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STRATIGRAPHIC ESSAY ON NAKHCHIVAN AUTONOMOUS REPUBLIC
Chapter III – Paleogene

The article, which is the third in a series dedicated to the stratigraphy of Nakhchivan Autonomous Republic, contains the full description of the lithological-stratigraphic section of the Palaeogenic sedimentary, volcanogenic-sedimentary and volcanogenic formations mostly developed in the eastern part of the region. This description rests on the findings of the long years' of research done by the staff of the Geology and Geophysics Institute of the NAS of Azerbaijan as well as by the field geologists of the former Geology and Natural Resources Department of the Azerbaijan Republic. The description of the palaeontologically founded local stratigraphic sub-divisions of the Palaeogenic structured matter complex is in concordance with the International Stratigraphic Scale. Also, palaeophytological materials and absolute rock values have been used in order to date certain stratigraphic intervals. The article contains the outlines of the palaeogeodynamic and palaeogeographic factors' impacts on the formation of various lithological-stratigraphic sub-divisions of the complex described here. The data that is first being published in English can be utilised for regional generalisations and stratigraphic correlations between Palaeogenic sections characterising the sedimentation conditions (predominantly rift in nature) in the rear of the Neothetys where the Earth's crust was subject to northward subduction under the Central Iranian Microcontinent.

Keywords: Stratigraphy, Nakhchivan Autonomous Republic, Palaeogene, section, correlation.

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

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

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

Introduction

Problem statement. The presented article, the third one dedicated to the modern stratigraphy of the territory of the Nakhchivan AR, is concerned with the lithographic and stratigraphic features of the Palaeogenic rocks. Such sedimentary rocks found within the boundaries of the Autonomous Republic occur in the Zanghezur and, in part, also the Dereleyez ridges. The authors have reviewed the lithological and paleontological patterns of those sediments and, staying reliant on the wealth of the geological research findings done during last 30 years, have developed their modern International Stratigraphic Chart as well as have made a new grounding for the local stratigraphic units (Babayev, Kəngərli, Məmmədov, 2015).

The Paleogenic System is represented in the geological structure of the Autonomous Republic by the sedimentary, volcanogenic-sedimentary and volcanogenic rocks subdivided into the lower, the middle and the upper series. Paleogene stratigraphic complexes compose most of the geological sections of the Ordubad and the Zanghezur tectonic zones while they also outcrop in the NE, SE and SW flanks of the Nakhchivan Depression and in the basin of the River Arpachay (the Zeridere, Mehrideresi, Gumushdere, Yachideresi and Beysal sites) (Figure 1).

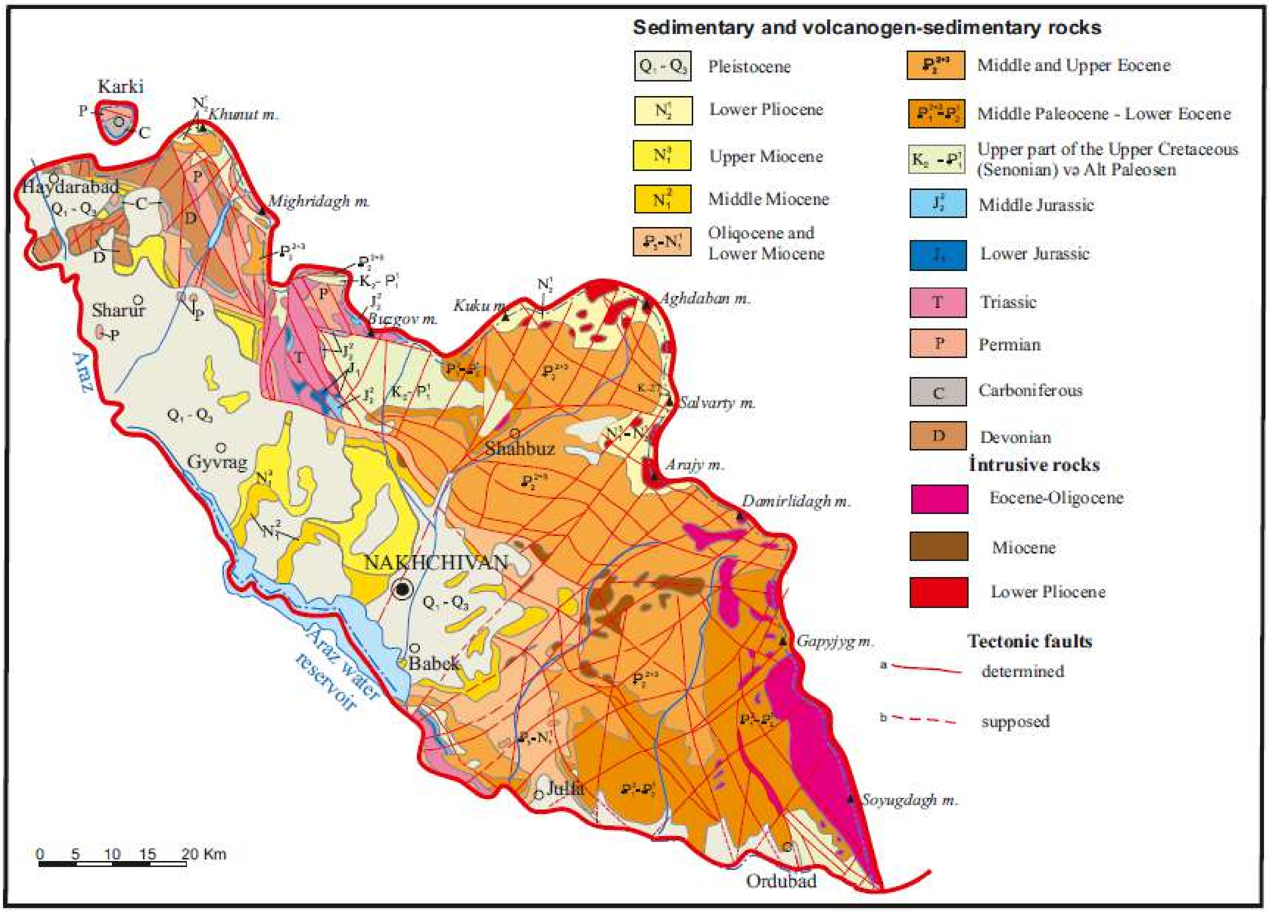
The cropping out Paleogene complexes has the average thickness equalling 5250 m and the maximum thickness equalling 8700 m.

The Paleogene of the Nakhchivan AR's territory begins with the emergence of the regression in the Iravan-Ordubad Depression, a part of the Late Cretaceous Basin, and reaches its maximum extent at the end of the Oligocene.

Those events were accompanied by the formation of the volcanogenic-sedimentary series of a great thickness and intrusive masses in the Ordubad Depression. All that was associated with the rifting that occurred in the relict Lesser Caucasian (Gyoyja) Basin of the Mesothetys with the collision of the Afro-Arabian and Eurasian continents taking place in the background. Considering that this basin is back arc basin created by the subduction of the northern flank of the Neothetys under the southern flank of the Central Iranian Platform it is assumed that in connection with this process the rift basins located behind the volcanic arc were created.

The western part of the Autonomous Republic (the Sharur-Julfa uplift) corresponded to the erosion zone developed in the Mesozoic Era while the outcrop axial band was situated between the Ghilanchay and Chahrichay Valleys. A very thick terrigenous-carbonate series were accumulated in the Ordubad Depression in the Paleocene.

There occurred the powerful homotypic calcium-alkaline and sub-alkaline basaltic-andesidacite-rhyolite volcanism that began in the Early Eocene and ended with granitoid plutonism (the Ordubad batholith and the satellites) in the Oligocene-the Early Miocene, resulted in the formation of the Iravan-Ordubad volcanic-plutonic belt.



A

B

Figure 1. The Geological Map (**A**) and scheme of the Paleogene stratotype sections' location (**B**), Nakhchivan Autonomous Republic; by T.N.Kengerli:
1 – Aza Series, **2** –Turkesh Series, **3** –Ordubad Series, **4** –Aylis Series, **5** – Arysu Series, **6** – Gilanchay Series, **7** –Kalaki Series, **8** – Kukuchay Series, **9** – Bilav Series, **10** –Paradash Series, **11** – Darydagh Series, **12** – Abraqunus Series

As a result of Late Eocene-Oligocene diasrofizm the inversion of geodymanic setting occured, which was followed by the initial stage of the formation of the Lesser Caucasus main structures.

The lithological-stratigraphic features and the fauna of the Paleogene System were described, at various times, by G.Abich, G.Sulukidze, P.Bonne, F.Frech, G.Artgaber, B.F.Meffert, A.N.Ryabinin, K.N.Paffenholz, A.A.Florenskiy, Y.K.Ustiyev, M.I.Varentsov, B.P.Guset, V.Y.Hein, L.A.Nechayev, I.N.Sitkovskiy, Sh.A.Azizbekov, R.N.Abdullayev, T.G.Hajiyev, M.I.Rustamov, D.M.Khalilov, G.A.Alizade, T.A.Mamedov, F.A.Mustafayev, M.A.Bahmanov, A.I.Azizbekova, Sh.A.Babayev, H.I.Aliyev, G.I.Allahverdiyev and others. The paleontological materials were compiled and determined in different years by Sh.A.Babayev, M.A.Bahmanov, G.A.Alizade, A.I.Azizbekova, V.V.Bogachev, D.M.Khalilov, I.V.Kacharava, S.S.Kuznetsov, G.M.Gasimova, R.Goshgarli, R.G.Guliyev, B.F.Meffert, T.A.Mamedov, M.M.Moskvin, B.V.Vetrova and others.

The local stratigraphic units contributing to the geological section are given in the Table 1.

Table 1

The Sub-divisions of the Paleogene System in the territory of the Nakhchivan AR

Stage	**Age**	**Layer and Sub-Series**
Lower Paleocene	Danian	The Aza Series
Upper Paleocene	Selandian	The Turkesh Series
Upper Paleocene	Thanetian	The Ordubad Series
Lower Eocene	Ypresian	The Aylis Series The Arisu Series The Ghilanchay Series The Kalaki Series
Middle Eocene	Lutetian	The Kukuchay Series The Bilav Series The Lower Paradash Subseries
	Bartonian	The Middle Paradash Sub-Series
Upper Eocene	Priabonian	The Upper Paradash Sub-Series
Lower Oligocene	Rupelian[1]	The Daridag Series
Upper Oligocene	Chattian	The Abragunus Series

The Paleocene

The units of the Paleocene Series found in the basins of the Chahrichay and the Nakhchivanchay (Figure 2) as well as along the left bank of the Aras river between the towns of Julfa and Ordubad (Figure 3) and consist of sedimentary rocks of the Lower (the Danian Age), the Upper (the Selandian Age) and the Upper (the Thanetian Age) subseries with the average thickness equalling 670 m and the general maximum thickness equalling 1,120 m.

The Aza Series (named after the village of Aza) received its name from G.I.Allahverdiyev in 1985. It is predominantly represented by terrigenous rocks and is biostratigraphically divided into the minor foraminifer zones of the Lower portion (*Globoconusa daubjergensis*) and the Upper portion (*Acarinina schakhdagica*). The stratotype is located in the vicinity of the Aza village downstream the Ghilanchay river (Figure 4) while the parastratotype does in the NW edge of the village of Turkesh in the basin of Nakhchivanchay. Outcrops are also observable on the northern and NW sides of Aggaya in the Chahrichay basin, in the Ghirdashar Ridge, on the western and southern sides of the Tekne Mountain, in the surroundings of the village of Shada in the Salasyuzchay River's basin and, in the SE, also in the SE part of the Dagustu (Daridag) Ridge and, to the East from it, along the left bankof the Aras until the Duglunchay River basin as well as on the flanks of the Kilit-Kotam Crest between Ordubadchay and Kilitchay.

Figure 2. The NW visinities of the Turkesh village; the outcrop of the Paleocene and Lower Eocene Sedimentary complex

Figure 3. The outcrop of Paleocene sediments located near the Aza Village

Figure 4. Near the Aza village; the Aza Series, the outcrop is dated by the Danian Stage

In the stratotypic section, it is an intercalation of grey, yellow, reddish and yellowish-grey clays, argillite and sandstones. In the parastratotypical section (Tekne Mountain, near the villages of Turkesh and Shada), the Aza Series is embordering the Maastrichtian sediments and sometimes overlays them; the Series consists of the alternating sandy clay, clayey sandstone, argillite, marls, sometimes limestone (seldom overlain by gravelstones and conglomerates, and is, in turn, covered transgressively by the Turkesh basal conglomerates). Its thickness ranges from 70 m to 400 mn in different outcrops. The section was found to have a faunal complex consisting of foraminiferas, nanoplankton, nanofossils, nummulites, molluscs and echinoids: the foraminiferas – *Epistominella culter, Eponides sparksi, Karreria fallax, Spiroplectammina excolata, Sp. kurtischensis, Sp. dentata, Sp. kurtiachonois* Balakhm., *Subbotina triloculinoides, Stensioina caucasica, St. whitei, Bolivinoides delicatulus, Biantholithus sparsus, Bulimina whitei, B. inflata, Bolivina plaita, B. delicatulus, Biantholithus sparsus, Dorothia retusa, D. bulletta, D. pupoides, Verneuilina cretosa, V. bronni, V. tricarinata, Acarinina schakhdagica, A. schakhdagicaformis, A. inconstans, A. trifida, A. trinidadensis, A. taurica, A. spirialis, Ammodiscus incertus, Heterohelix gradata, H. elongata, H. perquadrata, H. ilkhidagensis, H. ujliaensis, Globoconusa daubjergensis, Globigerina varianta, G. fringa, G. zeidensis, G. edita, G. legitima, G. pseudotriloba, G. trivialis, G. quadrata, G. triangularis, Globorotalia pseudobulloides, Gl. angulata, Gl. compressa, Gl. pyramidata, Gavelinella danica, G. welleri, G. danica, G. affinis, Gaudryina pyramidata, G. caucasica, Cibicidoides clipeatus, C. spiropunctatus, Chiloguembelina crinita, Ch. perquadrata, Ch. ujliaensis, Ch. crinita, Coccolithus cavus, C. subpertusus, C. ruciplacolithus tenuis, Cruciplacolithus tenuis, Clavulinoides aspera, C.trilatera, Marcalius inversus, Micratholithus fornicates, Marssonella indentata, Zygolithus concinnus, Tritaxia tricarinata, T. pyramidata;* the nummulites – *Nummulites* cf. *priscus* Khlopotin, *N. fraosi* de la Harp. et al.; the echinoids – *Echinocorys pyrenaicus* Seun., *E. renngarteni* Moskv., *E. depressum* Eichw., *E. semiglobus* Kongiel, *E. arnaudi* Seun., *Cyclaster sphaericus* Seun., *Homocaster atiohi* Anth.; the nanoplankton – *Placozygus sigmoides, Chiasmolithus californicus, Ellipsolithus macellus, Cyclococcolithina* sp.; *Biantholithus sparsus, Coccolithus supertusus, Micrantholithus fornicatus, Ellipsolithus macellus nanofossils: Markalius inversus, Cruciplacolithus tenuis, Thoracosphaera operculina,* 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 Turkesh Series (named after the Turkesh village) was so called by Sh.A.Babayev in 1981. It is represented by terrigenous rocks. Faunistically, it is expressed by the *Globorotalia angulata* plankton foraminifera zones in its lower portion and by the *Acarinina conicotruncatafer* in the upper portion. The stratotype outcrops to the NW of the Turkesh village while the parastratotype does between Ordubad and the village of Ashaghi Aylis. There are also the outcrops in the basin of the Jahrichay on the sides of Aggaya Mountain, on the Ghirdasar Ridge, on the sides of Tekne Mountain and NE of the Payiz village, in the basin of the Salasyuzchay near the Shada village and, in SE, on the eastern ridge of Dagustu (Daridag) and, farther to the East, along the left bank of the Aras and until the Dulunchay basin as well as in the Ordubadchay-Kilitchay area on the slopes of the Kilit-Kotam Mountain. In the stratotypic section it begins with the basal conglomerates that cover the Aza Series unconformabally, and is represented by an intercalation of coarse sandstone, gravelstones and conglomerates. In the parastratotypical section, it consists of the sandstone, grey clay and argillite interlayers that continue the Aza Series. The thickness varies between 60 m and 230 mn in different outcrops. The section was found to contain the characteristic foraminifera fauna: *Globorotalia angulata, G. ehrenbergi, G. pseudomenardii, G. compressa, G. schakhdagicaformis, Acarinina conicotruncata, A. praepentacamerata, Globigerina varianta, Gl. triangularis, Gl. tortiva, Subbotina triloculinoides, Dorothia retusa, Bolivina subincrassata, Chiloguembelina crinita, Bulimina inflata, Stensioina caucasica, Cyclococcolithina robusta, Cruciplacolithus tenuis, Zygodiscus sygmoides,* et al. (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; Мустафаев, Алиев, Алиев, и др., 1973).

The Ordubad Series (named after the town of Ordubad) was dintiguished by G.I.Allahverdiyev in 1985. It is mainly represented by terrigenous rocks. Faunistically, it stands out for the *Akarinina subsphaerica* and *Akarinina acarinata* plankton foraminifera zones. The stratotype is located in the area between the town of Ordubad and the village of Ashaghi Aylis (Figure 5), the parastratotype is NW of the Turkesh village. There are the outcrops also between the Diza village (Kerimgulu-Dize) and the Agdash Ridge and on eastwards along the left bank of the Aras to the Ordubadchay riverbasin and, in NW, in the basin of the Jahrichay on the sides of Aggaya Mountain, on the Ghirdasar Ridge, on the NE side of Tekne Mountain and to NE of the Payiz village, also, in the basin of the Salasyuzchay near the villages of Shada and Badamli. In the stratotypic section, it is an intercalation of grey clay, argillite and sandstone overlying the surface of the Turkesh Series, while in the parastratotypical section it is represented by the thin limestone and gravelstone layers. It is found upon the surface of the Pirchay Series (the Maastrichtian) in the Shada and Badamli areas where it crosses the Aza and Turkesh Series. The thickness varies from 95 m to 490 m in different outcrops. A complex of minor foraminiferas, corals, molluscs, nanoplankton and nanofossils was discovered in its section: the foraminiferas – *Acarinina subsphaerica, A. acarinata, A. primitiva, A. praepentacamerata, A. mckanei, A. tadjikistanensis, A. intermedia, Globigerina varianta, G. nana, G. quadritriloculinoides, G. triangularis, G. velascoensis, G. pileata, G. varianta, G. bacuana, G. linaperta, G. compressaeformis, Globorotalia pseudomenardii, Gl. pseudomenardii, Gl. angulata, Gl. conicotruncata, Gl. aequa, G. aculata, Nummulites solitarius, N. fraasi, N. deserti, N. praeexilis, N. silvanus, N. subplanulatus, Discocyclina seunesii, Operculina heberti, Ranikothalia sindensis, Subbotina triloculinoides, Pitat lamberti,* et al.; the molluscs – *Pitar lamberti, P. montensis, Tellina donaxialis, Taras radians*; the corals – *Goniopora rudis, Actinacis rollei*; the nanoplankton – *Fasciculithus tympaniformis, Toweis eminensis, Chiasmolithus bidens, C. californicus, Coccolithus eopelagicus, Ellipsolithus distichus, Chiasmolithus consuetus*; *Cyclococcolithina robusta, Cruciplacolithus tenuis, Zygodiscus sygmoides, Discoaster nobilis, D. multiradiatus, Braarudosphaera bigelovi,* et al. (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; Мустафаев, Алиев, Алиев, и др., 1973). The 60-m-thick upper part of the section represents a transition to the Lower Eocene judging by the presence of the characteristic microfauna *Globigerina compressaeformis* Chaliliov and others.

Figure 5. The outcrop between the town of Ordubad and the village of Ashaghi Aylis; the Ordubad Series; the Upper Paleocene

The Eocene

The Eocene is represented by all its subseries and stages in the NW of the Jahrichay and Nakhchivanchay basins and partly also in the Arpachay basin (the areas Zerlidere, Mehrideresi, Gumushludere, Yachidere and Beysal) and in NE along the left bank of the Aras river. The lower (the Ypresian) and the middle (the Lutetian and Bartonian stages) subseries consist of the sedimentary, volcanogenic-sedimentary and volcanogenic formations, while the upper subseries (the Priabonian Stage) consist of terrigenous one. The average thickness of the Eocene complex equals 3,630 m; the cumulative maximum thickness is 6250 m.

The Aylish Series (after the village Ashaghi Aylis) was identified by G.I.Allahverdiyev as the upper portion of the Ordubad Series in 1985. Faunistically, it is characterised by the *Globorotalia aequa* plankton foraminifera zone. The SE outcrops are observable along the left bank of the Aras river between the Ordubadchay and the Garaderechay, and, a little to the North, also on the Ghilanchay anticlinal belt between the Oyuglu and Garovlukhana uplifts as well as to the NW of the Diza village (Kerimgulu-Diza), on the SW sides of the Aydag and Aglar ridges. The minor outcrop is observable at the eastern end of the Julfa Valley; there, it unconformabally overlies the Triassic dolomites and is in turn overlaid by the basal conglomerates pertaining to the Middle Eocene of the Kukuchay Series. In the NW, the outcrop is in the area between of the Jahrichay and Badamli near the villages of Turkesh and Shada. The stratotype is located in the western vicinity of the Ashaghi Aylis village, at the foot of Arisu Mountain (Figure 6) while the parastratotype – in the vicinity of the Turkesh village. The stratotypic section is formed of the proportional intercalation of grey argillites and fine sheet like calcareous sandstone (60 m) overlying the sedimentary rocks of the Upper Paleocene Ordubad Series. This alteration is overlaid transgressively by the tuff-conglomerates of the Arisu Series. In the parastratotypical section it is an intercalation of dark-grey thin-bedded lumpy clays with the medium-bedded sandstone (30 m) and overlies proportionally the Ordubad Series. The thickness is 30–120 m in different outcrops. The section was found to contain the characteristic foraminiferas – *Globorotalia aequa, Gl. wilcoxensis, Gl. apanthesma, Gl. perclara, Gl. aculata, Gl. quetra, Globigerina compresaeformic, G. velascoensis, G. nana, G. pileata, G. quadritriloculinoides, Acarinina acarinata, A. subsphaerica, A. intermedia, A. triplex, A. camerata, A. primitive,* et al. while the sandstone strata were also found to contain the nummulites – *Nummulites jacquoti, N. pernotus, N. partschi, N. vonderschmidti, N. nitidus*. (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; Бабаев, 1990; Багманов, 1966; Геология Азербайджана, 2007; Мустафаев, Алиев, Алиев, и др., 1973).

The Arisu Series (after Arisu Mountain) was so named by G.I.Allahverdiyev in 1985. Faunistically, it is identified by the *Globorotalia subbotinae* plankton-foraminifera zone. The outcrops are observable to the SE along the left bank of the Aras between the Ordubadchay and the Garadere River, a little to the North on the flank of the Ghilanchay anticline between the Oyuglu and Garovlukhana uplifts as well as on the Aydash and Aglar ridges to NW from the Diza (Kerimgulu-Diza) village. In the NW the Series outcrops in the area between of the Jahrichay and the Badamlichay near the villages of Turkesh, Shada and Badamli. The stratotype is located on the SE side of Arisu Mountain that is located in the western vicinity of the Ashaghi Aylis village (see Figure 6) while the parastratotype is located near the village of Turkesh. It overlies unconformabally the Aylish Series as it protrudes the volcanogenic-sedimentary rocks in the area between the Ordubadchay and the Aylischay. From there and westward between the rivers Ghilanchay and Garadere as well as in the outcrops between the rivers of the Jahrichay-Salasyuzchay it consists of terrigenous rocks and represents a gradual transition to the similarly composed rocks of the Series located below the Aylis and the Upper Ghilanchay ones. The belt within which the volcanogenic-sedimentary rocks becomes replaced by terrigenous deposits between the rivers Aylis and Ghilanchay is transgressively overlain by the volcanogenic strata of the Kalaki Series. In the stratotypic section, the Series is represented by three rock types. The tuff-conglomerate and conglomerate-breccias overlying the Aylish Series are observable at the base of the succession; they are overlain by the interlayered gravelstone, marl and individual tuff-conglomerate-breccia layers of grey argillite and sandstone (170 m). The middle layer consists of the sparse andesitic and andesidacite pyroclastolites (the agglomerate tuffs, tuff-breccias, tuff-conglomerates, lava and lava-breccias) (120–150 m) that contain sandstones and argillites. Lastly, the top is composed of dark-grey and slate grey argillites and sandstone (177.5 m).

Figure 6. The western side of the Ashaghi Aylis village, Arisu Mountain; the Lower Eocene, Lower Ypresian outcrops of the Aylis ($P_2{}^1i_1{}^1$) and Arisu ($P_2{}^1i_1{}^2$) Series

The parastratotype of the Series is an intercalation of dark thin-bedded argillites and greenish-dark grey clays with sparse organic and sandy limestones (73 m). The outcrop thicknesses vary between 50 m and 420 m. The section contains the characteristic foraminiferas – *Globorotalia subbotinae, Gl. aequa, Gl. marginodentata, Gl. nartanensis, Gl. simulatilis, Gl. apanthesma, Gl. wilcoxensis, Acarinina pseudotopilensis, A. subsphaerica, A. acarinata, A. camerata, A. intermedia, A. triplex, Globigerina compressaeformis, G. pileata, G. nana, G. rotundaenana, G. velascoensis, G. quadritriloculinoides, Bulimina ovate,* et al., nummulites in the limestone layers – *Nummulites bolcensis, N. exilis, N. spileccensis, N. praemurchisoni, N. globulus, N. murchisoni, N.* cf. *nitidus, Discocyolina douvillei* (Sohlumb.), *D. pratti* (Mich.), et al., and, in the sandstone layers, also *Nummulites exilis, N. spileccensis, N. bolcensis, N. akkuurdanensis,* et al. (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; Бабаев, 1990; Багманов, 1966; Геология Азербайджана, 2007; Мустафаев, Алиев, Алиев, и др., 1973).

The Ghilanchay Series (after the River Ghilanchay) was so named by G.I.Allahverdiyev in 1985. Faunistically it is represented by the *Globorotalia marginodentata* plankton-foraminifera zone. In the SE the outcrops are located along the left bank of the Aras between Ghilanchay and the Garadere River, while somewhat to the North they are on the flanks of the Ghilanchay anticline – from the Duylun village to the Garovlukhana uplift as well as they are found to the NW from the Diza (Kerimgulu-Diza) village and on the NE sides of the Aydash and Aglar ridges. In the NW, the outcrops are near the villages of Turkesh, Shada and Badamli. The stratotype outcrops in the western vicinity of the Duylun village in the Ghilanchay River's basin (Figure 7), while the parastratotype does so near the Turkesh village. It represents a gradual transition with the similarly-composed rocks of the underlying Series (Figure 8) and is overlain unconformabally by the igneous rocks of the Kalaki Series. In the stratotypic section, it consists of the uneven intercalation of bedded dark fine- to medium-grained sandstones, argillites and siltstones (584.5 m). In the parastratotypical section the Series outcrops as dark and lumpy clays (70 m). The thickness varies from 70 m to 600 mn in different outcrops. The other outcrops contain alternations of fine-grained sandstones, clays and sometimes limestones. The section contains the characteristic foraminiferas – *Globorotalia marginodentata, Gl. rex, Gl. formosa gracilis, Globigerina turgida, G. nana, G. quadritriloculinoides, G. pileata, G. compressaeformis, G. prolata, G. turgida, G. contmedium, Acarinina triplex, A. intermedia,* et al. and in the sandstone beds the nummulites – *Nummulites exilis, N. spileccensis, N. praemurchisoni, Discocyclina pratti* (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; Бабаев, 1990; Багманов, 1966; Геология Азербайджана, 2007; Мустафаев, Алиев, Алиев, и др., 1973).

The Kalaki Series (after the village of Kalaki) was so named by G.I.Allahverdiyev in 1985. Faunistically it is represented by *Globorotalia aragonensis* plankton foraminifera zone. In the SE the outcrops are large and are found in the basins of the Ordubadchay, the Aylischay, the Venendchay rivers (Figure 9) and of the Dulunchay

Figure 7. The vicinity of the Duylun Village; the outcrop of the Ghilanchay Series – the Ypresian, the Lower Eocene

Figure 8. The eastern vicinity of the Aza Village; the Arisu (in the foreground – $P_2^1 i_1^2$) and Ghilanchay (in the background – $P_2^1 i_2$) Series outcrops – the Ypresian, the Lower Eocene

Figure 9. The volcanogenic rocks of the Kalaki Series that dates to the Ypresian Stage of the Lower Eocene and outcrops above the road between the villages Unus and Pezmere (tuffs, tuff-lavas, lava-breccias); note the erosional features named "Gyalingaya composition"

as well as in the basins of the left-bank distributaries upstream the Ghilanchay. This Series is also observable on the NE flank of the Ghilanchay anticline from the Duylun village to the southern side of the Ilandag and, somewhat southern from there, it outcrops as a narrow band between the Ghilanchay village and the Toglugaya Ridge.

The Series outcrops in those areas as a volcanogenic-sedimentary facies that overlies the Ghilanchay Series unconformabally. It is in turn transgressively overlain by the Middle Eocene Kukuchay Series. In the NW, it outcrops near the village of Turkesh as a terrigenous facie upon the Series Ghilanchay and is overlain unconformabally by the Series Kukuchay. The stratotype is located near the Kalaki village between the Venendchay and the Dulunchay (NW of the Goruglar village) (Figure 10) and is composed of an intercalation of andesite, andesidacite and andesite-basalt layers and agglomeratic tuffs, tuff-sandstones, tuff-gravelstones, tuff-conglomerates, tuff-breccias and argillites. The overall thickness of the Series equals 2173.8 m in the stratotypic section. Some upper layers of the Series are pinching out or laterally gradually passing into the overlying transgressive Kukuchay Series westwards with the thickness decreasing dramatically to 40–120 m in the basin of the Garadere River.

The Series is pinching out into the Kukuchay SG completely in the Ilandag meridian. Lithologically, it is divided in the Lower and Upper stratigraphic subseries. The parastratotype outcrops in the vicinity of the Turkesh village where it is composed of alternating shales, argillites and sandstones and sometimes also of gravelstones (200–210 m). The parastratotypical section was found to be containing the characteristic foraminifera layers such as the minor foraminiferas – *Globorotalia aragonensis, Gl. lensiformis, Gl. caucasica, Globigerina turgida, G. transversa, G. pseudoeocaena, G. eocaenica, G. eocaena, G. turgida, Acarinina bullbrooki, A. pentacamerata, A. brodermanni, A. triplex, Pseudohastigerina,* et al.; the nummulites – *Nummulites partschi, N. anomalus, N. atacicus, N. globulus, N. nitidus, N. planulatus, N. praelucasi, N. jasquoti, N. vonderschmidti, N. bolcensis, N. spilecensis, N. aquitanicus, N. ritularius, Asterocyclina stella,* et al.; and the pelecypoda – *Nucula submargaritacea, Modiolus elegans, Turritella* cf. *compta,* et al. (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; Бабаев, 1990; Багманов, 1966; Геология Азербайджана, 2007).

Figure 10. The vicinity of the Kalaki Village; the outcrop of the volcanogenic-sedimentary complex of the Kalaki Series pertaining to the upper section of the Ypresian, the Lower Eocene

The Subseries Lower Kalaki in the stratotypic section is represented by tuff and lava sheets of dark, light-dark, slate, violet and dark greenish andesite and andesidacite with the sparse interlayers of tuff conglomerate and tuff-breccias (889,7 m). The thickness ranges from 40 m to 890 m in different outcrops.

The Subseries Upper Kalaki in the stratotypic section is represented by seven members (from base to top): 1 – the dark red tuffite, tuff silt, the coarse-grained sandstone and tuffs-psammites (50 m); 2 – an alternation of dark and dark-greenish basaltic rocks and tuffs with tuff conglomerates, tuff breccias, the coarse-grained sandstone and tuff agglomerates (498 m); 3 – in the lower portion – the coarse-grained sandstone, tuff-gravelstone and the dark, brown and reddish brown tuffconglomerates (65 m); in the upper portion – an intercalation of the dark and dark-greenish argillites with the rare sandstone layers (204 m); 4 – an intercalation of dark and dark-greenish andesite-basalt tuffs with rare interbeds of tuff sandstone and of tuff gravelstone (76,3 m); 5 – the intercalation of dark and dark-greenish argillites, tuff sandstone and tuff gravelstones with the bluish tuffs siltstones (80 m); 6 – the uneven intercalation of dark and the reddish brown tuffs, tuffites, tuff sandstone, siltstones and argillites (182.5 m); 7 – the intercalation of the dark-coloured limestones and argillites (128 m). The overall thickness equals 1,283.8 m. The section was found to contain the faunal fossils characteristic to the upper portion of the Lower Eocene: *Nummulites partschi, N. aquitanicus, N. jacquoti,* et al. in the 3rd-member sandstone and *Globorotalia* cf. *aragonensis, Gl. caucasica, Globigerina boweri, Acarinina* cf. *pentacamerata,* et al. in the sixth-member argillites.

The Kukuchay Series (after the Kukuchay) was so named by H.I.Aliyev in 1981. Faunistically it is represented by plankton foraminifera zone containing *Hantkenina aragonensis*. It overlays unconformabally the erosional surface of the Permian and Upper Cretaceous sediments in the Agsal, Shahbulag, Berdidash, Yukhari Yaychi and Ghelingaya sites in the basin of the Arpachay in the farthest NW of the Nakhchivan Autonomous Republic. On the NE flank of the Julfa Uplift it covers transgressively the Triassic, Jurassic and Upper Cretaceous sediments. The Kukuchay Series covers unconformabally the Lower Eocene rocks elsewhere (the basins of the Nakhchivanchay, of the Alinjachay, of the Garadere, of the Ghilanchay and of the Dulunchay as well as at the NE edge of the Julfa Uplift) (Figure 11). The basal conglomerates are observable in most of the Series outcrops (Figure 12). The stratotype outcrops are on the right bank of the Kukuchay near the village of Ghizil Ghishlag while the parastratotype section outcrops in the area close to the Dashbashi Uplift between the Duylunchay and the Ghilanchay. Volcanogenic rocks occupy a substantial proportion of the Series's section in the Nakhchivanchay basin; the section generally is an alternation of tuff sandstone, tuff gravelstone, tuff conglomerate, tuff breccias, sandstone, argillite, clays, gravelstone and conglomerates with the thin interlayers of agglomerate breccias, tuff breccias, and limestones (Figure 13).

The Series crosses the Lower Eocene sediments occuring from NW to SE between the Salasyuzchay and the Kukuchay and overlays unconformabally the Ordubad Series that dates to the Paleocene. In the stratotypic section, it presents itself by 5 members alternating from bottom up: 1 – an intercalation of tuff sandstone, tuff gravelstone, argillites and sandstones with few layers of tuff breccias, tuff and conglomerate (508 m); 2 – an intercalation of sandstones, argillites and siltstones with few layers of tuff, tuff sandstones and gravelstone (188 m); 3 – an intercalation of tuff sandstones and tuffs gravelstones with few layers of argillite, gravelstone and sandstone (89 m); 4 – an intercalation argillite and sandstones with few layers of tuff-sandstone (171.3 m); 5 – an intercalation of tuff sandstones, tuff gravelstone and tuff breccias with a small amount of argillite and sandstone and sometimes also of tuffs (206.5 m). In the stratotypic section, the overall thickness equals 1162.8 m. In the parastratotypical section, the Series mainly consists of the sedimentary rocks and outcrops in the two successions: 1 – the layers of limestone, sandstone, clays and the reddish-brown conglomerates (150 m); 2 – an alternating sandstone, tuff sandstone and argillites with scarce layers of limestone and gravelstones (150 m). The thickness ranges from 75 m to 910 m in the other sites (Figure 14).

Figure 11. The Twin Rock Oglan-Ghiz; the high ground in the Garaderechay-Ghilanchay interstream area NW of the Bash Dize village. The Lower Lutetian, Middle Eocene conglomerates of the Kukuchay Series ($P_2^2l_1$) and the unconformabally lying Lower Eocene tuff sandstones on the erosional surface of the Ghilanchay Series ($P_2^1i_2$). The difference in rock composition makes an expressive landscape

Figure 12. The vicinity of the Bilav village, midstream the River Ghilanchay. The basal conglomerates of the Kukuchay Series, the Lower Lutetian, the Middle Eocene. The erosion-generated rock called ‘Zavvarlar’ Series (the Pilgrims)

Figure 13. The right bank of the Nakhchivanchay near the Kolanli village. The Lower Lutetian, Middle Eocene tuff sandstones and tuffgravelstones of the Kukuchay Series

Figure 14. The right bank of the Alinjachay near the Arafja village; The Lutetian, Middle Eocene tuffaceous rocks of the Kukuchay Series

The limestones and sandstones of the section were found to contain the characteristic faunal fossils rich in foraminiferas, nummulites, bivalve and gastropods molluscs: the minor foraminiferas – *Acarinina bullbrooki, A. broedermanni, A. triplex, A. pentacamerata, Globigerina pseudoeocaena, G. posttriloculinoides, G. senni, G. inaequispira, G. boweri, G. tirgida, Pseudohastigerina micra, Hantkenina aragonensis,* et al.; the nummulites – *Nummulites distans, N. anomalus, N.* cf. *globulus, N. perforatus, N. puschi, N. laevigatus, N. atacicus, N. uroniensis, N. gallensis, As. exponens, Operculina alpina, O. ammonea, Discocylina archiaci, D. nummullica, D.* cf. *pratti,* et al.; the molluscs – *Durtinella spirulaca, Crommium willemexi, Landinensis lerisch, Turritella imbricataria, Spondilus buchi, Chlamus subtripartida, Pecten subosbicularis, Mytilus rimosus,* et al. (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; Бабаев, 1990; Багманов, 1966; Геология Азербайджана, 2007; Мустафаев, Алиев, Алиев, и др., 1973).

The Bilav Series (after the village of Bilav) was so named by G.I.Allahverdiyev in 1985. Faunistically it is represented by a plankton-foraminifera zone containing *Globigerinatheka subconglabata*. The Bilav Series is wide-spread in various parts of the Ordubad trough: and it known in the basins of the Jahrichay, the Nakhchivanchay, the Alinjachay, the Garadere, the Ghilanchay and the Duylunchay; it also overlays unconformabally the Kukuchay Series in all the sections. The stratotype is located in the NW vicinity of the Bilav village (Figure 15) while the parastratotype is between the Ashaghi Ghishlag and Agbulag villages in the basin of the Nakhchivanchay. In the stratotypic section, this Series is represented by the containing tuff-sandstone and tuff-gravelstone lenses, agglomerate-tuff, tuff-lava, tuffite and tuffs-conglomerates that are andesitic and andesidacitic in composition (875 m). The sandstones in the upper portion of the section were found to contain *Nummulites* ex. gr. *laevigatus* (Brug.). The thickness of the Series falls to 120–40 m in the SW direction; laterally, the volcanogenic facie is replaced with sedimentary rocks. The Series presents itself as an intercalation of the clays, sandstones, tuff-sandstones, malms and seldom-occurring limestones containing a faunistic complex rich in foraminiferas, nummulites, bivalve and gastropods molluscs in the basin of the Garadere River as well as in the Jarajur, Ilandag and Paradash areas. The volcanogenic sediments of the Series graduate into the volcanogenic-sedimentary lithofacies in the NW direction (the basins of the Alinjachay, the Nakhchivanchay and the Jahrichay) and are arranged (including the parastratotypical section) as an intercalation of the diversely-grained tuff conglomerates, tuff-breccias, lava-breccias, the coarse-grained tuff-sandstones and tuff-gravelstones and the rare sandstone and argillite layers (Figure 16). The thickness of the outcrops in those areas varies from 40–115 m (the basin of the Jahrichay) to 250–810 m. The section was found to contain characteristic fauna rich in foraminiferas, nummulites, bivalve and gastropods molluscs: the minor foraminiferas – *Acarinina bullbrooki, A. triplex, A. pentacamerata, Globigerina boweri, G. senni, G. pseudoeocaena, G.osttriloculinoides, G. ellipsocamera, Globigerinatheka subconglobata, G. index, G. ugleri, G. eocaenica, Pseudohastigerina micra, Globorotalia spinulosa, G. osttriloculinoides, G. ocaenica, G. inaequispira, Globorotalia renzi, G. senni, G. boweri,* et al.; the nummulites – *Nummulites uroniensis, N. laevigatus, N. distans, N. gallensis, N. atacicus, N. polygyratus, N. striatus, N. perforatus, N. azerbaijanensis, N. puschi, N. brongniarti, Operculina alpina, Assilina exponens, Discocylina sella* (d'Arch.), et al. (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; Бабаев, 1990; Багманов, 1966; Геология Азербайджана, 2007; Мустафаев, Алиев, Алиев, и др., 1973; Шихлинский, 1986).

Figure 15. Midstream Ghilanchay near the Bilav village; the Middle Lutetian/the Middle Eocene tuff-sandstones and tuffs conglomerates of the Bilav Series. The tuff-conglomerate rock can be seen in the centre

Figure 16. Midstream the Nakhchivanchay, the vicinitys of the Mahmudoba village. The mushroom-shaped rock remnant called 'Papagdash' (a tuff-conglomerate block dating to the Middle Lutetian/the Middle Eocene, on a tuff-sandstone leg)

The Paradash Series (after the former village of Paradash) was first described by H.Abich as a 'nummulite' Series in 1902. Sh.A.Azizbekov examined the stratotypic section situated between the Shurud and Paradash villages in detail and dated it to the upper section of the Middle Eocene/the Upper Eocene in 1952. Faunistically it is represented by plankton-foraminiferous zones *Acarinina rotundimarginata, Truncorotaloides rohri* and *Nummulites fabianii.* This Series is found in the territory of the Autonomous Republic in the basins of the Jahrichay, the Nakhchivanchay, the Alinjachay, the Garadere and the Ghilanchay; it constitutes most of the geological cross-section Paradash as well as Gazanchi-Sirab, Nursu-Shahbuz and Merelik-Turkesh. It mainly occurs transgressively in the SW, NE and NW sections upon the erosional top of the Bilav and even Kukuchay Series and it is only in the central trough of Shurud-Paradash that it demonstrates a gradual transition to the Series Bilav. The transitory strata that are observable there are constituted of clay and sandstones or re-precipitated tuffs-breccias and tuffs-conglomerates. Also, the top portion and in some cases also the bottom portion of it are not included in the geological section in many outcrops. It is only in the stratotypic portion that it outcrops as a complete series while the overall thickness that exceeds 870 m is divided in the Lower, Middle and Upper sub-Series. The thickness varies between 230 m and 875 m in the other outcrops. The section was found to contain the faunal fossils rich of nummulites, foraminiferas, corals, echinoderms, bivalve and gastropod molluscs and characteristic to the upper section of the Middle Eocene and to the Upper Eocene alike.

The Lower Paradash Subseries's section is stratotypically an intercalation of dark-coloured sandstones, clays and argillites with rare gravelstone and conglomerates layers. The thickness varies from 140 m to 370 m in its various parts. Faunistically it is represented by lower portion of the *Acarinina rotundimarginata* plankton foraminifera zone. In it are found the folloflank species: the minor foraminiferas – *Acarinina rotundimarginata, A. bullbrooki, A. punctocarinata, Globigerina frontosa, G. pseudoeocaena compacta, G. ouachitaensis, G. pseudovenezuelana, G. eocaenica, G. boweri, Globigerinatheka subconglobata, Gl. index, G. kugleri, Globorotalia spinolusa, Pseudohastigerina micra,* et al.; the nummulites – *Nummulites millecaput, N. lorioli, N. laevigatus, N. uroniensis, N.*

atacicus, N. uroniensis, N. gallensis, N. pratti, N. perforatus, N. brongniarti, N. garnieri, N. variolarius, N. acutus, N. incrassatus, N. rotularius, N. partschi, N. striatus, Assilina spira, A. exponensis, Operculina parva, O. alpina, Discocyclina pratti, D. archiaci D. numullica, D. augustae, et al. (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; Бабаев, 1990; Багманов, 1966; Геология Азербайджана, 2007; Мустафаев, Алиев, Алиев, и др., 1973; Шихлинский, 1986).

The Middle Paradash Subseries stratotype consists of an intercalation of dark and the reddish brown sandstones, clays and argillites (Figure 17). In the NW in the basins of the Jahrichay and the Nakhchivanchay it is an intercalation of dark and dark-bluish clays, sandstone and argillite with the rare limestone interlayers containing the small-fragment conglomerate and gravelstones. The thickness varies from 50 m to 460 m in various parts. Faunistically it is represented by upper part of the *Acarinina rotundimarginata* plankton-foraminifera zone and the *Truncorotaloides rohri* plankton-foraminifera zone. The following species are found: the minor foraminiferas – *Acarinina rotundimarginata, A. rugosoaculeata, A. kievensis, Globorotalia centralis, Gl. pomeroli, Gl. spinulosa, Gl. renzi, Gl. lehneri, Globigerina frontosa, G. boweri, G. inaequispira, G. pseudoeocaena, G. eocaenica, G. oauchitaensis, G. pseudovenezuelana, G. subtriloculinoides, G. incretacea, G. azerbaijanica, G. turkmenica, G. pseudocorpulenta, G.* aff. *corpulenta, G. praebulloides, Globigerinita howei, Globigerinatheka index, G. kugleri, G. rubriformis, Truncorotaloides rohri, T. topilensis, T.* aff. *rohri, R. valvuliniformis, R. similis, R. similis nachitschevavevsis, R. azerbaijanica, R. octocamerata, R. suboctocamerata, R. bulla, R. triangulicamerata, Hantkenina lehneri, H. liebusi, H. alabamensis,* et al.; the nummulites – *Nummulites perforatus, N. striatus, N. chavannesi, N. incrassatus, N. brongniarti, N. garnieri, N. variolarius, N. puschi, N. globulus, N. chavannesi, N. acutus, N. incrassatus, N. atacicus, N. rotularis, N. globulus, N. chavannesi, N. distans, N. osvaldi, N.* cf. *gizehensis, Operculina alpina, Operculina granulosa, Discocyclina numullica, D.* cf. *augustne, D. sella D. pratti, D. augustas, D. enormis, Discoaster saipanensis, D. furus,* et al.; the molluscs – *Amussium corneum* Sow., *Spondulus* cf. *cisalpinus* Bron., *Sp.* aff. *bifrons, Natica* sp., *N. (Cepatia) cepacea* Umk., *Pecten* sp., *Trochus* cf. *funiculosus, Turritella imbricataria* Lam. var. *carinifera* Desh., *Cerithium* sp., *Solarium* aff. *licidum* Opp. *S.* aff. *planoconcavum, Chlamys subdiscors* d'Arch., et al.; the brachiopods – *Terebratulum fusiforme* Laym. et al. Speaking of the micro-flora *Discoaster barbadiensis, D. taninodifer, D. saipanensis, Pemma papillatum* and *Nannotetrina fulgens Coccolithus* are found in the sub-Series. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Алиев, Омаров, Бурджалиев, Зейналов, и др., 1982; Алиюлла, Бабаев, Шихлинский, Алиев, Рагимли, Азизбекова, 1980; Аллахвердиев, Тарасова, и др., 1973; Бабаев, 1990; Багманов, 1966; Геология Азербайджана, 2007; Меловая фауна Азербайджана, 1988; Халилов, 1967; Шихлинский, 1986).

The stratotype of the Upper Paradash Subseries is composed of the intercalation of dark-coloured sandstones and conglomerates (Figure 18). The thickness ranges from 40 m to 50 m in different outcrops. Faunistically it is represented by plankton foraminifera zone containing *Nummulites fabianii*. The following species were identified within it: the minor foraminiferas – *Globigerina corpulenta, G. galavisi, G. irregularis, G. subcorpulenta, G. praebulloides, G. subtriloculinoides, G. pseudovenezuelana, Globorotalia bolivariana, Gl. cerroazulensis, Globigerinatheka tropicalis, G. tropicalis, G. semiinvoluta, Operculina alpina, Rotalia similis, R.* aff. *cubaensis, R. azerbaijanica, R. octocamerata, R. suboctocamerata, R. longocamerata, R. triangulicamerata, R. bulla, R. valvuliniformis,* *R. similis, R. similis nachitschevavevsis, R. azerbaijanica, R. valvuliniformis, Azera transversa,* et al.; the nummulites – *Nummulites striatus, N. paradaschensis, N. incrassatus, N.* cf. *fabianii, N. garnieri, N. pulchellus, N. chavannesi, N. prestwicluanus, N. concinnus, N. perforatus, N. acutus, N. puschi, N. striatus, N.* cf. *rectus, N. chavannesi, N. budensis, N. gizehensis, Spiroclypeus carpaticus,* et al. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Алиев, Омаров, Бурджалиев, Зейналов, и др., 1982; Алиюлла, Бабаев, Шихлинский, Алиев, Рагимли, Азизбекова, 1980; Аллахвердиев, Тарасова, и др., 1973; Бабаев, 1990; Багманов, 1966; Геология Азербайджана, 2007; Меловая фауна Азербайджана, 1988; Халилов, 1967).

Figure 17. The 'Three Brothers' outcrop between the Ghizilja and Kirna villages on the left bank of the Alinjachay; it emerged as a result of the weathering of the Bartonian/Middle Eocene sandstone of the Middle Paradash Subseries

Figure 18. The vicinity of the former village Paradash; the outcrop dates to the Priabonian/Upper Eocene; the Upper Paradash Sub-Series

The Oligocene

The Oligocene Series outcrops as a whole section in the basin of the Alinjachay while its upper portion does so along the NE flank of the Nakhchivan Depression until it reaches the village of Sadarak. It is represented by the volcanogenic, volcanogenic-sedimentary and partly sedimentary facies of the Lower Rupelian (the Series Daridag) and the Upper Chattian (the Series Abragunus) Subseries with the average and the general maximum thicknesses equalling 950 m and 1,300 m respectively.

The Daridag Series (after Daridag) was so called by K.N.Paffenholz in 1940. It outcrops in the autonomous republic at the junction of the Ordubad and Nakhchivan tectonic zones, in the lower part of the Alinjachay River's basin and the Highland Ridge (Daridag) (Figure 19) as well as is traceable along the SW flank of the Nakhchivan Depression to the Arak Water Reservoir; in the NE flank it presents itself as a narrow and deep fault stretching along the downwarped SW flank of the Nakhchivan Deep Fault to the Payiz village. The stratotype is located on the Highland Ridge (Daridag) while the parastratotype is between the Ghizilja village and the Chaghirdag Ridge in the Alinjachay River's basin and is represented by the volcanogenic and volcanogenic-sedimentary andesite formation facies. The section mainly contains pyroclastolites (tuffs, silty tuffs, tuff sandstones, tuff gravelstones, tuff breccias and tuff conglomerates) and is divided in the three subseries: 1 – the red-coloured underlying Series is mainly represented by tuff, tuff sandstone, tuff conglomerate and tuff breccia; 2 – the light-coloured middle Subseries mainly consists of tuff gravelstones and of tuff conglomerates and a minor quantity of tuffs and tuff sandstones; 3 – the upper red Subseries is predominantly composed of tuff sandstone and tuff conglomerate and a minor quantity of tuff gravelstones and tuff breccias. It overlies unconformabally various Middle Eocene sediments sometimes with basal conglomerates in the observed outcrops

(Figure 20). The thickness varies from 530 m to 980 mn depending on the section. The characteristic floras were found in the lower portion of the section.

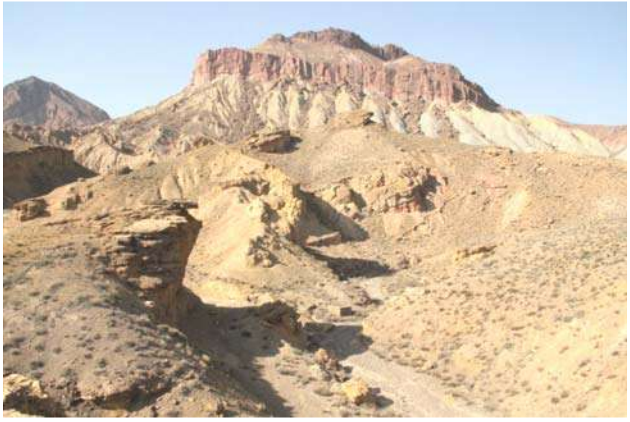


Figure 19. The Rupelian/Lower Oligocene outcrop of the Daridag Series in the Highland Ridge (Daridag)

Figure 20. The Upper Eocene sandstones of the Subseries the Upper Paradash overlying unconformabally the Lower Oligocene basal conglomerates of the Series Daridag around the Sirab Mineral Well

The Lower Daridag Subseries outcrops at the junction of the Ordubad and Nakhchivan tectonic zones on the banks of the Alinjachay and on the Dagustu Ridge (Daridag) and, having basal conglomerates at its heels sometimes, overlies unconformabally the Middle Eocene rocks. The lower portion of the section is an intercalation the tuffs turned to iron, tuff-sandstone, tuff-silt, tuff-gravelstone, tuff conglomerate, tuff-breccias and (in some areas in the middle of the layer) argillites (90–185 m) while the upper portion consists of multi-coloured tuff breccias, tuff conglomerate, tuff gravelstone and tuff sandstone (200–265 m). The overall thickness varies from 290 m to 450 m in different outcrops. The following characteristic palynological complex was found in the argillite and tuff sandstone occuring in the section: *Pteris oeningensis* Ung., *Podocarpus eocenica* Ung., *Blechnum braunii* Ett., *Panicum miocenicum* Ett., *Zelkova araxina* Palib., *Sabal haeringina* Heer., *S. major* Heer., *Murica hakealfolia* Sap., *Cinnamomum schenchzeri* Heer., *C. cezannense* Wat., *C. polymorphum* Heer., *C. rossmaesleri* Heer., *C. lanceolatum* Ung., *Eogenia bogatschevi* Palib., *Pisonia eocenica* Ett., *Lencothae protogae* Schimper, *Aralia cordifolia* Sap., *Zizyphus ungeri* Heer., *Lastrea* cf. *stiriachi* Heer., *Podo,* et al. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Ализаде, Азизбекова, Атаева, 1980; Алиюлла, Бабаев, Шихлинский, Алиев, Рагимли, Азизбекова, 1980; Аллахвердиев, Тарасова, и др., 1973; Бабаев, 1990; Багманов, 1966; Геология Азербайджана, 2007; Меловая фауна Азербайджана, 1988; Мустафаев, Алиев, Алиев, и др., 1973).

The Middle Daridag Subseries is a Series of bluish-greyish rocks that thrust out as a marker (Figure 21). It is cropping out at the junction of the Ordubad and Nakhchivan tectonic zones, the SW side of the Dagustu Ridge (Daridag) and on the banks of the Alinjachay (near the villages of Abragunus and Ghizilja, between the villages of Jamaldin and Gulustan). Overall, it is a dark-bluish rock Series; it overlies the lower Subseries in the core of the Yaychi-Erezinna synclinal traceable along the side of the Dagustu Ridge while it crosses the Series on the ridge's SW flank and overlies immediately the Middle Eocene sediments. In the stratotypic and other sections it is an intercalation of the bluish, greenish, dark-brown and other dark-coloured tuff gravelstones, tuffs, tuff sandstones, tuff conglomerates and tuff breccias.

The thickness varies from 200 m to 280 m in different outcrops.

Figure 21. The Middle Daridag Subseries outcrop near the Daridag Ammonium Mine

The Upper Daridag Subseries is traceable in the SE of the Nakhchivan Depression eastwards from the shore of the Aras Water Reservoir and takes the shape of a broad band that passes through the Ghirmizidag-I and Ghirmizidag-II uplifts to the Ghizilgaya Ridge and from there along the rightsides of the Alinjachay basin to the western vicinity of the Gazanchi village. The subsequent outcrops are located on the NE flank of the depression and extend as a narrow band from the Nakhchivan Deep Fault and along its SW flank on to the Payiz village. This Subseries also contributes to the geological structure of the left bank of the Alinjachay, the SW side of the Dagustu Ridge (Daridag) and the area between Ghizilja and Abragunus. Also, it overlies transgressively the Middle Eocene rocks near the Bananiyar village. The stratotype is located on the banks of the Alinjachay near the villages of Bananiyar and Abragunus while the parastratotype is on the Ghizildag-1 uplift. It is an intercalation of diversely coloured (reddish and greyish-brown, greyish-brown, brownish and dark ashy, brick red and violet) tuff sandstones, tuff conglomerates, tuff gravelstones and tuff breccias that have transformed to iron. The thickness varies from 40 m to 250 m in different sections. *Globigerina officinalis* Subb was found in some areas of the bottom portion of the argillite and siliceous limestone section.

The Abragunus Series (after the village of Abragunus) was so called by L.N.Leontyev in 1949. It is formed by the volcanogenic-sedimentary, volcanogenic rocks and partly also sedimentary facies, and is identical to the 'red-coloured bed' that Sh.A.Azizbekov identified in 1952 and that forms the base of the *Duzsakhlayan Series*. The stratotype is located in the SE part of the Nakhchivan Depression, on the eastern side of the Chashirdag-Ushagli Ridge and to the NW from the villages of Abragunus and Bananiyar while the parastratotype outcrops in the NW in the Sadarak-Garabulag area. It outcrops along the NW, NE, SE and SW flanks of the Nakhchivan Depression, in the Sadarak, Garabulag, Akhura, Garabaglar, Tenenem, Chalkhangala, Payiz, Vaykhur, Khalkhal, Garagala, Ghizilbogaz, Sirab, Gahab, Chaghirdag, Bananiyar, Abragunus, Ghizilja (Figure 22), Erezin, Ghizilgaya and Ghirmizidag-Nehram areas as well as on the SW side of the Dagustu Ridge (Daridag) (Figure 23). In the remote NW part of the Sadarak site where it has basal conglomerates upon its heel it overlies various Palaeozoic sedimentary horizons and is made up of an intercalation of ruddy-coloured clay, sandstones and siltstones (30–45 m). The thickness of the Series increases gradually to the SE and the tuff sandstone, tuff gravelstone and tuff conglomerate strata emerge within the section. The thickness of the Series consisting of tuff gravelstones, silty tuffites, tuff sandstones and tuff conglomerates reaches 350 m near Chalkhangala. There are ruddy-coloured tuff gravelstones, silty tuffites, tuff sandstones, tuff conglomerates and tuff breccias in the Series's section in the area between the villages of Vaykhur and Gahab on the left bank of the Nakhchivanchay. The stratotypic section is an intercalation of ruddy-coloured and dark violet tuff-sandstones, fine grained tuff breccias, tuff conglomerates and tuffs gravelstones. There are limestone strata in the Erezin, Ghizilgaya and Ghirmizidag-Nehram areas further to the South from there.

Figure 22. The eastern vicinity of the Ghizilja village on the left bank of the Alinjachay; the volcanogenic-sedimentary complex of the Upper Oligocene Series Abragunus

Figure 23. The Upper Oligocene outcrop of the Series Abragunus on the SW side of the Highland Ridge (Daridag) between the town of Julfa and the village of Jamaldin

The thickness is between 30–350 m in different sections. The section was found to contain the following characteristic palynological assemblage: *Aspidiaceae* cf. *cyclosorus* sp., *Pteridaceae pteris paz.* Ung., *Pinaceae pinus palocostrolus* (Ett.) Heer., *Podocarpaceae podocarpus eocenica* Ung., *Cramineae phragmites oeningensis* A.Br., *Typhaceae typha latissima* A.Br., *Myricaceae myrica lignitum* (Ung.) Sap., *M. vindebonensis* (Ett.) Heer., *Pegaceae guerous neriidolia* A.Br., *Quercus drymeja* Ung., *Uemaceae zelkova araxina* Palib., *Zacuraceae cinnamomum lanceobatum* H., *Ram melidaceae liduidambar europaea* A.Br., *Aceraceae acer* cf. *dalycarpoides* Heer., *A. trilobatum* (Sterub.) A.Br. and so forth. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Ализаде, Азизбекова, Атаева, 1980; Алиюлла, Бабаев, Шихлинский, Алиев, Рагимли, Азизбекова, 1980; Аллахвердиев, Тарасова, и др., 1973; Бабаев, 1990; Багманов, 1966; Геология Азербайджана, 2007; Меловая фауна Азербайджана, 1988; Мустафаев, Алиев, Алиев, и др., 1973). The absolute age of the andesidacite sample that G.I.Allahverdiyev collected from this section is 23.4 Ma (using the K-Ar method); so, it dates to the Chattian (Аллахвердиев, Тарасова и др., 1973).

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NAXÇIVAN MR ƏRAZİSİ ÜZRƏ STRATİQRAFİK ESSE
Oçerk III – Paleogen

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

Məqalə AMEA Geologiya və Geofizika İnstitutunun əməkdaşları və keçmiş Geologiya və Təbii Ehtiyatlar İdarəsinin mütəxəssisləri tərəfindən aparılmış çoxillik tədqiqatların materialları əsasında yazılmış və Naxçıvan Muxtar Respublikasının stratiqrafiyasına həsr edilmiş silsilə əsərlərdən üçüncüsü olmaqla ərazinin əsasən şərq hissəsində yayılmış çökmə, vulkanogen-çökmə və vulkanogen mənşəli Paleogen törəmələrinin litoloji-stratiqrafik kəsilişinin tam təsvirinə həsr edilmişdir. Paleogen struktur-maddi kompleksinin paleontoloji əsaslandırılmış yerli stratiqrafik bölgüsü və bölgü vahidlərinin təsviri müasir Beynəlxalq Stratiqrafik Cədvəlin uyğun aparılır. Bəzi stratiqrafik intervalların yaşı paleofitoloji materiallar və süxurların mütləq yaşının təyini əsasında verilir. Təsvir edilən kompleksin müxtəlif litoloji-stratiqrafik bölmələrinin formalaşmasına paleogeodinamik və paleocoğrafi amillərin təsiri barədə qısa icmal təqdim edilir. İlk dəfə ingilis dilində işıq üzü görən bu məlumatlar şimal istiqamətdə Mərkəzi İran mikroqitəsinin altına subduksiya edən Neotetisin arxasında çöküntüəmələgəlmə şəraitini səciyyələndirən Paleogen kəsilişlərinin stratiqrafik korrelyasiyası və regional ümumiləşdirməsində istifadə edilə bilər.

ОЧЕРКИ ПО СТРАТИГРАФИИ НАХЧЫВАНСКОЙ АР
Очерк III – Палеоген

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

В статье, являющейся третьей из серии публикаций, посвященных стратиграфии Нахчыванской Автономной Республики, по материалам многолетних исследований сотрудников Института геологии и геофизики НАН Азербайджана и полевых геологов бывшего Управления геологии и природных ресурсов Азербайджанской Республики приводится полное описание литолого-стратиграфического разреза осадочных, вулканогенно-осадочных и вулканогенных образований палеогена, развитых преимущественно в восточной части региона. Описание палеонтологически обоснованных местных стратиграфических подразделений палеогенового структурно-вещественного комплекса дается на базе современной Международной Стратиграфической Шкалы. Для датировки некоторых стратиграфических интервалов использованы также палеофитологические материалы и определения абсолютного возраста пород. Приводятся краткие сведения о воздействии палеогеодинамических и палеогеографических факторов на формирование различных литолого-стратиграфических подразделений описываемого комплекса. Впервые публикуемые на английском языке данные могут быть использованы для региональных обобщений и стратиграфической корреляции разрезов палеогена, характеризующих обстановки осадконакопления (преимущественно рифтогенного) в тылу Неотетиса, земная кора которого подвергалась субдукции в северном направлении под Центрально-Иранский микроконтинент.

STRATIGRAPHIC ESSAY ON NAKHCHIVAN AUTONOMOUS REPUBLIC
Chapter IV – Neogene

The final one of the publication series on the stratigraphy of Nakhchivan Autonomous Republic, the article characterises the lithological-stratigraphic section of the Neogene sedimentary, volcanogenic-sedimentary and volcanogenic formations contributing to the geological composition of the Nakhchivan Depression and partly also the Ordubad Depression. Further, the article provides brief information about the Quarternary continental deposits. The generalisation that is based on the modern International Stratigraphic Scale provides for the dating and description of the selected local stratigraphic sub-divisions and with the reliable palaentological justifications in the majority of cases. The information presented here is being published in English for the first time; it can be utilised for correlation between the Miocene basin sections of the Middle East.

Keywords: Stratigraphy, Neogene Nakhchivan Autonomous Republic, continental deposit, sedimentary.

Sh.A. Babayev

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

T.N. Kangarli

Azerbaijan National Academy of Sciences,
Geology and Geophysics Institute,
H.Javid ave., 119, Az 1143, Baku, Azerbaijan
E-mail: tkangarli@gmail.com

H.I. Aliyev

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

Introduction

Problem Definition. This article is the last one in a series of articles dedicated to the modern stratigraphy of Nakhchivan AR; it is about the lithological and stratigraphic features of the Neogene and the Quarternary rock complexes. The authors have reviewed the lithological and palaentological features of those sediments and generalised the wealth of the geological planning work and target exploration information for last 30 years encompassing the stratigraphic units by the present-day International Stratigraphic Table as well as by the local division chart (Babayev, Kəngərli, Məmmədov, 2015). The materials covered in the article are based on such generalised information.

The Neogene

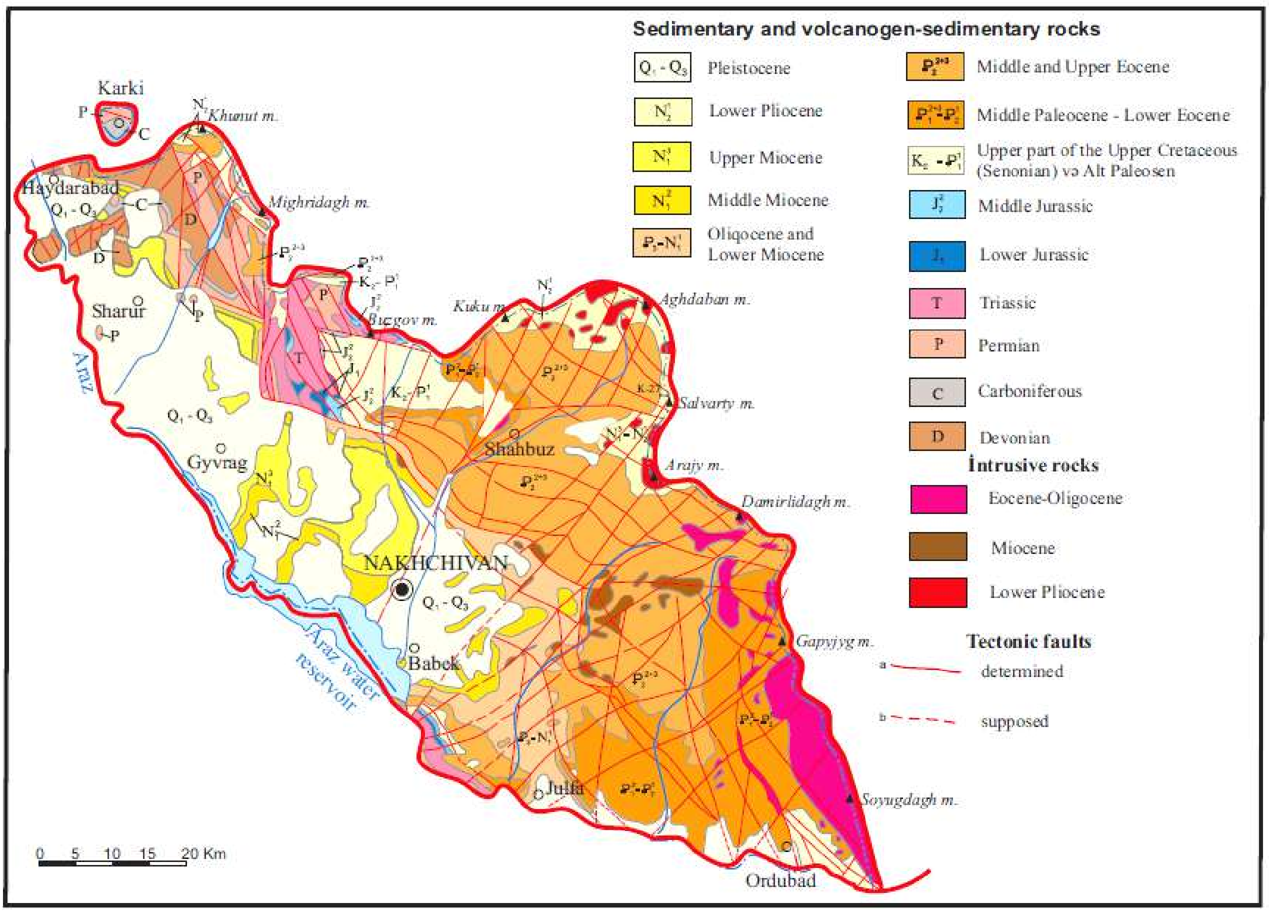
The Neogene system is represented in the geological structure of the autonomous republic by its lower and top divisions containing the sedimentary, volcanogenic-sedimentary and volcanogenic facies. The derivatives mainly compound the section of the Nakhchivan Depression (the Miocene) and in part are developed in the water-parting section of the Nakhchivan Basin as well as in the Komurludag and Gunnut areas in the basin of the Arpachay River (the Lower Pliocene) (Figure 1). The average thickness of the rock complex reaches 2400 m while the general maximum thickness equals 3500 m.

The Ordubad Zone that corresponds to the rift bowl still in Nakhchivan AR contributes to the overall rising of the Lesser Caucasus dome on the transition from the Oligocene to the Miocene; while the warping area migrates into the

Sharur-Julfa Elevation. Seawater left the territory temporarily at the end of the Early Miocene – only to return by the middle of the Tarkhanian Age. The marine and continental-marine molasses containing gypsum and salt strata were accumulating in the shallow parts of the sea and in the marginal lakes that had developed by then. The plains and mountainous territories that were girding the basin on the North, the East and the SE served as the migration areas for those molasses. These processes were accompanied along the northern and eastern girds of the Nakhchivan Depression by the minor teschenite and dioritic intrusions. Seawater left the territory completely at the end of the Miocene and the beginning of the Pliocene. At the same time, the following period of tectonic activity creates to directed width folds and magmatism in the explosive, effusive, extrusive and intrusive forms. The sub-volcanic and extrusive dioritic, andesitic and andesidacitic masses and a thick effusive cover – the Early Pliocene magmatism products – in the initial section of the Nakhchivan River's basin and in the highlands of the Lesser Caucasus.

The lithological-stratigraphic features and fauna of the Neogene rock complex were studied and described in detail at various times by G.Abich, F.Frech, G.Artgaber, P.Bonnet, F.F.Oswald, V.V.Bogachev, K.N.Paffenholz, I.A.Preobrazhenskiy, M.I.Varentsov, V.V.Tikhomirov, B.P.Juzet, V.I.Khahin, Sh.A.Azizbekov, M.I.Rustamov, A.I.Azizbekova, K.M.Sultanov, A.G.Voroshilova, L.N.Leontyev, M.T.Pronina, F.A.Mustafayev, G.I.Aliyev, G.I.Allahverdiyev, et al. A.G.Eberzin, A.I.Azizbekova, A.N.Krysztofowicz, G.K.Gasimova, M.T.Pronina, G.M.Sultanov and A.G.Voroshilova collected and descrybed palaentological materials at different times.

The local stratigraphic units present in the geological section are shown in the Table 1 below.



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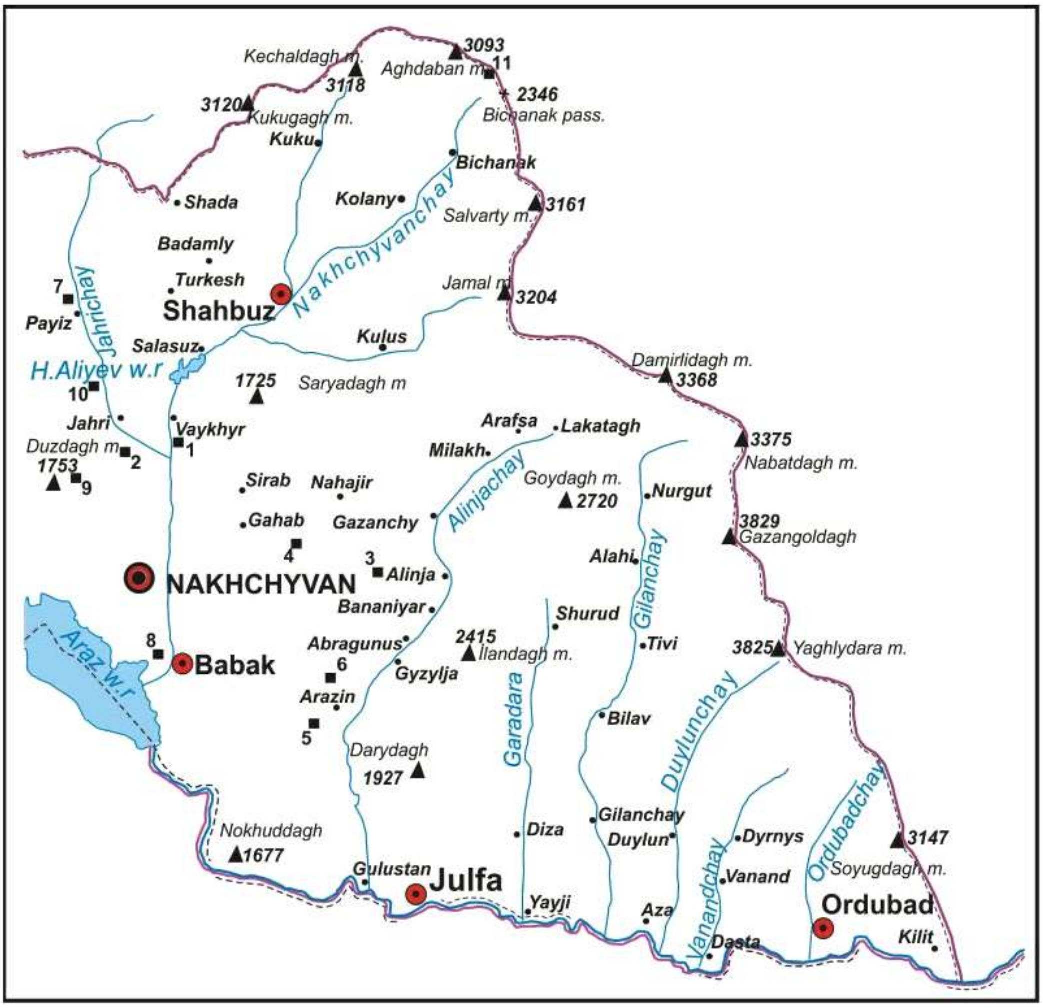

B

Figure 1. The Geological Map (**A**) and scheme of the Neogene stratotype sections' location (**B**), Nakhchivan Autonomous Republic; by T.N.Kengerli:
1 – Khalkhal Series, **2** – Garagala Series, **3** – Chashyrdagh Series, **4** – Dizazina Series, **5** – Arazin Series, **6** – Paradash Series, **7** – Payiz Series, **8** – Tumbul Series, **9** – Duzdagh Series, **10** – Gulshanabad Series, **11** – Bichanak Series

Table 1

The Neogene System Distribution across Nakhchivan AR's Territory

Subdivision	Regiostage	Series
The Lower Miocene	Caucasian	Khalkhal
	Sakaraul	Garagala
The Middle Miocene	Upper Tarkhanian	Chashirdag, Dizazina and Erezin
	Chokrak	Garadash
	Karagan	Payiz
	Konka	Tumbul
The Upper Miocene	Sarmatian	Duzdag
	Meothis	Gulshanabad
The Lower Pliocene	Balakhany	Bichanak

The Miocene

The Miocene Series only are identifiable in the geological section the Nakhchivan Depression in the territory of the autonomous republic; there, it outcrops all its sections excluding Kotsakhur, the Lower Tarkhanian and the Pontian. It is represented by *the Duzsakhlayan Series* that Sh.A.Azizbekov identified in 1952; the total thickness reaches 2,600 m (Азизбеков, 1961). In general, the lower part of the section has the presence of volcanogenic-sedimentary, volcanogenic and sedimentary rocks while the top part has terrigenous rocks containing gypsum and salt rock. The lower subdivision series is represented by the derivatives of a multi-coloured carbon-terrigenous-tuffite mixed formation; the middle subdivision is mainly halicit – terrigenous and partly also contains multi-coloured carbon-terrigenous-tuffite mixed formations; the upper subdivision consists of halicit-terrigenous formations.

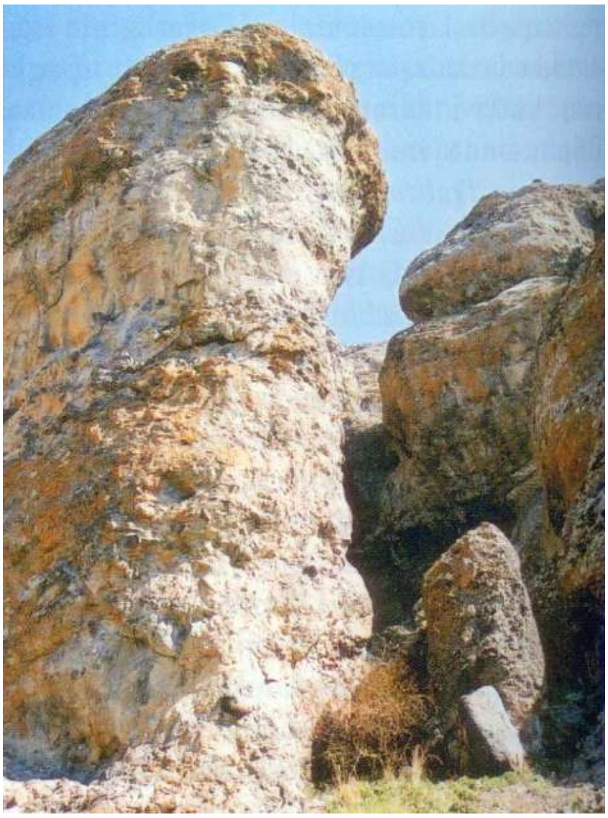

Figure 2. The entry to the cleft where the Ashabi-Kahf Cave is situated; the outcrop corresponds to the Caucasian Regiostage of the Khalkhal Series

Khalkhal Series (after the Khalkhal village) is identical to the bottom part of *the 'multi-coloured stratum' Salt-Impermeable' (Duzsakhlayan) Series* that Sh.A.Azizbekov identified in 1952 and that overlies the '*red-coloured stratum'* in the foundation part concordance. G.I.Aliyev gave it its name in 1981. The stratotype is situated near the Khalkhal village on the NE fringe of the Nakhchivan Depression. The group outcrops in the Sadarak, Velidag, Garabulag (the parastratotypical section), Akhura, Garabaglar, Tenenem, Chalkhangala, Payiz, Vaykhir, Khalkhal, Garagala, Ghizilbogaz, Sirab, Gahab, Najafalidize, Nahajir and Ashabi-Kahf (Figure 2), Ghirkhlardag, Chashirdag, Bananiyar, Khachaparag, Erezin, Ghirmizidag-Nehram and other sites on the NW, NE, SE and SW fringes of the Nakhchivan Depression. It overlies the Upper Oligocene Abragunus Series concordance in the stratotypical and other sections that are situated between the Nakhchivanchay and the Alinjachay (Figure 3), and is formed of the multi-coloured (grey, greenish-, yellowish-, brownish-, reddish-, bluish- and fallow-grey) sandstones, clays, aleurolites, sometimes also siliceous limestone and in other places it is the non-uniform alternation of gritstones, malms and aleurotuffites (20–195 m). In the lower part of the Alinjachay basin and in the Ghirmizidag-Nehram area the section has tuff-conglomerates, tuff-breccias and aleurotuffites. The basal conglomerates of the Series overlie transgressively and immediately the Devonian, Carbonic and the Permian sediments in the Garabulag, Sadarak and Velidag areas in the NW of the Nakhchivan Depression while the subsequent section is generally demonstrating the most reddish clays, clayey sandstones, aleurolites, sometimes tuff-sandstones, tuff-gritstones and tuff-conglomerates (30–185 m). The section in Gahab and other sites was found to contain the following molluscan-fauna fossils characteristic of the Lower Miocene: *Planorbarius (Coretus) corneus, Pl. cornucopia* (Baily), *Hydrobia acuta* (Drap.), *Bythinia* sp., *Unio* sp., *Puludina* sp., etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбекова, 1972; Ализаде, Азизбекова, Атаева, 1980 and Геология Азербайджана, 2007).

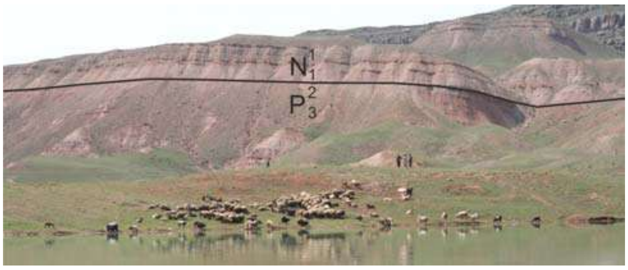

Figure 3. The Proportional Bedding of the Upper Oligocene (P_3^2) and the Lower Miocene (N_1^1) Sediments on the NW Bank of the Bananiyar River

Garagala Series (after the Garagala village) is identical to the upper portion of *the ‘multi-coloured stratum’ Salt-Impermeable’ (Duzsakhlayan) Series* that overlies the ‘reddish layer’ on the base and that Sh.A.Azizbekov identified in 1952. G.I.Aliyev named it so in 1981. The stratotype is situated on the NE fringe of the Nakhchivan Depression near the village of Garagala. It outcrops in the Sadarak, Garabulag (the parastratotypical section), Akhura, Garabaglar, Tenenem, Chalkhangala, Payiz, Vaykhir, Khalkhal, Garagala, Ghizilbogaz, Sirab, Gahab, Najafalidize, Nahajir, Ashabi-Kahf, Ghirkhlardag, Chashirdag, Bananiyar, Khachaparag, Erezin and Ghirmizidag-Nehram (Figure 4) and in other sites on the NW, NE, SE and SW fringes of the Nakhchivan Depression and overlies the Khalkhal Series concordance. In the stratotypical and other sections it is an irregular alternation of multi-coloured (grey, greenish-, yellowish-, brownish-, reddish-, bluish- and ruddy-grey) sandstones, gritstones, aleurolites, siliceous limestones, clays and malms (250–300 m). In the SE direction the thickness of the Series reduces (to 11–15 m in the Ghirmizidag-Nehram site) and there are strata of tuff-sandstones and tuff- conglomerate in some parts of the section. The outcrops in the NW of the Nakhchivan Depression represent the Series mainly with limestones (predominantly ferriferous), sandstones, aleurolites and clays (15–250 m). One specific feature of the Series is that its section is dominated by the numerous (8–50) and thick (0.5–4.0 m) siliceous limestone, which is sharply manifest in the relief and plays the role of a marker. The section in Nehram, Khachaparag, Chashirdag, Gahab and other sites is found to be containing the following molluscan-fauna fossils characteristic of the Lower Miocene: *Planorbarius corneus* (L.), *Pl. (Coretus) corneus, Pl. cornucopia* (Baily), *Pl. corneus* Linne, *Hydrobia acuta* (Drap.), *Bythinia tentaculata* (L.), *Lithophaga inclusa* Phil., *Poiretia* ex gr. *inflata* Reuss, *Lumnaea* sp., *Zumnea* sp., etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбекова, 1972; Ализаде, Азизбекова, Атаева, 1980; Геология Азербайджана, 2007).

Figure 4. The Sakaraul Regiostage/Lower Miocene Outcrop of the Garagala Series between the villages of Nehram and Erezin

Chashirdag Series (after the Chashirdag) is identical to the ‘*pyroclastic stratum’* (the third one from bottom up) of the *Multi-Coloured Salt-Impermeable Series* that Sh.A.Azizbekov identified in 1952. M.I.Rustamov named it so by in 1954. The section formed of the derivatives of the stratotype’s trachyandesite-teschenite formation derivatives is found in the Chashirdag that is situated on the SE fringe of the Nakhchivan Depression. The outcrops make up the separated massifs Chashirdag-Ushagli (Figure 5) and Ghirkhlardag. In the Chashirdag area the formation overlies discordance the Garagala (the Sakaraul Regiostage) and Khalkhal (the Caucasian Regiostage) Series derivatives while in the Ghirkhlardag site it does the Khalkhal (the Caucasian Regional Stage) and Abragunus (the Chattian) Series derivatives. Composed of volcanic flow materials, it is a regular alternation of trachyandesite and latite igneous breccia, agglomerate and crystalline-clastic tuffs and autoclastics. The thickness reaches 160 m. A gradual wedging of volcanites is occurring to the NW while the Series is only represented by crystalline-lithoclastic tuffs (8–10 m) in the outskirt of the Gahab village. There is the only trachyandesite-basalt lava flow in the Ghirkhlardag site. The absolute age of the trachyandesite samples that M.I.Rustamov obtained in 1984 is (by the K-Ar method) 14.9–15.9 mn years and corresponds to the Middle-Upper Tarkhanian (the Upper Langian substage).

Figure 5. The Outcrop of the Chashirdag Series on the escarpments of Ushagli Mountain

Dizazina Series (after Dizazina Mountain) pertains to the Middle Miocene Subdivision of the Neogene System of the Cainozoic Erathem. G.Abich, F.Frechs, Artgaber, P.Bonnet, K.N.Paffenholz, I.A.Preobrazhenskiy, M.I.Varentsov, V.V.Tikhomirov, B.P.Guset, V.Y.Khahin, Sh.A.Azizbekov, M.I.Rustamov, A.I.Azizbekova, K.M.Sultanov, A.G.Voroshilova, L.N.Leontyev, M.T.Pronina, F.A.Mustafayev, G.I.Aliyev, G.I.Allahverdiyev and others studied and described the outcrops at different times. The group dates back to the Tarkhanian-Chokrak within the *Salt-Impermeable Series* that Sh.Azizbekov identified in 1952. The biostratigraphic examination of the Miocene sediments resulted in A.I.Azizbekov identifying '*the grey stratum*' dating back to the Lower Miocene (Burdigalian) sediments in 1972. The present-time name came from G.I.Aliyev in 1981. The stratotype is situated on the NE fringe of the Nakhchivan Depression, the SE side of the not-so-high Dizazina Ridge and near the ruins of the Kurme-Mahmud wintering-place. The formation also outcrops in the Garagala, Sirab, Gahab and Khachaparag areas. The formation overlies discordance the pyroclastic rocks of the Chashirdag Series in the Khachaparag area and as it covers them wholly along the full lengths in both NW and SW directions, it comes into a transgressive contact with the derivatives of the Garagala Series. On the top it is overlain discordance by the Erezin Series derivatives confirmed faunistically. Because it is between the Chashirdag and Erezin Series within the geological section it is attributed to the lower part of the Upper Tarkhanian substage. In the stratotypical section it protrudes from the carbon-terrigenous facies as an alternation of yellowish- and greyish-green, reddish-ruddy and grey calcareous sandstones (1–19 m), lumpy and slaty clays (0.5–7.0 m), siliceous limestone (0.3–2.0 m), aleurolites and malms (0.5–2.0 m) (142 m). The thickness of the Series rises from E to W starting at 70 m (the Khachaparag area) and ending at 162 m (the Garagala section). Numerous *Lithophaga inclusa* Phil. and *Planorbarius cornu cornucopia* (Baily) fauna fossils were found in the section of the Khachaparag area (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Азизбекова, 1972; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Ализаде, Азизбекова, Атаева, 1980; Аллахвердиев, Тарасова и др., 1973; Геология Азербайджана, 2007).

Erezin Series (after the Erezin village) pertains to the Tarkhanian-Chokrak formation within *the Salt-Impermeable Series* that Sh.Azizbekov identified in 1952. Following a biostratigraphic research of the Miocene sediments A.I.Azizbekova identified the group as the Tarkhanian '*aleurolite-sandstone strata with turritella* in 1972. G.I.Allahverdiyev named the group as we know it today back in 1985. The stratotype is situated to the West from the Erezin village and in the Nehram-Khachaparag site in the SE margin the Nakhchivan Depression while the parastratotype outcrops NE of the Akhura village. The group is also observable along the NW wing of the Nakhchivan Depression, in the Chashirdag, Gahab, Sirab, Khalkhal, Payiz, Chalkhangala, Beyukduz, Dashbashi, Garachug, Tenenem and Hamzali sites and between the Arpachay and the Chapanchay. In the area between the Nakhchivanchay and the Alinjachay within the Nakhchivan Depression it overlies discordance the Chashirdag and Dizazina (the Khachaparag area) Series rocks or immediately the Lower Miocene rocks of the Garagala Series (in the other peripheral sites). In the stratotypical section it is an alternation of the thin strata containing rare gypsum lenses as well as stringers of greenish-ruddy, greenish and yellowish-grey diversely-grained gypsified sandstones, clays, aleurolites and malmrocks with gypsum lenses. The thickness is between 40–180 m depending on the outcrop. The basal portion normally has a thick (4–12 m) sandstone horizon. Coming parastratotypically section and, in general, in the NW outcrops (the Tenenem and Hamzali sites and between the Arpachay and the Chapanchay) in the volcanogenic-sedimentary facies, the formation contains basal conglomerates at its foundation and is an alternation of the thick strata of trachyandesite-tuff and the agglomerate of clayey-sandstone derivatives (160–230 m). The following specific foraminiferous and gastropod faunal fossils were found in the section in the Nehram-Khachaparag site: the gastropods – *Turritella* ex gr. *tricarinata* Brocc., *T.* cf. *vermicularis* Brocc., *T. strangulata* Grat., *Potamides bidentatus* Defr., *P. picrus elongata* Stch., *Terebralia bidentata* Defr., *P. (Pirenella) platus* var. *elongata* Jtch. and etc; and the foraminifers – *Globigerina tarchanensis* Subb. et Chutz., *Gl. billoides* Orb., *Nodosaria tarchanensis* Pron., *Nonion subbotinae* Chutz., *N. bouenum* (d'Orb.), *Bolivina tarchanensis* Subb. et Chutz., etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Азизбекова, 1972; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Ализаде, Азизбекова, Атаева, 1980; Аллахвердиев, Тарасова и др., 1973; Геология Азербайджана, 2007).

Garadash Series (named after a locality on the western side of the Saridag Elevation to the N from the Erezin village) pertains to the Chokrak regiostage within *the Salt-Impermeable Series* that Sh.A.Azizbekov identified in 1952. A.I.Azizbekova described it as the Chokrak Age *'clay-sandstone spirialis-zandbergeriya strata'*. G.I.Aliyev gave it its present-day name in 1981. The stratotype is situated in the Nehram-Khachaparag site on the SE margin of the Nakhchivan Depression; it also outcrops along the NW fringe of the Nakhchivan Depression and in the Chashirdag, Khalkhal, Payiz, Chalkhangala, Beyukduz, Dashbashi and Garachug sites. In the SE it is an alternation of sandstones, clays, aleurolites and gritstones with the rare strata of conglomerates and malms with gypsum lenses (65 m) that overlie concordance the Erezin Series (the Upper Tarkhanian regiostage) sediments. On the NE margin of the Nakhchivan Depression it is identified together with the Erezin Series lying below it owing to the identical lithological composition and absence of faunal fossils. The specific molluscan and ostracod fossils that were found in the sequence in the Nehram-Khachaparag site are: the ostracods – *Condionella negramica* Pron. and etc.; and the molluscs – *Spiratella andrussovi* Kittl., *Sandbergeria ilina* Azizb., *Dentalium* sp., etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбекова, 1972; Ализаде, Азизбекова, Атаева, 1980 and Геология Азербайджана, 2007).

The Payiz Series (after the Payiz village) corresponds to the seventh stratum of *the Salt-Impermeable Series* that Sh.A.Azizbekov identified in 1952. A.I.Azizbekova described it as the ‘*gypsum-salt impermeable strata’* of the Karagan Age in 1972. The present-time name came from G.I.Aliyev in 1981. The stratotype is situated on the right-side bank of the Jahrichay and to NW of the Payiz village. The group also outcrops in the sites near the town of Nakhchivan, near the villages of Nehram, Najafalidize, Jahri, Dashbashi, Beyukduz, Gargalig, Khok and Chalkhangala, near the ruins of the Khachaparag village and in other places coming from under the Upper Miocene/Pleistocene derivatives. It overlies concordance the rocks of the Khachaparag Series (the Chokrak stage). In the stratotypical section it is an alternation of the reddish-brown and greenish-yellowish-grey clays, aleurolites and sandstones that contain gypsum and salt strata and lenses. Some outcrops also present themselves as alternations of gypsified clays, sandstones and aleurolites with rare thin gritstone and malm layers. The sections wells in the eastern part of the Nakhchivan Depression have the hydrochemical sediments being the layers salt rock, anhydrides and gypsum. The thicknesses are between 75 m and 300 m on the surface and the thickness determined in the section of the Beyukduz test hole equals 624 m. The following ostracods that are characteristic of the Karagan Regiostage were discovered in this and other sections: *Ilyocypris brady* Sars., *Il. gibba* Ramdohr, *Cytheridea* cf. *derri* Lal., *Gerithium* cf. *mitribe* Eichw., *Eucupris azizbekovi* Vorosh., *E. bejykdusichm* Vorosh. and *Cyprideis gigantica* Vorosh. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Азизбекова, 1972; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Ализаде, Азизбекова, Атаева, 1980; Аллахвердиев, Тарасова и др., 1973; Геология Азербайджана, 2007).

The Tumbul Series (after the village of Tumbul) pertains to the eighth stratum of *the Salt-Impermeable Series* that Sh.A.Azizbekov identified in 1952. A.I.Azizbekova described it as the Konka ‘*the layers containing pholads* in 1972. The present name came from G.I.Allahverdiyev in 1985. The stratotype outcrops near the village of Tumbul that is situated in the SE part of the Nakhchivan Depression (Figure 6). The group also outcrops in the sites near the town of Nakhchivan and near the villages of Nehram, Najafalidize, Jahri, Dashbashi, Beyukduz, Taziuchan, Gargalig, Khok and Chalkhangala, near the ruins of the Khachaparag village and in other places, coming from under the Upper Miocene/Pleistocene derivatives. The group overlies concordance the rocks of the Payiz Series (the Karagan Regiostage). In the stratotypical section, it is an alternation of the brownish-ruddy and greenish-grey strata of tuff-sandstones, clays and aleurolites. In other outcrops it presents itself as the alternating rare gritstone and conglomerate layers sometimes containing gypsum lenses and the aleurolite, clay and sandstone strata. The thickness is between 30 m and 220 m depending on the outcrop; it equals 225 m in the section of the Beyukduz test hole. The section was found to contain littoral molluscan (gastropods, pholads), foraminiferous and ostracod fossils, namely: the molluscs – *Pholas* ex gr. *bogatshovi* Ossip., *Barnea* oft. *sinzovi* Ossip., *B. pseudoustjurtensis* Bog., *B. ustjurtensis* Ossip., *B. ujramatica* Andrus., *B. tumbluica* Azizb., *Theodoxus pictus* Ferussac, *Microstele* cf. *caucasica* Stekl., *Caucasotachea* cf. *kubanica* Stekl., *Chondrula (Mastus) tumbluica* Azizb., *Ch. (Mastus) alizadei* Azizb., *Helix nachishewanicus* Azizb., etc.; the foraminifers – *Cibicides lobatulas* Walk. et Juc., *Milliolina* ex. gr. *consobrina* Orb., *M. articulinoides* Vorosh., *M. beyucduzica* Vorosh., *M. rotunda* Vorosh., *Globigerina* ex. gr. *bulloides* Orb., *Elphidium kudokensis* Bogd., *E. macellum* (Ficht. et Moll.), *Bulimina elongata* Orb., *Angularina angulosa* Will., *Ammonia beccarii* (Linne) *konkensis* Pron., etc. The top of the section contains, alongside shallow-water marine pholads in dark-grey aleurolites and sandstones (1.5–2.0 m), also the terraneous molluscs *Microstele* cf. *caucasica* Stekl., *Caucasotachea* cf. *kubanica* Stekl., *Chondrula (Mastus) tumbluica* Azizb., *Ch. (Mastus) alizadei* Azizb., *Helix nachishewanicus* Azizb., etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961;

Азизбекова, 1972) (Ализаде, Азизбекова, Атаева, 1980; Аллахвердиев, Тарасова и др., 1973; Геология Азербайджана, 2007).

Figure 6. Near the Tumbul Village; the Konka Regio-stage/Middle Miocene Outcrop of the Tumbul Series (‘*the layers containing dactyls*‘)

The Duzdag Series (after Duzdag Mountain) is made up of the upper strata of the Salt Impermeable Series identified by Sh.A.Azizbekov in 1952. G.I.Aliyev gave it its name in 1981. The stratotype is situated on the plateau of Duzdag and on its sides (Figures 7, 8) while the parastratotype is in the Khachaparag site. Within the Nakhchivan Depression the formation also outcrops in the sites Taziuchan, Saridag and Bozdag, around the villages of Jahri, Payiz, Tezekend, Chalkhangala, Garabaglar, Tenenem, Habilli, Khok, Beyukduz, Shahtakhti, Zeyve and Sadarak and in other places, coming from under the Pleistocene continental molasses. Owing to the lithological compositional differences and the facial variability the group is divided into the following three subformations: 1 – the lower subformation group that is an alternation of sandstones, aleurolites and clays; 2 – the middle sub-stratigraphic group composed of clays, sand, sandstones, malms and aleurites; and 3 – the upper subformation group that is an alternation of sandstone, clay, aleurolites, gritstones and conglomerates. There are strata, lenses and stringers of gypsum and salt rock across the whole section. The thickness is between 200–600 m depending on the different sections. The section is found to contain the specific molluscan, foraminiferous and ostracod fossils.

The Lower Duzdag Subseries corresponds to the lower horizons of the Lower Sarmatian within the Salt Impermeable Series identified by Sh.A.Azizbekov in 1952. A.I.Azizbekova identified it as an independent stratigraphic unit owing to the specific lithological-stratigraphic and faunistic features in 1972. The stratotype is situated on the right-side bank of the Jahrichay in the NE of the Duzdag Plateau while the parastratotype is in the site Khachaparag. It is an alternation of the strata of reddish-brown, dark grey, yellowish- and greenish-grey sandstones and aleurolites and a minor quantity of clayey gypsums in layers, lenses and stringers. The thickness varies from 40 m to 350 m depending on the location. The section was found to contain the specific faunal fossils (molluscs, foraminiferas and ostracods including: the molluscs – *Pireneella disjuncta* (Sow.), *P. picta mitralis* (Eichw.), *P. nodosoplicata* (M.Hörn.), *P. gamlitzensis theodisca* (Rolle) (Hilb), *Terebralia bidentata (Defr*.) (Grat.), etc. The microfauna fossils also include foraminiferas – *Quinqueloculina consobrina* (d’Orb.), *Q*. aff. *anticulinoides* Vorosh., and ostracods – *Loxoconcha* aff. *virides* (Mull.), *Leprocythere* sp., etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Азизбекова, 1972; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Ализаде, Азизбекова, Атаева, 1980; Геология Азербайджана, 2007).

The Middle Duzdag Subseries corresponds to the top horizons of the Lower Sarmatian Stratum within *the Salt Impermeable Series* identified by Sh.A.Azizbekov in 1952. A.I.Azizbekova identified it as an independent stratigraphic unit owing to the specific lithological-stratigraphic and faunistic features in 1972. The stratotype is situated on the right-side bank of the Jahrichay in the NE of the Duzdag Plateau while the parastratotype is in the Khachaparag area. It is an alternation of the strata of reddish-brown, dark grey, yellowish- and greenish-grey clays, sands, sandstones, malms and aleurolites with gypsum in strata, lenses and stringers. The thickness is between 30–360 m depending on the location. The section was found to contain the specific faunal fossils molluscs, foraminifers and ostracods including: *Nonion subgrnosum* (d'Orb.), *Ammonia beccari* (Linne), *Cytheridea torosa littoralis* (Brady), *Miliolina consorbina* (d'Orb.), *Sphaerium sarmaticum* (Azizb.), *Hydrobia uiratamensis* (Koles.), etc; the microfauna is also represented by *Porcoononion hatelliformis* (Pron.), *Globigerina subtarchanensis* (Pron.), *G. trilcoulinoides* (Plumm), *Quinqueloculina consobrina nitona* (Reuss.), *Q. reussi* (Bogdan.), *Q. consobrina plana* (Vorosh.), *Nonion martkobi variana* (Pron.), *Leptocythere plana* (Sehn.), *Alphiehum venustus* (Vorosh), etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Азизбекова, 1972; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Ализаде, Азизбекова, Атаева, 1980; Геология Азербайджана, 2007).

The Upper Duzdag Subseries corresponds to the Upper Sarmatian within *the Salt Impermeable Series* identified by Sh.A.Azizbekov in 1952. The stratotype is situated on the right-side bank of the Jahrichay in the NE of the Duzdag Plateau. It is an alternation of grey, greenish-grey and sometimes yellowish-grey diversely-grained sandstones, clays, aleurolites, gritstones and conglomerates with rare gypsum strata and lenses. The base of the subseries has a salt rock layer that is 5–10 m thick. The subseries overlie transgressively the Lower/Middle Duzdag subseries sediments along the northern fringe of the Nakhchivan Depression and is rested upon basal conglomerates. It overlies discordance and immediately the Lower Miocene and even the Palaeozoic sediments in the basin of the Arpachay and in the Sadarak, Bozdag and Saridag sites. The thickness varies from 100 m to 300 m in different sections. The section was found to contain the specific faunal fossils molluscs, foraminiferas and ostracods including: the molluscs – *Mactra (Chersonimactraq) caspia* (Eichw.), *M. (Ch.) bulgarica* Toula, *M. crassicolis* (Sinz.), *M. (Sarmat imactra) podolica* (Eichw.), etc..; and the foraminifers – *Quinqueloculina* ex gr. *consobrina* (Orb.), *Elphidium crispum robusta* (Pobed.), etc. (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Азизбекова, 1972; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Ализаде, Азизбекова, Атаева, 1980; Геология Азербайджана, 2007).

Figure 7. The Duzdag Series Outcrop pertaining to the Sarmatian Regiostage of the Upper Miocene; the western side of the Nakhchivan-Duzdag motoring road

Figure 8. The SE Side of Duzdag Mountain; the Upper Miocene, Salt Impermeable Series Sediments

The Gulshanabad Series (after the Gulshanabad village) was so called by G.I.Aliyev in 1981. The stratotype outcrops on the right-hand bank of the Jahrichay, western of the Gulshanabad village; there, it overlies discordance the Upper Duzdag subseries. M.T.Pronina examined the section in 1961. It is an alternation of bluish-grey clay and thin aleurite interlayers. The thickness reaches 25–30 m. The section holds numerous *Miliolina*: *Quinqueloculina* aff. *seminilum maeotica* Gerke, etc. (Ализаде, Азизбекова, Атаева, 1980; Геология Азербайджана, 2007; Пронина, 1961).

The Pliocene

The Pliocene sequence is identifiable on the water-parting between the Zanghezur and Dereleyez ridges at the sources of the Nakhchivanchay River as well as near the Gunnut village (NE) and is represented by the Lower Pliocene Bichanak formation that corresponds to the volcanogenic-pyroclastic strata with the maximum thickness in excess of 900 m.

The Bichanak Series (after the Bichanak Pass) was so called by Sh.A.Azizbekov in 1952. It was first studied by K.N.Paffenholz (1940); he ascribed it to the Oligocene. Later on, Sh.A.Azizbekov reduced the age of the group and lifted it to the Lower Pliocene.

The stratotype is situated NW from the Bichanak Pass and is generally a disproportional alternation of andesitic agglomerates and volcanic breccia strata (Figure 9). The thickness varies from 600 m to 915 m. The Bichanak formations volcanogenic-pyroclastic rocks collar the peaks and sides of the elevations Ghedikdag, Dibekli, Toplugaya, Uchgardash, Shalvarli, Tekelik, Kecheldag, Kukudag and so forth at the sources of the Nakhchivanchay. There are minor outcrops in the NW of the autonomous republic, at the sources of the small river Baghirsagdere near the village of Gunnut (the parastratotypical section). The formation rocks overlie discordance and with a slight tilt the scalped surface of the strongly fractured Middle/Upper Eocene sediments in all the outcrops. The foundation of the formation is made of a basal conglomerate of andesite, andesidacite and their tuffs, quartz-diorite, syenite-diorite, diorite-porphyrite, tonalite, diabase and fragments upstream the Arafshachay. The rocks of the formation stand out for the diversity of their lithological composition, the changes in facial directions and thickenings. They consist of the grey and magenta-grey medium-grained andesite and andesidacite lavas upstream the Minor Arafsachay and the Gheviksu, of the andesite-agglomerate-breccia lavas midstream the rivers and of andesite and andesidacite upstream the rivers. They consist of andesite and andesidacite in the lower part, of the medium to large-grained andesibasalt volcanic breccias in the middle part and are an alternation of dark-grey andesibasalts and the homogenously composed agglomerates in the top portion in the Toglugaya-Uchgardash area (Figure 10).

Figure 9. The Volcanogenic-Pyroclastic Complex of the Lower Pliocene Bichanak Series that forms the Bichanak Ridge’s water-parting. The Lake Batabat is in the foreground

Figure 10. The Batabat Upland; the volcanic breccias of the Lower Pliocene Bichanak Series

The Quarternary

The Quarternary (Anthropogen) system is represented in the Nakhchivan AR by the alluvial, proluvial-alluvial, eluvial-deluvial, fluvioglacial and other continental sediments and outcrops through all the divisions except Eopleistocene (Babayev, Kəngərli, Məmmədov, 2015; Азизбеков, 1961; Алиев, Омаров, Бурджалиев, Зейналов и др., 1982; Геология Азербайджана, 2007). The derivatives developed in the plain, highland and mountainous terrains and especially so in the geological section of the Nakhchivan Depression.

The geo-anticlinal tendencies and the general lift movements continued in the territory of the Nakhchivan AR in the Quarternary (the last stage of the Alp Evolution). Simultaneously, the terrestrial volcanism was taking place on the NE, NW and W fringes of the territory. Being derivative to the areal volcanism, they are located in the junction areas of the recent submeridional and NW tension zones. The lift processes were occurred the most in the NE and E parts of the autonomous republic and observed as a background to the differential low-degree shifts. The latter are characterised by the gradual increment of the discontinuous folding and are observable in our time, too, as can be seen from the height of river terraces, impaction of the hydrographical network, the configuration of river valleys, terrain features and the recent braced openings and other features present in the Quarternary sediments.

The Quarternary sediments were studied and described in detail and at various times by G.Abich, F.Frech, G.Artgaber, P.Bonnet, K.N.Paffenholz, I.A.Preobrazhenskiy, M.I.Varentsov, V.V.Tikhomirov, B.P.Guset, V.Y.Khahin, Sh.A.Azizbekov, M.I.Rustamov, A.I.Azizbekova, K.M.Sultanov, A.G.Voroshilova, L.N.Leontyev, M.T.Pronina, F.A.Mustafayev, G.I.Aliyev, G.I.Allahverdiyev and so forth. A.G.Eberzin, A.I.Azizbekova, A.N.Krysztofowicz, G.K.Gasimova, M.T.Pronina, G.M.Sultanov and A.G.Voroshilova identified the palaentological materials in various years.

The Pleistocene

The Pleistocene is represented in the Ordubad and Nakhchivan plains by the continental molasses (alluvial, proluvial, proluvial-alluvial, eluvial-deluvial, fluvioglacial formations) as well as travertine conglomerates and freshwater limestone, and is sub-divided in the Lower, Middle and Upper Pleistocene subdivisions.

The Lower Pleistocene is represented by alluvial-proluvial formations, travertine conglomerates and freshwater limestone.

The alluvial sediments occur in the E and the SE of the Nakhchivan AR and consist of conglomerates of the Triassic, Jurassic, Cretaceous and Eocene sandstone, limestone, dolomite, malm, argillite and quartzite chips. They are wide-spread in the sites with a slight tilt towards the Aras River, in the relatively elevated terrain areas (in the villages of Aylis, Duyun, Bash Dize, Yukhari Aza, Ashaghi Uzunoba, Yukhari Uzunoba, Nazarabad and in other territories) as well as in the water-parting areas between the Paragachay and the Jannatchay, the Ghilanchay and the Garaderechay. These sediments are mainly composed of the Ordubad granitoid intrusive etching materials in the area between the Paragachay and the Ghilanchay as well as on the summit of Gurdtepesi Mountain. The thickness varies from 2.5 m to 20–25 m.

The alluvial-proluvial sediments in are on the Duzdag Plateau and elevations and form a slightly tilted horizon (20–40 m thick) going towards the Aras River. There is a thick layer of conglomerates made of the Triassic, Jurassic, Cretaceous and Eocene sandstone, limestone, dolomite, malm, argillite and quartzite chips in the lower part of the sediments. The alluvial-proluvial sediments in the top portion are poorly sorted and made of poorly-rounded sand, sandy loam and clay-gravel lumps. The fragment sizes range from 20–30 sm to 50–60 sm.

The travertine conglomerates occur widely in the NW of the autonomous republic – in the area between the villages of Garabaglar, Yurdchu and Gabilli as well as in singular areas in the upper part of the terrain where they overlie the scalped surface of the Miocene sediments. The thickness is between 3–5 m and 10–15 m. The conglomerates are covered with the Middle/Upper Pleistocene alluvial-proluvial sediments between the villages of Garabaglar and Khok. The travertine conglomerate fragments consist of the Palaeozoic, Triassic and Cretaceous limestone, dolomite, quartzite and sandstones. The cement consists of the grey and brown-grey carbonate materials.

Travertine limestone is wide-spread near the villages of Shahtakhti, Ghivrag, Garabaglar and Khok where it overlies with a slight tilt the scalped surfaces of the Palaeozoic, Triassic and Miocene sediments. There are grey, light-grey and light brownish-grey firm weak-, medium-, thick- and massively stratum and sometimes soft limestones. Quasifissile layers are encountered sometimes as well. The thickness is between 3–5 m and 60–80 m. The solid and firm type of those limestones can be used for decoration and wall-paving; the soft and infirm type can be used to produce lime and cement material from it.

The Middle Pleistocene is represented by alluvial-proluvial and deluvial-proluvial formations and travertine limestones.

The alluvial-proluvial sediments in of the Nakhchivan AR predominantly occur in piedmont areas, the territories close to the Aras and in the NE of the Nakhchivan Depression (near the villages of Nahajir, Najafalidize and Gahab, and near the ruins of the Khachaparag village). There, they overlie the scalped Miocene sediments and form oval, plateau-shaped and conic elevations in the terrain. Besides, there are isolated and not thick sedimentary crusts in the basins of the Arpachay, the Jahrichay and the Nakhchivanchay where they form medium-height and tall terraces. These sediments are made up of differently-sized Palaeozoic, Triassic, Cretaceous and Eocene pebble and rock boulders. The rocks in some areas contain transversal and diagonal sand and loam layers. The thickness ranges from 3–5 m to 20–30 m.

The deluvial-proluvial sediments occur in the piedmont areas of the autonomous republic around the villages of Sadarak and Akhura, to the North from the Hamzali village, to the west from the Saltag village, to the South from the ruins of Khachaparag and in the SW of the Nahajir village. They consist of poorly-rounded and poorly-sorted gravel blocks containing sandy loam and clay. The thickness ranges from 2–5 m to 10–15 m.

The fluvioglacial sediments mainly occur on the SW and S sides of the Zanghezur Ridge, in the upper reaches of the basins of the Nakhchivanchay (the Pustachay, Zernetukchay, Ghemurchay and Shahbuzchay and other river-branches) and of the Ghilanchay (the Saggarsu, Nesirvazchay and other river-branches) as well as on the southern sides of the Dereleyez Ridge upstream the small rivers of Kukuchay, Pirchay and Baghirsagdere. In the Gazanghyol site, on the Bichanak Pass and near the Ghemur village the fluvioglacial sediments form the central parts of the caldera-like structures. Those sediments form slanted plateau-like elevations and consist of the poorly-sorted conglomerates to the west from the Shada village and 2 km away from Arachig Mountain. Travertine, sand and sandy loam act as the cementing agents. The occurrence areas of these sediments are broken by narrow and deep conic ravines. The thickness ranges from 2–5 m to 15–20 m.

The travertine limestones occur in the central and elevated terraced deposits spreading out into the basin of the Jahrichay as well as to the North from the Ashaghi Buzgov village, in the basin of the Nahajirchay and near the villages of Najafalidize and Nahajir. The travertine cover's length, width and length reaches 2,000 m, width 100 m and thickness 2–3 to 5 m respectively around the Najafalidize and Nahajir villages. The travertine limestones cover 1 km^2 and are 10–15 m thick at the Buzgov village. The pale-grey, thin, massive, firm and homogenously composed formation contains rare ingrained argillites, limestones and sandstones in the bottom portion. It can be used to cut out stone for decoration and as a chemical raw resource.

The Upper Pleistocene is represented by alluvial-proluvial, deluvial, deluvial-proluvial and eluvial-deluvial formations and shift formations as well as freshwater limestone.

The alluvial-proluvial sediments occur widely in of the Nakhchivan Depression. They form the slanted valleys of Sadarak, Sharur, Beyukduz, Nakhchivan, Julfa, Yaychi, Aza, Deste and Ordubad. They are also wide-spread in the basins of the Nakhchivanchay as well as its tributaries Ghemurchay, Kukuchay, Turkeshchay and Jahrichay and in the alluvial cones of the rivers Jahannamdere, Baghirsagdere, Arpachay, Gahabsu, Alinjachay, Ghilanchay, Ordubadchay and other rivers; there, those sediments cover the pebbly terraces of those rivers. The sediments also occur in the NE part of the Nakhchivan Depression and near the villages of Sirab, Najafalidize and Nahajir. They consist of well-rounded and well-sorted pebble, sand and sandy loam and loan and sometimes contain poorly-sorted pebbles and boulders. The thickness ranges between 5–10 m and 50–60 m.

The deluvial-proluvial sediments occur in the basins of the rivers Nursu, Ghemurchay, Kukuchay, Nakhchivanchay, Jahrichay, Lizbirtchay, Gabaglichay, Yayjideresi and Gumushdere, near the villages of Shahbulag, Yukhari Yaychi, Akhura, Chalkhangala, Payiz, Vaykhir, Kuku, Ghemur, Paradash, Gazanchi, Nesirvaz, Arafsa, Milah, Khoshkeshin and Saltag. The formation made of poorly-rounded and poorly-sorted gritstones and sandy loams contains boulders sometimes. The thickness is between 3–5 m and 10–15 m.

The eluvial-deluvial sediments mainly occur of the efflorescent on ridge sides and piedmonts made of laminated volcanogenic sedimentary rocks on the right-side bank of the Zernetukchay, the southern side of Tekelik Mountain, on the right-side bank of the Lizbirtchay, in the Yukhari Buzgov village, to the North from Beysal Mountain and in the Ghirkhlardag area in the Paradash Depression. The gravel-clayey foundations contain heterogeneously-composed boulders and stand out for the poor sorting and poor rounding. The thickness is between 5–10 m and 15–20 m.

The deluvial sediments occur relatively seldom; they form large barrows mainly on sub-volcano and intrusive formation sides. They occur on the northern side of the Kuku Sub-Volcano, upstream the Nakhchivanchay, to the NW from the Batabat Lake, on the sides of the Nahajir, Goydag and Ashabi-Kahf intrusive formations, on the southern side of Alchalidag Mountain and on the western sides of the Zanghezur Ridge. The thickness is between 3–4 m and 10–15 m.

The travertine limestones rim the mineral water springs of Nahajir, Sirab and Badamli and occur also around the villages of Vaykhir and Arafsa. The travertine limestones overlies at a slant the scalped surface of the Eocene sediments, covers 0.5 km^2 and is 3–5 m thick near the Vaykhir village. Those grey and pale-grey travertines contain argillite and sandstone fragments; they are firm; the local population use them as building stone.

The slide formations can be observed on the left-side side of the basin of the Ghemurchay, to the North from the Bichanak village near the villages of Kuku, Guney Ghishlag, Shada, Yukhari Buzgov, Khavun, Akhura, Yukhari Yaychi and Shahbulag. Those shifts normally occurred where the rocks of different ages and compositions contacted as well as in the fluvioglacial sedimentation regions. Shift dislodgements are normally characterised by high pressures and destruction of strata. In the given terrain they are sometimes characterised by the presence of a bench structure and uneven surfaces.

The Holocene

The Holocene sediments found in of the Nakhchivan AR are the alluvial and alluvial-proluvial formations in the river alluvial flats and in dry ravines. There are also deluvial-proluvial and eluvial-deluvial sediments on mountain sides, modern shift masses and the travertines generated by the active mineral springs.

The alluvial sediments occur at the sources and flood plains of the rivers Aras, Arpachay, Nakhchivanchay, Jahrichay, Alinjachay, Ghilanchay and so forth. They are mainly formed of well-rounded pebbles, gravel, sand, sandy loam and loam. The thickness equals 5–15 m in the flood plains and reaches 20 m upstream the Nakhchivanchay.

The alluvial-proluvial sediments occur in river basins where there are alluvial rocks; they also occur at the sources and in the flood plains of the rivers Jahannamdere, Baghirsagdere, Chalkhangala, Ghemurchay, Kukuchay, Shahbuzchay, Arafshachay, Paragachay, Aylischay and Ordubadchay. They consist of poorly-rounded and poorly-sorted boulder-pebbly formations containing pebble, sand and loamy. The thickness is between 3–5 m and 10–15 m.

The deluvial-proluvial sediments mainly occur in dry ravines, in piedmont areas and on slanted sides. Those sediments occur on the right-side bank slopes of the Nakhchivanchay, around the villages of Daylagli and Salasyuz and upstream the Alinjachay River. They consist of poorly-rounded and poorly-sorted gravel and have sandy-clayey fillers. The thickness ranges from 2–3 m to 10 m.

The eluvial-deluvial sediments usually occur on the water-parting ridges, their sides and piedmonts. Overlying layers are also encountered in the basin of the Shahbuzchay. They consist of degradable and fissured sedimentary and volcanogenic rocks. The thickness is between 1–3 m and 10–12 m.

The travertines occur around the active mineral springs. They also overlie the ancient firm travertines and the Middle Pleistocene alluvial-proluvial sediments to the North from the Garabaglar village, in the basins of the rivers Kolanisu and Demirlisu and to the South from the Arafja village. They are grey and pale-grey, non-hardened and porous. The thickness is between 0.5–1.0 m and 2–3 m.

The slide formations are well-developed and cover large areas on the SE side of Dibekli Mountain and to the North from the Kuku village as well as in the adjoining parts of the Eocene and Lower Pliocene sediments in the volcanogenic-pyroclastic rocks upstream the Zernetukchay, where the Cognac and Santonian formations abut in the basin of the Jahrichay and where the Permian and Upper Cretaceous sediments contact on the southern side of Buzgov Mountain. There are minor slide areas also upstream the Pirchay, Shahbuzchay and Tendirchay. The slides are at the contact of the Upper Eocene sedimentary rocks and fluvioglacial sediments in the area between the villages of Kulush and Kechili.

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NAXÇIVAN MR ƏRAZİSİ ÜZRƏ STRATİQRAFİK ESSE
Oçerk IV – Neogen və Dördüncü dövr

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

Naxçıvan Muxtar Respublikasının stratiqrafiyasına həsr edilmiş silsilə əsərlərdən sonuncusu olan məqalədə əsasən Naxçıvan, qismən də Ordubad çökəklərinin geoloji quruluşunda iştirak edən çökmə, vulkanogen-çökmə və vulkanogen mənşəli Neogen törəmələrinin litoloji-stratiqrafik kəsilişi səciyyələndirilir, həm də Dördüncü dövrün qitə mənşəli çöküntüləri barədə yığcam məlumat verilir. Müasir Beynəlxalq Stratiqrafik Cədvələ əsaslanan ümumiləşdirmə ərazidə ayrılan və paleontoloji cəhətdən əksərən təsdiq edilmiş yerli stratiqrafik bölgü vahidlərinin təsviri və yaşının qiymətləndirilməsinə imkan yaradır. İlk dəfə ingilis dilində təqdim edilən məlumat Orta Şərq Miosen hövzələrinə xas olan kəsilişlərin korrelyasiyasında istifadə edilə bilər.

ОЧЕРКИ ПО СТРАТИГРАФИИ НАХЧЫВАНСКОЙ АР
Очерк IV – Неоген и четвертичный период

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

Заключительная из серии публикаций, посвященных стратиграфии Нахчыванской Автономной Республики, статья характеризует литолого-стратиграфический разрез осадочных, вулканогенно-осадочных и вулканогенных образований неогена, которые участвуют в геологическом строении Нахчыванского и, частично, Ордубадского прогибов, а также дает краткую информацию о континентальных отложениях четвертичного возраста. Базирующееся на современной Международной Стратиграфической Шкале обобщение позволяет дать возрастную оценку и описать выделенные местные стратиграфические подразделения, в большинстве своем надежно палеонтологически обоснованные. Представленная информация, впервые публикуемая на английском языке, может быть использована при корреляции разрезов миоценовых бассейнов Среднего Востока.

THE SPATIAL HETEROGENEITY OF PETROPHYSICAL PROPERTIES OF THE GARADAGH (AZERBAIJAN) FIELD'S PRODUCTIVE HORIZON IN CONNECTION WITH UNDERGROUND GAS STORAGE

The article presents the reservoir property (RP) and gas saturation models of the productive series (the horizons VII–VIIa of the Productive Series – the Lower Pliocene) of the gas-condensate field of Garadagh (Azerbaijan) used as an underground gas storage facility currently (UGS). Those models have been made using the software package 'ROXAR' (Irap RMS). The purpose of the research is to identify the spatial non-uniformity of the productive series. We have specified the mosaic nature of the spatial changes in the PR rocks that control the gas/water saturation of the reservoir and predetermine the usage of the UGS (the spatially uneven volumes of gas injected and drawn through the wells). The series' fluid saturation model clearly indicates the gas-water contact and demonstrates the progress of water infiltration of the productive series with the trend for its fragmentation into isolated pillars. It is recommended to monitor and record the found factors in order to enhance the efficiency of the continued use of the Garadagh UGS.

Keywords: the 'ROXAR' (Irap RMS) software, the depleted field Garadagh, the productive series, spatial non-uniformity of the series, the reservoir properties of the rocks, underground gas storage.

A.A. Feyzullayev

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

A.A. Gojayev

The Gas Storage Operation Department,
Azneft PA, the State Oil Company of
Azerbaijan (SOCAR)

N.B. Khalygov

Azneft PA SOCAR
Field Development Division
E-mail: Nasir.Xaliqov@socar.az

Introduction

The gas-supply process is known to be exposed to massive seasonal unevenness between demand and offer. This problem was solved thanks to the idea of using depleted petroleum fields and, later, also water-bearing beds, salt caverns and mineral coal excavations as the underground gas storage (UGS) facilities.

There are 688 UGS facilities with the total active capacity in excess of 377 bn m³ around the world right now. A further 236 UGS (Underground gas storage in the world, 2013) are in the plan or being organised already. The largest volumes of gas are held in those UGS facilities that were founded in lieu of depleted gas and gas-condensate fields (Study on Underground Gas Storage in Europe and Central Asia, 2013).

There are 2 UGS facilities in Azerbaijan, organised in lieu of the depleted gas and gas-condensate fields Galmaz and Garadagh in 1974 and 1986 respectively (Figure 1).

The past studies of the geo-structural specificities of petroleum fields presents the kind of experience that is of importance to creation of UGS facilities; this experience shows that despite the whole tectonic, lithological and hydrogeological diversities, all those fields have in common the spatial macro- and micro-non-uniformity of their productive series (Борисов, Воинов, Рябинина, 1970; Дементьев, 1965; Обухов, 1964; Пулькина, Зимина, 2012; Семин, 1962; Фильтрационные модели неоднородных газовых залежей, 1983).

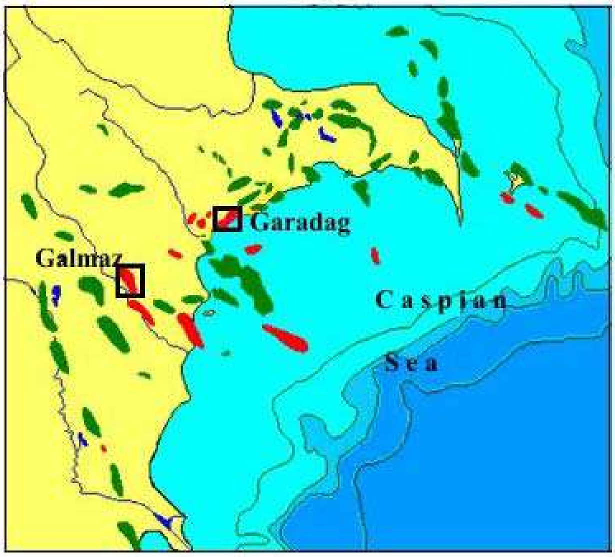

Figure 1. The Garadagh and Galmaz Field/UGS (Azerbaijan) Location Map (red – gas/gas-condensate fields; green – oil-fields)

The non-uniformity of series manifests itself in petroleum geology through spatial variability of their material compositions and lithological-physical properties, such as particle composition, porosity, permeability, carbonate content, saturation with oil and water and so forth (Пулькина, Зимина, 2012).

The laboratory as well as field (geophysical) analyses of collectors' physical properties indicate that even the thick sandstone series that appear homogenous at first sight change their properties significantly over space and section-wise (Мелик-Пашаев, 1979; Пулькина, Зимина, 2012).

The more complex a field's geological structure and the less homogenous a development target, the more difficult it is to pick a rational field development system. The simplified approach based on the perception of a reservoir as a homogenous geological object results in the wrong development system being picked, a dramatic watering of the output and reduction of the series' oil recovery factor (Белозёров, 2011; Кочнева, Седунова, 2013; Мусихин, 2016).

Clarification of non-uniformities' geological causes is a challenging scientific task solving which can provide for more efficient development of fields as well as the UGS facilities created in depleted petroleum deposits (Пулькина, Зимина, 2012; Семенов, 2010).

The 30–40 years past have seen a leap in computer technologies thus providing for generation of 3D geological reservoir models. The use of such technologies lays a sound foundation for raising the efficiency of using the existing as well as planned UGS facilities. All the design and technological documents are made using 3D geological-hydrodynamic models of oil and gas fields in our time (Лифантьев, 2014).

The purpose of the present article is to present a retrospective analysis of the spatial petrophysical non-uniformity of the productive series – the VII horizon of the Lower Pliocene Productive Series (PS) of the depleted gas-condensate field of Garadagh that is employed as a UGS – and of this factor's impact on its usage mode.

The Methodological Basis for the Research

The methods of studying the productive series' non-uniformities and of their impacts on the reservoir properties (RP) of the rock massif in operation of a UGS facility were addressed by many researchers attacking the subject from the geological as well as the technological viewpoints. The studies were mainly confined to solving the task of building a geological, lithological model of a natural reservoir (Берман, Нейман, 1972; Гайсина, 2015; Зубарев, 2010; Пулькина, Зимина, 2012; Семин, 1962; Стасенко, Климушин, 1972; Фильтрационные модели неоднородных газовых залежей, 1983 and Hewett, Behrens, 1990).

The study of the processes that occur during development of hydrocarbon fields has recently been reliant on the mathematical modelling methods. There is a wide array of software for geological modelling and development of petroleum fields, such as Eclipse, Pertrel (created by the French company Schlumberger), IRAP, TempestMORE (by Norway's Roxar) and Techschema (by SurgutNIPIneft). Those packages let one model an individual well as well as a field as a whole. The modelling by means of those software solutions is based on the analysis and processing of experimental, laboratory and geophysical findings. The physic-mechanical and reservoir properties are determined thusly (Попов, 2007).

ROXAR (Irap RMS) developed by the Norwegian company Roxar has been used to study the regularities of the changes in RP across the horizon VII of the PS in the gas-condensate Field/UGS Garadagh for the purposes of this article (Программы компании Roxar, 2013; About: Roxar AS, 1984; Reservoir Management Software, 2016). This software incorporates the most advanced solutions pertaining to geological and hydrodynamic modelling and well-design. Many specialists (Гайсина, 2015; Минликаев, 2005; From Field Data to Reservoir Model…, 2008, et al.) find IRAP RMS to be the best 2D/3D geo-modelling, deposit estimation, hydrodynamic computation, risk analysis and well trajectory plotting tool that there is. The software in question is used in more than 20 countries the world over (About: Roxar AS, 1984; Excellence in reservoir description and flow dynamics, 2016; The future of geological modeling in hydrocarbon development, 2016).

Irap RMS Petrophysical produces correlated 3D porosity, permeability and initial saturation fields.

The well geophysical study (WGS) data obtained with the use of the integrated data processing system PRIME WGS have been used in making the petrophysical models of the horizon VII of the gas-condensate Field/UGS Garadagh (Интегрированная система обработки данных геофизических исследований скважин, 2005).

The 3D interpolated parameter maps of the series based on the well cutting study data are usually not so exacting because of their reliance on the discretional data of the vertically variable parameters. Neither do they reflect the spatial variability of such data in interwell spaces with the required degree of detail.

The Findings and the Discussions

Briefly on the Garadagh Field/UGS

The Field/UGS Garadagh is situated on the southern wing of the asymmetric anticline that was discovered in the course of seismic exploration in the farthest SW of the Absheron Peninsula; it is 30 km away from Baku (Figure 1). Judging by the Productive Series (PS – Lower Pliocene) sediments, the axis of this structure's western portion has a latitudinal strike. The eastern portion of the fold bends southwards and grades into ex-meridian strike. The short northern wing of the fold has the 30–35° dip while the dip of the southern wing is up to 60°. The crest of the fold is complicated with the parallel up-leap type faults in the North. The fault amplitudes equal 600 m on the crest, 500 m on the western pericline and down to 100 m on the eastern pericline.

The gas reservoir found on the horizons VII+VIIa consists of an agglomeration of blocks. The block structure of the reservoir is also indicated by the existing findings from its exploration and subsequent development – those findings have been quoted (Подсчет подземных запасов нефти и газа…, 1964; Построение блочной фильтрационной модели подземного газохранилища Карадаг…, 2013 and Технологическая схема опытно-промышленной эксплуатации II очереди Карадагского ПХГ, 1985).

The structural model of the field is shown in the Figure 2.

The gas-condensate deposit of the PS' horizon VII is different from the others in that it has high productivity. Its section has the following three intervals: the top (the horizon VII) and the bottom (the horizon VII^{a}) collector horizons divided by a clayey layer as thick as 16–36 m. The horizon VII consists of 4–5 sandstone interlayers as thick as 5–10 m in the SE part of the southern wing. Those interlayers are divided by the clay intercalations as thick as 2–4 m.

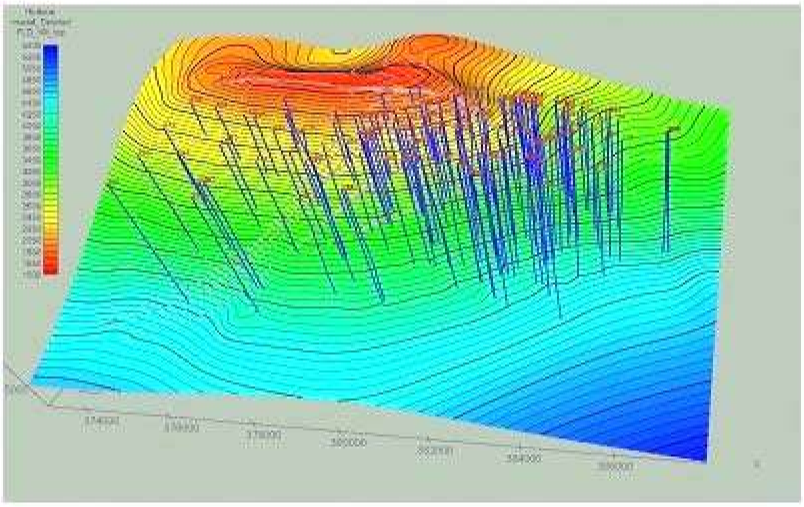

Figure 2. The Structural Model of the Horizon VII of the Garadagh Field/UGS Garadagh (the isolines cross the horizon's crest)

In turn, the section of the horizon VII[a] has two sandstone interlayers that are divided by a 5-m clayey layer. The upper interlayer's thickness is 10 m; that of the bottom one is 15 m and the latter reaches 20–25 m in the downwarped portion of the fold's southern wing. The overall thickness of the horizon VII[a] is between 21 and 52 m.

The horizons VII and VII[a] are merged into a thick sandstone layer in the SE part of the southern wing. The reduction of the overall thickness of the horizons VII–VII[a] towards the NW results in the lesser net thickness. Thusly, the net thickness of the horizons VII–VII[a] reaches 10–25 m in the NW and 5575 m in the SE. The net thickness of the horizon VII decreases towards the Western and NW parts and towards the crest of the fold also because clayey layers grow in quantity there.

The development of the Garadagh field began with the development of an oil-gas deposit on the horizon V of the PS in 1939. The horizons I–VII (the upper section of the PS) were the main development targets and so were the horizon VIII (the lower section of the PS) and the Upper Miocene deposits, with the average depth of the oil-bearing targets equalling 2,750 m.

The gas-condensate deposit with an oil fringe located on the horizons VII–VIIa was commissioned for development in 1955. The cover thickness of the horizon VII is 1,900 m in the crest part and 4,250 mn in the downwarped part with the average thickness equalling 3,125 m.

The productivity of the wells drilled into the suite of the horizon VII is uneven horizontally (Table 1). The wells in the downwarped SE portion of the deposit are more productive than the others.

The Garadagh gas-condensate field was developed without reservoir pressure maintenance and so the deposits of the horizons VII–VII[a] had been depleted by the late 1980s. More than 20.5 bn m^3 were extracted from the horizons VII–VIIa during 1955–1978. The formation pressure had dropped from 9Mpa to 3.5Mpa. The depleted reservoir's contents were as follows as on 01.01.1976 (Технологическая схема опытно-промышленной эксплуатации II очереди Карадагского ПХГ, 1985):

– Approximately 2 bn m^3 of non-recoverable gas resources;

– About 2 mn tonnes of liquid condensate resulting from retrograde processes.

– Some 8 mn tonnes of residual crude oil.

Table 1

The Initial Gas-Condensate Factor (GCF) and the Well Condensate Yields in various parts of the structure

Well Location	Well No	Filter Depth, m	GCF, m^3/t	Condensate Yield, g/cm^3
Near the Crest	140	2,945	7,631	131
" …"	155	2,646–2,661		145
" …"	212	3,092–3,129		136
Midsection	120	3,310–3,410	7,000	143
The SE Section	105	3,850–3,944	5,225	191
" …"	130	3,993–4,033		136
" …"	78	3,815–3,823	5,200	192

The UGS Garadagh (the horizons VII–VII^a of it) fell into use in 1986. The gas-bearing area of the horizon VII^a was the largest at the beginning of its development but had mostly been watered by the time Garadagh became a UGS. Right now, only a smaller portion of the horizon is used for injection and outtake of gas.

The UGS worked in the injection mode for two years after the commission; it was then put in the cyclic 'injection/outtake' mode with the gradual increase of the injected gas' pressure and volume. The operation of the UGS has been managed on the regulation and systematic bases since it was placed in the charge of Azneft PA in 2005.

Most of the injected gas practically enters a portion (a third to a half) of the initial reservoir capacity on the horizons VII+VIIa at present (Построение блочной фильтрационной модели…, 2013).

The macro- and micro- non-uniformity of the productive series may be one of the factors producing that aforementioned well yield change that occurs horizontally.

The macroinhomogeneity of the series manifests itself in the presence of several productive horizons along the section, their thicknesses changing horizontally as well as the presence of fringes and horizontal reservoir substitution in the section.

The *microinhomogeneity* is manifested by the considerable variability of the rock petrophysical properties on the horizon VII of the PS. The study of more than 90 well core samples indicates that the rock porosity varies from 3.3% to 24.5% while the permeability ranges between 0.001 μm^2 and 0.527 μm^2, and the carbonate content is between 5.7% and 26%.

The nature of the horizontal and section-wise changes in the rock reservoir properties is reflected by the porosity and permeability charts built for the upper and lower portions of the PS horizons VII and VIIa made using the software application RMSPetrophysical (Figures 3 and 4). It follows from those charts that the rock porosity and permeability changes are mosaic in nature with the RP structural changes present not only between the horizons VII and VIIa but also between the near-crest and near-bottom portions of those horizons. Whilst the lower portion of the horizon VII (Figure 3–a_2) has better porosity relatively, the rocks of the same horizon's upper portion have the more favourable permeability (Figure 3–b_1). The rock RP changes are of the akin if yet more contrasting nature on the horizon VIIa (Figures 4–a_2 and 4–b_1).

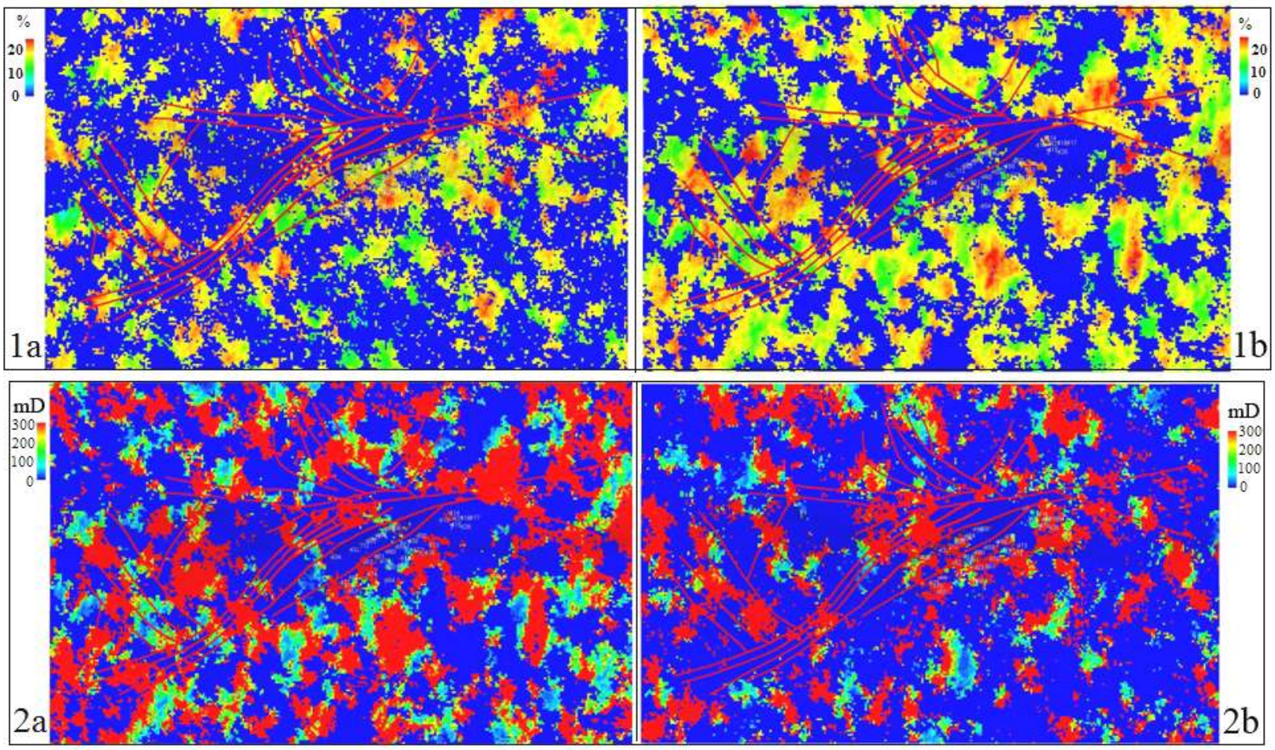

Figure 3. The Horizontal and Section-Wise Porosity (%) and Permeability (mD) Changes in the Upper (a_1 and b_1) and the Lower (a_2 and b_2) Portions of the PS' Horizon VII in the Garadagh Field/UGS

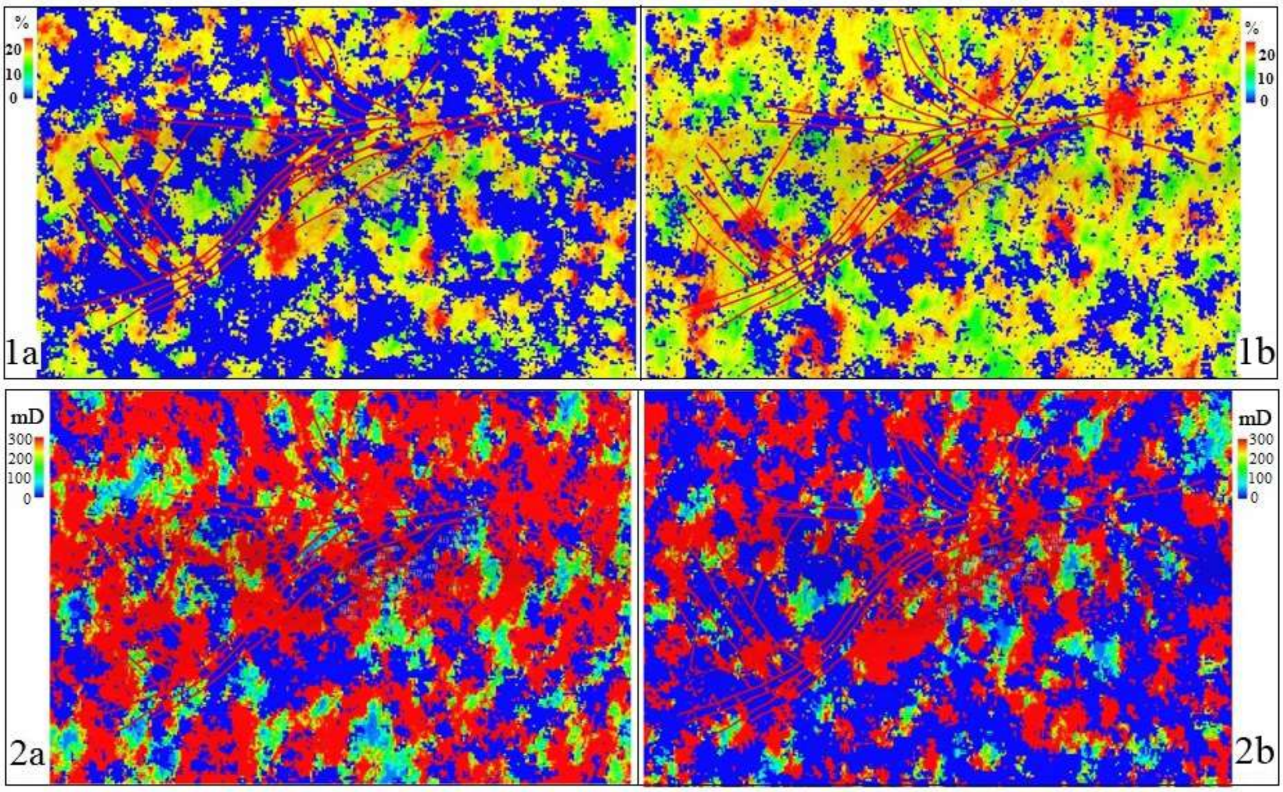

Figure 4. The Horizontal and Section-Wise Porosity (%) and Permeability (mD) Changes in the Upper (a_1 and b_1) and the Lower (a_2 and b_2) Portions of the PS' Horizon VIIa in the Garadagh Field/UGS

In full agreement with the spatial structure, the RP of the VII and VIIa of the horizons is the mosaic nature of the gas-saturation changes of the rock (Figure 5). Importantly, the models indicate clearly the border between the gas- and water-saturated portions of the studied object – the so-called 'gas-water contact', that is. The gas-bearing portion has the water-saturated areas connected to the water-saturated portion of the object. This nature of water saturation of the productive series resulted in its fragmentation in individual gas pillars, which is characteristic of four rock gas-saturation models. Only the upper section of the horizon VIIa has a more favourable (less fragmented) kind of gas saturation (Figures 5–b_1).

The attempt at expanding the gas-bearing area of the horizon VIIa at the expense of the water-saturated portion of the reservoir failed because the waters of this horizon have the pressure that is higher than that of the waters on the horizon VII. As a result, all the wells drilled to 3,000 m fountained water and an attempt to supress the fountains by injecting gas using a compressor with the output pressure of 160 atm did not succeed. Perhaps, a more powerful compressor would be needed to accomplish this task.

The unevenness of the rocks' gas saturation horizontally conditioned by their varied RP conforms to the uneven gas saturation vertically on the horizon VII detected on consideration of the mud logging findings. The averaging of the mud logging curves shown in the Figure 6 indicates that the well 473 column situated within the area having the relatively favourable RP stands out for a higher content of hydrocarbon (HC) gases in comparison with the well 474 that is situated within the area with the relatively low rock RP.

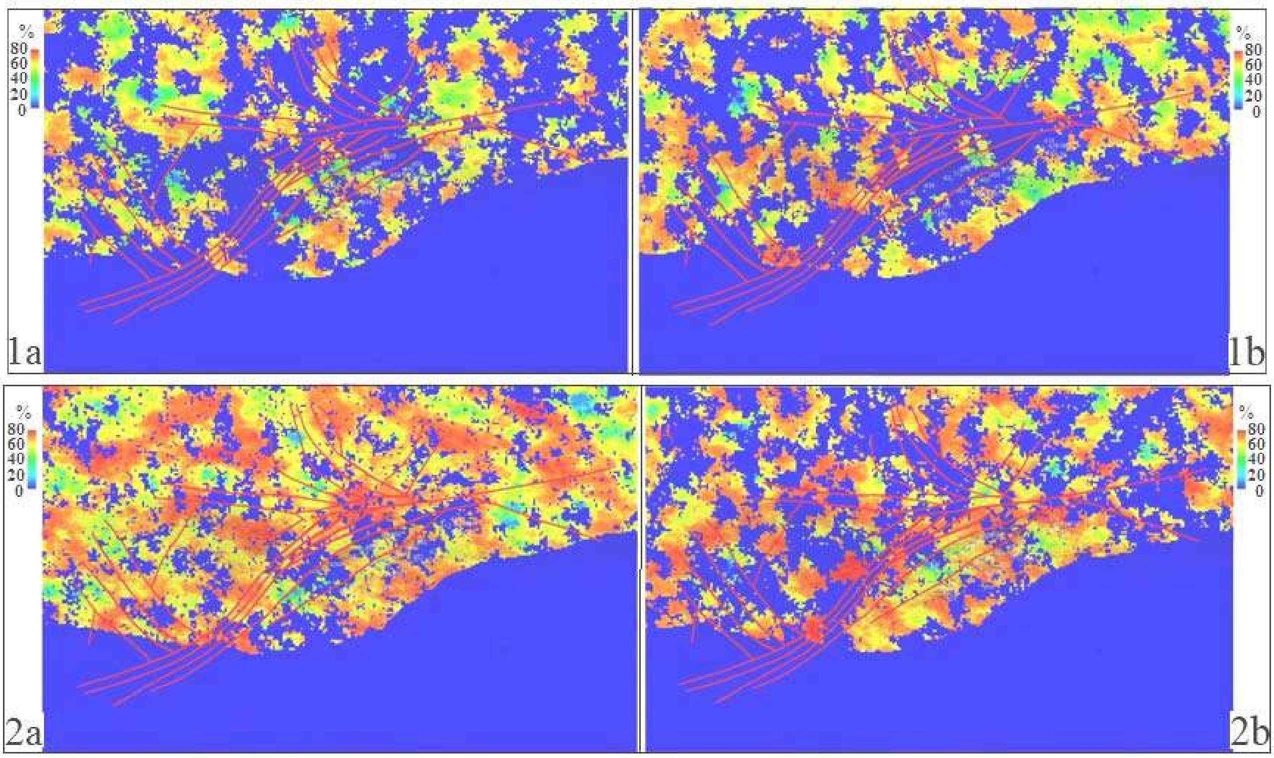

Figure 5. The Horizontal and Section-Wise Gas Saturation (%) Alterations of the Horizon VII rock matter (the upper part – a_1 and the lower one – a_2) and of the Horizon VIIa (the upper part - b_1 and the lower one – b_2) of the PS in the Garadagh Field/UGS (the colour blue denotes the watercut portion of the deposit)

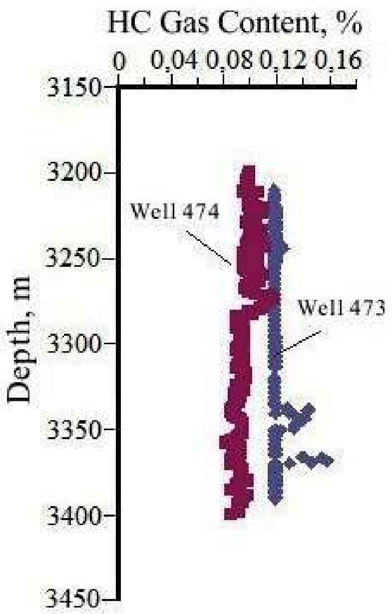

Figure 6. The Vertical HC Gas Content on the Horizon VII as indicated by mud logging data in the Well 473 (in a favourable RP area) and the Well 474 (in a relatively lower RP area)

The specificities of the spatial rock RP changes predetermine the mode of operation of the UGS Garadagh that manifests itself in such parameters as gas injection and outtake. The analyses we have carried out shows that both injection and outtake were lower in the wells located in the low-RP area than in the wells located in the higher RP area during 2010–2012 (Table 2).

Table 2

Gas Injection and Outtake at the UGS Garadagh during 2010–2012 (depending on the RP variations)

Areas/Wells	Gas Injected and Out-taken, m^3 thousands			
	Season 2010–2011		Season 2011–2012	
	Injection	Outtake	Injection	Outtake
The low RP:				
Well 453	28,698	26,703	33,768	34,632
Well 458	23,666	29,301	30,724	35,129
Well 467	12,783	24,982	29,199	34,460
Well 470	7,766	9,915	11,412	10,584
Well 471	13,212	10,146	27,136	26,852
THE AVERAGE	17,225	20,209	26,448	28,331
The high RP:				
Well 450	59,567	48,508	59,035	60,876
Well 456	25,725	33,621	45,512	56,604
Well 459	47,483	45,703	55,544	49,788
Well 464	57,196	41,043	58,066	54,157
Well 465	54,066	44,157	60,528	52,264
THE AVERAGE	**48,807**	**42,606**	**55,737**	**54,738**

Conclusion

The modelling of spatial RP and gas saturation variations in the productive series (the PS horizons VII–VIIa) in the Garadagh Field/UGS using the software application ROXAR (Irap RMS) has once again confirmed its efficiency.

We discovered the spatial non-uniformity of the petrophysical properties of the horizons VII–VIIa, which manifests itself through the mosaic spatial RP and gas-saturation variations.

The uneven nature of the horizontal RP variations, the emergence of isolated zones within the reservoir and the unpredictable motion directions of the fluids are the main causes of the declining operational effectiveness of the facility. Namely, we have found that the rock RP influenced the gas injection and outtake in the UGS Garadagh. At the same time, the PS' fluid saturation model clearly shows the gas-water contact and bears an indication to the advancement of water intrusion into the productive series with a tend towards its fragmentation into isolated gas pillar. Those facts should be taken into account in the course of the continued operation of the UGS.

The research provides for a conclusion about the expediency of using the software ROXAR (Irap RMS) to monitor water movement dynamics within the reservoir.

Considering that creation of underground gas storage facilities in aquifer reservoirs is a successful practice around the world, it is recommended that expanding the area of the UGS Garadagh into the watercut portion of the reservoir should be considered in earnest.

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QAZIN YERALTI SAXLANILMASI İLƏ ƏLAQƏDAR OLARAQ QARADAĞ (AZƏRBAYCAN) YATAĞININ MƏHSULDAR HORİZONTUNUN PETROFİZİKİ XASSƏLƏRİNİN MƏKAN QEYRİBİRCİNSLİYİ

A.A. Feyzullayev, A.Q. Qocayev, N.B. Xalıqov

Məqalədə "Roxar" (İrap RMC) paket proqramından istifadə olunaraq qaz-kondensat Qaradağ yatağının (Azərbaycan) məhsuldar layının qazadoymuşluğu və süzülmə-həcm xassələrinin (məhsuldar layın VII−VIIa horizontu-alt Pliosen) dəyişmə modelləri tərtib olunmuşdur. Hal-hazırda yeraltı qaz ambarı kimi istifadə olunur. Tədqiqatın hədəfi məhsuldar layın məkan qeyribircinsliliyini göstərməkdir. Həm rezervuarın qaza və suyadoymuşluğunu, həm də qazın yeraltı saxlanılmasının istismar rejiminə nəzarət edən süxurların süzülmə-həcm xassələrinin dəyişməsinin mozaik xarakteri müəyyən olunmuşdur. Layın flüidə doymuşluğu modeli üzərində qaz-su əlaqəsi aydın seçilir və məhsuldar zonaya suyun yeridilməsi prosesi ilə onun ayrıca qaz sütunlarına parçalanmasının inkişafı göstərilir. Gələcəkdə Qaradağ qazın yeraltı saxlanılmasının istismarının effektivliyini artırmaq üçün monitorinqin keçirilməsi və aşkara çıxarılan amillərin hesaba alınması tövsiyə olunur.

ПРОСТРАНСТВЕННАЯ НЕОДНОРОДНОСТЬ ПЕТРОФИЗИЧЕСКИХ СВОЙСТВ ПРОДУКТИВНОГО ГОРИЗОНТА МЕСТОРОЖДЕНИЯ ГАРАДАГ (АЗЕРБАЙДЖАН) В СВЯЗИ С ПОДЗЕМНЫМ ХРАНЕНИЕМ ГАЗА

А.А. Фейзуллаев, А.Г. Годжаев, Н.Б. Халыгов

В статье с использованием программного пакета «ROXAR» ((Irap RMS) составлены модели изменения фильтрационно-емкостных свойств (ФЕС) и газонасыщенности продуктивного пласта (VII−VIIa горизонты Продуктивной толщи – нижний Плиоцен) газоконденсатного месторождения Гарадаг (Азербайджан), в настоящее время используемого для подземного хранения газа (ПХГ). Цель исследований – выявление пространственной неоднородности продуктивного пласта. Установлен мозаичный характер изменения в пространстве ФЕС пород, контролирующий газо- и водонасыщенность резервуара, а также режим эксплуатации ПХГ (неравномерные в пространстве объемы закачки и отбора газа из скважин). На модели флюидонасыщенности пласта уверенно выделен газоводяной контакт и показано развитие процесса внедрения воды в продуктивную зону с тенденцией раздробления ее на изолированные целики газа. С целью повышения эффективности дальнейшей эксплуатации ПХГ Гарадаг рекомендуется проведение мониторинга и учет выявленных факторов.

WORLD OCEAN FLOOR GEOMORPHOLOGY IN THE GENERAL GEOMORPHOLOGICAL MAP OF THE WORLD

The mapping problems of underwater relief are considered. As an example, it is represented the Geomorphological map of the World Ocean floor, compiled and released in 1988 on Geographical Faculty of the Lomonosov Moscow State University, Russia. It is proved the importance of morphostructural approach to the classification of the seafloor relief, because underwater conditions are better preserved features of its primary tectonic origin. By types of the Earth's crust and the relief peculiarities it has been allocated 4 major (planetary) morphostructures: submarine continental margin, ocean floor, and transitional zone from the continent to the ocean floor, mid-oceanic ridges. Each of these the largest morphostructures can be consistently subdivided on morphostructures of lower-order – 1st, 2nd, etc. ranks. All of these morphostructures make up the core content of the legend to the map. The area ratio of the largest morphostructures is represented. The map shows also the 22 varieties of individual forms of underwater topography, including elements of exogenous origin. Geomorphological (morphostructural) map of the World Ocean floor, compiled in association with Geomorphological map of continents, gives an idea of the general regularities of the Earth' relief structure, as a whole.

Keywords: seafloor landform classification, planetary morphostructures.

S.A. Lukyanova

Department of geography of Lomonosov Moscow State University, Moscow, Russia
Тел. +7 (8-495) 939-22-32
E-mail: geomorpho2006@yandex.ru

V.I. Myslivets

Department of geography of Lomonosov Moscow State University, Moscow, Russia
Тел. +7 (8-495) 939-22-32
E-mail: myslivets@yandex.ru

G.D. Solovieva

Department of geography of Lomonosov Moscow State University, Moscow, Russia
Тел. +7 (8-495) 939-22-32
E-mail: g.d.solovieva@yandex.ru

Introduction

At present the ocean floor covers more than two thirds of the solid Earth surface. That is why no global problem of geology and geomorphology can be seriously considered without having a clear view of the sea floor relief.

However, our information on the subject hardly may be considered as comprehensive. As had been stated by one of participants of the 8th International Conference (AIG) on Geomorphology (August, 2013), “we probably know more about the surface of the Moon or Mars than we do about the ocean floor” (Brunsden, 2013). With due regard to that statement, it seems to be useful to return to particular works performed on the seafloor geomorphology and mapping.

During the 20th century three main approaches were developed in the seafloor relief presentation in general maps. The first and the most common way is the isobath technique used to create bathymetric charts. The most reliable of the latter is the General Bathymetric Chart of Oceans (GEBCO) showing the bathymetry of the world's ocean floor; it has been regularly updated and is now maintained in digital form (Agapova, 2004). The second technique in the seafloor relief mapping was applied to development of physiographic maps of oceans. The earliest of them were compiled by Heezen B.C. and Tharp M. in 1961–1964 and became highly popular. The physiographic map of the Pacific Ocean was compiled by N.A.Marova (Institute of Oceanology, the USSR Academy of Sciences) in 1979.

The technique used in the map development allowed measuring the seafloor roughness. In the course of time physiographic maps have been replaced by the digital elevation models based on digital dataset of bathymetry. The third line is aimed at compiling proper geomorphological maps displaying the seafloor relief morphology, genesis, age and dynamics.

Each group of the maps has both its advantages and disadvantages. Bathymetric charts give an accurate representation of the landform morphology (and occasionally of its origin and relative age), though they a certain training is required to use them properly. Physiographic maps are the most demonstrative and were in wide use, especially among younger specialists who only recently began investigating the seafloor problems. Geomorphological maps, though less easy-to-interpret than physiographic images and digital models, still provide reliable (considering the state of knowledge at the moment) information on the seafloor landforms. The legends of such maps are usually developed on the basis of a thoroughly worked out landform classification and provide a reasonably good idea of the hierarchy of geomorphological objects.

Unlike many countries where specialists concentrated their efforts on development and improvement of bathymetric charts of oceans, in Russia the emphasis was placed directly on the study of the seafloor geomorphology and mapping. Those investigations became particularly extensive in the1960s–1980s, when a series of geomorphological maps and books were published (Ilyin, 1976; Udintsev, 1972; Leontyev, 1965, 1968; Atlas of Oceans, 1974, 1977, 1980; Kanaev, 1979; Structural-geomorphological map…, 1981; Leontyev et al., 1980). Most of the maps prepared in this period dealt with relief of individual oceans or their large parts. There were developed, however, some general small-scale geomorphological maps (1:40 000 000–1:60 000 000) covering the entire World Ocean. They were issued as separate publications or formed parts of atlases (Bashenina et al., 1967).

One of the most detailed maps was the Geomorphological map of the World Ocean floor, scale 1:15 000 000, compiled and edited at the Geographical Faculty, Moscow State University, in 1988. The present paper discusses distinctive features of the map and the principles taken as a basis for the map compilation.

Geomorphological map of the World Ocean floor

A series of maps intended for the high school was prepared and published by the team of the Geographical Faculty of the Moscow State University in the 1980s. Among them was the Geomorphological Map of the World at the scale of 1: 15 000 000. An essential part of the map content was the characteristic of the seafloor relief. The marine constituent of this cartographic work is actually a separate geomorphological map showing the World Ocean floor and summarizing materials on the seafloor relief available at that time.

In their work on the map the authors sought to make it really documental and based on the factual material, not on imaginary features inferred from some geotectonic concept.

Various bathymetric charts issued mostly in the 1970s served as the base all the specific information was plotted on. Among them, there were general bathymetric maps of the World Ocean (1: 40 000 000), the Pacific (1:25 000 000), Indian (1:15 000 000), and Atlantic (1:20 000 000) oceans published in the USSR; maps of the Pacific Ocean, scale 1:6 000 000, published in the USA under the editorship of T.E.Chase and Y.Mammerickx; bathymetric map of the Arctic regions, scale 1:5 000 000 (Heezen, Tharp, 1975); Russian atlases of the World Ocean (1969–1975); a series of general maps of the northern Atlantic, Arctic Ocean shelf and many others prepared in marine research institutes in Russia, etc.

Besides the bathymetric data, various geological-geophysical and geomorphological materials were used; they were taken both from

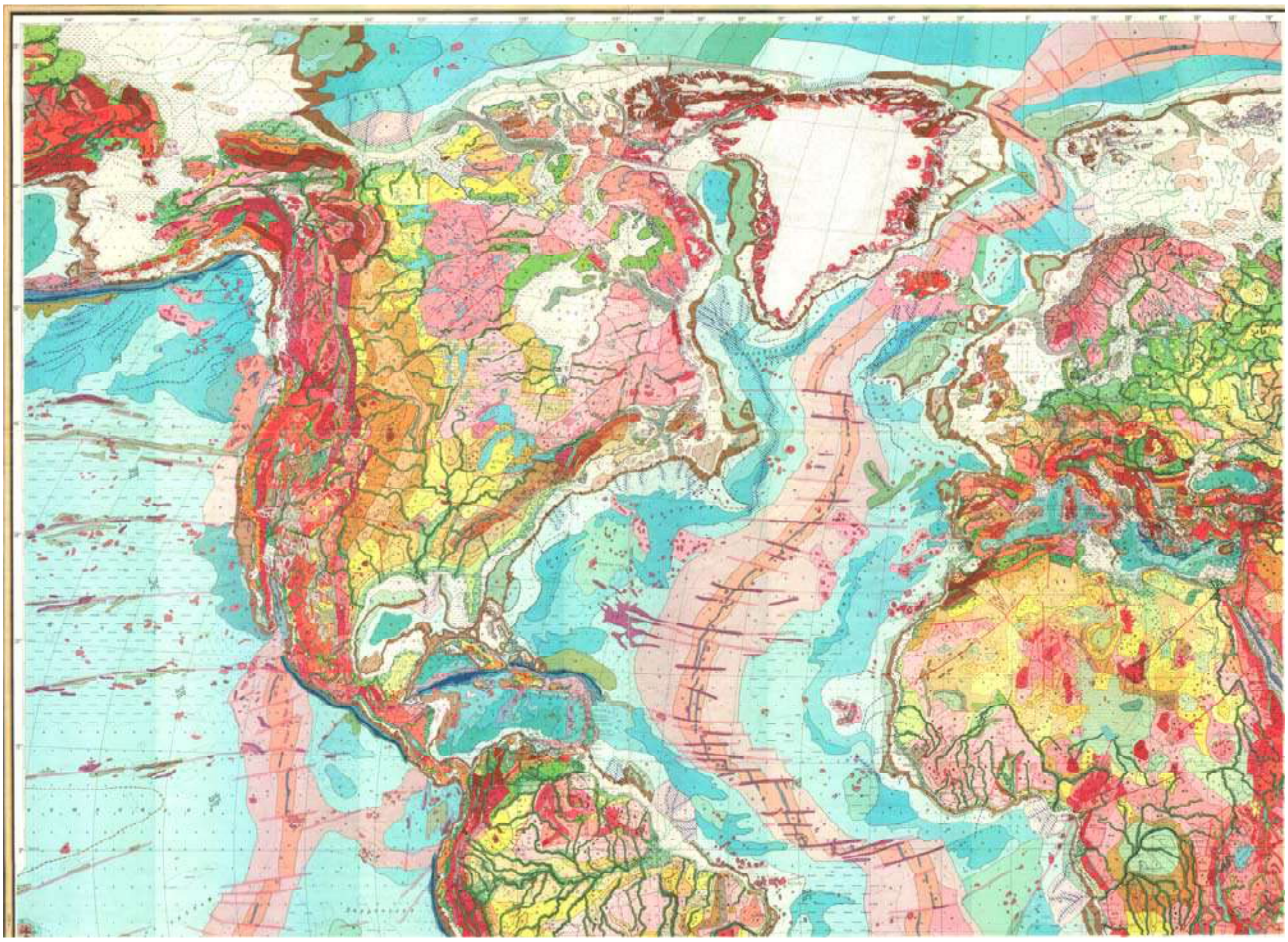

Figure 1. General view of sheet 1 of the Geomorphological map of the World. The whole map consists of 4 such sheets

cartographic sources and from numerous monographs dealing with marine geology. The list of sources, by no means complete, includes "Geological map of the Pacific mobile belt and the Pacific Ocean" (ed. L.I.Krasny, 1970); results of Soviet expeditions to Arctic and Antarctic regions, and to Indian, Atlantic and Pacific oceans (Leontyev, 1975; Matishov, 1977; Zhivago et al., 1975; Zhivago, 1977; Volokitina, 1977; Lastochkin, 1978). Some geomorphological and geological-geophysical information was taken from general works, such as "The Sea" (Hill (Ed.), 1963); "Geomorphology and tectonics of the Pacific Ocean floor" by G.B.Udintsev (1972); "Investigations into the problem of the World Ocean rift zones" (1974–1976), "The geology of continental margins" (Burk, Drake, (Eds), 1974), Emery, Uchupy (1984). Considerable attention was given to results of the deep sea drilling performed from the research vessel "Glomar Challenger" as a part of international scientific ocean drilling program; the drilling provided valuable and extensive scientific information on the ocean floor.

The Geomorphological map of the World Ocean floor based on the above-cited and many other materials provides guidance on the diversified seafloor relief and on the relationship between its main elements.

Classification of the seafloor landforms

The theoretical basis of the map consists in the idea of the endogenous nature of the largest topographic elements on the World Ocean floor (morphostructures). The largest features of the

Figure 2. Small fragment of the Geomorphological map of the World
Main elements of legend: 50 – depositional-denudational plains of shelf; **53** – elevations on shelf; **55** – depositional inclined plains of continental slope; **56** – depositional-denudational marginal plateaus of continental slope; **57** – rugged relief on the continental slope; **58** – scarps on the continental slope; **59** – depositional inclined plains of the continental rise; **63** – hills and low mountain relief on the continental rise; **69** – depositional-denudational plains at the bottom of the rift valleys; **$70_{1,2,3}$** – depositional plains in the oceanic basins: **1)** flat, **2)** undulating, **3)** hilly; **72** – depositional plains of the bottom of oceanic troughs; **78** – mountain relief in the axial zones of mid-oceanic ridges; **79** – mountain relief on the flanks of mid-oceanic ridges; **83** – block ridges on the ocean floor; **85** – underwater volcanic seamounts and undersea slopes of the volcanic islands

seafloor relief are distinguished for well-preserved traces of their primary tectonic origin – the fact attributable to much slower process of erosion and deposition over the greater part of the ocean floor as compared with continents; thus tectonic landforms and their assemblages are better represented on the seafloor than on the land. It may be stated that the undersea topography is structurally controlled in its main features. Accordingly, the classification of seafloor landforms that served as a basis for the map legend is itself based on the morphostructural principle, that is to say the endogenous factor is assumed to be leading in the origin of larger landforms on the seafloor.

The morphostructural approach applied to the analysis and mapping of the World Ocean floor relief was based on the classification of large and very large morphostructural elements suggested by O.K.Leontyev (1971). The classification is primarily based on the earth's crust types identified in the oceanic part of the Earth’s lithosphere. As has been established by fundamental geological and geophysical investigations, four types of the earth's crust may be distinguished within the limits of oceans, namely: continental, oceanic, geosynclinal, and riftogenic. According to the classification by Leontyev, the listed earth's crust types control development of the so called planetary morphostructures (Leontyev, 1971), or geotectures (Gerasimov, 1967). Planetary morphostructures are the largest landforms which correspond more or less directly to the most important features of the earth's crust geological structure. They are distinct for global (planetary) occurrence and geotectonic peculiarity and constitute the taxonomically highest rank of morphostructures. There are four morphostructures of that rank identified within the limits of oceans; those are: continental margin (a part of continental planetary morphostructure), transitional zone, ocean floor, and mid-oceanic ridges.

The validity of the earth's surface division into the above mentioned types of planetary morphostructures is proved by the facts that: 1) their number cannot be reduced without prejudice to scientific logic and factual data, and 2) there is no part of the earth's surface that would not belong to one or another of the above listed morphostructures.

The continental margin is the part of continent lying below ocean level and flooded with its water. The earth's crust within its limits is essentially of continental type. In the opinion of V.E.Khain (1989), however, it is "thinned and transformed continental crust" with some specific characteristics. In its thickness (about 15–20 km) and in velocity of longitudinal seismic waves (~6.5–7.0 km/s) it is intermediate between continental and oceanic types of the earth's crust. It was those intermediate characteristics that gave grounds to Khain to place the continental margins (so called passive margins) into the same taxonomic series as continents and oceans. It should be noted that the term "passive margin" is relative and used only by convention; actually, stresses would be necessarily generated at the interface of two types of the earth's crust (continental and oceanic) different in thickness and structure. The stresses in the earth crust result primarily in seismic activity. By way of illustration we refer to well known earthquakes of Lisbon (1755), Newfoundland (1929) and later those in Guinea and Brazil, as well as a series of weaker quakes at the periphery of Scandinavia, Africa, and NW Australia. There are also volcanic manifestations related to continental margins (Canary Islands, Cape Verde Islands, Plio-Pleistocene volcanoes on the continental rise off the South America coasts). Tectonic movements of considerable range account for development of steep scarps on the shelf and continental slope, as well as for downwarping in sedimentary basins on the periphery of continents. Morphologically, the submerged continental margin is a specific formation, known also as "continental terrace". It consists of shelf (surface of the terrace) and continental slope with continental rise at its base, the two latter elements forming the scarp of continental terrace.

The ocean floor differs from the continental margin in greater depth and also in that it is underlain with the earth's crust of oceanic type different from the continental one in its composition, structure and age, as well as in thickness and other specific characteristics (Khain, 1989). A distinctive feature of the ocean floor is its differentiation into basins and rises (ridges and other elevations that occur both within basins and between them); those elements not only differ in morphology, but reveal also somewhat specific characteristics of the earth's crust (increased thickness and an appearance of a denser layer at the crust base under ridges and elevations).

The continental margin occurs immediately adjacent to the ocean floor over a considerable length of the coasts of the Atlantic and Indian oceans. However, it is not always the case. In some regions, such as the western margin of the Pacific, the Caribbean Sea, Mediterranean, at the NE periphery of the Indian Ocean, and in the Scotia Sea, there are so-called transitional areas. Taken together those areas (considered to be modern geosynclines by some specialists) form the third planetary morphostructure, namely the transitional zone. The earth's crust in the transitional zone is of geosynclinal type, with blocks of oceanic (suboceanic) crust alternating with those of continental (subcontinental) crust. The inner structure of the zones is rather intricate, which is reflected in their topography. The latter is extremely contrasting, the deepest on Earth trenches and troughs neighboring on high ridges that rise up to a few thousands of meters above the adjacent sea floor. The distinctive features of this planetary morphostructure may be stated as follows: mosaicity of the earth's crust; high intensity of tectonic processes; and highly contrasting relief incomparable with other areas of the earth surface.

The listed characteristics cast some doubt on the validity of the commonly used term "active margin of continent" (as opposed to the "passive margins") when applied to the transitional zones. It seems particularly wrong and even giving false ideas of the real earth's crust properties and seafloor morphostructures when dealing with the youngest transitional zones, like that of the Philippine Sea with its deep-sea trenches and island arcs, such as Volcano, Izu-Bonin, the Marianas, Yap and Palau. Such areas cannot be assigned to continental margins because of a clearly pronounced oceanic or suboceanic type of the earth's crust within their limits.

Mid-oceanic ridges are recognized as the fourth planetary morphostructure. Those are zones of active present-day rifting with a specific type of the earth's crust (riftogenic or ultraoceanic, according to G.B.Udinstev (1972)). So the mid-oceanic ridges are considered not as a part of ocean floor, but as specific new formations resulting from the mantle diapirism and rifting processes. When exposed to those processes, the ocean floor and oceanic crust undergo essential alterations. Mid-oceanic ridges form a single global system of mountain ranges extending over all the oceans and having no analogue on continents.

Unlike continental platforms and ocean floor noted for relative tectonic stability, the transitional zones and mid-oceanic ridges feature high seismicity, active volcanism, and high level of tectonic activity at present. It should be noted, however, that each of the planetary morphostructures displays specific characteristics in its seismicity, volcanism, and tectonic processes; those distinctions account for diversification of the largest morphostructural elements.

The above-named four planetary morphostructures form the principal units the World Ocean floor is divided into. There are also structural elements of lower rank recognized within the planetary morphostructures – those of the 1st and 2nd orders. They are classified by such morphostructural characteristics as finer distinctions in the earth's crust structure and tectonic movement intensity, and by specific features of their manifestation in the seafloor relief. By way of example, we refer to the submerged continental margin: there are three 1st order morphostructures – shelf, continental slope and continental rise – distinguished within its limits. The shelf, however, is not a self-consistent morphostructure, as it actually belongs to the continental platform and therefore is an integral part of the adjacent continent that "happened" to be partly submerged.

Morphostructures of the 1st order in transitional zones are basins of marginal and inland seas, island arcs or isolated continental massifs and deep trenches; on the ocean floor those are deep-sea basins and oceanic rises, and on the mid-oceanic ridges there are their rift and flank zones distinguished.

Morphostructures of lower (2nd) order on the shelf are platform plains, depressions and elevations; on the continental slope – sloping plains, scarps and plateaus; on the continental rise – plains, depressions and elevations. In the transitional zone, within the marginal and inland sea basins there are depressions, elevations and ridges, and the ocean floor also features basins and elevations of various size and outlines.

Such a classification of high order morphostructures form the basis of the conventional signs used when compiling the Geomorphological (morphostructural) map of the World Ocean floor.

Legend of the Geomorphological map of the World Ocean floor

The legend of the Geomorphological map of the World Ocean floor is entirely based on the morphostructural principle applied to the undersea relief characteristics. The morphostructures of higher order (planetary and those of the 1st order) form the main content of the legend. The morphostructure mapping offers a clearer view of their areas and relative importance.

Roughly calculated areas of the mapped morphostructures of the highest order are given in Table 1 (Leontyev et al., 1976).

As seen in the table, 23% of the ocean floor area (or 16% of the total area of the earth's surface) are underlain with the crust of continental type. Taking into account the fact, that the continents are mostly underlain with the continental crust and, besides, it forms some elements of the transitional zone relief, the proportion of continental crust area increases to 40% of the earth's surface. Assuming the oceans to be primary and the continents – secondary formations, it may be understood that the process of the more primitive oceanic crust conversion into continental one has advanced considerably, and the Earth becomes more and more "continental" in its structure.

Another trend in the oceanic crust reprocessing is its conversion to the riftogenic type in the process of mid-oceanic ridge development. In the course of that process the continental crust may be destroyed and replaced by the crust of riftogenic type, with associated landforms also coming into being. Dramatic examples of such a development are the Red Sea, Gulf of Aden and Gulf of California.

It should be noted that boundaries of the high order morphostructures not always coincide with outlines of the corresponding types of the earth's crust; that fact was duly taken into consideration in the mapping of the morphostructures. Such a discrepancy may result from various factors, and first of all – sedimentation processes which exert a conspicuous effect on relief formation on the ocean floor (Leontyev et al., 1983). To take one example, the outer margin of the continental terrace is known to be sometimes depositional in structure and to present a thick prism of sediments. The prism either builds over the "structural base" of the continental terrace and buries consolidated basement composed of the continental crust, or forms an accretionary wedge on the seaward side of the shelf. In the latter case the continental rise composed entirely of loose or poorly consolidated deposits is underlain with the crust of oceanic, and not of continental, type; in that case the boundary of the continental margin is drawn based on morphological characteristics.

Table 1

Relative areas of the principal topographic elements of the World Ocean floor in % (Leontyev at al., 1976)

Oceans	Submarine continental margin			Transitional zones				Ocean floor			Mid-oceanic ridges
	shelf	continental slope	continental rise	island arcs	inner rises	inland sea basins	deep-sea trenches	oceanic basins and troughs	oceanic rises	marginal rises	
Arctic	50.3	18.4	5.9	–	–	–	–	15.4	7.0	–	3.0
Indian	5.7	11.3	12.3	1.1	–	0.6	0.6	46.4	4.7	0.5	16.8
Atlantic	10.3	8.5	11.8	1.4	0.6	2.7	0.5	32.5	2.8	2.3	24.6
Pacific	5.5	3.0	1.7	2.2	2.6	6.5	2.2	51.1	12.0	2.2	11.0
World	**8.6**	**6.8**	**7.2**	**1.7**	**1.4**	**4.0**	**1.3**	**43.9**	**8.0**	**1.8**	**15.3**

A particularly great difference between the boundaries of geomorphological and tectonic structures is observed in places where the continental rise is overlain with vast fans of turbidity currents like those in the Bay of Bengal, or gigantic constructional landforms like the Blake-Bahama or Newfoundland "sedimentary ridges"; the ridges are composed of sediments brought by bottom abyssal currents. Morphologically the formations belong to the continental rise, though they are underlain mostly with typical oceanic earth's crust.

When depicting morphostructures of the 2nd and lower order, specific features of montane and low (flat) topography of the seafloor were necessarily taken into account, according to the legend. Thus, the shelf has mostly a flat depositional, partly erosional, surface. Sloping depositional plains are widely spread over the continental slope and more so – at the continental rise. The montane topography is represented by low mountain areas densely dissected by submarine canyons and scarps due to fault tectonics. Rugged relief of the mid-oceanic ridges is dominant in the rift zones of oceans.

For the purpose of more complete and many-sided characteristic of the seafloor relief (in accordance with the general structure of the legend), a special section of the legend contains symbols for designating individual landforms and form assemblages on the seafloor which enrich considerably the map contents. There are smaller structural landforms grouped in the section; those are submarine mounts, mostly of volcanic or block tectonic origin; some of them bear coral constructions (atolls, coral banks) or display traces of marine erosion, or even of subaerial denudation (guyots, table mounts). Relatively small elevations due to mud volcanism or salt tectonics are also shown. Another group includes compensatory depressions at the base of seamounts and some ridges; rift valleys; oceanic troughs; and submarine canyons. Besides, an assemblage of structural landforms is also recognized; their relative position allows tracing the zones of planetary oceanic (so called transform) faults.

Hilly relief widely distributed within the abyssal areas (relief of abyssal hills) is also indicated in legend and shown in the map. Along with the sites of the abyssal hills, there are distinguished different stages of their burial under bottom sediments (shown as flat and wavy abyssal plains).

Numerous small and large (sometimes gigantic) exogenic landforms have been also mapped. That group includes submerged river valleys; relict glacial landforms; tidal flats and ridges related to tidal currents; channels of turbidity currents; submarine landslides and by far greater fans of turbidity currents; and depositional landforms related to the abyssal bottom currents.

The suggested legend (Table 2) is easily understood and represents adequately specific features of the submarine relief depicted in the Geomorphological map.

Conclusion

The geomorphological (morphostructural) map clearly illustrates the complexity and diversity of the seafloor relief. Many elements of this relief have no analogues on continents, among them the greatest mountain system of mid-oceanic ridges and the deepest oceanic trenches.

The map compiled using the described legend proves a usability of the morphostructural approach when mapping the ocean floor. Large elements of the submarine relief are shown in the map in their relation with endogenic factors; that is particularly important for the ocean floor where the relief visually preserves distinct features of its primary tectonic origin. The advisability of such an approach is also confirmed by a number of other maps having been compiled in much the same technique. Among them are Structural-geomorphological map of the Pacific Ocean floor, 1:15 000 000 (1981), ed. by O.K.Leontyev, under the sponsorship of the USSR Ministry of Geology; unpublished Structural-geomorphological map of the World Ocean floor, 1:10 000 000, 1987, based on the

Bathymetric Chart of Oceans (GEBCO) and compiled under the direction of O.K.Leontyev; and others.

One of the latest maps in this series is the Morphostructural map of the World Ocean floor, 1:60 000 000 (Geomorphological…, 1998). It was developed in the Laboratory of Marine Geomorphology, Faculty of Geography, Moscow State University, as a part of a general map of the Earth's Morphostructure. The map clearly demonstrates morphostructural features of the ocean floor. The small scale of the map required an appropriate generalization of all the materials available, with the result that only large morphostructural elements were shown in the map. The map, however, still gives an adequate picture of extremely complex submarine relief.

Table 2

Morphostructures of the World Ocean floor (legend of the map)

MORPHOSTRUCTURES OF THE WORLD OCEAN FLOOR	
Submarine continental margin	
Shelf	Depositional-denudational plains
	Depositional plains in shelf depression and on the submerged shelf
	Plains at the bottom of deep depressions on shelf
	Rugged relief on slopes of deep shelf depressions
	Elevations on shelf
Continental slope	Depositional-denudational plains of marginal plateaus
	Depositional inclined undulating plain
	Rugged (low-mountain) relief on the continental slope
	Scarps on the continental slope
Continental rise	Depositional inclined undulating plains
	Depositional plains at basin bottoms on the continental rise
	Elevations and ridges
	Hills and low mountain relief
Transitional zone from the ocean floor to continents	
Basins of marginal and inland seas	Depositional plains at the bottom of basins: a) flat, b) undulating, c) hilly, and d) with hills and low ridges
	Depositional plains at the bottom of depressions
	Elevations (rises and plateaus) on the bottom of basins
	Fold-block and block ridges
Island arcs	Depositional plains at the bottom of mid-arc trenches (in double island arcs)
	Erosional-depositional plains of island shelves
	Mountain relief on the undersea slopes of mature island arcs
	Young island arcs (rises and undersea slopes)
Deep-sea trenches	Depositional plains at the bottom of deep-sea trenches
	Sloping plains of marginal steps
Rift zones of the oceans (mid-oceanic ridges)	
	Mountain relief in the axial zones of mid-oceanic ridges
	Mountain relief on the flanks of mid-oceanic ridges
	Low mountains and poorly differentiated relief in axial and flank zones

Ocean floor	
	Abyssal plains in oceanic basins: a)flat, b) undulating, c) hilly
	Arched ridges
	Block ridges
	Rises
INDIVIDUAL LANDFORMS AND LANDFORM ASSEMBLAGES ON THE SEA FLOOR: **1** – submerged river valleys; **2** – assemblage of submerged relict glacial landforms; **3** – tidal flats (watten); **4** – assemblage of tidal ridges; **5** – submerged wave-built depositional landforms; **6** – erosional-denudational remnants (stacks, submarine rocks); **7** – coral structures; **8** – channels of turbidity currents and abyssal valleys; **9** – fans of turbidity currents; **10** – submarine landslide assemblages; **11** – depositional forms related to bottom abyssal currents; **12** – submarine canyons; **13** – submarine mud volcanoes; **14** – submarine rises and hills related to salt tectonics; **15** – volcanic seamounts and undersea slopes of volcanic islands; **16** – underwater volcanic seamounts with flat tops (guyots); **17** – coral banks (submarine volcanic seamounts with submerged coral structures); **18** – tectonic landform assemblages related to major oceanic fracture zones; **19** – oceanic troughs; **20** – compensational depressions; **21** – rift valleys of mid-oceanic ridges; **22** – borderlands	

The Geomorphological (morphostructural) map of the World Ocean floor discussed in this paper is a part of the general Geomorphological map of the World giving a general idea of the Earth's relief as a whole. When presented at scientific conferences, the map invariably attracted interest of specialists. A copy of it has been exposed in the Madrid University, Spain, for a long time. During almost 25 years passed since it was published a good deal of new data on the undersea topography were obtained, additions and specifications were introduced into geomorphological maps of many regions. Such a map compilation, however, is an experience that has never been repeated, and it is still a unique cartographic document.

Of the new data on the relief of the World Ocean floor the following are worthy of notice. First, tectonically fractured block terrains of the borderland type appear to be widespread in the near-polar regions (Naryshkin, 2010). Second, the exogenic – morphosculptural – landforms appear to be more common on the ocean floor than it was earlier thought (Matishov, 1984; Ananyev et al. (eds), 1999). Third, living organisms are proved to be of great importance in the evolution of the ocean floor; that discovery played a noticeable part in the development of the "living ocean" concept (Vereshchaka (ed.), 2008). Taking all the above into consideration, the map should be stored as an electronic document. That would be instrumental in the map preservation and would enlarge the circle of its users.

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DÜNYANIN ÜMUMİ GEOMORFOLOJİ XƏRİTƏSİNDƏ OKEAN DİBİNİN GEOMORFOLOGİYASI

S.A. Lukyanova, V.İ. Mıslives, Q.D. Solovyeva

Sualtı relyefin xəritələşməsi problemlərinə baxılmışdır. Nümunə kimi Rusiyada M.V.Lomonosov adına Moskva Universitetinin coğrafiya fakültəsində 1988-ci ildə tərtib olunan və çap edilən Dünya okeanının dibinin Geomorfoloji xəritəsi təqdim olunmuşdur. Dəniz dibinin relyefinin təsnifatında morfostruktur yanaşmanın böyük rol oynadığı sübut edilir. Çünki sualtı şəraitdə onun ilkin tektonik mənşəinin əlamətləri yaxşı qorunub saxlanılır. Yer qabığının tipləri və relyefin xüsusiyyətlərinə görə 4 ən böyük (planetar) morfostruktur ayrılmışdır: materiklərin sualtı kənarı, okean yatağı, materikdən okean yatağına keçid zonası, aralıq-okean sıra dağları. Həmin morfostrukturlardan ardıcıl olaraq 1-ci, 2-ci və s. kimi dərəcələrdə morfostrukturlar ayrılır. Bütün bu morfostrukturlar xəritənin şərti işarələrinin əsas məzmununu təşkil edir. Böyük morfostrukturların sahə nisbəti təqdim olunmuşdur. Xəritədə sualtı relyefin, eyni zamanda, ekzogen törəmələrinin ayrı-ayrı formalarının 22 müxtəlif növü göstərilmişdir. Materiklərin geomorfoloji xəritəsi ilə müştərək tərtib olunan Dünya okeanının dibinin Geomorfoloji (morfostruktur) xəritəsi Yer relyefinin quruluşunun ümumi qanunauyğunluqları barədə müəyyən təsəvvür yaradır.

ГЕОМОРФОЛОГИЯ ДНА ОКЕАНА В ОБЩЕЙ ГЕОМОРФОЛОГИЧЕСКОЙ КАРТЕ МИРА

С.А. Лукьянова, В.И. Мысливец, Г.Д. Соловьева

Рассмотрены проблемы картирования подводного рельефа. В качестве примера представлена Геоморфологическая карта дна Мирового океана, составленная и изданная в 1988 г. на географическом факультете Московского университета им. М.В.Ломоносова, Россия. Доказывается важность морфоструктурного подхода к классификации рельефа морского дна, поскольку в подводных условиях лучше сохраняются черты его первично тектонического происхождения. По типам земной коры и особенностям рельефа выделено 4 крупнейших (планетарных) морфоструктуры: подводная окраина материков, ложе океана, переходная зона от материка к ложу океана, срединно-океанические хребты. В каждой из этих крупнейших морфоструктур могут быть последовательно выделены морфоструктуры более низкого порядка – 1-го, 2-го и т.д. рангов. Все эти морфоструктуры составляют основное содержание легенды к карте. Представлены площадные соотношения крупнейших морфоструктур. На карте показаны также 22 разновидности отдельных форм подводного рельефа, в том числе экзогенного происхождения. Геоморфологическая (морфоструктурная) карта дна Мирового океана, составленная совместно с Геоморфологической картой материков, дает представление об общих закономерностях строения рельефа Земли.

THE HISTORY OF THE TIMAN DIAMONDS STUDY

Diamonds have been known to exist in Timan since the beginning of the 20th century. Iona Popov was the first to discover them. But the systematic search for diamonds only began there in the mid-1950s. There are 3 stages in the research into the diamond content of Timan:

The region's diamond content reference was generalised and suggestions were made as to the possible age of its protosources and that the interim collectors dated to the Middle Devonian at the first stage. The first Timan diamonds were discovered in the alluviums of the rivers Mezenskaya Pizhma, Tsilma and Pechorskaya Pizhma.

The kimberlitic chimney deposits were identified and diamonds and their accessory minerals were then discovered in the Devonian sandstones at the second stage. Also, the first small diamonds were found in the modern alluvium and accessory minerals were in the Middle Jurassic basaltic sediments in the South Timan.

The third stage was heralded by the discovery of the connate Devonian diamond placer of Ichetyu in the basin of the River Pechorskaya Pizhma and of diamonds in the modern alluvium in Jejimparma. The Komi Geology Institute of the Research Centre of the RAS' Urals Branch founded a diamond mineralogy laboratory. Thin native metal (Au, Ag, Fe, Ti, Pb, Sn, Bi, etc.) films were found on the diamonds' faces. The first pilot development was undertaken at the Ichetyu placer under V.A.Dudar. The diamond work was completed in 2002.

Keywords: the Middle Timan, diamond, the Devonian sandstones, kimberlites, pyropes, chrome spinellides.

A.M. Plyakin

The Ukhta State Technical University;
Ukhta, Russia
E-mails: aplyakin09@yandex.ru,
zav_miggg@ugtu.net

The Timan Ridge is known for its wealth of raw mineral resources. The first Russian crude oil and the first Soviet radium were discovered there. Those discoveries are connected to the Devonian deposits and so are the local largest bauxite fields, polymineral placers and deposits of many other mineral deposits.

The first accounts of the Timan diamonds ever reached the dowser Iona Popov at the turn of the 20th century, according to N.P.Yushkin (Юшкин, 2001). Popov reported the discoveries of small diamonds in alluvial sediments to the Mining Department and the Russian Minister for Finance in 1904–1906. He wrote, '*...sending you a precious stone that I consider to be a diamond. I ask for prospecting for such precious stones to be organised along the River Pizhma.'* He submitted the claims to the Mining Department (1904) and the Minister for Finance (1906) but no action was initiated on either.

The modern history of the enquiry into Timan's diamond content dates back over almost half a century during which active work was replaced with inactivity until all that work was stopped completely. The following three progressive stages of the diamond prospecting can be singled out in Timan's case:

The first stage began as all the geological materials were generalised by G.V.Matveyeva and A.V.Pozdnyakov in 1954. They produced a perspective evaluation of Timan indicating the modern placers and considering the pre-Palaeozoic rocks to be the primary source of diamonds. They held the coarse-grained Middle Devonian sediments of the rivers Chernaya, Velikaya, Mezenskaya and Pechorskaya Pizhma to be an interim diamond collector.

A.S.Godovan and M.I.Plotnikova found the first diamond in the alluvium of the River

Mezenskaya Pizhma in 1955. They found 6 diamonds more in the basin of the rivers Tsilma and Pechorskaya Pizhma in 1956.

The scientific forecasts by A.A.Chernov (1955, 1960), V.O.Ruzhitskiy (1957–1960), G.V.Matveyeva, A.V.Pozdnyakov and others provided enough ground for starting the diamond prospecting in Timan. A.A.Chernov pointed at the bends '*…of the Pechora Pizhma downstream from the mouth of the Umba'* (Chernov, 1960) as the most promising region with the astonishing accuracy in 1960. It was there that the Ichetyu field with the unique complex of rare-metal/gold/diamond/titanium mineralisation complex was discovered eventually.

The prospecting done by M.A.Apenko, S.A.Godovan, V.I.Gorskiy-Kruchinin, M.I.Osadchuk, M.I.Plotnikova and others resulted in the discovery of 7 fine diamond crystals in the alluviums of the rivers Tsilma, Mezenskaya Pizhma and Pechora Pizhma. At the same time, pyropes were found in the alluviums of the other rivers of Timan and, later on, also in the Devonian sandstones. Those discoveries allowed the researchers to talk about the diamond placer prospects of the Middle Timan.

Kimberlites were considered as the primal source of diamonds from the very beginning. The Middle Devonian basaltic sediments were put down as interim collectors. M.I.Osadchuk described the eruptive breccias of the alkali-ultrabasic composition in the valley of the River Bobrovaya in 1958–1959 and biotitic picrites, eruptive breccias and kimberlites in the basin of the River Kosyu in 1960–1961. Y.P.Ivensen, M.I.Osadchuk and V.G.Cherniy paid a great attention to that rock unit.

The additional study of the veined kimberlites of the Chetlass Kamen in 1965–1967 was carried out by Y.D.Smirnov and N.A.Rumyantseva. Y.D.Smirnov remarked that the diamonds '*are associated with the rocks akin to the described one in all the regions of the world.'* However, the Ministry of Geology stopped the diamond prospecting in Timan for want of positive results.

The first diamond exploration stage in Timan (1954–1967) resulted in the discovery of diamonds and accessory minerals in the modern alluvium and the finding of kimberlites, eruptive breccias and biotitic.

The second stage of the active diamond prospecting in the Middle Timan had to do with the bauxite operations unfolding.

A meeting on the geology, magmatism and metallogeny of Timan was held focusing on the diamond and bauxite prospecting in Ukhta in 1973. Both placer and hardrock diamond contents were discussed in regards to the diamond subject. V.I.Bashilov and the co-authors (Башилов, Каминский, Шевченко, 1973) reported the discovery of pyrope, chrome-diopside, olivine grains and of one diamond in the alluvium in the Obdyr Elevation. M.A.Danilov and V.I.Gorskiy-Kruchinin (1973) made presumptions as to the hardrock origins of the local diamonds in Timan. B.A.Malkov acting in co-authorship with Y.B.Bushuyeva and T.N.Popova (Мальков, Бушуева, Попова, 1973) pointed at kimberlites as the hardrock source of the Timan diamonds while putting the Givetian sediments as interim collectors. M.I.Osadchuk (Осадчук, 1973) and others connected Timan's diamonds to kimberlites, too.

The combination of the geophysical research methods put to use provided for a detailed in-depth study of the territory. G.A.Yerema (1972, 1978) and R.S.Kontarovich (1976–1979) found the isometric local magnetic anomalies pointing at the presence of chimney deposits.

B.S.Shutov and M.Y.Ostryzhniy drilled into one of such anomalies to find the first chimney deposit – the Umba Pipe made of kimberlitic tuff breccias – in 1976. The Srednenskaya and Vodorazdelnaya pipes were discovered there eventually; pyropes, chrome spinellides and chrome-diopsides were found in them. Many geologists associated those rocks to kimberlites while B.A.Malkov characterised them alneits – futureless for diamond prospecting.

V.A.Dudar and L.P.Bakulina found a small diamond shard and pyropes in the modern alluvium of the River Bolshaya Krutaya and they found also pyropes in the Devonian conglomerates, all in 1977–1978.

The geologists of the Middle Timan field party formed in 1978 found four diamonds adding up to 89.2 carats in the modern alluviums of the rivers Umba, Middle Pizhma and Pechorskaya Pizhma. A large-volume sample taken from the Devonian sediments of the Pechorskaya Pizhma in 1984 was found to contain the first diamonds of the placer that was called Ichetyu eventually.

The pilot work done on the placer later on found diamonds, most of them of the troy quality, and gold. The national emblem of the Komi Republic was made of them eventually.

The diamond mother lode search done in that region ended without success.

Picrite porphyrites and kimberlite pipes (with a small diamond shard found in one of the pipes) were discovered under V.C.Cherniy in the Kosyu Site. Five diamonds – one weighing 178 mg – were found in the alluvium of the River Kosyu.

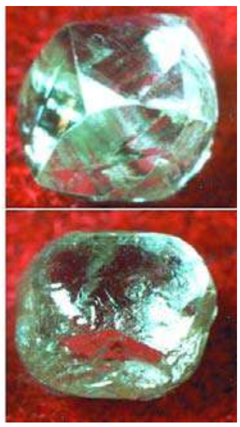
V.A.Dudar led the diamond prospecting done along the Vym Ridge. A.V.Tereshenko found 5 small diamonds in the Devonian basalts in the South Timan in 1986–1991.

A republican conference on the problems of the diamond content of the Timan-North Urals Region was held in Syktyvkar in 1988. A meeting on the diamond content of Russia's European North was convened in 1993. K.M.Alexeyevskiy (Алексеевский, 1993) reported the local pyropes and their association with kimberlites as well as the diamond-bearing rocks of the North Timan which *'…only differ composition-wise from those of Yakutia very slightly'*. The resemblance that the Timan chrome spinellides and pyropes bore to the accessory minerals found in the Palaeozoic kimberlites of the Arkhangelsk Province was also highlighted by V.K.Garanin and his associates [1993]. L.P.Bakulina (Бакулина, Афанасьев, Тополюк, 1993) stated her observations about the manifestation of the pre-Carboniferous kimberlite magmatism in the Obdyr Elevation.

However, all further diamond prospecting was stopped in Timan.

The third stage set in with the diamond prospecting in the Vadyavoda Elevation and the Nemsk Site of the South Timan under V.A.Dudar and V.G.Shametko in 1994 (Плякин, Дудар, 2001). Small diamonds (+1–2 mm, +2–4 mm) were discovered in the modern alluvium and the Riphean rocks of Jejimparma. S.N.Mityakov found the fragments of a new diamond-gold placer dating to the Mesozoic and the Quarternary in the southern provinces of the republic (1998).

V.I.Vaganov and colleagues (Ваганов, Голубев, Прусакова, Егоров, 1994) pointed at the high hardrock diamond prospects of the Middle Timan, which he attributed to the kimberlite-lamproite sources.



Left: the Ichetyu Placer's productive series has been tapped; right: the troy Ichetyu diamonds; centre: the national emblem of the Komi Republic wrought of the Ichetyu gold and diamonds.

A diamond mineral studies laboratory under A.B.Makeyev was founded at the Research Centre of the RAS' Urals Branch at the Komi Geology Institute in 1997. Makeyev supported the idea of A.Y.Rybalchenko et al. (1997) of the tuffizit nature of the Timan diamonds. The Russian national conferences and meetings on the diamond problem of the Timan-Urals Region were held in Syktyvkar during 1998–2001. Among the reporters were B.A.Malkov (Мальков, 1999) and N.A.Malyshev, T.M.Rybalchenko, A.B.Makeyev (Макеев, Дудар, Лютоев, Деревянко, Глухов, Исаенко, Филиппов, 1999), Y.V.Glukhov, A.V.Bovkun and V.K.Garanin. The Volsk-Vym Ridge, the Obdyr Elevation, the Chetlass Rock and the Polyudov Ridge were mentioned as the most promising ones in terms of diamonds in the European North.

The monograph by A.B.Makeyev, V.A.Dudar, V.P.Lutoyev, et al. entitled 'The Diamonds of the Middle Timan' was published in 1999 (Макеев, Дудар, Лютоев, Деревянко, Глухов, Исаенко, Филиппов, 1999). It described the crystalline morphology of diamonds and the accessory minerals. A.B.Makeyev had found thin films of native metals (Au, Ag, Fe, Ti, Pb, Sn, Bi, etc.), several silicates, oxides and alumina-sulphate-phosphates on the facets of the Middle Timan diamonds found in the negative land forms.

The search for hardrock diamond deposits in the Middle Timan began with the exploration of the Vym Ridge's northern part and of the Chetlass Rock using the aerial geophysical methods in 2000. Eighty-three anomalous zones were identified and recommended for drilling operations as a result with 13 of them having been prioritised. But no new and positive results were had.

S.N.Mityakov found the quasi-kimberlite rocks in the Vashkin Suite that he described as the autolith breccia containing diamonds in 2000 (Шумилова, Митяков, 2001).

The problem background and the research findings (N.P.Yushkin, A.M.Pystin, Y.I.Pystina, A.M.Plyakin, V.A.Dudar), the nature and prospects of the diamond content (I.V.Derevyanko, V.I.Vaganov, Y.K.Golubev, A.B.Makeyev, B.A.Makeyev, N.A.Prusakov, B.A.Malkov, L.P.Bakulina, V.A.Dudar, O.P.Telnova, et al.) were looked at during the conference on the gold content of the Timan-Urals Region that was held in 2001. The conditions associative of the formation and occurrence of the diamond deposits of the Middle/South Timan were addressed in the work by E.S.Sherbakov, A.M.Plyakin and P.P.Bitkov. The new reference on the Middle Timan kimberlites was reported by V.A.Pervov, V.A.Kononova and I.P.Ilupin.

M.Y.Smirnov found the diamond content in the alkali-type lamprophyres in the North Timan in 1996. The diamonds contained in those rocks pertain to the -1+0.5 mm and -0.5+0.25 mm classes and are accompanied by the diamond association chrome-diopsides. The garnets and chrome spinellides of the alkali-type lamprophyres do not belong to the diamond association meanwhile.

The diamond exploration that went on in Timan during 2000–2001 was accompanied by the mounting deficit of funds until it was halted completely in 2002.


V.A.Dudar


L.P.Bakulina


A.B.Makeyev,


V.G.Cherniy,


E.G.Dojikova

The monograph by A.B.Makeyev and V.A.Dudar titled 'The Mineralogy of the Timan Diamonds' was published in 2001 (Макеев, Дудар, 2001). It was one of the at-the-curtain-fall works of the third stage in the diamond prospecting in Timan. It contained a conclusion based on the detailed morphometric and morphological study of the diamonds and of the thin native metal films, occlusions and coats on the diamonds and the spectroscopic features of the diamonds as well as of the diamond accessory minerals of Timan and the Polyudov Ridge – the conclusion, namely, that most of the crystals had no signs of mechanical wear and that the Timan diamonds paragenesis was a protogenous one. Lamproite magma was mentioned as the most probable hardrock source of those diamonds and it was mentioned also that A.B.Makeyev and A.Y.Rybalchenko had discovered a xeno-tuffizit (visherit) diatreme containing quasi-lamproite rock xenoliths in the Ichetyu area.

The report on the diamond hardrock exploration work done in the northern portion of the Volsk-Vym Ridge was finalised under the guidance of V.G.Shametko at the end of 2002. It recommended prospecting drilling in the anomalous zones found with reliance on the high-precision aerial geophysical work that was carried out during 2000–2001.

The results of the third stage of the exploration:

1) The discovery of the ultrafine native metal films as well as such films also of several silicates, alumino-sulphate-phosphates and oxides on the diamond facets;

2) The conduct of the large-areal aero-geophysical research using high-precision equipment in the Middle Timan; the discovery of dozens of feebly magnetic isometric anomalies;

3) The emergence of the tuffizit genesis hypothesis of the Timan diamonds;

4) The new diamond discoveries in the alluvial sediments of Timan and the Cistiman.

The experimental development work carried out in the Ichetyu Field at that stage produced more than 160 diamonds and several kilograms of gold.

That the prospecting, exploration and development stopped in the Ichetyu area did not mean that the diamond research would stop as well. The researchers of the Geology Institute led by A.B.Makeyev and A.M.Pystin had continued the field work in the Middle Timan that had involved E.S.Sherbakov under the contract with ALROSA up till 2008. The formation conditions of the Ichetyu polymineral placer were explored further in order to determine where the prospecting should go eventually.

The detailed mineral composition, gradation, segregation, density and mineral ratio analyses of the Ichetyu Field done by B.A.Makeyev (2002) confirmed cogently enough the sedimentary origins of all the minerals found in that field – that is, that it is a placer. According to Makeyev, the average weights and sizes of the heavy-fraction mineral grains were in direct proportional dependence and formed an alluvial parasteresis.

In the meantime, V.I.Remizov (2002) advanced an opinion that the Ichetyu Field's genesis was a pending question. While admitting the presence of the purely sedimentary psephites, Remizov also believes that fluid-gas streams could have brought the quartz material up from deeper sections.

An international symposium 'The Geology of the Devonian System' and the Pan-Russian Conference 'The Southern Regions of the Komi Republic: the Geology, the Mineral Resources and the Development Problems' were held at the Research Centre of the RAS' Urals Branch at the Komi Geology Institute in 2002. Much attention was paid by the speakers of the symposium to the factors and dynamic circumstances that had controlled the formation of the Devonian Placers of Timan (Sherbakov, Plyakin, Bitkov (Щербаков, Плякин, Битков, 2002)); the possible primary sources (Malkov, Kholopova, Makeyev, Dudar) and the justification of the age of the Ichetyu Placer (Telnova, Makeyev, Gorbunov).

The conference focused on the analysis of the compositional specificities of the Middle Jurassic chrome spinellides in the Ukhta Region (Makeyev, Yumanov) and the Vychegda-Sysol Downfold (Malkov, Shvetsova, Kholopova). The report by S.N.Mityakov and T.G.Shumilova reported the first find of a diamond shard in the Vashkin Site (the West Cistiman). As regards the originating rock of that diamond, I.I.Shulepova offered an opinion that it was an autholith tuff breccia analogous to the vent fraction rocks of the diamond blow pipes of the Arkhangelsk Province. I.I.Golubeva considers that it is a completely transformed alkali-type basite tuff or kimberlite. L.I.Lukyanova professed, if rather tentatively, the sub-volcanic genesis of those rocks that form the diatremes of the olivine melilotic, alneits, kimberlites and picrites. S.N.Mityakov and T.G.Shumilova (2002) spoke in this connection about the real prerequisites for the discovery of the diamond hardrock sources in the West Cistiman.

The 14th Geological Congress was held in Syktyvkar in 2004. Traditionally, the problem of the diamond content of the Timan-Urals Region had a place of pride in the 'Noble Metals, Diamonds and Gemstones' section. A.B.Makeyev suggested that the study of the Middle Timan kimberlite pipes should be continued in order to further the search for the hardrock origins within the Devonian rock occurrence area in the Ichetyu Placer and in the Upper Proterozoic rock occurrence region to the South.

B.A.Malkov (2004) outlined the following priority work areas: 1) the search for new diamond-bearing pipes 'next' to those found already; 2) determining the main diamond-bearing material ablation directions; 3) determining the isotopic age of the Sysol Dome's kimberlites; and 4) the regional geophysical forecast for diamond-bearing kimberlites within the development area of the thickest (up to 200–300 km) cratonal lithosphere.

V.A.Milashev (VNII Oceanology) confirmed the kimberlitic nature of the rocks tapped in the Umba and the Water-Parting pipes in the Middle Timan. At that, he described the Umba Pipe rocks as an autholith kimberlite breccia and those of the Water-Parting Pipe as massive brecciated kimberlites containing lherzolite association garnets. The sedimentation circumstances of the Ichetyu Placer's diamond accumulation were analysed by E.S.Sherbakov and the associates; they then opinionated about a relation between the diamond-bearing deposits and the outwashed deltaic deposits. The report by a group of authors led by N.P.Yushkin (Yushkin, Pystin, Konanova, et al.) consisted in the in-depth analysis of the diamond-content prospects of the Timan-Urals Region. The history of the studies done in the Ichetyu-Pizhma Placer was laid down in the report by A.M.Plyakin and V.G.Shametko.

The new and serious contribution to the diamond exploration in the Timan-Urals Region came from the traditional Pan-Russian meeting 'Diamonds and Noble Metals of the Timan-Urals Region' (2006). The diamond-related part of it addressed such issues as the structural specificity and formation traits of black diamonds (Silayev et al., Petrovskiy et al.), the genesis of the main types of diamonds (Shodzinskiy, Lutoyev and Glukhov) and the specificities of diamonds' morphology (Makeyev and co-authors, Rakin and Petrovskiy).

As regards the Timan-Urals Region, the problems of its exploration for diamonds (Plyakin, Sherbakov (Плякин, Щербаков, 2006)) and the prospects of the regions (Pystin and co-authors, Malkov (Мальков, 2006)) were addressed. Also, the formation conditions of the Ichetyu Placer were covered (Kotov, Shvetsova; Sherbakov, Plyakin (Щербаков, Плякин, Битков, 2002)).

At the same meeting were discussed the problems of diamond-content of the other regions of Russia: of the Kirov Province (Osovetskiy et al.), the Perm Region (Sychkin), the Ufa Plateau (Kisin), the White Sea Region (Maslov), Karelia (Lobkova et al., Lukyanova et al.), the Central Siberia (Kurgankov) and Yakutia (Specius et al., Tomilenko et al.).

The diamond subject was not singled out to make a stand-alone section and what few reports were delivered upon it were scattered across various thematic sections at the 15th and 16th Geology Congresses of the Komi Republic in 2009 and 2014 because the diamond exploration in Timan had been halted completely.

The industrial and scholarly geologists of the Komi Republic consider the Timan-North Urals Region to be one of the most promising ones in terms of hardrock diamond prospecting in Russia.

The work described above had the achievements in the diamond studies that we are giving below now:

1. The ultrabasic rocks (biotite picrites, kimberlites and autholith kimberlite breccias with pyropes, chrome-diopsides, chrome spinellides and carbonatites with the diamond-content signs) were identified in the geological structure of Timan.

2. The diamond-bearing polymineral (gold and the titan, rare metal and rare-earth metal minerals) Ichetyu Placer was discovered and partly developed in the Middle Timan.

3. Kimberlitic rocks containing small-size diamonds in hardrock containers were identified in the North Timan.

4. Accessory minerals diamonds were detected everywhere around Timan: in the Silurian (North Timan), Lower Carboniferous (Middle Timan), Middle Jurassic (Middle/South Timan) and Middle Devonian and Quarternary deposits (everywhere).

5. The detailed aeromagnetic and land magnetometric studies done in the Middle Timan found dozens of feebly magnetic isometric anomalies presumably associated with kimberlite pipes.

The following problems of Timan's gold content remain unsolved:

1. There are no primary hardrock sources of the Ichetyu Placer's diamonds identified reliably.

2. There are no diamond-bearing kimberlites identified in Timan reliably.

3. The known local magnetic anomalies have not been verified by means of direct geological methods.

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CONFERENCE INFORMATION

GEOMET 2016 — 3RD INTERNATIONAL SEMINAR ON GEOMETALLURGY

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Website: http://www.gecamin.com/geomet

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Website: http://www.eage.org/event/index.php?eventid=1497&Opendivs=s3

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26–31 March, 2017, Aspen Center for Physics

Website: http://ciera.northwestern.edu/Aspen2017.php

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27–31 March, 2017, Tyumen, Russia

Website: http://www.eage.org/event/index.php?eventid=1491&Opendivs=s3

ASSOCIATION OF PETROLEUM GEOLOGISTS ANNUAL CONVENTION AND EXHIBITION 2017

02–05 April, 2017, Houston, United States

Website: http://ace.aapg.org/2017
Website: http://www.aapg.org/events/conferences/ace/announcement/articleid/5663/aapg-2017-annual-convention-exhibition

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24–27 April, 2017, Stavanger, Norway

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CONFERENCE INFORMATION

WACMA1 – THE FIRST WEST AFRICAN CRATON AND MARGINS INTERNATIONAL WORKSHOP

24–29 April, 2017, DAKHLA, Morocco

Email: omarsaddiqi@yahoo.fr; omar.saddiqi@univcasa.ma;
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XVI[TH] INTERNATIONAL CONFERENCE GEOINFORMATICS THEORETICAL AND APPLIED ASPECTS

15–17 May, 2017, Kiev, Ukraine

Website: http://www.eage.org/event/index.php?eventid=1502&Opendivs=s3

HORIZONTAL WELLS 2017: CHALLENGES AND OPPORTUNITIES SECOND SCIENTIFIC CONFERENCE

15–19 May, 2017, Kazan, Russia

http://www.eage.org/event/index.php?eventid=1492&Opendivs=s3

ISPE-2017 — XI INTERNATIONAL SYMPOSIUM ON PERMAFROST ENGINEERING

05–08 September, 2017, Magadan, Russia

Website: http://mpi.ysn.ru/en/permafrost-engineering-symposiums

INTERNATIONAL EARTH SCIENCE COLLOQUIUM ON THE AEGEAN REGION, IESCA-2017

02–06 October, 2017, Izmir, Turkey

Website: http://iesca.deu.edu.tr/
Website: http://webb.deu.edu.tr/iesca/ocs/index.php/iesca/2012

FACHSEKTIONSTAGE GEOTECHNIK – INTERDISZIPLINÄRES FORUM

06–08 September, 2017, Würzburg, Germany

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Website: http://fachsektionstage-geotechnik.com/
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ASSOCIATION OF PETROLEUM GEOLOGISTS ANNUAL CONVENTION AND EXHIBITION 2018

20–23 May, 2018, Salt Lake City, Utah, United States

Website: http://www.aapg.org/events/conferences/ace/announcement/articleid/12061/aapg-2018-annual-convention-exhibition

GUIDE FOR AUTHORS

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

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

Manuscripts

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

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

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

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

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

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

Text should include:

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

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

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

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

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

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

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

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

Mathematics

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

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

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

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

Authors should use the system illustrated below.

Books:

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

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

Papers published in periodical journals:

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

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

Papers published in volumes (including periodical):

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

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

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

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

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

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

MÜƏLLİFLƏR ÜÇÜN QAYDALAR

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

Məqalələrin təqdim olunma forması

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

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

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

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

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

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

Məqalənin mətninə aşağıdakılar daxil edilməlidir:

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

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

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

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

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

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

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

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

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

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

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

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

Aşağıda müxtəlif biblioqrafik istinadların nümunələri verilir:

Kitablar:

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

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

Dövri nəşrlərdə/jurnallardakı məqalələr:

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

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

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

Məcmuələrdəki (o cümlədən dövri məcmuələrdəki) məqalələr:

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

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

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

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

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

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

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

Jurnalın redaksiya heyəti rəngli şəkillərin ödənişsiz çapını təmin edir.

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

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

Məqaləyə müəllifin arayışı və ekspertiza aktı əlavə olunmalıdır.

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

ПРАВИЛА ДЛЯ АВТОРОВ

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

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

Форма представления статьи

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

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

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

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

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

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

Текст статьи должен включать:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Ниже приводятся примеры различных библиографических ссылок.

Книги:

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

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

Статьи в периодических журналах:

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

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

Статьи в сборниках (в том числе перодических):

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

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

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

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

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

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

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

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

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

К статье должны прилагаться авторская справка и акт экспертизы.

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

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