty-muddy rocks were accumulated. The dominance of the reducing geochemical conditions in such depositional environment could be the consequence of the basin's contamination.

Shamakha-Gobustan oil-gas region

Lithology, mineralogy, mineral stratigraphy, provenance

The depth of subsidence of the Cretaceous complex in Shamakha-Gobustan oil-gas region has very big variations. The top of these sediments is recorded at the hypsometrical levels changing from 0m in the northern part of the region to 13 km in its south-eastern part (Figure 5).

The rock samples selected from the Cretaceous outcrops of North Gobustan were used for the study of the mineralogical composition of the Cretaceous sediments (Figure 1). Based on the content of several minerals the Cretaceous succession in several fields is well stratified into lower and upper portions (Figure 6).

The upper portion of the Cretaceous section occurring in the interval from the top of the Albian stage upward the section differs from the lower portion for the significantly higher content of magnetite, ilmenite, garnet, zircon, tourmaline and rutile (Figure 6). Staurolite, picotite, titanite and glauconite are completely absent in the Neocomian but the content of muscovite and chlorite is considerably higher.

Glauconite appears in the Aptian succession and reaches the greater quantities in the Aptian-Albian and the Turonian-Coniacian rocks. The Aptian deposits differ in mineralogical composition from the other Lower Cretaceous deposits: they have the lowest quartz and feldspar content (Figures 6, 7).

The 10-metre horizon of the Kululu sandstones containing the increased quartz, feldspar, garnet, rutile, tourmaline, muscovite and chlorite content and the decreased magnetite and ilmenite content (Figure 8) emerges in the Pirbeyli section. This fact points to crystalline metamorphic rocks, which served as a source for clastic material for the Kululu sandstones. Thus, the quantitative and qualitative characteristics of the heavy fraction's minerals in the Cretaceous deposits in North Gobustan and the southern part of the PreCaspian-Guba region are very similar that testifies to the same provenance area for those sediments.

Yevlakh-Aghjabedi depression (Muradkhanly and Gyandja oil-gas regions)

Petrography, mineralogy, mineral stratigraphy

It should be mentioned while describing the composite section of the Upper Cretaceous deposits of Yevlakh-Aghjabedi depression (Figures 8, 9) that the changes in geodynamic setting caused the accumulation of the different



genesis and composition rocks. The thick series of volcanogenic and volcanogenic-clastic rocks appear in the Upper Cretaceous succession of the Yevlakh-Aghjabedi region. For instance, the petrographic composition of the Turonian stage that consists of limestones, interbeds of sandstones and tuffaceous conglomerates, tuffaceous gravelstones and porphyrites testifies to active volcanism in the marginal parts of the basin.

The fine grain size is common to the rocks of the Coniacian stage; they are composed of tuffaceous sandstones, marls with shale interbeds, sands and volcanic rocks, which points to the more distal conditions in the depositional basin, probably, to sedimentation in the transi-

tion area between the shoreface and shelf zones on the background of continuing volcanism.

The appearance of plant debris in shale and sand beds in the middle part of the Santonian succession suggests the occurrence of continental environment there, which were later replaced with marine facies.

The Campanian-Maastrichtian succession is almost completely consists of carbonate rocks. The gravel inclusions in them tell about the high energy environment. The occurrence of ash beds in the Campanian succession are evidence of the volcanic activity, which apparently stopped in the Maastrichtian time.

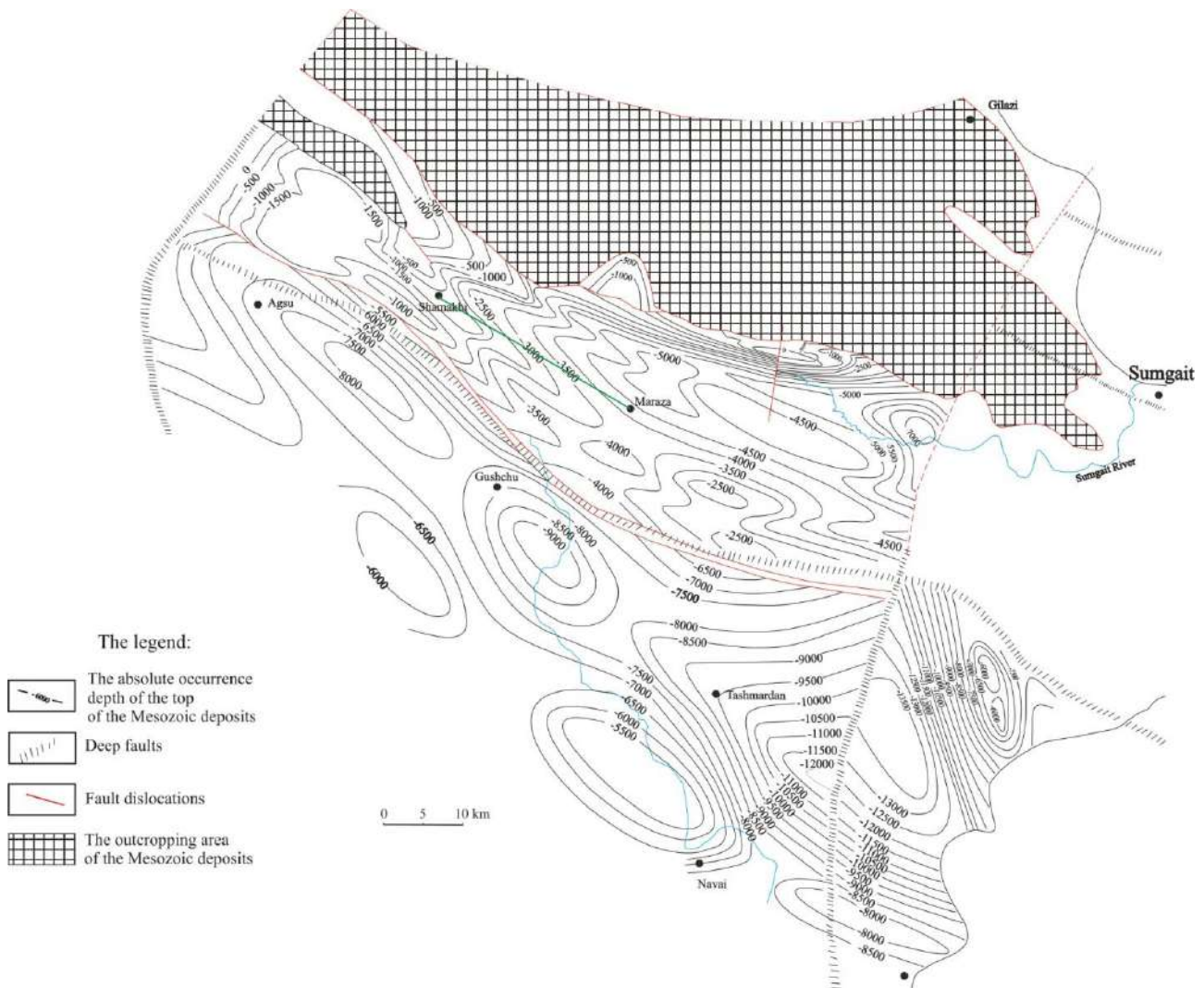


Figure 5. The structural map on the top of Mesozoic succession of the Shamakha-Gobustan oil-gas bearing region (The Conditions of the Formation and Location....., 1985)

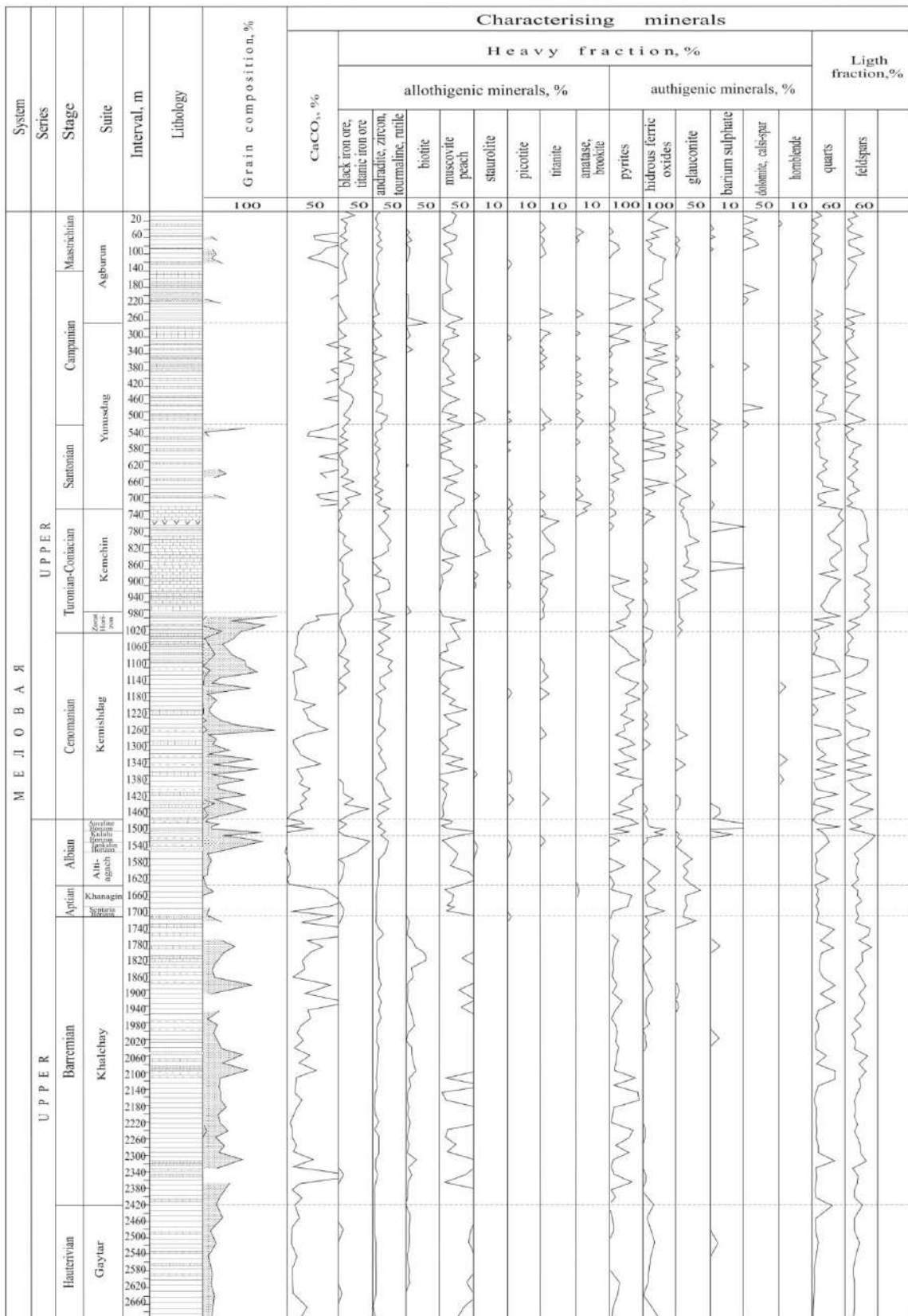


Figure 6. The lithological-mineralogical description of the Cretaceous deposits of the northern part of the Shamakha-Gobustan oil-gas bearing region (based on the studies of Mamedtepe, Agdere, Dubrar, Hilmili, Gabandag and Janghichay areas) (see the legend in Figure 3)

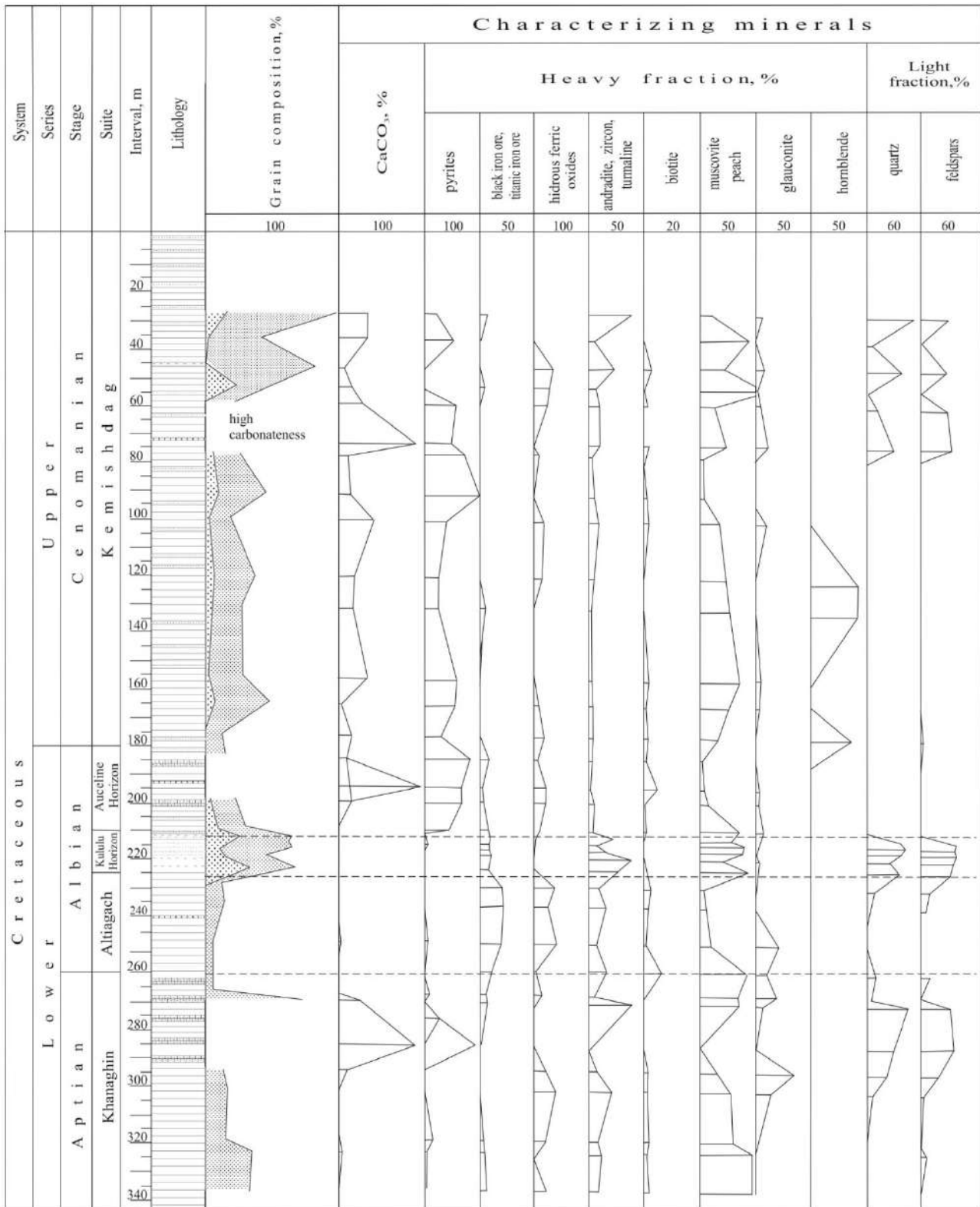


Figure 7. The lithological-mineralogical description of the Cretaceous deposits in the Pirbeyli area in the northern part of the Shamakha-Gobustan oil-gas bearing region (see the legend in Figure 3)

The aggregate thickness of the Upper Cretaceous deposits equals 1200 m on the average in the Yevlakh-Aghjabedi depression.

The Turonian, Coniacian and Santonian stages of the Dalimamedli field are represented by the 930-m series of porphyrites, andesites, basalts and tuffs as well as tuff breccias (Figure 8). The uppers of the Santonian and Campanian-Maastrichtian are composed of carbonate rocks – muddy limestones and marls with the aggregate thickness equalling 300 m.

Differently from the Dalimamedli field, the Upper Cretaceous succession of the Sovetlyar field is completely comprised of carbonaceous rocks as thick as 800 m (Figure 8).

The thick series of effusive rocks is found in the Lower Cretaceous in the Sor-Sor field within the Yevlakh-Aghjabedi depression. These rocks are replaced with the 220-m-thick series of argillites with marl interbeds in the Barremian succession (Figure 9).

The reactivation of volcanism in the Aptian brought about the accumulation of the volcanogenic-clastic rocks: tuffaceous sandstones, tuffaceous siltstones and terrigenous sediments, to the aggregate thickness of 100 m.

The Albian and Turonian stages fall out of the succession in the Sor-Sor field. The Coniacian Stage is the last stratigraphic unit of the Cretaceous to have clastic rocks with the thickness equalling 110 m.

The underlying Cenomanian and the overlying Santonian-Maastrichtian (510 m thick) deposits are composed of carbonate rocks – organogenic and crystalline limestones, dolomites and marls. The occurrence of the volcanoclasts in the Cenomanian succession suggests the submarine volcanism in that time.

The Cretaceous complex in the Muradkhanly field is represented only by the Upper Cretaceous sediments (Figure 9). The thick Turonian-Santonian series is completely composed of volcanogenic and volcanogenic-sedimentary rocks. The occurrence of tuffaceous gravelstones and tuffaceous sandstones in the succession testifies to shallow water volcanism. The uppermost sediments in the Santonian and Campanian-Maastrichtian sections are predominantly composed of carbonate rocks. The over-

all thickness of the sedimentary portion of the succession equals 220 m.

Similarly to the Sor-Sor field, the active submarine eruptions is notable in some intervals of the Turonian-Coniacian time and continues in the Santonian time in the Mamedtepe field in the Kura-Gabyrry oil-gas bearing region (Figure 10). There is only carbonate sedimentation in the Campanian-Maastrichtian there. The volcanogenic-sedimentary rocks were accumulating in the area of Tarsdallyar field. That tells about the extinction of the volcanic centres in the region's western part and their shift eastwards.

Conclusions

In the western Azerbaijan the volcanism started in the Lower Cretaceous acquired the submarine character at the end of the Neocomian. In the Barremian, the volcanic activity stopped, and reactivated again in the shallow water environment in the Aptian. The absence of the Albian rocks in the Sor-Sor field suggests both the shift of the Cretaceous basin boundaries and volcanic activity southwards. The underwater volcanism resumes in the Cenomanian. The volcanic eruptions this time as well as in Turonian time occurred in the marginal-shallow water zones of the basin. There is a significant shift of the volcanic centres to the south from Sor-Sor field which is confirmed by the absence of the Turonian rocks and accumulation of the sedimentary rocks started from the Coniacian onwards.

The underwater volcanic eruptions continued until almost the end of the Santonian in Gyanja region, in the south of the Muradkhanly oil-gas bearing region and in the Kura-Gabyrry interfluvial area. Thus, volcanism acquired the regional nature in the Turonian-Coniacian to be replaced with the sporadic volcanic centres in the Santonian. The data presented in the paper testify to the occurrence of the forearc and backarc basins within the limits of the Gyanja and Yevlakh-Aghjabedi regions as well as in the Kura-Gabyrry interfluvial areas.

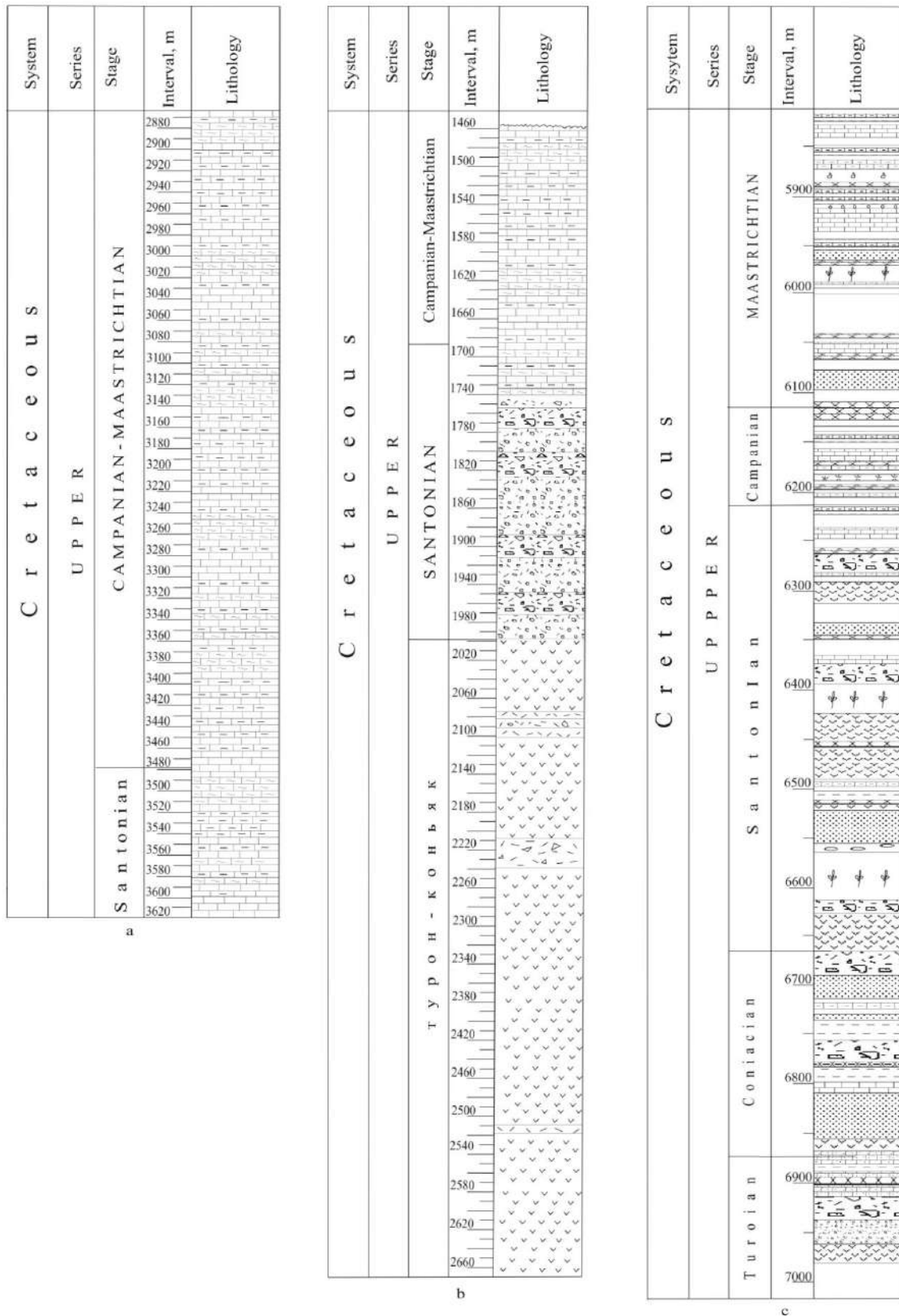


Figure 8. The lithologic section of the Cretaceous deposits of Yevlakh-Aghjabedi depression: **a.** the Sovetlyar field, well 1; **b.** the Dalimamedli field, wells No. 4, 18 and 28; **c.** the composite section – the Shirvanly, East Aghjabedi, Duzdag and Sovetlyar fields (see the legend in Figure 3)

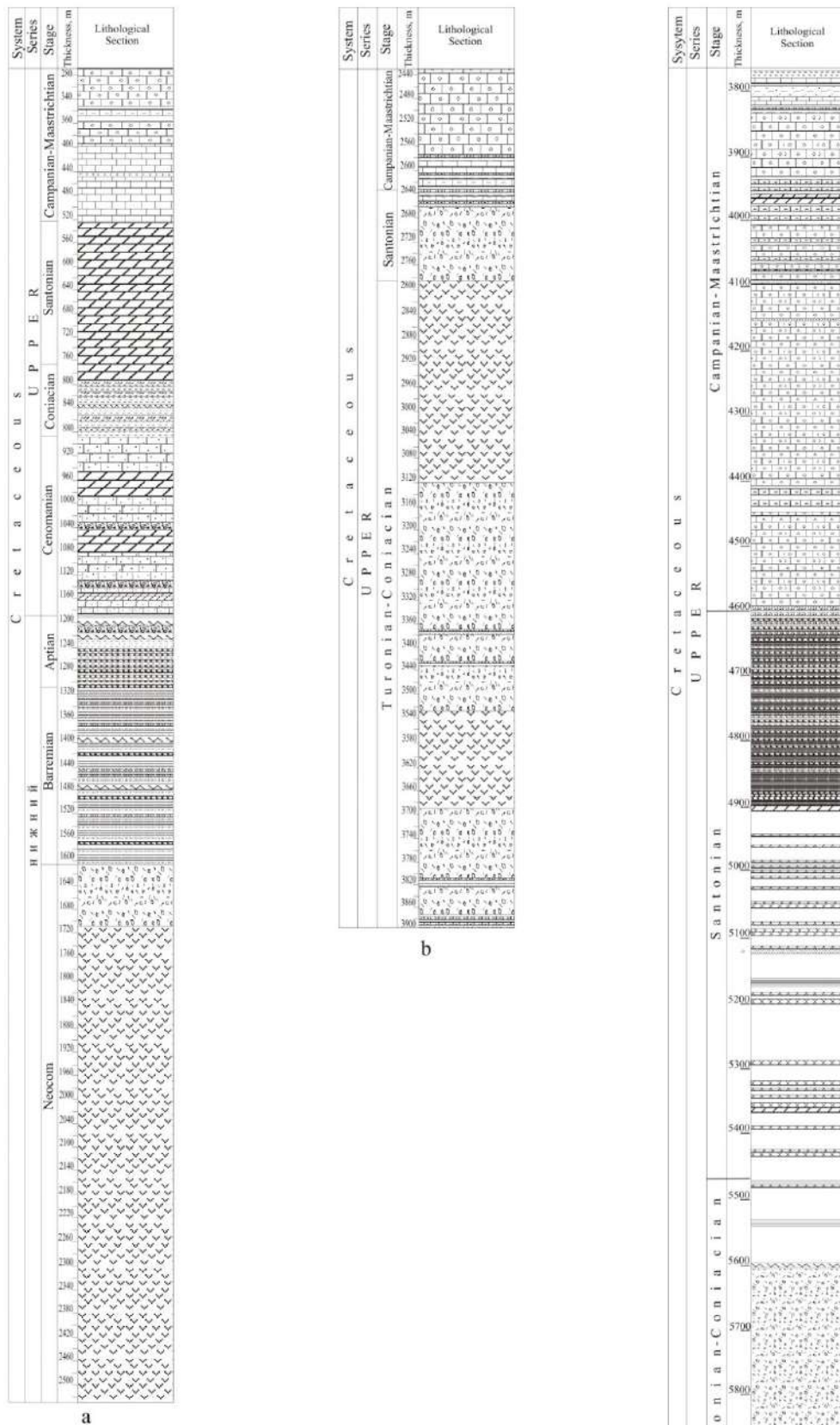


Figure 9. The lithological-petrological descriptions of the Cretaceous deposits of the Yevlakh-Agjabedi depression: **a.** The Jarly field, well 1; the Sor-Sor field, well 2; **b.** the Muradkhanly field, wells 7 and 12; **c.** the composite section of the eastern part of the SW flank (see the legend in Figure 3)

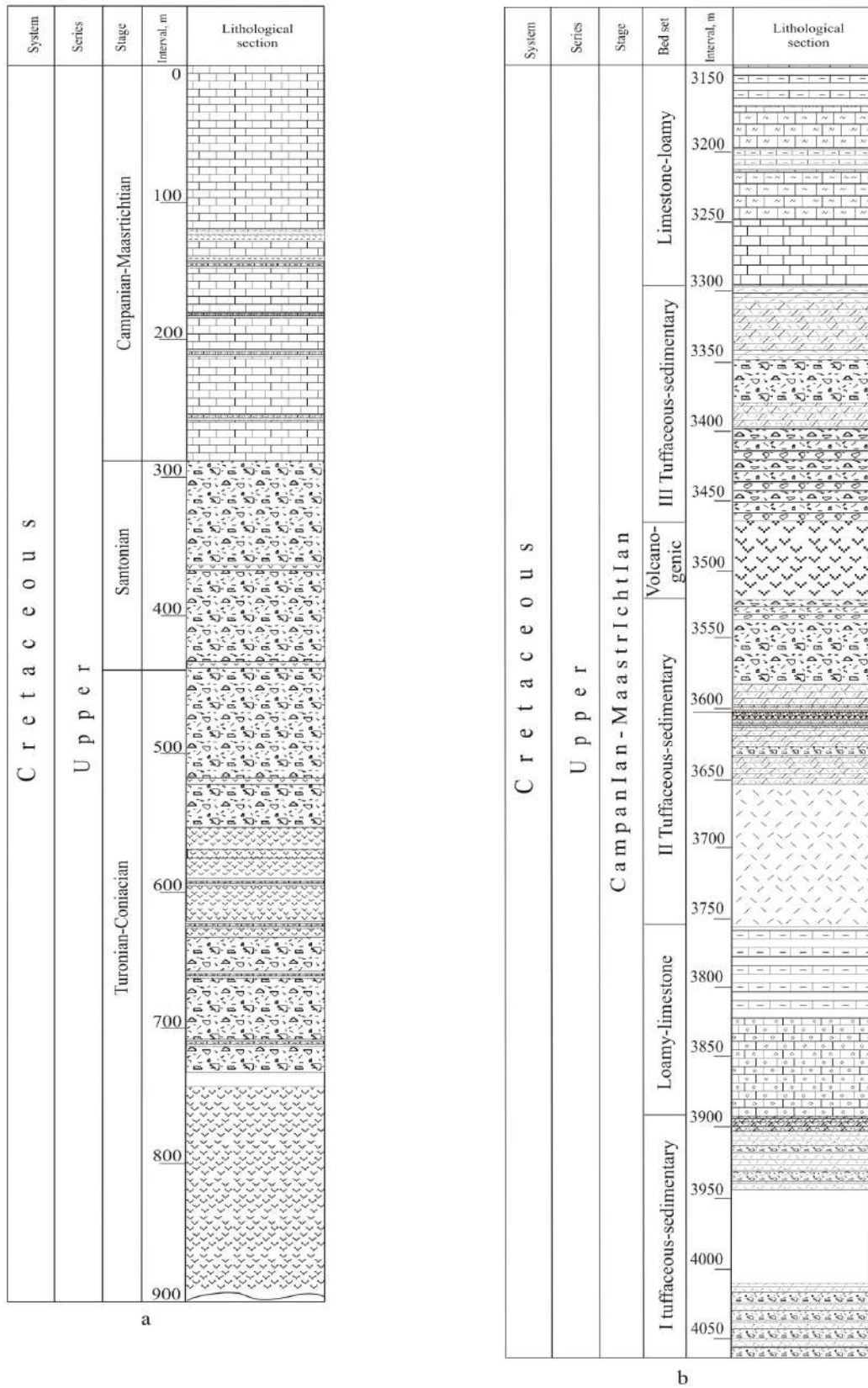


Figure 10. The lithological-petrological descriptions of the Cretaceous deposits in the Kura-Gabryry oil-gas bearing region:
a. the Mamedtepe field, well 1; **b.** the Tarsdallyar field, well 9 (see the legend in Figure 3).

Sedimentation occurred in the warm marine basin in the Campanian-Maastrichtian. Volcanogenic-sedimentary rocks are only encountered within the limits of the interfluvial area of the rivers Kura and Gabyrry.

Thus, the whole of the southern part of the Kura Depression was covered by the volcanism

and sedimentation of volcanogenic-clastic rocks, and in the Campanian-Maastrichtian carbonate sedimentation. Sedimentary rocks were accumulated only in the Eastern Azerbaijan-Absheron, Shamakha-Gobustan and Pre-Caspian-Guba regions.

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MINERALOJİ GÖSTƏRİCİLƏRƏ GÖRƏ AZƏRBAYCANIN TƏBAŞİR ÇÖKÜNTÜLƏRİNİN STRATİQRAFIYASI

E.H. Əliyeva, Ə.C. İmanov, K.H. Səfərli,
S.M. İsmaylova, A.T. Həkimova, A.N. Nəsirov

Məqalədə Azərbaycanın neftli-qazlı rayonları – Xəzəryanı-Quba, Şamaxı-Qobustan, Gəncə, Yevlax-Ağcabədi, Kür-Qabarrı çayları arasındakı ərazinin təbaşir çöküntülərinin bir sıra kəsilişlərinin detal lito-petroqrafik analizi verilmişdir.

Xəzəryanı-Quba və Şamaxı-Qobustan rayonlarının təbaşir çöküntülərinin toplanma mənbələrinin oxşarlığı göstərilmişdir. Verilən mineraloji tərkib əsasında öyrənilən kəsilişlərin stratigrafik bölgüsü aparılmışdır. Alınan nəticələr həmçinin Şərqi və Qərbi Azərbaycanın geodinamik və paleocoğrafi şəraitinin nə qədər fərqli olduğunu da göstərir. İddia etmək olar ki, sonuncunun hüdudlarında vulkanogen-çökmə qatın toplanması ilə xarakterizə olunan ada qövsünün ön və arxa hövzələri mövcud olub. Şərqi Azərbaycanda yalnız çökmə süxurlar toplanmış, sedimentasiya normal dəniz hövzəsi şəraitində baş vermişdir.

СТРАТИГРАФИЯ МЕЛОВЫХ ОТЛОЖЕНИЙ АЗЕРБАЙДЖАНА ПО МИНЕРАЛОГИЧЕСКИМ ПОКАЗАТЕЛЯМ

Э.Г. Алиева, А.Дж. Иманов, К.Г. Сафарли,
С.М. Исмаилова, А.Т. Хакимова, А.Н. Насиров

В статье дан детальный литолого-петрографический анализ целого ряда разрезов меловых отложений нефтегазоносных районов (НГР) Азербайджана – Прикаспийско-Губинского, Шамаха-Гобустанского, Гянджинского, Евлах-Агджабединского, между речья Куры и Габырры.

Показана схожесть источников сноса меловых отложений Прикаспийско-Губинского и Шамаха-Гобустанского районов, произведена стратиграфическая разбивка изученных разрезов на основании данных минералогического состава. Полученные результаты также свидетельствуют о различии геодинамических и палеогеографических обстановок Восточного и Западного Азербайджана. Можно утверждать, что в пределах последнего существовали фронтальные и тыловые бассейны островных дуг, характеризующиеся накоплением вулканогенно-осадочных толщ. В Восточном Азербайджане имело место лишь накопление осадочных пород, седиментация протекала в условиях нормально морского бассейна.

HYDROCARBON POTENTIAL AND RESOURCES OF LOWER PLIOCENE DEPOSITS (PRODUCTIVE SERIES) IN THE SOUTH CASPIAN BASIN

Two opposing points of view concerning the sources of hydrocarbons (HC) in the main reservoirs of the South Caspian Basin (SCB) Productive Series (PS-Lower Pliocene) reflect syngenetic or epigenetic genesis. Results of investigation are showed that neither quantity nor quality of OM and its maturation level do not support the idea of PS as a source rock. The hydrocarbon generative potential of PS is inadequate to the estimated and observed great petroleum resources in these deposits. It should be suggesting that petroleum fields in PS occurred as a consequence of subvertical migration from underlying (predominantly Oligocene-Miocene) deposits.

Keywords: *Petroleum, Field, Formation, Syngenetic, Epigenetic, Lower Pliocene-*

Introduction

For all history of exploration in the South Caspian basin (SCB) in low Pliocene Productive series (PS) 83 multipay fields (Azerbaijan sector of SCB) have been discovered (Figure 1), included 487 pools, about 54% of which are oil, 21 % – gas-oil and 25 % – gas-condensate.

PS ability for in-situ hydrocarbon (HC) generation is one of the fundamental challenges of the SCB petroleum geology and geochemistry. The geoscientists' ideas concerning the way of oil entrapment in PS reservoirs falls into 2 groups:

- (1) PS oil deposits are syngenetic (Agabekov, 1963; Alizadeh, 1980; Alizade et al., 1985; Aliyev, 2004; Dadashov et. al., 2006);
- (2) PS oil deposits are epigenetic (Bailey et al., 1996; Guliyev and Feyzullayev, 1996; Wavrek et al., 1996; Abrams and Narimanov, 1997; Inan et al., 1997; Katz et al., 2000; Feyzullaev et al., 2001; Gurgey, 2003).

Results of the latest studying of the sedimentary section in SCB, based on the modern laboratory techniques of organic matter, oil and gas examination enable to make impartial assessment of the HC potential of PS and consequently of its role in formation of petroleum fields in SCB, which is main goal of this paper.

A.A. Feyzullayev

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



D.A. Huseynov

Azerbaijan National Academy of Sciences,
Institute of Geology and Geophysics,
H.Cavid pr. 119, Baku, AZ 1143
d_huseynov@yahoo.com



Results of studies

Estimation of HC potential of PS

Evaluation of the hydrocarbon potential of the PS sediments was carried out based on the pyrolysis of core samples collected from the petroleum fields in SCB.

Sampling was selective related to the lithological character of the core (tested samples were represented argillaceous intervals of well sections). The laboratory studies of organic matter (OM) in clayey rocks included optical examination, pyrolysis, determination of total organic carbon (TOC) content. Optical data included measurements of vitrinite reflectance.

Pyrolysis-derived quantitative and qualitative characterization of OM in the Lower Pliocene PS sediments is given in Table 1.

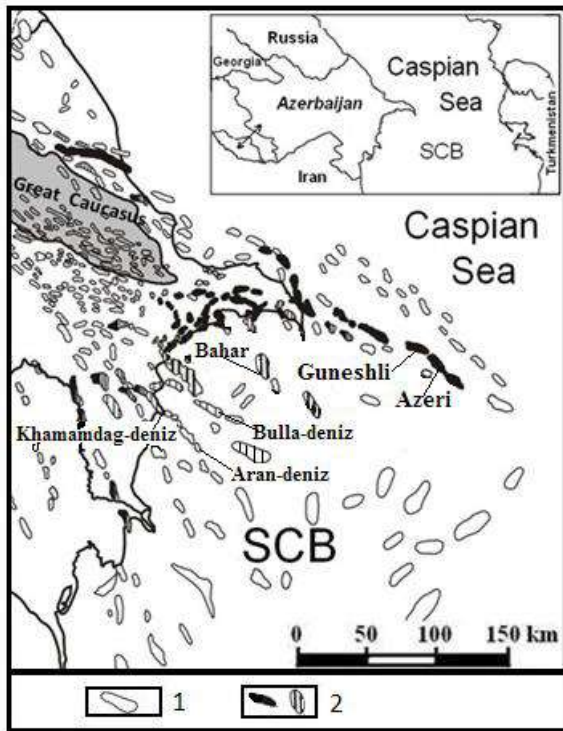


Figure 1. Map of location perspective structures (1) and oil-gas and gas-condensate fields (2) in SCB

According to Table 1, Figure 2 the sediments of the Productive Series were deposited in deltaic and near-shore/marine environments. Organic matter in this unit has poor source quality, with kerogen types 2/3, composed largely of reworked and woody material with minor amorphous and algal input.

Values of Oxygen Index (OI) allow concluding that the Lower Pliocene sedimentation took place in geochemically unfavourable (predominately oxidizing) conditions.

Table 1 give an overall geochemical characterization for the PS sediments in whole. Ge-

ochemical data for individual units of the PS are given in Table 2 show that the basal Kala suite (KaS) has relatively more favourable HC generative characteristics than other stratigraphic units of the PS (Huseynov, 2003).

Organic matter maturity

The corresponding temperature conditions are necessary for transformation of OM to HCs. Therefore, the level of a maturity of OM is the major parameter which together with other geological and geochemical parameters allows receiving certain information on depth of a zone of oil-and-gas generation, stratigraphic occurrence of the source rocks, the direction and mechanism of migration of HC fluids.

According to the existing conceptions based on experimental studies, value of present-day temperature of oil generation onset is about 100°C and a paleotemperature (R_o) – about 0,55% (Peters and Moldovan, 1993).

Vitrinite reflectance (% R_o) and T_{max} data indicate low maturity of OM (insufficient to start of oil generation) in Lower Pliocene rocks (see Table 1).

According to a modern geological structure of SCB top of PS reaches depth of start of oil generation only on the deepbured central part of basin. And its occurred at the final stage of history of development of basin. In other words, All parameters: history of subsiding, a modern occurring and heating duration indicated that there were no sufficient temperature conditions in PS for transformation OM into HCs.

Table 1

Statistic data of pyrolysis of Lower Pliocene rocks in SCB

Parameter	TOC (%)	S ₁ +S ₂ (mgHC/g rock)	S ₃ (mgCO ₂ /g rock)	HI (mgHC/g TOC)	OI (mgCO ₂ /g TOC)	T _{MAX} (°C)	R _o (%)
Number of samples	34	34	34	32	34	34	10
Minimum	0,14	0,16	0,02	21	2	315	0,25
Maximum	1,21	2,28	2,33	180	872	446	0,48
Average	0,47	0,57	1,02	84	269	389	0,33

Assessment of HC resources in PS

Many researchers attempted to estimate the HC resources of PS. Results of these estimates are significantly diverged. In our opinion the most reliable assessment is carried out by Guliyev et al. (2003) which results are given below.

The applied technique of assessment of HC resources is based on the determination of relationship between basin geodynamic type, sedimentation rate, and resource density in sedimentary basins.

Density of HC resources at calculated areas was established, basing on the implementation of reference values for reasonably assured HC resources at a number of fields that are used by calculations with correcting analogy factors, taking into account difference in parameters that control oil-and-gas content at reference and calculated areas.

Overwhelming majority of Azerbaijan oil and gas fields is confined to the Pliocene deposits. Meanwhile, potential discovery of new HC accumulations is nowhere near exhausted, particularly in Azerbaijan offshore part, including the Caspian Sea deep-sea section.

Reference sites have been chosen in Absheron, Lower Kura Regions and at the Baku Archipelago. Their density of commercial reserves varies from 25 (the Jeirankechmez Depression) to 910 th.t/km² (Absheron), averaged value of HC density being 470 th.t/km².

The Pliocene deposits of the Caspian Sea Azerbaijan section contain nearly 2.5-fold more (15.2 billion tons) of HCs than those of the on-shore (5.8 billion tons) (Figure 4 and Table 3).

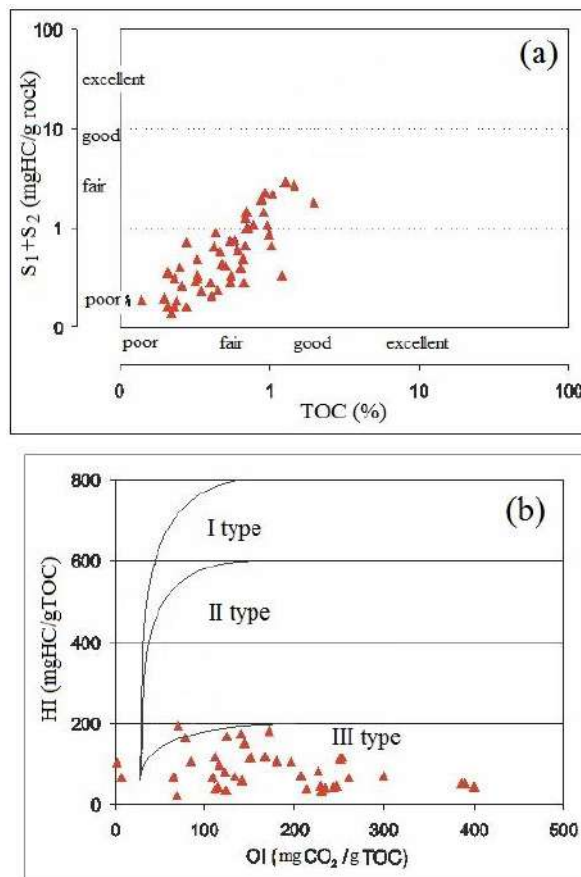


Figure 2. Generalized charts display the amount (a) and quality (b) of OM derived from Lower Pliocene deposits

Table 2
Quantity and Quality characteristics of OM from different suites of PS
(from younger to older)

Suite	TOC (%)	HI, (mgHC/gTOC)	OI (mgCO ₂ /gTOC)
Surakhany	0,16-0,48	27-31	346-1031
Sabunchu	0,19-0,53	17-43	296-609
Balakhany	0,11-1,31	24-169	97-638
Fasila	0,23-0,33	26-48	161-263
NKG	0,32-0,80	25-114	157-451
NKP	0,64	25	258
KS	0,48-0,82	27-67	151-381
PK	0,65-0,81	45-84	112-263
KaS	0,40-2,38	47-318	98-188

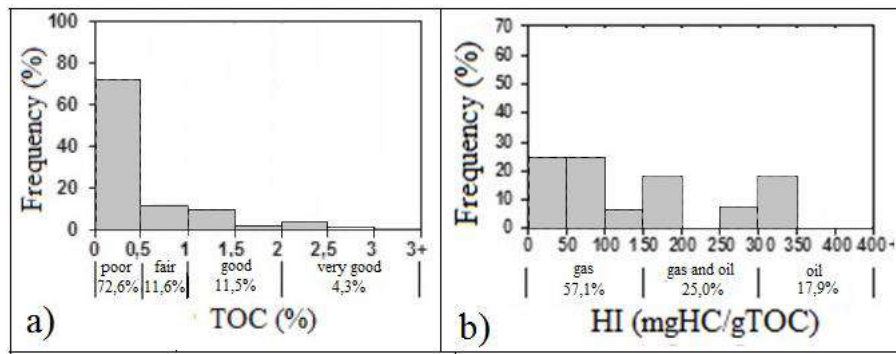


Figure 3. Histograms of TOC and HI values distribution for PS rocks. Classification of organic matter according to categories of Peters et al. (1986)

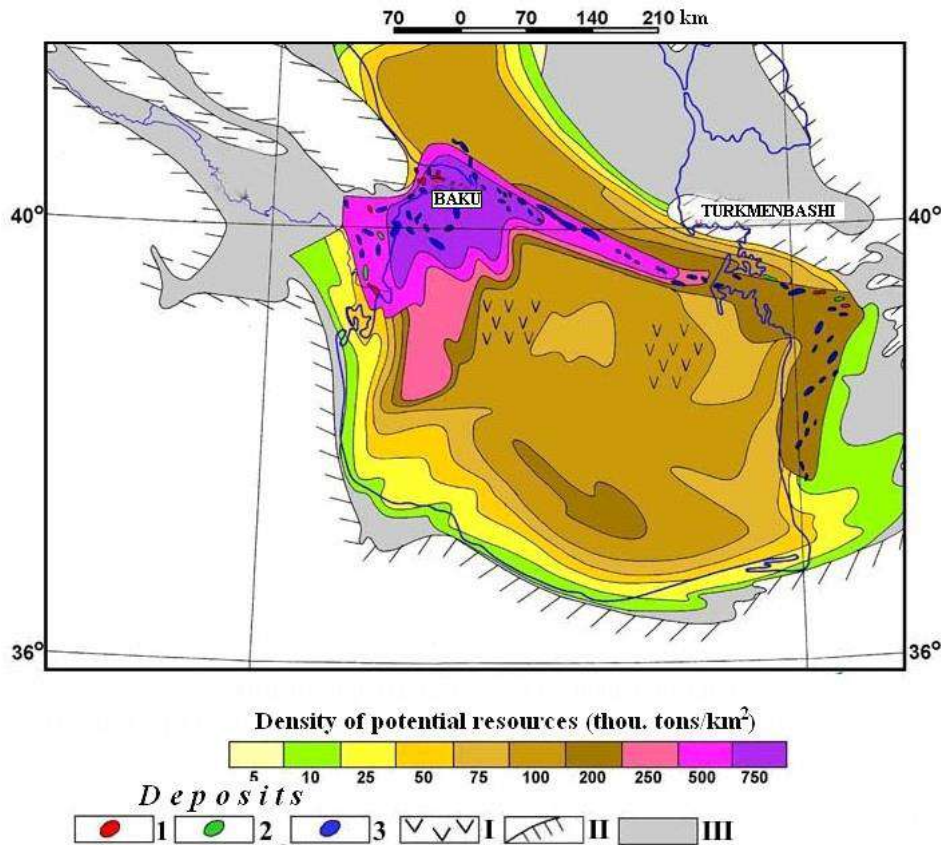


Figure 4. Distribution map of potential hydrocarbon resources in the Pliocene-Quaternary deposits: (1) oil; (2) gas; (3) oil-and-gas and gas condensate. I – regions of intense gas hydrate generation, hypothetical; II – distribution outlines for the Pliocene-Quaternary deposits; III - regions of low-thickness of sediments, not HC prospecting promising

Table 3

Ultimate potential geological resources in Pliocene deposits (in billion tons of RF)

Geological age	Onshore	Offshore	Onshore + offshore
Pliocene	5.8	15.2	21.0

As seen, basic volume of oil and gas resources is concentrated in the Pliocene complex, i.e., 21 billion tons of Reference Fuel (RF), or nearly 78% of the entire sum of HCs assessed for Azerbaijan as 27 billion tons of RF. In this, two thirds of these republican resources fall on the Caspian shelf (18.25 billion tons of RF).

Conclusion

Results of investigation of HC potential of PS are showed that neither quantity nor quality of OM and its maturation level do not support the idea of PS as a source rock.

The hydrocarbon generative potential of PS is inadequate to the estimated and observed great petroleum resources in these deposits. It should be suggesting that petroleum fields in PS have been formed due an inflow of allochthonous hydrocarbons from underlying units. This conclusion was confirmed by case study of one of larges in SCB Gyuneshli petroleum field, based on analyses of spatial distribution in PS the formation pressures, temperatures, isotopic composition of oil carbon, values of gas/oil ratio etc. All examined parameters indicated the abnormal zone, located in the SE part of the structure, reflecting conduits supplying HCs from the underlying strata (Feyzullayev, 2013; Feyzullayev et al., 2015).

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CƏNUBİ XƏZƏR HÖVZƏSİNİN ALT PLIOSENİN ÇÖKÜNTÜLƏRİNİN (MƏHSULDAR QAT) KARBOHİDROGEN POTENSİALI VƏ RESURSLARI

A.A. Feyzullayev, D.A. Hüseynov

Məqalədə Cənubi Xəzər hövzəsinin (CXH) məhsuldar qatında (MQ, alt pliosen) neft mənbəsinin mövcud olmağı barədə iki əks baxış öz əksini tapıb: singenetik və epigenetik əmələgəlmə. Müasir metodlarla aparılan tədqiqatların nəticəsi göstərir ki, üzvi maddələrin (ÜM) həm kəmiyyəti, həm də keyfiyyəti, həmçinin, onun yetkinlik dərəcəsi məhsuldar qatının özündə karbohidrogenlərin (KH) əmələ gəlməsinin mümkün olmadığını göstərir. Məhsuldar qatın törəmə potensialı burada özünü göstərən xeyli sayda karbohidrogen resurslarının formalaşması üçün yetərli deyil. Məhsuldar qatın neftli-qazlı yataqları karbohidrogenlərin altında yerləşən çöküntülərin subvertikal miqrasiyası nəticəsində yaranmışdır (xüsusilə oliqosen-miosen).

УГЛЕВОДОРОДНЫЙ ПОТЕНЦИАЛ И РЕСУРСЫ НИЖНЕПЛИОЦЕНОВЫХ ОТЛОЖЕНИЙ (ПРОДУКТИВНАЯ ТОЛЩА) В ЮЖНО-КАСПИЙСКОМ БАССЕЙНЕ

A.A. Фейзуллаев, Д.А. Гусейнов

В статье указано о существовании двух противоположных точек зрения относительно источников нефти в главном резервуаре Южно-Каспийского бассейна (ЮКБ) - продуктивной толще (ПТ, нижний Плиоцен): сингенетичное или эпигенетичное их происхождение. Результаты проведенных исследований с применением современных методов свидетельствуют о том, что ни количество, ни качество органического вещества (ОВ) и степень его зрелости не поддерживают идею об образовании углеводородов (УВ) в самой ПТ. Генерационный потенциал ПТ является недостаточным для формирования выявленных в ней значительных ресурсов УВ. Обосновывается, что нефтегазовые месторождения в ПТ образовались в результате субвертикальной миграции УВ из подстилающих ее отложений (преимущественно Олигоцен-Миоценовых).

THE CONTRIBUTION OF ALEXEY PAVLOVICH IVANOV INTO OIL AND GAS GEOLOGY

(On the occasion of the 150th anniversary)

Synopsis

Alexey Pavlovich Ivanov was born in the Smolensk Governorate on 1(13) March 1865. He graduated from the Moscow University in 1890. He was a wide-range geologist who studied the Sarmatian sediments, developed the stratigraphic diagram of the Cismoscow Carbonic, researched the phosphorite deposits and addressed the problems of water supplies in Moscow and other towns of Russia. He contributed significantly to the making of the oil geology at the beginning of the 20th century. He studied the Ukhta Province, Cheleken and the Volga Region. Ivanov's methodological tenets were the immutability of facts and the invariable consideration of all the materials without exception, especially, of those that contradicted the wide-spread 'aqidahs. He stood for the theory of the deep-seated origins of hydrocarbons and believed that their resources on the Earth are inexhaustible.

Keywords: Oil, Ukhta, Cheleken, the Volga Region, the origins of oil and oil resources, statistics in the oil industry, scientific methodology.

The Making



Alexey Pavlovich Ivanov was born in the village of Myasoyedovo in the Vyazemskiy Division of the Smolensk Governorate on 1(13) March 1865. He went to the gymnasium in Vyazma at first and in Moscow then. In Moscow, he began early on to earn his living as a private tutor. Ivanov entered the Natural Sciences Unit of the Physical-Mathematical Department at the Moscow University in 1884.

Similarly to many contemporaries, Alexey Ivanov spent his student's years revolting against the discipline and regulations that he did not like – and especially against the extraneous vigilance of the inspectors.

'The chronicle of the Moscow University dated 1887 has the 'Bryzgalov Case' related to the name of one of the obscurant inspectors. The 3rd-year student Alexey Ivanov was among those who were arrested and put in prison,' his daughter Elena reminisces in her own writings.

A.I. Galkin

The 'Local Historian' Ukhta Club
40, Lenin Street, Ukhta, 169 300,
the Komi Republic, Russia
E-mail: a.i.galkin@yandex.ru



Then, Ivanov was expelled from the university 'without the right to enrol at any postsecondary academic institution' and sent in an exile back to his native Vyazma. Alexey was only able to restore his status of a university student thanks to a happy coincidence. What's more, he even secured himself a government-paid student allowance (Иванова, 1940, page 8).

Ivanov went in chemistry, botany and geology at the university. He attracted the attention of Professor Alexey Pavlov at the geology graduation exam in his last year at the university. The inquisitive student had found the Callovian sediments near the village of Myachkovo where they had never been discovered before. Professor Pavlov suggested Ivanov should choose this problem as a subject of his diploma thesis; the suggestion was accepted and that predetermined the further path of the future's researcher. Alexey Ivanov graduated from the university in 1890



and devoted the rest of his life to geology (ibidem, page 9).

Professor Pavlov had intended to keep the promising graduate at the university so he could work on his master's thesis but the unblinking eye of the Ministry of Internal Affairs never let the politically unreliable young man out of sight – so much so that he had remained under police stakeout until 1908. Moreover, he never had a constant source of income for many years to come.

Alexey had earned his living and sustained the family as a private tutor since he was at school. This practice came to succour at the university and during the years that followed, too.

'A.P. lived by giving private lessons and small practical geology jobs from 1882 to 1901... Besides, he gave consultations to the Moscow Engineer Society on water supplies, organised and conducted explorations to find various minerals (iron ores in the Lipetsk Division, brick earth in the Vladimir Governorate, phosphorites in Podolia and so forth), gave scientific consultations about various geological and hydrogeological problems, such as about the cracks and subsidence of a cathedral in Vologda because of the Vologda-Arkhangelsk railway groundwork, the damage done to the moss moor from the groundwork on the Vindava Railway and so on,' (ibidem, page 10).

Perhaps, he would not do what he had no interest in doing but preferred the slender – but free – existence to any constant service with the guaranteed wages. So, he limited himself to sporadic and short-term contracts.

None the less, Alexey Ivanov never interrupted his research. He followed his graduation up with the continued study of the Sarmatian sediments and not only in the Cismoscow Region but also in the southern governorates of Russia and in the Baltics. The Moscow Society of Naturalists supported the young scientist in this drive in every way including the financial one. Soon enough, he had his first work titled 'The Palaentological Data for Vertical Stratifi-

cation of the South Podolian Sarmatian' in The MSN Bulletin. The publication in 1893 forerun his admission to the MSN as a full member as soon as at the beginning of next year. He remained a very active and thankful member of the MSN all his life: it was at the MSN sessions that he would first make his research announcements and it was in the MSN publications that he had many of his reports taken out and it was to the MSN that he donated his collections (ibidem, page 9).

Ivanov focused on the Sarmatian sediments during the first decade on graduation from the university: seven out of the nine publications of 1893–1899 by Ivanov were devoted to the Sarmatian.

Still, he remained invariably interested also in a broad range of issues and took part in the geological life of the country in that period. The reputation of an active MSN member allowed him to attend the sessions of the 7th International Geological Congress in Moscow. Because all the participants of the IGC session were entitled to free travels at field travels, Ivanov and his fellow Shirovsky visited many canonical sequences of Russia (Livonia, Estland, Bessarabia, etc.) (ibidem, page 10).

Ukhta

Alexey Ivanov first encountered oil in Timan in 1895 where he was sent on a research trip by the Von Wrangel Artesian Drilling Company to check the petroleum springs in the basin of the River Ukhta for reliability. Ivanov inspected the Permian and Post-Tertiary sediment outcrops along the banks of the Ukhta and along the banks of its tributaries also. The very succinct trip report only contains the rock lithology information and the faunal discoveries while it is completely devoid of oil-show descriptions. The author merely reported that *'such a research is not complete yet'* (ИВАНОВ, 1896, pages 32–33).

Having visited that province once, Alexey Ivanov never left it out of sight in the future. For instance, he made a commentary immediately

he heard the report by Alexander Chernov 'On the Geological Conditions of the Pechora Oil Occurrences' at the MSN session in 1907. Ivanov's objections concerned not so much the representations by the reporter as they did the materials about the age of the Devonian sediments on the difference sides of the hade fault at the Grand Rapid on the River Ukhta published by Theodosiy Chernishov previously. He wrote: 'As regards the research by A.P.Ivanov carried out in 1901, the rocks of both the eastern and the western wings of this hade fault pertain to the one and the same Domanic Horizon with the sole difference being that the lamellar malmstones of the goniatite (Domanic) horizon that are identical in fauna and petrographic composition are fully saturated with oil and turned into oil shale known as the "Domanic" in the western wing whilst the rocks of the eastern wing have no oil shows at all but represent the original parent rock of the Domanic... A.P.Ivanov found the Domanic parent rock not only in the eastern wing of the grand hade fault on the River Ukhta but also 1_{1/2}-2 versts upstream from the estuary of the River Gerd'-Tol'; there, the lamellar malmstones and limestones containing the goniatite horizontal fauna are clearly oil-saturated in the most permeable intermediate layers but barely smell of oil when heated or do not contain oil at all. Apart from the fault diastrophisms that were established by F.N.Chernishov and that had conditioned the localised oil-saturation of the goniatite and other horizons of the Devon, A.P.Ivanov found several (3-4) parallel cracks filled with the calc-spar cogs as thick as up to 10 cm in the mouth of the River Ukhta and a little downstream from the mouth of the Chutu. Doubtless, those cogs originated **after** the formation of the Domanic's **oil content** because the calc-spar mass of those cogs incorporate shards of the solid oil-bearing Domanic' (ИВАНОВ, 1908, pages 32-33; the author had inaccuracies in the river names; for instance, it should be the **Gherd-Eeol'**, downstream from the mouth of the **Chut'** – A. G.). Alexey Ivanov is a splendid observer here just

as he has been always and everywhere. The numerous cracks in the Devonian rocks did not escape his attention; he always examines the nature of their filling meticulously as ever he did. On seeing the ingrained Domanic rocks in the calc-spar mass of the cogs, he draws the conclusion about the time of the diastrophisms.

Alexander Zamyatin disagreed with the observations of Ivanov that the malmstones were the Domanic's parent rock because 'apart from the petrographic difference there is the sheer and substantial faunistic difference: the malmstones contain but the negligible portion of the extremely rich Domanic fauna; maybe, those malmstones represent a horizon higher than the Domanic ...' (ЗАМЯТИН, 1911, page 535). Zamyatin also argued against Ivanov's reasoning about the hade faults along the Chut' – Alexey Ivanov had argued for the presence by referencing the calc-spar cogs (ibidem, page 536). But Alexander Zamyatin is likely to be wrong about this particular point.

Another reference that Ivanov made to the Ukhta is very interesting. The journalists writing about the province in the Soviet times maintained (whether they themselves believed what they wrote or not) that the capitalists – the Nobels – did not wish competition from other provinces of any kind and so hindered the research in the Ukhta in every way they could. However, Alexey Ivanov saw the root of the failed oil-field search in the Ukhta Region not in some wire-pulling by the Nobel Brothers but in the fact that nobody would need oil-fields in the roadless backwater place whilst there were the rich fields in the habitable and populated regions connected to the centre of Russia by means of sound transport arteries and sea-ports (Ivanov, 1904, page 1972).

Cheleken

Alexey Ivanov happened to become familiar with the oil-fields of Absheron and Cheleken eventually. He spent about two years (from the spring of 1900 to the spring of 1902) working on the island. Ivanov was an excellent observer;



so, he studied the geological structure of Cheleken in general as well as in detail and very rigorously, too ('all the formations in the myriad places'). He put such questions to himself and to his colleagues that were very substantial for understanding the nature of the field.

'The first question about oil that the geology of Cheleken has to answer is **whether the oil present in the elevated and fractured Cheleken formations had been in them before their elevation and fracturing and in precisely which formations it had been,**' Ivanov wrote. And answered his own question thusly, '**...no sandy formation and no formation of any manner in general liable to contain oil had been an oil-bearing one prior to being elevated... Oil occurred in those parts of the formations following their elevation and not from the depths greater than 750–800 fathoms because there was no oil in the Cheleken Island in the formations up to that depth mark before**' (ИВАНОВ, 1903, page 395; the highlights in the quotes by Ivanov here and below).

In no formation did Ivanov note the *constant* signs of oil content, such as 'containing oil', 'brownish with oil' or 'smells of oil'. And it is only in bonnies that '**at some points many permeable formations bear oil to this or that extent.**' In the Caucasus, the uneven saturation is attributed to the sharp differences in physical composition of the formation but everything is accessible to examination in Cheleken, Ivanov remarks. And concludes as follows: '**...the bonny-like distribution of oil in a formation cannot be explained with the rock physical formation differences within the one and the same formation because in the overwhelming frequency of cases one has to observe that a formation that is completely homogenous in physical composition (sand) happens to contain oil in the one and the same uninterrupted outcrop facing kir sandstone here but to have no traces of oil there**' (ibidem, page 396).

Also there, and in one of the characteristic outcrops, too, Ivanov recorded that «...at this point, oil is filled into **the whole series of the**

rocks that outcrop here, that is, malmstones and clays, in some ways (via several faults' fissures that cross this outcrop transversely to the bearing). Apparently, it occurred under great pressure because malmstones as well as partly clays, even, turn out to be richly saturated with oil.' And this is how he ends the description: '*So, we see that oil occurs (occurred) in bonny patterns here – not only in only the sandpack but so that the bonny encompasses a whole good complex of diverse rocks with the thickness of approximately 15 fathoms*' (ibidem, page 399). Probably, he was not familiar with the work by Hermann Abich that offers the reasoning about the active impact of oil on the bearing formation (Абих, 1864, page 143). Otherwise, he would have definitely referred to his predecessor.

A detailed article by Alexey Ivanov that was published in 1909 is devoted to the mineralogy of Cheleken. Sulphates (anhydrite, gypsum, barite, jarosite and halotrichite), chlorides (halite), iron minerals (limonite, siderite and iron pyrite) as well as copperas and oil derivatives (ozokerite and kir) are encountered among the minerals he had noted on the island.

Ivanov distinguishes two types of ozokerite fields: '*The primary lode ones developed along cavity dislocations and mainly along those that have the insignificant widths*' (ИВАНОВ, 1909, page 170). Then follows a very curious observation confirmed by the witness by the local dwellers produced ozokerite, '*The ozokerite lodes are only located in those points of the fault fissures where the clayey and, in general, the hardly permeable beds adjoin – and are never there where sandy layers are found in one or both wings of a fault fissure*' (ibidem). Ivanov also recorded the consistency of ozokerite meticulously; he noted that it would become softer as depths increased and even doughy in the 10-cm diggings. Such observations by Alexey Ivanov were very valuable for geology and always attracted the attention of his colleagues. For instance, Kazimir Kalicky gave Ivanov's work its due in his overview (Калицкий, 1917,

page 16). Ivanov also offered interesting considerations about the earth material of the island. He wrote, '*There are the very clear indications on the Cheleken Island that the sediments of the vividly coastal nature could be of the deep (igneous) origin. Indeed, there are the lens-shaped interlayers of the black 'porphyraeous' clays within the thick (up to 75 metres) series of the typical mud-volcano clays in the upper sequence of the Baku Horizon; in their upper part they are accompanied by the interlayer of the coarse quartz grit as thick as up to 0.2 metres and with the grain sizes equalling 1–5 mm, with the pebbles of up to 5 cm, the milky-white quartz, the bluish semi-transparent chalcedony, the black sandy phosphorite with the rounded Lamna teeth as large as up to 4 cm and the shards of belemnites... By the sand particle sizes as well as by the composition of the boulder incrustations, the material of this grit interlayer is completely alien not only to the whole series (approximately 1600 m) of the bedding rocks that outcrop on the Island Cheleken but also to the nearest (in the vicinity of Krasnovodsk) bedding rock outcrops on the coasts of the Caspian'* (ИВАНОВ, 1908, pages 1013–1014).

An oil fountain gushed from the depth of several dozens of fathoms in the well No. 40 drilled in the Nobel Brothers' Company field in Cheleken at the end of 1907. The fountaining oil was estimated at 50–90 thousand stones per day. The debit of the well was unexpectedly high for the Cheleken Field at the time. Alexey Ivanov was not slow to respond to the numerous publications about the fountain. The rather spacious article he wrote have as its most interesting elements the author's reasoning about the water to oil ratio in the field as well as the age and the geological history of the field.

*'The time that has lapsed since the beginning of the formations' fracturing by dislocation cavities and until now defines **the age** of a field while this or that petrographic composition of formations determines the quality, either positive or negative, of the filter within which the*

productivity of a field is formed for the duration of the whole geological life of the field,' Ivanov wrote.

'The natural life of a field that is defined by a combination of geological factors continues many millennia; I have discovered (The Oil-Fields' Age, see The Oil Industry 1904, the issue No. 12) that oil welled out in the Absheron Peninsula on the earth surface as far back as in the Pliocene. To translate this to a language comprehensive commonly, it welled out long before the Stone Age in the human history, to wit, at least 10,000 years before now. We do not know how much more time would it take for a live field, for instance, the Bibi-Heybat one, to grow old and die – and become a deposit of asphalt, bituminous clays and sandstones or, even, a deposit of only stink clays and sandstones similarly to the immense formations of stink limestones of the Southern Urals that are the sheer monuments of the once-powerful oil processes that occurred there. At any rate, the period of weakening and dying of an oil-field consequent to surface dilution, plugging of oil-bearing canals and other reasons should be measured out on the geological scale – in millennia, that is' (ИВАНОВ, 1908, pages 10–11).

In the opinion of Ivanov, development of a field (human intervention) shortens its life to decades. The problem of exhaustion of oil-fields seemed quite real and important to Russian as well as overseas geologists of the time. It was constantly a discussion highlight in the press.

Despite the certain amount of pessimism about the possible life term of the Absheron fields due to their resource estimation, though, Ivanov finished the article in a rather optimistic vein: *'The above reasoning will, if applied to the Nobel fountain in the Cheleken Island, let us draw the following conclusions: that fountain is not an accidental phenomenon brought about by the well having tapped fortunately the immensely rich oil-bearing formation that has lied untroubled in the bowels since the world began and has miraculously remained untapped despite the dozens of wells drilled in that terrain.*



Rather, it is the sign of the overall **mounting oil content** of that particular province of the Cheleken Island that is under the influence of the water wells drilled to that formation from which the fountain emerged, or a little lower.

'Doubtless, the overall increase in the oil content of the region in question should influence all the wells located within its boundaries and, first and foremost, the productivity of the other producer wells in the Nobel fields' (ibidem, page 12, my highlight – A.G.).

To put a small fly in the ointment, the last lines of Ivanov's article run as follows: *'...however, we have no sufficient data to state this as a fact'* (ibidem).

In this crabwise way that might look somewhat strange to an adherent of the deep origination of oil that Alexey Ivanov arrives at the conclusion about the probable **increase in the oil content of an already-in-development (!) field**.

The problem of the longevity of an oil-field's life always preoccupied Ivanov's thoughts. He reasoned about it in practically every article he wrote. The editor of The Baku Oil Industry Review asked the readers in 1904 to give the Statistical Bureau of the Board of the Congress of the Baku Oil Industrialists their recommendations about how statistical accounting should be arranged. And Ivanov responded! And he did not limit himself to small remarks but had analysed the materials that the Bureau had published before he provided an in-depth analysis of arranging statistical accounting in Baku. It had not been properly organised, in his opinion. Because we cannot consider that article here in full, I would only quote Alexey Ivanov's remarks about the **life** and **death** of a field. He remarked that the latest account that the Bureau had issued had completely no references to the life lengths of a well, a site and a field (Иванов, 1906, page 10).

He capped the article thusly, *'The statistics would be assisted to a great extent by a complete statistical study of at least one field but we know not one already-dead field yet and neither do we have a single field curve from its birth to*

its death – the curve that maybe does not exist' (ibidem, page 17).

The Cheleken Island remained in the memory of Alexey Ivanov forever not only as a most interesting specimen of an oil-field but also as a splendid geological object in general. He never ignored his colleagues' new articles about the island and would usually respond to them in print.

On Classification of Oil Reservoirs

In his work 'The Main Questions of the Caucasian Oil Geology' dated 1903, Alexey Ivanov reminded his readers once more that *'the anticlinal-formation theory of oil occurrence that remains predominant in our time as well is not applicable to the Cheleken Field... the occurrence of oil in Cheleken is typically vein type and connected to the as typical and manifest fault crevices and hade slips, that is, to disjunctive dislocation'* (Иванов, 1903, page 1068).

Further, he expresses a doubt as to the universality of the **anticlinal-formation-Oligocene** theory.

Ivanov maintains then that oil only saturates anticline bent formations sporadically rather than evenly. Then, Ivanov offers a classification of oil-fields of his very own:

- '1) Only one wing of an anticline is an oil-bearing one (the one-flank oil-bearing capability),*
- 2) One wing and one tip of an anticline are oil-bearing (the one-flank-tip oil-bearing capability),*
- 3) Only a narrow and more or less straight line is an oil-bearing one (the linear oil-bearing capability),*
- 4) The field formations are have the disseminated oil content (the sporadic/disseminated oil-bearing capability).'*

It is rather substantial that Ivanov does not insist on whatever universal quality of his qualification. In fact, he then wrote, *'Doubtless, this grouping is purely formal and we attach no significance to it other than that of the comfort of exposition'* (ibidem, page 1071).

Ivanov's criticism of the **anticlinal-formation-Oligocene theory** was correct in many respects. Had it not been for the polemic

gap, he might have formulated his objections clearer and with greater definition.

The oil deposits were found in Russia at that time – and had been known to exist in France even before – that lay on the monoclines and were associated with sandy pockets rather than formations. So, not only anticlines and not only formations are **oil reservoirs**. The oil-fields of the Urals-Emba Province and in Fergana were discovered in the Mesozoic deposits. Hence, not only the Oligocene was the ‘motherland’ and vessel of oil. Then, the oil-fields associated with reef masses (masses, not formations!) would be discovered in USA and Russia in 1929 and the theory of the mode of oil occurrence would be called a structural rather than an anticlinal one more often since then.

Alexey Ivanov was also right about that oil enters sands and sandstones (equally as clays and even malmstones!) via splits – as much as he was wrong about that only lodes (fault areas) and small formation areas adjacent to lodes were productive. A formation becomes productive within the boundaries of the whole structure or the larger portion of it (Бирина, 1963, Абих, 1864) as a result of the physical impact of oil entering a formation as it comes up from the depths (the **oil frac fissures** of Ludmila Birina, 1963) and dissolution of carbonaceous cement by the fluids coming up from the deep bowels (by Hermann Abich, 1864).

The scientific community did not take the oil-field classification by Alexey Ivanov in earnest; it is only of historical interest now as one of the first attempts at systematising that epoch’s rather reference on oil deposit forms – the reference rather modest in size at the time.

The primary and secondary reservoirs and the origins of oil

The geologists who were active during the first decades of the 20th century paid great attention to studying the hypothetical question about whether each individual reservoir in a given field is **primary** or **secondary** to the host formation and whether the formation is a **parent**

one to oil. Naturally, such questions only occupied the minds of the adherents of the biogenic hypothesis – and not all of them, too. Such pragmatic minds as Ivan Strizhov never brought such a virtual problem under deliberation. Neither did Alexey Ivanov find it of any importance and urged the colleagues to follow suit at the very beginning of that period.

Ivanov wrote in the article ‘The Cheleken Field’ dated 1903 that were touched on above, ‘*Considering it proven that the source of oil, its native area lies deeper than 800 fathoms on the Cheleken Island, I nonetheless do not find it possible to accept the oil contained within that 800-fathom depth as of a **secondary** occurrence because nowhere and never has the primary occurrence of oil been proven **scientifically** and nobody has ever determined the nature of such an occurrence of oil that should be considered to be the **primary** one.*

‘The question of either the primary or the secondary occurrence of oil is very closely related to the question of the origins of oil, the latter being very interesting in scientific terms but of no importance for the practical goal of estimating the quantity of oil. All the oil origin theories could be grouped around the two staple theories – the mineral and the organic ones, that is. Should one of the variations of the mineral (chemical) theory be proven, it would be as naïve to strive to find large quantities of oil at the location of its generation as it would be, with the same purpose in mind, to dig down to that cemetery that holds the corpses from which oil derived itself in accordance with the organic theories. Hardly anyone would maintain that the largest quantity of this ready product is in the building of that factory or that laboratory where this product is produced. No less strange is the reasoning by the empirics who hanker for finding their way right to the cemetery. All the oil-fields of the Globe only became known to the man as a result of the presence of various quantities of oil or its complements and derivatives on the Earth’s surface. Thinking – and hardly wrongly, too – that oil has come to such a sur-



face from below, the bowels, rather than from above, the atmosphere, an industrialist digs in to get it; but to what extent is he to dig and drill down? "To the very cemetery," will say the defenders of the organic theory; they'll add, "Because down below there is the primary occurrence of oil; meanwhile, all the oil between that cemetery and the Earth's surface and all the oil on the surface has occurred there coming from the cemetery and so is in the **secondary** occurrence instance." But if it is the "secondary" oil on the surface and, in general, it has been brought up from the cemetery itself, then who can arguably maintain that the cemetery has not been long emptied of oil and filled with water already? Given especially that water tends downwards in line with the law of gravitation at least as tenaciously as oil and gases tend upwards?

How the Cheleken oil was originated and its formations lies that laboratory that produces it or that cemetery from whence it has come is something that we do not know because we cannot find a single fact in the available data that we have examined to support us in our reasoning about such matters... **These matters as such... we consider to be completely truant from the practical point of view,**' Ivanov reasoned (ИВАНОВ, 1903, page 401, emphasis added – A.G.).

Alexey Ivanov seldom had to work the problems of oil personally but he browsed the oil geology literature constantly and always responded to the reports that aroused his interest. The article 'On the Conditions of Oil Occurrence in the Cheleken Island' by Kazimir Kalitsky that was published at the end of 1910 revoked commentaries by Ivanov immediately. He wrote: '...relying on the phacoidal and bonny occurrence of tar sand in the series of the Bakuvi Age malmstones predominantly, the author maintains the primary stratified of oil, be it in those lenses and clusters or in the Cheleken Island's parent rock horizons in general' (ИВАНОВ, 1911, page 489).

Alexey Ivanov then offers his own interpretation of the origins of the sand bonnies and lenses (including the bearing ones) within the normal stratiform deposits.

He starts with saying that the outcrops in the Cheleken that Kalitsky has described are very interesting, indeed.

'1) In front us is a vertical, completely smooth wall of solid malmstones without whatever traces of stratification; within it are the cavities of 1–5 cft filled with light sand and spread completely erratically and of the very arabesque shapes sometimes; 2) the short sandy lenses that are clearly visible are arranged in one bedding row; they are covered with the distinctively stratified malmstones and are underlain by such malmstones that are not stratified to the eye; 3) there are the completely irregularly-shaped, bent and decayed-shaped block masses of brown clays (malmstones) within the deposits of light sand as deep as 0.8 metre; those masses are either not too large, up to 2–3 feet in length only, or they occupy almost the complete spread of the sandy bank. We ascertain that the sandy bank (the 3rd case) is doubtless one traceable over many hundreds of metres and that the concretionary origin of the clayey chunks brazed into it is totally inapplicable here. The series of brown clays containing irregularly-shaped bonnies and lenses are a series that is without doubt tributary of the sedimentary suite as much as it is quite concordant with the overlying and underlying and clearly stratified sediments containing the marine fossils of the Bakuvi Age.

'There is no denying that the presence of the large (up to $\frac{1}{4} m^3$) and irregular light sand bonnies within the mass of the admittedly sedimentary clay series is an enigmatic enough occurrence...

'I observed during 1901–1901 all the Bakuvi series' outcrops with the lenses and bonnies of sand that Mr Kalitsky has described. They intrigued me, rather, specifically in the sense of their geological genesis that was clarified in a quite unexpected and curious form

eventually – the form that truly deserves to be described as a rare occasion of a sedimentary rock’ (ibidem, pages 490–491).

And because clayey series containing sandy bonnies and lenses are observed at several occasions more in Cheleken, too, Ivanov follows with a detailed description of the two characteristic outcrops. This is what he suggested about the origins of those series: ‘As regards the genesis of those clayey conglomerates, their overall *habitus* as well as the Absheron fauna within the individual massifs that retain the stratification of their own leave no doubt as to that in those conglomerates we encountered a remarkable specimen of the rock formed within the sea and at the foot of the high and vertical cliffs made of the thick clays of the Absheron Stage’ (ibidem, page 496).

Ivanov then writes the following about the sandy bonnies within the clayey conglomerate: ‘The sandy bonnies occur because sands fall down the cliff together with clay clasts. The arabesque nature of the sandy bonnies’ shapes and especially the stratified nature of sand that I have mentioned match the cavities’ contours and are demonstrated well in those cases in which the surf stuffs the sand in the space intervals and hollow spots that the surf has bored into clay falls.

‘The erratic clayey inclusions in sand-beds are essentially the hollowed-out clayey rock boulders that will normally preserve their stratified character’ (ibidem, page 500).

Further on, Ivanov goes directly to the question of finding isolated petroliferous sand lenses and bonnies within clayey formations.

‘...There were several periods of disjunctive dislocation in the Cheleken Island: the hade faults that cross the lower Absheron series do not continue into the upper Absheron one while the hade faults that cross the Upper-Absheron layers do not cross the Baku series and so forth. Thanks to that, not only the chunks of the Absheron clays and dry sands but also those of tar sands were falling into the Baku Sea from the steep cliffs. That is, exactly the same that is

happening at the foot of the commons Yergosh, Yanghi-tepe, Tazi-Kyan and so forth was happening back in the Baku Age – pieces of soft ozokerite polluted with sand, tar sand chunks and cutans of oil from the cliffs – all those find their way into the shore and partly sink to the seabed acting as the typically secondary elements (boulders) towards the creation of our contemporary sediments of the Caspian Sea.

‘If we accept as correct my explanation of the presence of oil in the lenses and bonnies that Mr Kalitsky described, then it must be admitted that he was the first one to discover and describe in detail such an occurrence of oil that should be deemed a typically **secondary** occurrence relative to the vein type deposit of oil in the Cheleken Island that I described – similarly to any boulder material relative to the bedding occurrence of the parent rock of those boulders. The boulders of asphaltic earth in the Absheron sands in the vicinity of Baku and the ozokerite pebbles in the volar strata of the Upper Aral-Caspian Age in the Cheleken Island that I described in the article ‘The Age of Oil-Fields’ (Нефтяное дело, 1904, No. 12) as well as the kir sandstone pebbles at the foot of the Bakuvi Age indicated by Mr K.Kalitsky and, last, the dry bituminous sands in the surface sediments of the Cheleken Island described, again, by Kalitsky (pages 17–19) are essentially the instances of the primary (rubby) occurrence of the oil derivatives; whilst the secondary occurrence of liquid oil will only remain for the time being in the lenses and bonnies of the Bakuvi Age in the Cheleken Island that Mr K.Kalitsky described’ (ibidem, pages 502–503).

Alexey Ivanov was doubtless correct about his perceptions about the origins of oil and the primary nature of all its deposits excluding the re-deposited pockets of oil-bearing rocks. It had been clear to his great predecessors Mendeleev and Abich as well as to some of his compatriots that the ‘factory where oil is produced’ is seated deep within the bowels of the Earth. Consequently, the disputes about primary and secondary reservoirs and the talk about the lower



boundary of oil occurrence are pointless. He was also right about that oil comes from that 'factory' into the sedimentary mantle via splits.

Ivanov was only wrong in thinking that water on the surface of the Earth reaches its bowels via splits. As one observed the joint discharges of mineral waters, oil and gases to the surface one could arrive at the opposite conclusion that the fluids located in the Earth's interior run up via splits and travel from high-pressure regions to lower-pressure ones. Probably, the reasoning about the movement of water downwards and into the depths of the Earth was something that Alexey Ivanov adopted from Dmitry Mendeleev. In principle, though, this is not essential.

Nikolay Andrusov touched on the perceptions of Alexey Ivanov in an article published in 1906.

Andrusov wrote, *'We need hardly mention that what is observed on the Cheleken Island and what Ivanov studied so fundamentally is gives us the extreme inclination to accept the eruptive hypothesis of oil generation what with the intensive disjunctive dislocation (the Cheleken Island puts me in mind of a plate shattered into many shards that were glued together artfully afterwards), the proximity of hot wells, the traces of the colossal mud volcanic activity the material of which has found its way up from the considerable depths and through wide cracks more often than not – those cracks that are filled with the thick dikes of the sopka lava now, and the presence in the latter of the enormous Mesozoic limestone boulders that spell the considerable dislocation depth. Nonetheless, that oil is found next to all those phenomena does not in itself necessitate its eruptive origination'* (Андрусов, 1906, page 13). Immediately afterwards, Andrusov mentions the possible contribution of magmatism to the formation of an oil-field: *'...the presence of the hot wells that are heavily mineralised on the Cheleken Island points, in my opinion, sooner that the recently-arrived large and intrusive masses lie at the depth there'* (ibidem, pages 13–14).

Alexey Ivanov's approach to the problem of the origins of oil was generally based on the methodological stances of Dmitry Mendeleev.

Ivanov wrote, *'The question of the origin of oil as well as of any other natural substance cannot be answered using the data supplied by only one science, chemistry of geology, for instance. Rather, it is required to combine the data of both those sciences as well as of all the others that pertain to such a natural substance'* (Иванов, 1905, page 1357). Ivanov called on his colleagues to make a clear choice in favour of this or that governing hypothesis that they would intend going by in their subsequent theoretical and practical work.

'Because the three principal oil origin hypotheses (the mineral, the depth and the space theories – A.G.) differ profoundly in contents, they certainly cannot be of whatever governing import to a geologist who is studying an individual oil-field. One cannot seek the assistance of the three different and mutually exclusive principles in the scientific study of a specific natural phenomenon, after all' (ibidem, page 1361).

Here, we should highlight the fact that Alexey Ivanov did not consider an oil-field as something constant and congealed but looked upon it as a dynamic process. He remarked that it was he who first formulated that postulation in his articles and reports of 1901–1906. Ivanov realised that his views were not shared commonly at that time; still, he tried to drive them home to all the specialists connected to the oil industry because he found those views of practical importance.

Ivanov wrote, *'...doubtless enough, a "deposit" of oil that has been immobile within the bowels in theory comes into motion from the moment that one or several boreholes enter an oil-field. Consequently, the "deposit" turns into a process akin to a "deposit" of water in tub or in a pond will turn into a process from the moment an active pump enters it. All those oil-fields the surfaces of which demonstrate the seepages of oil, gases and mineral water, too, prove the motion of such liquids and gases within the bowels...*

'The geological basis (casing) of this oil process is always constituted of the diversely-bent, fractured or displaced layers because geology knows of no oil in non-dislodged and horizontal laminations' (ИВАНОВ, 1913, pages 15–16).

The Volga Region

Ivanov returned to Moscow on completion of the fieldwork in the Cheleken in 1902. He processed the collected field findings quickly and took the results of his research and reasoning out in print. His interest in oil proved profound enough. He was not always in a position to undertake independent field studies, so, he processed the print sources meticulously.

Ivanov studied practically all the publications about the Volga Region starting with those by Alexander Gerngross (1837). He paid a lot of attention to considering Ghennady Romanovski's concepts of the volcanic origins of oil and paid his vast acumen its due.

'...One is only left to marvel at that remarkable ability of this geologist to catch the deeply-shrouded and unclear features of bygone earth shell phenomena, thanks to which ability he has been able to approach the truth so close despite the extremely scarce observation results,' Ivanov wrote.

'It is true that a combination of the volcanic eruptions that produced oil, on the one hand, and the search for the primary sources of oil deposited in formations through the capture of floating oil by mechanical sediments and the subsequent recognition of the horizontal and non-dislodged layers of carboniferous limestone within the area of the "volcanic eruptions" hardly comply to each other. Still, it is doubtless that we ought to see the first flashes of the emerging dislocation inorganic hypothesis of oil origination in those yet vague fragments of thinking by the veteran of the Russian geologist – the hypothesis that Abich and Mendelejev came to formulate shortly afterwards' (ИВАНОВ, 1904, page 941).

Alexey Ivanov was only sorry that Ghennady Romanovski had not spoken of a practical application of his hypothesis.

Still, Ivanov related in the greatest detail the concepts of his teacher, Professor Alexey Pavlov, of the geological structure of the Samara Bow.

'Relying solely on the purely geological observation and without exploring shafts and wells, Professor Pavlov proved that a slip dislocation occurred west of the Kanadey village (not far from the River Ardatovka that runs into the River Syzran) and somewhat south of Stavropol at the beginning of the Tertiary Period. Due to that dislocation, the layers south of the fault crevice that had been horizontal until that time were elevated by several hundreds of fathoms,' Ivanov wrote.

'It was due to that hade fault that the theretofore deeply-hidden Permian and Carboniferous system layers emerged in the present terrain of the Samara Bow. They lie now much higher relative to the Cretaceous and Tertiary layers to the north of the fault line that had stayed in place or were even foundered a somewhat. Thus, the elevation of the Samara Bow is the elevated southern wing of the Samara Hade Fault while the holm along the right-hand bank of the Volga that across by the rivers Syzran, Tomashevka, Krymza and Ussa is its northern foundered wing' (ibidem).

Further, Alexey Ivanov quoted almost wholly a page from the work by his teacher that contains the reasoning about the relation between the numerous asphalt and oil shows in the region and the dislocation in the Samara Bow discovered by him – and its possible extension towards NE. The quote is capped with the following conclusion: *'My stated assumption of the passage of a dislocation crack here does not contradict this view (the reasoning by Romanovski about a relation between surface oil discharges and the deep-seated Carbon and Devonian rocks – A.G.); rather, it poses it in a new light. It is very probable that a detailed geological study along the path of the dislocation crack I have indicated will lead to the discovery of yet many more oil and asphalt fields as well as their relation to the dislocation crack being proven in*



point of fact' (Павлов, 1887, page 57; Иванов, 1904, page 943).

With his conclusions Ivanov confirmed the conclusion made by Pavlov, namely, that oil is non-system and unrelated to the deposits of any particular age but that its occurrences are associated with tectonic dislocations – in this particular, with the Zhiguli Hade Fault.

'There are no oil-fields beyond a dislocation' (Иванов, 1904, page 1246).

A region's prospects or lack of prospects of oil content can only be determined by a borehole and direct production of oil from it or from a well, in Ivanov's opinion. The presence or absence of oil-permeable rocks is the crucial token for prospect appraisal, to his view.

'...There are several oil-permeable layers (sands) lying all along the Samara Hade Fault line and at the depths shallower than 200 fathoms. The most interesting one of them is the thick bank of micaceous fine sands that underlies the Jurassic clays and outcrops as tar sandstone in many locations in the southern elevated wing of the Samara Hade Fault. It is indeed difficult to presuppose that those sands had reached to the depths of the foundered northern wing near the hade fault without oil' (ibidem, page 1247).

Evidently, not all the problems that were covered in print appeared to be resolved completely to Alexey Ivanov. Therefore, he visited the Volga Region in 1913. He concerned himself with the very substantial question about the age of the Samara Hade Fault. He was wondering why there are no thermal phenomena in that dislocation area. Ivanov believed that that *'contradicts dramatically the post-Cretaceous age of the Zhiguli Hade Fault that Professor A.P.Pavlov determined'* and that he, Ivanov, had tried to resolve that contradiction during the research he undertook in the western part of the Samara Bow.

Ivanov observed a contact between the Lower Callovian and Permian systems in the outcrop near the village of Kostychi. At the foot of the Callovian there is deposited *'the con-*

glomerate that consists of rounded pebbles, chalcedonies and limestones; most of the pebbles and limestones are saturated with asphalt in varied degrees; there are also the pebbles of pure solid asphalt. This conglomerate that consists of the rounded ratchel of the rocks already impregnated with asphalt indicates firmly enough that the Lower Callovian sands were deposited upon the waterworn surface of the Palaeozoic limestones that had already been saturated with asphalt because there are not races of oil either in the moulded mass of the conglomerate or in the overlying sandy-clayey series. Consequently, the age of the Zhiguli oil-bearing hade fault dates ante the Jurassic and oil never rose through the pre-Jurassic dislocation cracks, at least in the western part of the Samara Bow to the meridian of the Ryazan Station, in the post-Jurassic time' (Иванов, 1922, page 24).

In the end, Ivanov concludes, *'The fact of dislocation of the Cretaceous and of almost all of the Palaeogenic rocks is determined by Professor A.P.Pavlov while the complements provided by A.N.Rozanov about the dislocated character of all bar none Palaeogenic series in the western extension of the Zhiguli hade fault and this is explainable with sufficient fullness by the fact that the long period of tranquillity was followed by a new dislocation motion along the pre-Jurassic hade fault at the end of the Palaeogene. That expressed itself in the bending and fracturing of the Mesozoic and Tertiary series'* (ibidem).

We should also mention a small essay by Alexey Ivanov that was issued in 1930 and dealt with the oil-fields in the Transurals Downfold. A well drilled in the region of Cherdyn had the first oil shows at the approximate depth of 558 m in August 1930. Ivanov reacted to that as soon as in September by reporting the oil show in the News of the Chief Geological Exploration Department. The oil-bearing limestones of Cherdyn and Chusovskiye Gorodki (oil was found a year earlier near the latter) apparently pertained to the one and the same age – the Up-

per Carboniferous one, Ivanov remarked. And the conclusion followed, *'The discovery of oil-bearing rocks in the Cherdyn Province that is farther than 200 km north of Chusovskiye Gorodki is a fact of utmost geological important and interest given the oil-show conditions, the lithological composition of the oil-bearing rocks and the geological section akin to the latter'* (ИВАНОВ, 1930, page 113). And further – *'... all the more interesting is the laying of a deep borehole in the Solikamsk Province that it is intended to drill down to 1000-1200 metres. That well will perhaps return the material to shed light on the questions about the stratigraphy of the deep-laying horizons of the saliferous and sub-saliferous deposits and will maybe even discover the oil content of that region'* (ibidem, page 115).

The Methodological Stances of Alexey Ivanov

Ivanov stated his perception of the method of exploration and presenting exploration findings in several articles. He wrote with regards the work done by Barbot de Marnie and Simonovich (1891) that *'While being disposed negatively towards the work 'The Geological Study of the Binagadi Region' that had claimed so much labour and financial expenses, I still believe that it would be properly to seek the causes of this book being useless for its stated goals not in the persons of its authors, with one of them deceased, at that, but, rather, in the laxity of the distinction drawn between the two areas of human effort – namely, the scientific and the practical ones. The means of science are experience, observations and logic and truth is its goal; meanwhile, the means of practice are innumerable and contain power, subordination, friendship, wealth, destitution, conscience, love, protection (as Ivanov put it – A.G.), altruism, hatred, creed, honour, glory... whilst either personal or public happiness and usefulness are the goals. What could these two areas possibly have in common? Only that science employs its means with a view to achieving its goal only and*

so can present its findings only as the tools that practice can in turn employ by virtue of one of its means in order to achieve its goals. Such negligibly modest is the role of science' (ИВАНОВ, 1903, pages 511–512).

In many other works, too, Alexey Ivanov laid down his methodological principles. The article *'The Geological Reference on the Bibi-Heybat Valley'* calls into question the theoretical assumptions of Ivanov's predecessors and offers his reasoning as to the reliability of drilling findings in general.

He wrote, *'The geologists who have created various theories (Batsevich, Konshin, Sokolovsky, Lebedev, Barbot de Marnie, etc.) have been using wells to confirm their theories; meanwhile, it is known full well that well data are so dark and contradictory that one could pick a group of them randomly just to prove a pre-determined theory. It would be desirable to have published, in the main, the data not from the wells that prove a theory but those that contradict it because one or two finely reliable boreholes contradicting a proposed theory radically would be much more useful in terms of generating a true theory than the dozens that proving it'* (ИВАНОВ, 1904).

D.V.Golubyatnikov agrees with A.P.Ivanov on the point.

*'The difference among the researchers as to such a substantial question (of either the primal or the secondary character of deposits – A.G.) stems from that **the researchers will ignore involuntarily the data that contradicts a hypothesis about the origins of oil that such researchers profess.***

Depending on the difference of outlooks upon the oil occurrence conditions differ also the practical instructions to prospect for oil. Some recommend that drilling should be done upon the line of rent while others point at the slopes and along the inclination of the seam. The practitioners, while they did not take the former advice, neither have been able to prove that the latter's suggestion is correct. The question of the conditions of oil occurrence remains an



open one therefore' (Голубятников, 1908, page 4, emphasis added by A.G.).

Alexey Ivanov did not leave a single subject covered in the print without his reflections and commentaries. The spirit of contradiction peculiar to him would take him quite as far sometimes as expressing doubts as to the presence of the outcrops that the colleagues had described. And those were the colleagues who were professional enough to be deserve respect. Such was his printed commentary about the sequence that Dmitry Golubyatnikov had observed – to the complete perplexity of Golubyatnikov's student Mikhail Abramovich. Responding to Alexey Ivanov, Abramovich pointed out that *'the sequence that D.V.Golubyatnikov described can be observed near the Mamed-Kala Station and in exactly the same shape in which the said author described it (Изв. Геол. Ком., V. 21, page 216)'* (Абрамович, 1914, pages 1019–1020).

The publications by Alexey Ivanov normally covered the very essential problems of oil geology as a whole as well as of the specific and very interesting fields in particular. They also evoked the contemporaries' replies more often than not. Such were his articles about the Cheleken Field and the fields of Grozny (the response came from Yevgheniy Yushkin). None the less, one would think that Ivanov's works did not win the recognition they deserved in his lifetime and were undeservedly forgotten afterwards.

The Statesman

The fears lest the oil resources would be exhausted in individual sites, fields and regions haunted oil industrialists and statesmen in all the countries ever since those sites, fields and regions had fallen into development. The Bakuvis and Groznians, be it the tempered geologists or the representatives of the financial circles of Russia, had such concerns more than once, too. Besides, there stood the rather pressing question of what the most rational oil refining methods could be. Should it be refined for lighting (kero-

sene), or to produce lubricating oils and/or to have the valuable chemical products? Even Dmitry Mendeleev had written that *to fire and heat with oil is the same as to fire and heat with payment orders.*

Alexey Ivanov thought big and reminded the reader: *'Science and technology are doing their bit, after all, in that they are working on finding the more comfortable and cheaper methods of satisfying human needs, not to mention our industrial competitors of whom you take so much care. They are working on carbonisation of turf, resolving the question of communicating power over distance, making storage batteries simpler and having the falling power of water and of wind to produce light instead of kerosene. Peat coal will burn instead of fuel oil and if left with the valuable lubricating oil as the only thing left of crude oil we would have to leave the market and go down into history because the lubricating oils alone are not worth drilling for as it is much more profitable to produce them from kerogenetic shales direct'* (ИВАНОВ, 1904, page 1969). He then moves on to the problem of oil resources on the Earth.

'But it may be that some who are depressed by the notion of the littleness of oil and trembling at the prospect of the imminent chill and darkness will still insist on the need to save oil. Let us now try to show that there is no reason for such unfounded fears in reality because oil is not scarce on the Earth in general and in Russia in particular,' wrote Ivanov (ibidem).

'First of all, what is the foundation for the claim that there is little oil on the Earth and how is one to picture this 'little' in quantitative terms? Who has counted the deposits of oil in the developed fields and, most importantly, who has counted the quantities of oil in the fields that are not in development and those that are unknown as yet?

Pennsylvania and Balakhany are given as the proof that oil-fields are exhaustible. But the doubtless facts of attenuation of well yields and reduction of oil levels in those fields may have two explanations. According to one which is based on

the old and already completely unfounded hypothesis that had held that any oil-field is a resource with the magnitude set once and forever – like a tank of a certain capacity – the observable tokens of exhaustion indeed indicate the ultimate emptying of a reservoir. There is another hypothesis which receives more and more confirmation with facts and which represents an oil-field as an expression of the dynamism of the deep bowels of the Earth and indicates that each oil-field is only a receptor of products (oil, water and gas) resulting from the perpetual underground work. Following this other hypothesis, the observable tokens of exhaustion may be explained differently; for instance, they can be attributable to that the overall production of oil from this given oil exceeds the inflow of oil from the underground bowels in any one given span of time.

This may be why an oil-field exhausted to the extent at which a well does no longer compensate its own operation costs can, in time, will be supplemented and become suitable for extraction of oil again in a certain amount of time' (ibidem, pages 1969–1970, emphasis added – A.G.).

The contents of this article are much broader than its title suggests. It is so very interesting, indeed, that it could be quoted completely. In it, Alexey Ivanov demonstrates himself as a State Scale Person. He reminds his readers of how weighty the oil industry's contribution to the state treasury happens to be. And he concludes the article in the following way:

'This last circumstance alone, namely, the vast contribution of the oil industry to the replenishment of the state budget, should have ruled out all talk about exhaustion of oil deposits and about the need to save oil. The well-meaning advice that what oil is left should be used to greater benefit somehow does not ring true with the honourable burden with which the natural advancement of the oil industry is being hindered for the benefit of its competitors. At any rate, if they want to aid the coal industry at the expense of the oil industry, they should certainly consult not only those who are aiding but

also those at whose expense this aid is being extended' (ibidem, page 1974).

The Conclusion

Alexey Ivanov was made a professor of the Geology Chair at the Shanyavsky Public University in Moscow upon the recommendation of Alexey Petrovich Pavlov in 1909. Ivanov went on to work for the State Moscow University until 1928 after the Shanyavsky Public University's merger with the SMU in 1919.

Alexey Ivanov practically always did field work either studying phosphorite deposits or addressing the problems of underground water-supply to Moscow and other industrial hubs in summer seasons. He wrote several works on palaeontology as well – including the monograph about the brachiopods of the Middle/Upper Carbonic Period of the Moscow Basin. He stratified those sediments into horizons. That stratigraphic chart by Ivanov was eventually adopted for the whole Russian Platform (Иванова, 1940).

The publications by Alexey Ivanov usually touched on the very pressing problems of oil geology as a whole as much as they did the specific and very interesting fields in particular. They often evoked the response of his contemporaries. Such were his articles about the Cheleken Field and about the fields of Grozny (responded to by Yevgheniy Yushkin). Still, one would think that Ivanov's works did not gain the recognition they deserved in his lifetime – and were forgotten completely undeservedly eventually.

In his person we perceive not only an excellent Observer of natural phenomena but also and doubtless an acute and original Thinker. He took interest not only in the origins of oil and the structure of oil-fields but also in the problem of developing them rationally and in upstream statistics. He demonstrated the extensive knowledge of any problem – if not the catholic one.

The linkage between oil-fields and tectonic structures is something that many overseas and Russian researchers began to accentuate as far back as in the first half of the 19th century. But



none of them managed the opposite so tenaciously; namely, that there can possibly be no oil outside a dislocation. That stipulation by Alexey Ivanov is rather central to understanding the process of formation of oil-fields as well as to their geological history.

Ivanov remains in the history of the oil and gas geology a very interesting researcher. His criticism of *the anticlinal theory* made his opponents ponder and seek further arguments in support of their own stances. And that did bring the desired fruit.

We should also mention the **crucial** (!) valediction by Alexey Ivanov to geologists given it remains very to the point even now, 111 years after it was uttered. It has to do with his reasoning about the prospecting for oil in the Volga Region but it holds equally true of any region of the Earth.

‘Because the Syukejev seepage is truly oily and liquid contrary to that of the Samara Bow

and because the oil-show under the barren gypsum strata underlying the oil-seepage upon the coastal cliff is much more abundant, then, of course, the Syukejev Field has greater chances of attracting the attention of oil prospectors. We would suggest only and so that the same that has happened on the Samara Bow should not happen again, that before the Syukejev oil is sought in the deep interior by means of powerful tool strings, it should first be sought with the use of simpler but as strong tools. ‘Mente et malleo’, that is’ (ИВАНОВ, 1904, page 946).

Still, it took decades of field trips, fruitless drilling attempts and numerous discussions before the first industrial-scale oil show was secured in Tatarstan (Нефтяные и газовые..., 1987). In many respects, it happened so because the oilers seldom thought of the valedictory advice given by Alexey Ivanov.

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The report ALEXEY PAVLOVICH IVANOV: The Works on the Oil Geology was made at the annual conference of the Institute of the History of Natural Studies and Technology in April 2015. The theses (4 pages) were submitted to the IHNST for publication in the conference bulletin.

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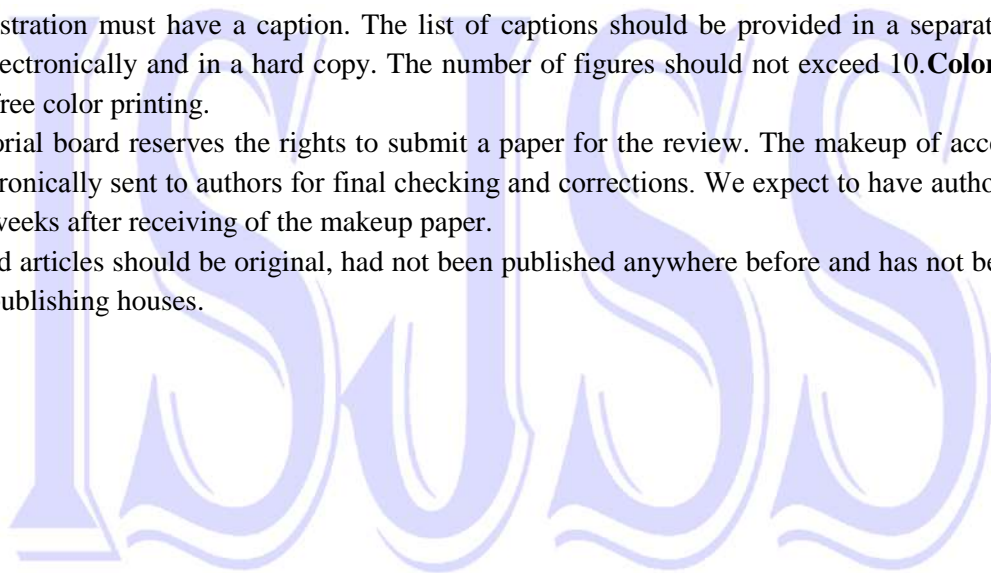
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Məqalələrin təqdim olunma forması

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 rəsmi nömrəsini göstərməklə qeyd edilməlidir. Rəsm olan faylların adlarında birinci müəllifin inisialları və rəsmi nömrəsi olmalıdır.

Məqalənin mətni Word formatında (Word 6.0 – 8.0) təqdim edilməlidir. Məqalə A4 formatına uyğun 20 səhifə həcmindən artıq olmamalıdır. Təvsiyə 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 şərti ilə düzəldilməlidir. Məqaləyə mətdən başqa müvafiq qrafik material (bir rəsmdən az olmayaraq), istifadə edilmiş ədəbiyyatın siyahısı, cədvəllər, və ehtiyac olarsa geniş rəzümə 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 stratigrafiyası 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.Quliyev¹, A.A.Feyzullayev² 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 yarımşərtlövhlərdən istifadə edilməsi tövsiyə olunur. Yarımşərtlövhlər qalın Times New Roman – 12 şrifti ilə səhifənin ortasına nisbətən simmetrik olaraq yazılmalı, və hər yarımşərtlövhlərdən bir intervalla ayrılmalıdır.

Cədvəllər məqalənin mətni çərçivəsində yerləşdirilir və Word formatında təqdim edilir. Cədvəllər yuxarı sağ küncündən ardıcıl olaraq nömrələnməlidir. Hər bir cədvəlın adı olmalıdır və bu ad nömrədən sonra yazılmalıdır. Cədvəllərin ad və nömrələri qalın Times New Roman – 12 şrifti ilə yazılmalıdır. Cədvəllərdəki sütunların yarımşərtlövhləri qısa olmalı, ölçü vahidlərinin adları dəyirmi mötərizələrdə verilməlidir. Cədvəllər mətnin kənarlarından qırağa çıxmamalıdır. Cədvəlın 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. Mətnədə 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. Mətnədə, 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 – mətnədə 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. Stratigrafiya 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 bibliografik istinadların nümunələri verilir:

Kitablar:

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

Köthe, 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 //



MÜƏLLİFLƏR ÜÇÜN QAYDALAR

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 dövrü məcmuələrdəki) məqalələr:

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

Rezümə. Özündə məqalə haqqında əsas məlumatı, araşdırmanın məqsəd və vəzifələri, istifadə olunan metodikanı, əldə edilən nəticələri özündə əks etdirən geniş rezümə 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 rəsmi nömrəsi və müəllifin inisialları olmalıdır.

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

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

Hər rəsmi 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 göstərməlidir.



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.

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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.

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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 назва-



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ние 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.Гулиев¹, А.А. Фейзуллаев² 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.

Köthe, 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 периодических):

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

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

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

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

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

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

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

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

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

К статье должны прилагаться авторская справка и акт экспертизы.

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

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