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GARABAGH. STRATIGRAPHIC ESSAY
Chapter I: Mesozoic

The paper summarizes the results of multi-year studies undertaken by many Azerbaijani geologists, and allowing to investigate the Jurassic - Cretaceous successions of Garabagh territory, which is located in the western part of Azerbaijan. The authors summarised these long-term studies based on the Stratigraphic Code of Azerbaijan, and developed the local stratigraphy of the studied successions based on the faunal assemblages identified in the local stratigraphic units (suites).

Keywords: Mesozoic, Jurassic, Cretaceous, stratigraphy, paleontology, lithology, local stratigraphic divisions, suites

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Introduction

Problem statement. The entire territory of Garabagh is distinguished for its complex geological and tectonic structure as well as full geological section covering a wide stratigraphic Middle Jurassic-Holocene interval.

Starting from middle XIX century, several generations of local and foreign geologists had implemented in the region a lot of studies resulted in the detail lithological, stratigraphic and paleontological descriptions of the geological sections and development of the different stratigraphic schemes. Outcomes of these multi-year researches have been summarized in a number of scientific papers and books (Abdulgasimzadeh, 1988; Hasanov, 1973; Geology of USSR, 1972-Shikhalibeyli, 1994; Geology of Azerbaijan, 2015; Geology of Azerbaijan, 1997, 2007). It has to be stated that these publications contain some errors in description and paleontological justification of local stratigraphic units, and inconsistencies in local stratotypic sections of some stratigraphic units. On the other hand, these sources didn't consider rich data produced by the geological survey in 1970-1980's.

Taking the importance of correction of the existing data, the authors had conducted a reinterpretation of the regional stratigraphic units within the frameworks of both international stratigraphic chart and local stratigraphic schemes.

Current article is the first part of the essay dedicated to the lithology and stratigraphy of the Jurassic and Cretaceous successions of Garabagh.

Research retrospective. The geological structure of the Azerbaijani part of the Lesser Caucasus including Garabagh has been studied since middle XIX century. History of regional studies can be divided into three subsequent periods, covering the second half of XIX century, the first half of XX century and the period of 1950-1990's.

First period was mainly connected with the name of G.V.Abich – famous geologist, who visited the region in 1843, 1867 and 1873, covered it by geological survey and developed first schematic description of the region's geological structure. In 1869-1870, the region was also studied by G.G.Sulukidze, V.I.Arkhipov and G.B.Khalatov, who had proposed different theories on the local geology.

Second period was marked by a collection of diverse scientific information on the region's geological structure. At that period, wide-scale regional geologic and exploration activities had started in Garabagh. As a result of these works a basis for modern understanding of the geological-tectonic structure, magmatism, lithology and stratigraphy of the Meso-Cenozoic complex of Garabagh was created.

Geological exploration of the region started with "Ganja section" developed by K.N.Paffenholz in 1923 by an order of the Geological Committee. Although mapping of some areas was rather schematic, implemented investigations allowed identifying main features of the region's geological structure. In 1932, catchment area of the Tartar river (here and further for the locations see Figure 1) was covered by mid-scale geological survey, which resulted in development of the stratigraphic scheme of this area and characterization of its magmatism and tectonics.

Starting in 1932, A.N.Solovkin had spent 15 years conducting large and medium scale geological survey to cover the entire region of Mountainous Garabagh, including the zone of Lachin-Kalbajar. Only shortage of the implemented research was its failure to propose an exact paleontological proof for separate lithological-stratigraphic units within the studied successions. Additionally, large scale geological survey had been implemented in 1932-1937, within the framework of ore exploration activities in the Aghdam, Agdere, Kalbajar, Gubadli and Zangilan fileds (Figure 1). Another set of midscale survey had covered the Jurassic volcanic and ophiolitic complexes of Lachin-Khankendi.

In 1935, K.N. Paffenholz conducted geological survey and compiled a midscale map of the Ganja area. In 1939, A.N. Solovkin conducted analogous studies in the Khankendi area.

Largescale maps have been compiled for the Shamkirchay-Goranchay interfluve in 1947-1949 (R.N.Abdullayev, I.P.Butenko), and for the catchment area of the Levchay river (Tartar's left tributary) in 1948 (Sh.A.Azizbekov, A.Sh.Shikhalibeyli). In 1946-1948, interfluve of Tartar and Araz has been covered by small-scale geological survey implemented by T.A.Gorshenin in order to study the oil-gas perspectives of Meso-Cenozoic deposits.

In 1948, K.N.Paffenholz and A.N.Solovkin developed the small-scale geological map of the Mountain Garabagh and its surroundings, which had summarized the results of the previous researches. In 1947-1950, largescale geological survey of the Tartar and Toragaychay rivers' basins was implemented by A.N.Solovkin, which resulted in more complete stratigraphic section of the Mesozoic sediments as well as more exact characterization of composition and dating of the intrusives.

In 1949, I.A.Vainer and I.N.Sitkovsky implemented geological survey in the upper reaches of Tartar, Khachinchay and Hakari rivers. In 1949, A.Sh.Shikhalibeyli carried out largescale geological survey in the river basin of Aghdabanchay as well as on the slopes of Shahdagh and Murovdagh ranges. Finally in 1950, A.Sh.Shikhalibeyli and M.N.Rajabov together carried out largescale geological survey in the upper reaches of Hakari river.

Region-wide geological researches of the first half of the XX century had resulted in the region's structural zonation, detail stratigraphy of the Meso-Cenozoic complex, and petrographic characterization of local heterochronous intrusive and effusive formations. Outcomes have been summarized in a number of monographs, including "Geomorphology, Stratigraphy" – one of the volumes under the multivolume edition of "Azerbaijan Geology", published in 1952.

During ***third period***, the region was covered by 1:50000 and 1:100000 scale geological survey, targeted geological-tectonic studies and aerospace remote sensing.

In the first half of 1950's, large and medium scale geological survey were implemented in Gubadli (I.G.Huseynzadeh, 1953) and Zangilan (M.D.Gavrilov, 1954-1955), resulted in the collection of comprehensive data on the regional stratigraphy, tectonics and petrography of the igneous rocks, and the development of relevant geological maps.

In the second half of 1950's, Mountain Garabagh was covered by a number of largescale geological survey performed by V.M.Allahverdiyev in 1957-1960, G.I.Allahverdiyev and F.I.Zeynalov in 1958-1959, A.A.Bayramov in 1957-1960, O.J.Hamzayev with colleagues in 1957-1959, and A.Sh. Shikhalibeyli with colleagues in 1955-1960. As a result of these investigations, detailed descriptions were done on the petrography, petrology, stratigraphy and tectonics of the volcanic-sedimentary complexes. In 1960's, the Hakari river basin located in the southeastern slope of the Lesser Caucasus was covered by geological survey, implemented by A.Z.Abdullayev in Gubadli, and by G.I.Allahverdiyev and F.I.Zeynalov in Zangilan.

During realization of the research project "Azerbaijan Tectonics" conducted in 1956-1957 by experts from the Geological Institute of the Azerbaijan Academy of Sciences, V.G.Khalilzadeh, V.M.Allahverdiyev and G.P.Kornev studied the geological structure and evolution of the region's central and southeastern segments. Data on stratigraphy, magmatism and tectonics of the eastern part the Lesser Caucasus were summarized in the fundamental three-volume edition (editor – in - chief is A.Sh.Shikhalibeyli, 1964-1967). This work did not lose its scientific significance yet, and is being widely used until present days.

In the beginning of 1960's a new largescale geological survey has been conducted to cover mainly the interfluve of Tartar and Khachinchay rivers, Bargushadchay river basin, middle reaches of Hakari river, and the northeastern and southeastern slopes of the Lesser Caucasus mountains. A diapason of performed works included but was not limited to the following areas: 1) Lachin area – implemented by A.Z.Abdullayev, A.Y.Nasirov, N.Kh.Khaimov and A.S.Mammadov in 1961-1965; 2) upper reaches of Shalva and Gorchuchay rivers – implemented by G.I.Allahverdiyev and F.I.Zeynalov in 1961; 3) upper reaches of Hakari, Shalva and Tutgunchay rivers – implemented by O.J.Hamzayev and T.Ab.Hasanov in 1961-1962; 4) Zarchay river basin (Tartar's left tributary)– implemented by F.I.Zeynalov and G.I.Allahverdiyev in 1962; 5) area of Hadrut, Fuzuli and Zangilan – implemented by A.Y.Ismayilov and M.D.Gavrilov in 1962-1963; 6) Hakari-Khachinchay catchement area, Tartar river's upper and middle basins - implemented by V.M.Allahverdiyev, H.M.Hasanov and A.M.Aghakishiyev in 1961-1965; and 7) interfluve of Tartar and Khachinchay rivers – implemented by H.M.Hasanov, M.T.Aliyev and A.M.Akhundov in 1965. Besides that, A.A.Bayramov and A.Y.Ismayilov had mapped the territories of the southeastern margin of Lok-Garabagh and Goycha-Hakari structural zones in 1961-1962, and correlated reference sections of the Mountainous Garabagh in 1964. Additionally, the largescale instrumental survey of Bahramli and Mirikend areas was implemented by I.G.Huseynzadeh (1962-1963), and the lithologic-paleontological descriptions of Mountainous Garabagh were performed by A.A.Bayramov and M.D.Gavrilov (1965-1967).

Over a period of 1970-1998, T.A. Hasanov and T.M.Karimov implemented detailed largescale geological survey in the Carabagh region, and made singnificant changes in the existing ideas on the geological structure and stratigraphy of the studied area.

Finally, at the end of XX – beginning of XXI centuries, H.M. Hasanov implemented 1:50000 scale geological mapping at the northeastern territories of Garabagh, and got new interesting data.

Along with wide-scale geological survey programs implemented in the second half of XX century, the region has also been covered by targeted scientific studies carried out by many Azerbaijani[1] and Russian[2] researchers. These studies were devoted to stratigraphic measurements, structural and tectonic-magmatic evolutions of the region in a whole and separate structural-tectonic zones in Mesozoic-Cenozoic.

The achieved results have been summarized in chapter “Azerbaijan SSR. Geological Survey” of the 47th Volume of “USSR Geology” published in 1972. Later, these studies were continued by M.R.Abdulgasimzadeh (1984, 1988), T.A.Hasanov et al. (1973), A.G.Khalilov and H.A.Aliyev (1974, 1985), etc.

The last published works on Garabagh geology are “Geology and Mineral Deposits of the Mountainous Garabagh of Azerbaijan” (A.Sh.Shikhalibayli, 1994), Volume 1 (“Stratigraphy”, in Russian) of the eight-volume collaborative monograph “Azerbaijan Geology” (first edition in 1997, second edition in 2007) and Volume I of the three-volume collaborative monograph “Azerbaijan Geology” (2015, in Azerbaijani), as well as in the various geological maps. However, it should be emphasized that the big part of the geological survey’s outcomes remain unconsidered and need a good interpretation.

It motivated us to make in this paper an attempt to summarize all of the existed material (both published and taken from reports), and present outcomes of the lithological-stratigraphic studies resulted in the development of the local stratigraphic scale accepted according to the Stratigraphic Code of Azerbaijan (Stratigraphic Code of Azerbaijan, 1995). Below we give a brief lithological-stratigraphic descriptions.

Description of lithological-stratigraphic sections. Territory of Garabagh extends from Ganja lowland on the right bank of the Kura river, through the southeastern plunging part of the Lesser Caucasus till the left bank of the Araz river on the Armenian boundary in the southwest and Araz –Kura rivers interfluves in the northeast. Geological structure of Garabagh includes different successions covering Middle Jurassic - Pleistocene stratigraphic interval (Figure 1).

Tectonic structure of the region includes the southeastern margins of Lok-Garabagh, Goycha-Hakari and Gafan structural zones within the Lesser Caucasus orogenic system (Geology of Azerbaijan 2015; Geology of Azerbaijan, 2005). In the high-mountain part of Garabagh, the structures of Goycha-Hakari and Gafan zones are smoothed by the Paleogene-Neogene succession of the latitude oriented Kalbajar superimposed trough. Plain Garabagh covers major southeastern part of the Middle Kura depression in the northeast and the east, and corresponds to a latitude oriented Lower Araz superimposed trough on the southeastern plunge of Goycha-Hakari and Gafan structural zones infilled with Pliocene-Pleistocene rocks (Figure 2).

Below we give a brief overview of sedimentary, volcanic -sedimentary and volcanic complexes of Garabagh. This summary has been developed based on the published sources (Abdulgasimzadeh, 1988 - Geology of Azerbaijan, 1997, 2007; Geology of USSR, 1972 - Shikhalibeyli, 1994), and on the unpublished results of geological survey implemented in 1970-1990’s by the researchers from former State Committee of Geology and Natural Resources (A.Z.Abdullayev, G.I.Allahverdiyev, V.M.Allahverdiyev, A.A.Bayramov, O.J.Hamzayev, H.M.Hasanov, T.Ab.Hasanov, A.Y.Ismayılov, F.I.Zeynalov, etc.).

[1] R.N. Abdullayev, F.A. Akhundov, M.H. Aghabeyov, Sh.I. Allahverdiyev, M.M. Aliyev, Sh.A. Azizbayov, A.A. Bayramov, Khalil Aliyulla, R.A. Khalafova, A.G. Khalilov, M.A. Gashgai, T.A. Hasanov, T.H. Hajiyev, T.Ab. Hasanov, H.T. Hagverdiyev, N.A. Imamverdiyev, A.J. Ismayilzadeh, G.P. Kornev, R.N. Mammadzadeh, H.V. Mustafayev, A.V. Mammadov, M.I.Rustamov, A.Sh. Shikhalibeyli, etc.

[2] V.A. Aristov, Y.V. Karyakin, A.L. Knipper, M.G. Lomize, Y.Y. Milanovsky, S.D. Sokolov, V.Y. Khain

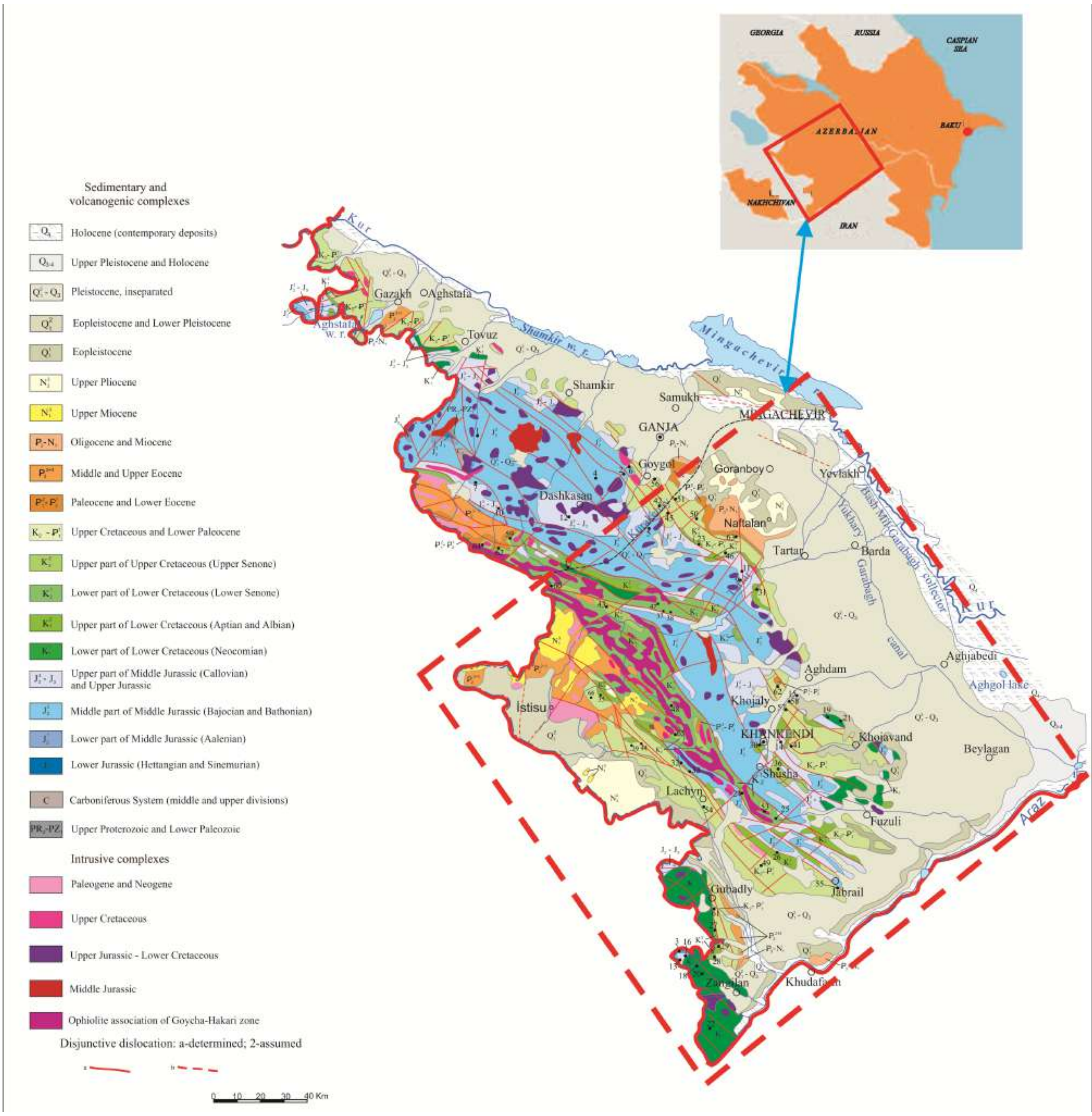

Figure 1. Geological map of the Azerbaijani part of Lesser Caucasus – by T.N. Kangarli (National Atlas, 2014).

Suites: **1 -** Zayamchay, **2 -** Gyzylja, **3 -** Aghkend, **4 -** Dashkasan, **5 -** Kurakchay, **6 -** Khachagaya, **7 -** Kichik Garamurad, **8 -** Kapaz, **9 -** Tapakend, **10 -** Galakend, **11 -** Gulustan, **12 -** Gonaggormaz, **13 -** Gungishlag, **14 -** Gushchular, **15 -** Aranzamin, **16 -** Kaganly, **17 -** Bughdadagh, **18 -** Okhchuchay, **19 -** Shelli, **20 -** Burunlu, **21 -** Gulably, **22 -** Bartaz, **23 -** Garachay, **24 -** Farjan, **25 -** Alijanly, **26 -** Sirik, **27 -** Gartiz, **28 -** Guyudara Khashtab, **29 -** Sarili Khashtab, **30 -** Khankendi, **31 -** Lulasaz, **32 -** Altintakhta, **33 -** Ayibazary, **34 -** Dashbashy, **35 -** Chovdarsu, **36 -** Damirchilar, **37 -** Aghdaban, **38 -** Charakdar, **39 -** Tilloid, **40 -** Sheylanly, **41 -** Dashkend, **42 -** Chaykend, **43 -** Nadirkhanly, **44 -** Hochazsu, **45 -** Garabulag, **46 -** Injachay, **47 -** Bulanligsu, **48 -** Qarabayli, **49 -** Dolanlar, **50 -** Todan, **51 -** Shorsu, **52 -** Mahuchay, **53 -** Yurtiyal, **54 -** Lachin, **55 -** Tulusdagh, **56 -** Tulakdagh, **57 -** Dahraz, **58 -** Asgaran, **59 -** Darvadagh, **60 -** Gonur, **61 -** Gubadly, **62 -** Gargarchay, **63 -** Aghjakend, **64 -** Gojadagh, **65 -** Chichakli, **66 -** Aghgaya

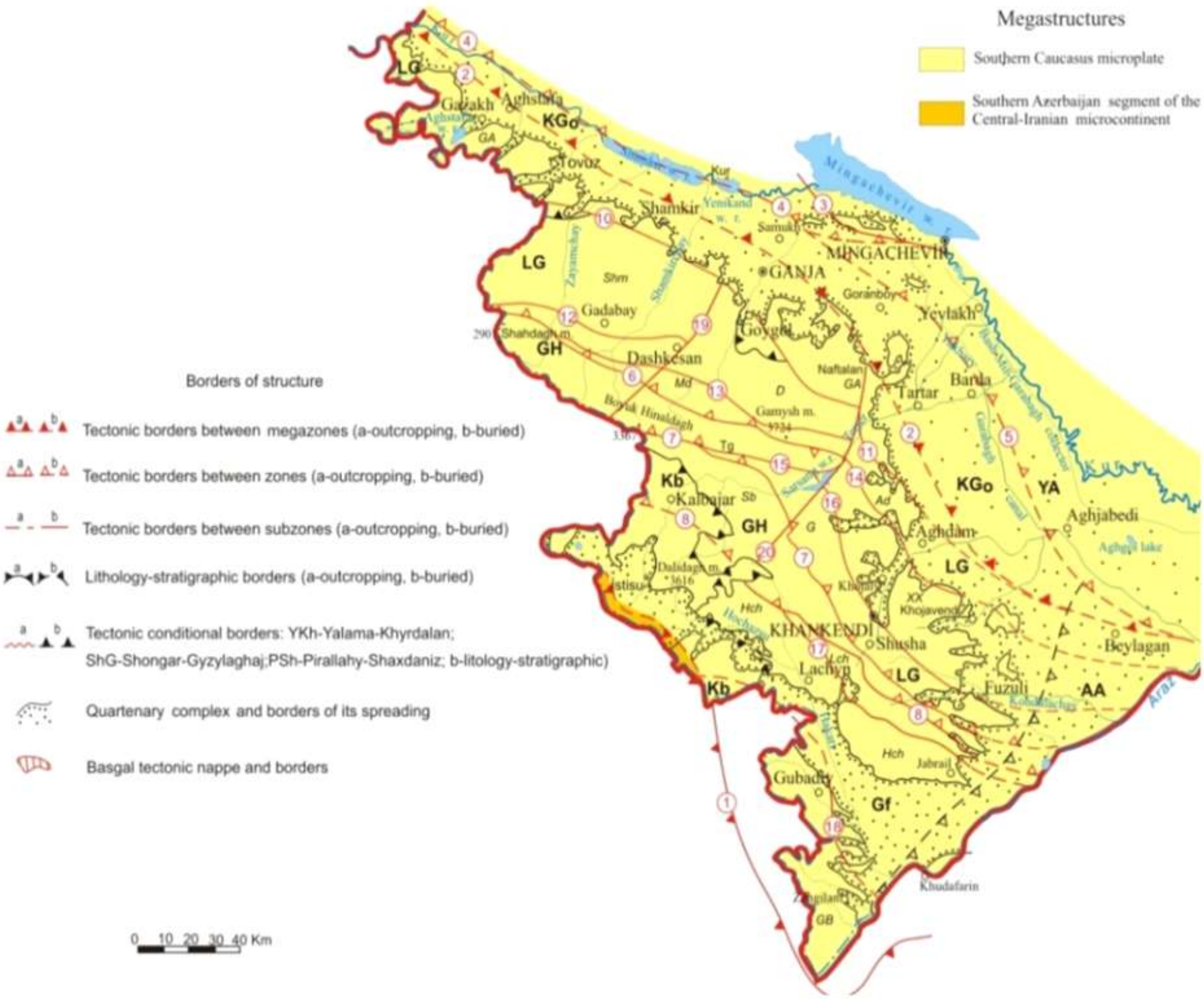

Figure 2. Tectonic scheme of the Azerbaijani part of the Lesser Caucasus – by T.N. Kangarli (National Atlas, 2014).

Kura intermountain depression (Miocene-Pliocene superimposed depression): Middle Kur (Orta Kur) megazone: zones: KGy – Pre-Lesser Caucasus (Kichikgafgazonu); **YA** – Yevlakh-Aghjabadi. **Mountain-fold system of Lesser Caucasus: Artvin-Garabagh megazone: zones: LG** – Lok-Garabagh; **GH** – Goycha-Hakari; **Qf** – Gafan; **Kb** – Kalbajar (Eocene-Pliocenic superimposed depression); **AA** – Lower Araz (Ashaghy Araz – Eopleistocene-Holocenic superimposed depression); subzones: **GA** – Gazakh-Aghburun; Shm – Shamkir; **Ad** – Aghdam; **D** – Dashkasan; **XX** – Khachynchay-Khojavand; **Md** – Murovdagh; **G** – Garabagh; **Tg** – Toraghaychay; **Sb** – Saribaba; **Lch**– Lachin; **Hch** – Hochaz; **GB** – Gafan-Basitchay. **Faults: on the boundaries of megazones: 1** – Girratagh; **on the boundaries of zones**: **2** – Pre-Lesser Caucasus (Kichikgafgazonu); **3** – Arikdar-Bozdagh-Padar; **4** – Kur; **5** – Southern Kur (Janubi Kur); **6** – Murovdagh; **7** – Garabagh; **8** – Lachin-Bashlibel; **9** – Goychay-Imishli; **on the boundaries of subzones: 10** – Yasamal; **11** – Aghdara; **12** – Aryghdam; **13** –Arisu-Zivlan-Balligaya; **14** – Aghdam; **15** – Sarsang; **16** – Meydanchay–Shusha; **17** – Deyhan; **18** – Hakari; **19** – Goshgarchay; **20** – Tartar-Injachay

Some stratotypic Jurassic and Cretaceous sections are located out of the territory of Garabagh, but we used the same local stratigraphic names in our stratigraphic descriptions of the Garabagh.

Jurassic system

Jurassic system of Garabagh is represented by Bajocian, Bathonian and Callovian series of the Middle Jurassic, as well as Oxfordian, Kimmeridgian and Tithonian series of the Upper Jurassic (Geology of Azerbaijan, 2015; Geology of Azerbaijan, 1997, 2007; Geology of USSR, 1972). ***Middle Jurassic complex*** is built by more than 2500 m thick succession of volcanic and volcanic-sedimentary rocks, cropping out in all tectonic zones.

Bajocian series is mainly exposed within the Lok-Garabagh zone's boundaries, including watershed and northeastern slope of the Lesser Caucasus, as well as Tartar-Khachinchay interfluve on the southern slope of Murovdagh range. The Lower Bajocian deposits with unexposed basement (***Zayamchay suite***), are represented by tuff-conglomerates, tuffites and pillow lavas (>250 m), while the Upper Bajocian complex (***Gyzylja suite***) is composed of liparite-dacite porphyries and pyroclastic formations (about 360 m). In Tartar-Khachinchay interfluve, only Gyzylja suite's deposits are exposed (Figure 3).

Figure 3. Outcrop of Upper Bajocian series: left bank of the Tartar river (Tartar-Kalbajar road)

Upper Bajocian series is also cropping out in the southwest of Gafan zone, and constitutes the ***Aghkend suite*** recorded in the valley of Okhchuchay river located close to the Armenian boundary within the structure of Gafan-Basitchay uplift. Base of the section (Gafan town's vicinities) contains 60 m thick sandstones, tuffobreccias and tuffites, which is overlapped by 260-300 m thick tuffs, lava-breccias and flows of quartz porphyrites.

Bathonian succession is more widely occurring in the region, where it is recognized mainly within the structure of Lok-Garabagh zone, and partly in the southeastern segments of Goycha-Hakari and Gafan zones. The lower boundary of the succession lies over the top of liparite-dacite tuffs. In some places, Bathonian complex is underlaid by a layer of basal conglomerates consist of liparite-dacite tuff clasts. The upper boundary of the succession is distinguished by the appearance of Callovian rocks.

According to fauna assamblages, Bathonian series is divided into lower (***Dashkasan suite***), middle (***Kurakchay suite***) and upper (***Khachagaya suite***) subseries. The last one is a transition to the Callovian series.

Murovdagh range delineates the northern boundary of the Garabagh. Its Upper Bajocian liparite-dacite tuffs are overlaid by the *Dashkasan suite* composed of flows of plagioclase and mandelstone containing tuffs. On the northern slope of the range, these tuffs are replaced by the *Kurakchay suite's* tuff-conglomerates, tuffaceous sandstones, muddy sandstones and tuff lavas. *Khachagaya suite* is only revealed in the interfluve of Buzlugchay and Garachay rivers, where it is represented by 273 m thick alternating argillites, sandstones, sandy limestones, tuffaceous sandstones and tuff gravelites, which transgressively overlaps the Kurakchay suite. The suite contains fossils of *Andemantastraea sp.ind., Actinaraea subturbinata (Gregory), Tramnastraea lyelli M.Edw. et Haime, Montrivaltia chariensis (Gregory), Adelocoenia bachmanni (Koby),* etc. Total thickness of the Bathonian complex reaches 1800 m.

In Aghdara trough within the interfluve of Tartar and Khachinchay rivers, Middle Bathonian succession is represented by volcanic sedimentary facies composed of tuffaceous sandstones, sandstones and argillites (100-120 m) in the bottom, and sandstones and silts (200 m) in the top of the section (Figure 4). Muddy sandstones from the middle portion of the section contain remnants of *Bullatimorphites cf. sulvicum, Oecotraustes splendens, Oxycerites cf. limosus, O. cf. falax, Lissoceras psilodiscus, and Calliphylloceras cf. disputabile*.

In the remaining part of Garabagh, Bathonian section is predominantly built by volcanic rocks. Thus, the Lower Bathonian succession is represented by the alternation of tuff conglomerates, tuff breccias, tuffs and tuffites with flows of andesites and andesitic basalts. In Middle Bathonian section siltstones and argillites are also occurring. Total thickness of the Bathonian complex varies between 400 m and 1500 m. In some sections, Lower-Middle Bathonian sandstones contain fossils of *Oecotraustes splendens, O. ziegleri, Choffatia sp. indet., Perisphinctes cf. evolutoides, Partshiceras cf. subobtusum, Holcophylloceras zignodianum, Caliphylloceras cf. disputabile, Lissoceras ex gr. psilodiscus, Hibolites ex gr. rusiformis* etc. Upper Bathonian argillites and sandstones contain *Holcophylloceras zignodianum, Partschiceras subobtusum, Nannolytoceras sp. indet., Oxycerites cf. aspidoides, Syncyclonema demissum, Plagiostoma cf. harpax, Mytilus asper*.

Callovian stage is constituted of the volcanic sedimentary rocks (***Kichik Garamurad and Kapaz suites***), which conformably and sometimes unconformably overlie the Bathonian succession (Figure 5). The stage is divided into three portions. Lower and Middle Callovian substages correspond to *Kichik Garamurad suite*. The lower subsuite (Lower Callovian) consists of alternating argillites, tuffaceous sandstones, siltstones, schists, micro- conglomerates and tuffs. The upper subsuite (Middle Callovian) is represented by calcareous tuffites, tuff siltstones, tuffaceous sandstones, argillites, gravelites and micro - conglomerates. The Upper Callovian substage is represented by *Kapaz suite* of tuffaceous sandstones and calcareous tuffites. Depending on section, the total thickness of the stage varies between 65 and 530 m. Lower substage contains fossils of *Macrocephalites macrocephalus, Pleurocephalites subtimidus etc.;* middle substage - *Reineckeia anceps, Erymnoceras coronatum etc*.; upper substage -*Peltoceras athleta, Oecoptychius refractu*, etc.

The ***Upper Jurassic complex*** consists of volcanic, volcanic sedimentary and sedimentary successions.

Figure 4. Outcrop of Bathonian series: Aghdara trough (river basin of Khachinchay)

Figure 5. Outcrop of Callovian and Upper Jurassic successions: Tugh village (basin of Guruchay river)

Oxfordian succession conformably overlies the Upper Callovian series. These rocks are splitted into the Lower (***Tapakend suite***) and Middle-Upper (***Galakend suite***). The both suites are predominantly composed of sedimentary rocks. In Lok-Garabagh zone Oxfordian stage is occuring in the southeastern part of Dashkasan-Galakend trough (Kapaz syncline), where it is built by 170-240 m thick strata of siliceous and oolitic limestones (Figure 6) that contain remnants of *Pentacrinus cf. pentaganalis Voldf., P. cf. allyscocaris Thurn., Plegiocidaris ex. gr. ornata (Quenst)*, *Colamphylla flobellum*, etc. In the other parts of Garabagh Lower Oxfordian stage is mainly constituted of sedimentary rocks, which are comprised of 50-80 m thick marl beds, sandstones, sandy limestones, muddy tuffaceous sandstones and argillites, partly tuffites, tuff siltstones, etc. These rocks contain the Lower Oxfordian fauna of *Perisphinctes biplex, Calliphylloceras manfredi, Sowerbyceras protortisulcatum*, etc. Middle-Upper Oxfordian deposits conformably overlie the Lower Oxfordian series, and consist of 300 m thick alternating tuffs, tuff breccias, tuff conglomerates, tuffaceous sandstones and tuffites described in the basin of the Toraghaychay river. Volcanic facies are replaced by sedimentary series in the southeast, which include 100-130 m thick layer of sandy, marbled, siliceous, pelitomorphic and organic limestones recorded in the river basins of Gabartichay, Khachinchay, Gargarchay and Kondalanchay (Figure 7). These limestones contain the Middle-Upper Oxfordian fauna of *Ptygmatis pseudobruntrutana, Pseudonerinea yailensis, P. pupoidea*, etc.

Kimmeridgian stage demonstrates a limited occurrence in the structure of Dashkasan-Galakend, Toraghaychay, Khojavand and Hadrut troughs, and is divided into Lower (***Gulustan suite***) and Upper (***Gonaggormaz suite***) substages (Figure 8). Kimmeridgian series conformably overlaps the Oxfordian succession in the north and northeast of the region under study, and transgressively overlies the Upper Bajocian volcanics in the southwest in the river valley of Okhchuchay. Lower Kimmeridgian series is composed of 300-370 m thick strata of pyroclastolites, which contain the flows of augitic porphyrites and the veins of limestones. In Khachinchay section and in the sections recorded to the southeast, the Lower Kimmeridgian substage is constituted of alternating organic-fragmental, pelitomorphic and sandy limestones, tuffites, tuffaceous sandstones, silty tuffites, tuff gravelites, gravelites and conglomerates (700-820 m), dated according to a presence of *Taramelliceras externnodosus, Ataxioceras pseudohomalinum, Phaneroptyxis pupoides, Ptygmatis pseudobruntrutana, Helicocoenia variabilis etc*. Upper Kimmeridgian complex is comprised of tuff conglomerates, tuff breccias, tuffaceous sandstones, tuff gravelites, andesitic porphyrites and sandy limestones (25-160 m). The limestones contain the Upper Kimmeridgian fauna of *Trochocyathus laminus*, *Pygope jznitor* and *Terebratula angusta*.

The Upper Kimmeridgian complex is represented by its upper substage (***Gungishlag suite***) within the Gafan-Basitchay uplift, where it is comprised of 300 m thick alternation of tuff conglomerates, tuff breccias, tuff gravelites, tuffaceous sandstones and porphyrites that unconformably overlie the Bajocian volcanics belonging to Aghkend suite.

Tithonian complex is limitedly occurring within the territory of Garabagh. It participates in the geological structure of Aghjakend, Aghdara, Khojavand and Aghdam tectonic zones located at the northeastern margin of Lok-Garabagh area (Figure 9). This succession includes Lower (***Gushchular suite***) and Middle-Upper (***Aranzamin suite***) substages, which unconformably overlie the Kimmeridgian and Oxfordian complexes.

Figure 6. Outcrop of Oxfordian succession: Kapaz mountain

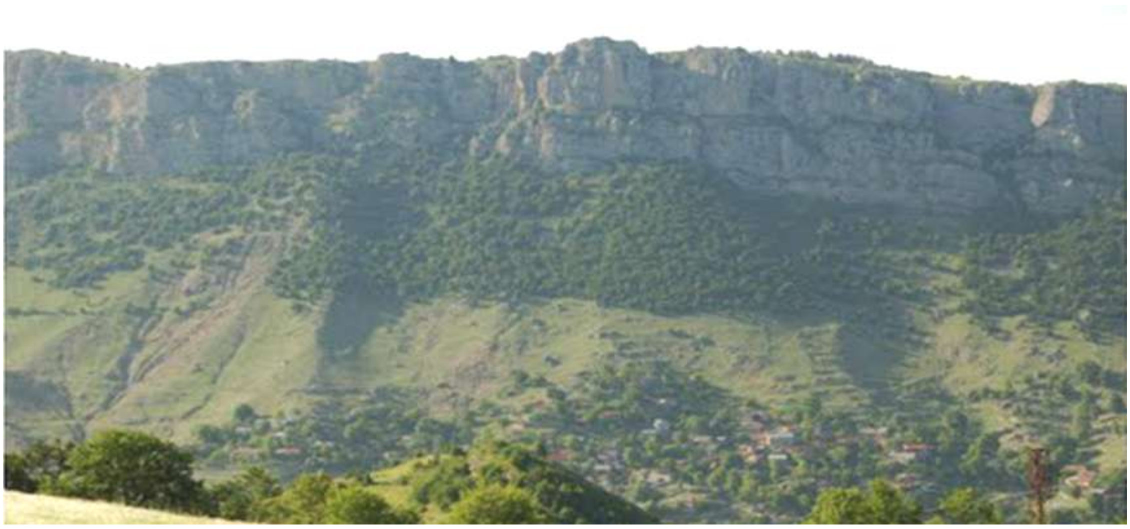

Figure 7. Outcrop of Middle-Upper Oxfordian succession: Dashalty village (southern slope of Shusha plateau)

Figure 8. Outcrop of Kimmeridgian succession: Almaly village (Khachinchay-Gargarchay watershed)

Figure 9. Outcrop of Tithonian succession: Saidbayli village (Khachinchay-Gargarchay watershed)

Lower Tithonian Gushchular suite is mainly composed of the organic-detrital, sandy and siliceous limestones (200-270 m), while Middle-Upper Tithonian Aranzamin suite is constituted of organic, gravelitic, sandy, siliceous limestones with the interbeds of microfragmental conglomerates (60-170 m). Described section contains numerous fossils of Tithonian gastropods and mollusks (*Lamellaptuchus beyrichi (Opp.), L. cf. punctatus (Voltz.), Perisphinctes zittell Semirad., Subplanites contiguous Cattullo., Pyncaptychus punctatus Pict. et. Zor.*, etc.).

Tithonian series is also occurring in the southwest of Garabagh, where it is comprised of the ***Kaganly suite*** occurring in the structure of Gafan-Basitchay uplift. The suite consists of 60-70 m thick bed of oolitic, sometimes sandy, fragmental clastic siliceous limestones, which conformably overlies the Gungishlag suite. The limestones contain faunal assemblage composed of *Calamophylliopsis etalloni Koby, Paradiceras cf. favrei Pchel., Phaneroptyxis staszycii Zeu.*, etc.

Cretaceous System

Sedimentary and volcanic sedimentary complexes belonging to the Cretaceous system occupy a considerable part of the Garabagh region's territory, and include both Lower and Upper Cretaceous series. Lower Cretaceous succession is more developed in the southeast and southwest Garabagh, whereas the Upper Cretaceous series is occuring in the northern and central segments as well as along the northeastern margin of Garabagh. Cretaceous stratigraphy of Garabagh was developed accordingly to typical lithological and paleontological patterns.

In composite geological section of Garabagh, the ***Lower Cretaceous complex*** displays an entire range of Berriasian-to-Albian rocks in volcanic, pyroclastic, terrigenous and carbonate facies.

Berriasian and **Valanginian** series demonstrate a lithological similarity in the geological sections of Lok-Garabagh and Goycha-Hakari zones, and therefore are considered as a single ***Bughdadagh suite***. Berriasian-Valanginian rocks participate in the geological structure of Aghdam, Darakend and Kohnatagh uplifts, as well as in Toraghaychay, Saribaba, Agdara, Khojavand (Figure 10), Hadrut and Chaylaggala troughs, where they are usually composed of sandy or siliceous limestones intercalating with pyroclastolites (70-360 m). Age of local limestones has been determined according to a presence of the following faunal complex in their section: *Berriasella cf. callisto, Lamellaptychus punctatus punctatus etc., L. beyrichi, L. cf. mortilleti, L. cf. subdiday, Pseudosubplanites subrichteri, Duvalia cf. lata, Dyctyothris cf. jacerdi, Protetragonites cf. quadrisulcatus*, etc.

Within the Gafan zone's boundaries, Berriasian-Valanginian complex is occurring in the structure of Gafan-Basitchay uplift, where it forms the ***Okhchuchay suite*** that covers lower and middle, mainly volcanic, parts of a volcanic - sedimentary strata exposed in the uplift's southwestern flank. The suite's geological section is mainly represented by the alternation of diabases and andesite-porphyrites with tuffs, tuffites, tuff-conglomerates, tuff-breccias, tuff-gravelites, tuffaceous sandstones and partly limestones (600-800 m).

Figure 10. Outcrop of Valanginian and Hauterivian succession: Jutchu village (left bank of Aghoghlanchay river, Khojavand)

Hauterivian stage occurs in carbonate facies (***Shelli suite***) recorded above the Berriasian-Valanginian limestones exposure in Lok-Garabagh and Goycha-Hakari zones.

Forming a gradual transition from Berriasian-Valanginian series, the suite is comprised of the alternating various (crystalline, organic, oolitic, sandy, muddy, siliceous, gravelite and fragmental) limestones with thin and rare interbeds of tuffaceous sandstones and silicium (30-250 m). Hauterivian limestones contain the same-aged fossils of *Hibolites subfusiformis, Lamellaptychus angulicostata atlantica etc., Subsaynella sayni, Lamellaptychus angulicostatus, Duvalia lata, Spitidiscus rotula, Crioceratites cf. duvali etc., Phyllopachigeras cf. kateschiense, Pseudobelus bipartitus,* etc.

In the Gafan-Basitchay uplift located in Gafan zone, Hauterivian series form 200-350 m thick ***Burunlu suite*** of porphyrites, tuff-conglomerates, tuff breccias, tuffaceous sandstones and limestones, which covers an exposed upper part of the thick Lower Cretaceous volcanic sedimentary complex. Upper part of the section is mainly constituting of calcareous tuf-sandstones and sandy limestones, which contain the Valanginian-Hauterivian fauna of *Terebratula acuta, Zeillerta cf. tamarindus, Exogyra sp.*, etc.

In Lok-Garabagh zone, **Barremian succession** displays gradual transition from Hauterivian series, and forms the ***Gulably suite*** which is mainly composed of organic, oolitic and pseudo-oolitic, sandy, pelitomorphic and crystalline limestones (Figure 11). Depending on section, the suite's thickness varies between 20-400 m. The following typical faunal remnants are recognised in the Barremian rocks: *Sellithyris sella, Symphyttyris neocomiensis, Cyclothyris lata etc., Cosdidiscus cf. recticostatus, Silesites seranonis, Barremites biasalensis, Protetragonites crabrisulcatus etc., Eugyra lanckoronensis, Cryptocoenia neocomiensis, Orbitolina delicata, O. lenticularis, O.discoidea etc., Parapacliytraga gigantea, Neithea atava, Requenia ammonia etc., Mesohibolites uhligi, M. elegans, Silesites seranonis,* etc.

Within the Gafan zone's limits, Barremian succession includes the Upper Barremian ***Bartaz suite*** occurring in the basins of Bargushad (Bazarchay) and Okhchuchay rivers, and consisting of the alternating calcareous sandstones, tuffaceous sandstones as well as sandy and organic limestones (340-530 m).

Figure 11. Outcrop of Barremian succession: southeastern margin of Sarintagh range, 2 km to the north of Garakend village (Khojavand trough)

The Suite unconformably overlaps Hauterivian and in some places Valanginian series, and contains following fossils: *Neithea dagestanica, N. atava, Terebratula praelonga, T. sella, T. acuta, Harpogodes pelagi, Lima royeriana, L. cf. undata, Belbekella multiformis, Lelleria cf. tamarindus, Waldhem aff. morrisi, Weithea dagestanica, Requenia ammonia, Monopleura urgonensis*, etc.

Aptian stage is limitedly occurring within the territory of Garabagh. It is recorded in the geological structure of Aghjakend, Saribaba and Chaylaggala troughs, where its incomplete section is comprising of the alternating organic, sandy, crystalline and fragmental limestones with the tuffaceous sandstones, tuffites, sometimes marls and argillites .

On the southwestern flank of Aghjakend trough, Aptian stage is represented by the ***Garachay suite*** composed of alternating sandstones, siltstones, gravelites, argillites and marls (55-120 m), and containing fossils *İnoceramus undulata plicatus michaeli Heinz., Micraster coranguinum Goldf., Globotruncanata coronata Bolli.*, etc., in its composition.

In the Alijanly area of Saribaba trough, Aptian stage is constituted of the middle and upper substages. Middle Aptian series (***Farjan suite***) are composed of 90-100 m thick alternating argillites, siltstones and sandstones, which unconformably overlie the Hauterivian limestones and contain fauna of *Deshayesites deshoyi Papp., D. deshoyesi Zeym., d. weissi Neum. et Uhl., Aucellina aptiensis d'Orb*. 150 m thick section of the Upper Aptian ***Alijanly suite*** conglomerates, gravelites and sandstones contains fauna of *Hedbergella infracretacea Gl., Patellina aptica Agal., Ammodiscus incertus Orb., Gyroidina sokolovae Mjatt*., etc.

Exceptionally thick (up to 500 m) undivided Aptian strata form the ***Sirik suite,*** which is revealed in Chaylaggala trough on the northeastern flank of Gafan zone (vicinities of Dolanlar and Sirik villages) and built by sandy limestones, limy tuffaceous sandstones and conglomerates. The Aptian sediments contain following typical fossils: *Deshayesites weissi, Costidiscus pausinovosum, Duvalia gressiana, Pseudohaploceras matherani, Mesohibolites uhligi, Neohibolites ewaldi etc., Acanthoplites aschiltensis subangula, Aucellina caucasica, A. aptiensis, A. nassibianri*, etc.

Finally, in the Gafan zone's southwest (Gafan-Basitchay uplift), Aptian stage is divided into three substages based on the faunal and lithologic composition. Lower Aptian series is represented by ***Gartiz suite***, which is built by tuffaceous sandstones, calcareous sandstones, clays and marls in the bottom, and by tuff-conglomerates, tuffaceous sandstones and tuff-gravelites in the top of its section 30-360 m). Middle Aptian substage includes ***Guyudara Khashtab suite*** composed of alternating shales, marls, limestones, tuff breccias, tuff conglomerates and tuffaceous sandstones (230-290 m). Finally, the Upper Aptian ***Sarili Khashtab suite*** had been only preserved in the same-named village's vicinities, where it is comprised of marls with mudstone and sandstone intervals (35 m). These deposits contain fauna of *Acanthoplites aschietaensis Anth., A. miltispinatus Anth., Hipacanthoplites cf. jacobi presula Glasun.*, etc.

Albian stage is constituted of middle and upper substages within the region under study. These sediments are recorded in the geological section of Aghjakend, Aghdara, Khojavand, Saribaba, Hadrut and Chaylaggala troughs (Figure 12). During Lower Albian time hiatus in sedimentation brought to deep erosion of the Aptian sediments, and resulted in unconformity between Middle, Upper Albian and Aptian, and in some places, Barremian and Hauterivian deposits.

In Aghjakend, Aghdara and Khojavand troughs, Middle Albian stage includes the ***Khankendi suite***, which contains alternating argillites, sandstones, tuffaceous sandstones, tuffs, marls, sometimes limestones, tuff siltstones and tuff breccias (20-290 m). In the same outcrops Upper Albian deposits are represented by the ***Lulasaz suite*** of tuffaceous sandstones, tuff gravelites, tuff breccias, tuff conglomerates, sandstones, marls and argillites (30-280 m).

Figure 12. Outcrop of the Albian rocks: Taghaser village in the upper reaches of Gozlu-chay river, Khojavand.

In Saribaba trough, Middle Albian sediments (***Altintakhta suite***) are composed of tuff-conglomerates, tuff gravelites and tuffaceous sandstones in the bottom, and sandstones and sandy limestones with argillite intervals in the top (100-120 m). 41 m thick bed of crystalline limestones is recorded within the Middle Albian volcanics. Upper Albian stage corresponds to the ***Ayibazary suite*** of tuffaceous sandstones, argillites, sandstones, limestones and marls (160-320 m).

Within the structure of Hadrut and Chaylaggala troughs, Middle Albian stage forms ***Dashbashy suite*** of tuffaceous sandstones, tuffs, tuffites, argillites, marls, sandstones and limestones (50-160 m). At the same time, the Upper Albian deposits (marls, argillites, sandstones, tuffaceous sandstones, sometimes limestones and gravelites) are as thick as 50-200 m and titled as ***Chovdarsu suite***.

Albian rocks of Garabagh contain following typical fossils: 1) Middle Albian – *Neohibolites cf. minimus List., N. stylioides Renng., Puzosia cf. mayoriana d'Orb., Aucellina aptiensis d'Orb., Inoceramus concentricus Park., Picatula inflate Sow.*, etc.; 2) Upper Albian – *Plicatula inflata etc., P. gurgitis pict. et Roux., Mariella bergeri Brongn., Puzosia planulata Sow., Kossmatella agassiziana Pict., Aucellina aptiensis d'Orb., Barbatia narzanensis Renng., Scaphites hugardianus d'Orb., Haustator vibrayeanus d'Orb., Turrilites hugardi, Mortoniceras inflata, Variamussium ninae Kar., Anisoceras armatum Sow., Hysterogeras orbignyi Spath*, etc.

Upper Cretaceous rocks are more widely occurring in the Garabagh region than the Lower Cretaceous complex. All Upper Cretaceous stages are recorded in the geological section through their sedimentary, volcanic sedimentary and volcanic successions. Upper Cretaceous complex is widely developed in the geological structure of Goycha-Hakari and Gafan zones. Also, these rocks are exposed along the north-eastern flank and the southeastern plunge of Lok-Garabagh zone. The typical feature of the Upper Cretaceous section of Goycha-Hakari area (Upper Cenomanian – Lower Santonian) are occurrence of olistoliths and olistostromes derived from the ophiolitic complex.

Cenomanian succession. In Lok-Garabagh zone, this stage is represented mainly by its lower portion in Aghjakend and Aghdara troughs, and by the entire section in Khojavand trough

(***Damirchilar suite***). The suite unconformably overlies Albian deposits. Together with the base containing 1.5-3.0 m thick layer of basal conglomerates in some sections, this 60-560 m thick suite is composed of alternating shales, argillites, sandstones, tuffaceous sandstones, limestones, sometimes marls and conglomerates. The following faunal assemblage is recorded in the limestones and sandstones: *Colicoras sarthasense Boyle, Plesiopiocus subbauga Pchel., Neithea cf. quinquecjstata Sow., Exogyra columba, Oligoptyxis ornata, Trochactaeon matensis, Hedbergella aff. infracretacea*, etc.

Various facies of the Cenomanian stage are occurring in the structure of Goycha-Hakari zone as well. In Toraghaychay trough, faunistically justified mudstones belonging to three Cenomanian substages are combined in the ***Aghdaban suite***, which includes 165-275 m thick strata of Lower-Middle Cenomanian carbonate shales and argillites in the bottom, and 60-165 m thick alternation of Upper Cenomanian carbonate shales and argillites with sandstones in the top. In Saribaba trough (Figure 13), Lower-Middle Cenomanian complex is corresponds to the ***Charakdar suite*** of tuffaceous sandstones, limestones, marls and gravelites (150-270 m). In the same trough Upper Cenomanian series is composed of 5-80 m thick succession of shales, argillites, sandstones and serpentinite gravelites. This stratigraphic interval contains multiple fragments of serpentinites, dunites, gabbro-amphibolites, radiolarites, limestones and marbles, and distinguished as the ***Tilloidal horizon***.

Cenomanian stage of Gafan zone is represented by 20-495 m thick ***Sheylanly suite***, stratotype section of which exposes in the same-named village's vicinities and consists of faunistically justified three substages. The suite is constituted of the alternating limestones, sandstones and argillites and conglomerate beds.

In all outcrops, the age of Cenomanian sediments is confirmed accordingly to the typical fossils recorded in the sections: 1) Lower Cenomanian complex contains faunal assemblages of *Edhemia edhemi Alij., Vavulineria lenticula Reuss., Hedbergella infracretacea Glaesn., H. globigerinellinoides Subb., Thalmanninella brotzeni Sigal, Striataella cenomana Agal., Purosia cf. dschumiensis (Sim., Bac. et Sar.), Neohibolites ultimus Orb.*, etc; 2) Middle Cenomanian contains the following fossils: *Mantelliceras cf. mantelli Sow., Gyroidinoides nitidus Reuss, Gavelinella cuvillieri Carb., Praeglobotruncana touragatchaiensis Alij.,*

Figure 13. Outcrop of Cenomanian succession: Tutgunchay river, southwestern limb of Saribaba trough

Hedbergella amabilis Loeb. et Tapp., Hyploplites crassafalcatus Sem., etc.; and 3) Upper Cenomanian contains remnants of *Gavelinella vesca Bykova, Cibicides gorbenkoi Akim., Hedbergella delrioensis Cars., Gyroidinoides cf. nitidus Reuss., Puzosia cf. planulata Sow., Praeglobotruncana cf. stephani Gand., Neithea quinquecostata Sow., Guembelitria cenomana Kell., Acanthoceras cf. rothomagense Defr., Amphidonta Columba plicatula Lam.*, etc.

Turonian, Coniacian and Lower Santonian stages. In Goycha-Hakari zone, the Upper Cenomanian Tilloidal horizon is gradually transiting to the 650-1700 m thick **Olistostrome strata**. The strata's section is composed of the alternating serpentinites, dunites, gabbro-amphibolites, radiolarites, limestones and marbles with the olistolith and olistostrome consisting of shales, argillites, muddy schists, siltstones and carbonate sandstones. Argillites contain numerous typical Turonian-Lower Santonian fossils, e.g. *Anomalina berthelini Kell., A. anomalinoides Brotz., Globotruncana fenzi Gand., Gl. lapparenti Br., Gl. bulloides Volog., Lenticulina ponti Cushm., Heterohelix pseudotessera Gushm., Gyroidina nitida Rss., Gyromorphina allomorphinoides Reuss*, etc.

Turonian sediments are quite rarely occurring in the Garabagh's territory. Their complete section is recorded in the troughs within Lok-Garabagh area. Lower substage (***Dashkend suite***) is constituted of 80-175 m thick strata of limestones, which unconformably overlap the eroded Cenomanian surface and contain scarce layers of gravelites, sandstones, tuffaceous sandstones and shales. Upper substage (***Chaykend suite***) is recorded in the Aghjakend trough, and mainly composed of limestones, and partly gravelites, tuffaceous sandstones, tuffs, shales, andesitic -basaltic porphyrites and their pyroclasts (41 m). Within the Aghjakend trough the Upper Turonian sandstones, tuffaceous sandstones, tuffs and limestones are recorded in Kichik Garabay village's surroundings, whereas the Lower Turonian carbonate argillites, sandy marls and tuff conglomerates occur in the Hadrut syncline (145 m). Following fossils are present in the Turonian complex: 1) Lower Turonian *Caprinula cf. sharpei Choff., Radiolites peroni Choff., Durania arnaudi Choff., Pseudomisalia bicarinata Pchel., Actaconella azerbaidjanica K.Aliyev*, etc.; 2) Upper Turonian *Amphidonta columba shaperi Bayle, Haustator sp.in, İnoseramus inconstans lueckendorfensis Trog., İ. crippsi Mant., İ. dunveganensis Nolcarn*, etc.

Turonian rocks of Goycha-Hakari (***Nadirkhanly suite***) are only exposed in Saribaba trough in the valley of the Tartar river and in the vicinities of Nadirkhanly and Gilinjli villages. Confined to the olistostrome stratas' bottom, the suite consists of 110 m thick argillite bed with olistoliths and olistostromes from ophiolitic series. Presence of echinoidea fossils (*Conulus subrotundus Mant., C. suconicus Orb., Micraster leskei Desm., M. cortestubinarium Goldf.*) in its section allows dating the suite as Late Turonian – Early Coniacian.

Within the Hochaz and Chaylaggala troughs located in Gafan zone, the stage is composed of the Lower and Middle Turonian ***Hochazsu suite*** consisting of conglomerates, gravelites, shales, marls, limestones and sandstones (90-120 m). The suite contains fossils *Stensioina praeexsculpta, Whitenella holzli, Globotruncana renzi etc., Gl. ex gr. inornata Bolli, Praeglobotruncana stephani, Helvetoglobotruncana helvetica*, etc.

Coniacian stage in Garabagh is subdivided into lower and upper portions in the Garabagh area. In the Lok-Garabagh zone Lower Coniacian series (***Garabulag suite***) transgressively (in some sections with basal conglomerates) overlap the Lower Cretaceous, Cenomanian and Turonian successions of Aghjakend and Aghdara troughs. The suite is consisting of 100-150 m thick strata of calcareous sandstones, tuffaceous sandstones, shales, tuffs and conglomerates, which contain fossils *Neogaudriceras denseplicatum, Haustator kurdistanensis, Actaeonella crassa, Inoceramus wandereri*, etc. In this area the Upper Coniacian sediments (***Injachay suite***) consist of 50-150 m thick shale, sandstone, tuffaceous sandstone, gravelite and marl beds with faunal assemblage

İnoceramus involutus, Valvulineria cretacea, Heterohelix striata recovered from the section. Coniacian deposits are also occurring in a large part of Khojavand trough, where they form 75-147 m thick strata of Lower-Upper Coniacian muddy sandstones, calcareous and sandy muddy marls. Following fossils are recorded in the Coniacian section: *Rugoglobiguina ordinaria, Globotruncana lapparenti etc., Hastigerina aspera, H. globifera, Histiastrum aster, Drepanochelus cf. complexus etc*., *Gavelinella thalmanni, Striatella porosa,* etc.

In Goycha-Hakari zone Coniacian sediments form the middle part of the olistostrome strata. In Toraghaychay trough, they are comprised of 40-175 m thick ***Bulanligsu suite*** composed of the alternating limestones, argillites, siltstones, sandstones, marls, tuffaceous sandstones and tuff gravelites. In Saribaba trough Coniacian and Lower Santonian series together form 200-210 m thick ***Garabayli suite*** consisting of tuffaceous sandstones, marls, sandstones and shales, containing fossils *Globotruncana chalilovi, Striatella striata, Heterohelix globulosa, Trigonoarca quadrans, Cardium productum etc*., *Dorysphaera armenica, Dictyomitra torquata, Thanaria veneta,* etc.

Finally in Gafan zone (Hochaz syncline - Figure 14), Coniacian stage forms the ***Dolanlar suite*** mainly represented by the alternation of limestones, calcareous sandstones, marls and argillites (40-100 m). The suite contains typical fossils *İnoceramus inconstans, İn. crassus, Globotruncana subbotinae, Striatella striata etc., Actaeonella gracilis, Trochactaeon angustatus, Protocardia cf. hillana,* etc.

Santonian stage occurs in all sections through its lower and upper substages characterized by facies variability. In the Aghdara trough of Lok-Garabagh zone the Lower Santonian rocks form the ***Todan suite*** comprising the volcanic sedimentary complexes recorded in the basins of Kurakchay and Goshgarchay rivers. Stratigraphically deeper portion of the suite consists of the basalts, andesitic basalts and andesitic porphyrites alternating with tuffs, tuffaceous sandstones, tuff siltstones and tuff gravelites, and its upper portion composed of tuffs, shales, limestones, tuffaceous sandstones, sandstones and porphyrites interbedded with lava breccias (100-550 m). The suite's volcanic complex pinches out in the southeast, leaving only sedimentary formations to be present in the profile.

Figure 14. Outcrop of Coniacian and Santonian rocks: Hochaz trough, the ruins of Hochaz village (left bank of Hochazsu river)

The suite includes the alternating shales, sandstones and marls in the areas of Yukhari Aghjakend and Gulustan (50-85 m), and shales, marls and limestones in the Agdere trough (20-85 m). In Khojavand and Hadrut troughs, effusive-pyroclastic rocks in volcanic sedimentary complex belonging to the Todan suite, is composed of the alternating basalts, plagiobasalts and porphyrites with tuffs, tuff breccias, volcanic breccias, tuff conglomerates and agglomerates. The suite displays gradually reducing thickness from 600-750 m in the troughs' centers to 10-15 m in their limbs, and facial transition to sedimentary-pyroclastic rocks (tuff-gravelites, tuffaceous sandstones, tuffs, tuffites, marls and limestones).

Upper Santonian deposits (***Shorsu suite***) are relatively less developed within the Aghjakend trough, and composed of tuffaceous-sedimentary complex consisting of the tuffs, tuffites interbedded with limestones, sandstones, shales, marls and tuff gravelites (10-140 m). In some places basal conglomerates are recorded at the section's bottom. In Aghdara and Khojavand troughs the suite's section contains 30-180 m thick strata of limestones, marls and shales. In all outcrops the age of Santonian rocks is justified accordingly to the typical faunal complex, which includes: 1) Lower Santonian *Caudruina piramidata Cushm., Discorbis anellus Alij., Gyroidinoides turgibus obliquaseptata Mjatl., Globotruncanella chalilovi Alij., Valvulineria agdjakendensis Alij., Eponides concinnus Brothz., Planulina lundegreni Brothz., Globotrunkana ventricosa White, Striatella santonica Agal., Osangularia whitei Brothz., Planoglobulina eggeri Cushm., Metacerithium amudariensis Pchel., Drepanochilus complexus Pchel.*, etc; 2) Upper Santonian *Stensioina exculpta Reuss, Eponides guelistanensis Alij., Globotruncana subarca Alij., İnoceramus goldfussi Orb., Verneuilina bronni Reuss, Massonella oxycona Reuss, Gyromorphina allomorphinoides Reuss,* etc.

As discussed, Lower Santonian and Coniacian successions form the upper part of the ***Olistostrome strata*** in Goycha-Hakari. The stratas' section is comprised of shale, argillite and siltstone beds containing serpentinite, dunite, gabbro-amphibolite, radiolarite, limestone beds as well as the marble olistoliths and olistostromes. The upper portion of the section is constituted of carbonate shales. Age of the rocks is determined by a presence of typical microfauna fossils such as *Anomalina anomalinoides Brotz., Globotruncana lapparenti Br., Gl. bulloides Volog., Bulimina ventricosa Br., Gyroidina nitida Rss., Gyromorphina allomorphinoides Reuss, Globorotalites michelinianus Reuss*, etc.

The upper Santonian sedimentary rocks are characterized by the facial heterogeneity in various sections. In Toraghaychay trough in their section a relatively thin (30-50 m) ***Mahuchay horizon*** consisting of gravelites, sandy and clastic limestones is distinguished. 100-130 m thick Upper Santonian succession developed in the Saribaba trough's limits constitutes the ***Yurtiyal suite***, the basal conglomerates of which transgressively overlap the Olistostrome strata's surface. The Olistostrome strata are composed of alternating gravelite, sandy and clastic limestones with tuff conglomerate, tuff breccia, andesite and andesitic basalt beds. Age of the suite's lower portion is determined by the typical fossils *Gryphaea vesicularis vesicularis Lam., G. vesicularis valaticus, Orbitoides tissoti Schlumb., Or. tissoti douvillei Silvest., Or. tissoti densa Neum*.

Recorded within the Hochaz trough (Gafan zone) 700-1200 m thick Lower Santonian volcanic sedimentary series (***Lachin suite***) consist of two portions. The suite's 300-400 m thick lower portion contains the volcanic sedimentary rocks (tuff conglomerates, tuff breccias, tuffites, sandstones, siltstones and argillites), and its 400-800 m thick top portion is represented by pyroclastic-sedimentary complex (e.g. agglomeration lavas, tuff lavas, lava breccias, tuff conglomerates, tuffites, tuff gravelites, tuffaceous sandstones, etc.). Thickness of this volcanic sedimentary series gradually reduces (35-120 m) towards the trough's margins, and in some sections transition to the terrigenous-carbonate facies is being observed. The suite's sandstones and tuffaceous sandstones contain typical Lower Santonian fauna, e.g. *Actaeon subovum Pchel., Spondylus reguienianus d'Orb., Neithea quinquecostata Sow., Orbignya microstyla Douv. var., Vernuilina bronni Reuss, Stensionia emscherica Barysch., Globotruncana cubbotinae Al., Globotruncanella chalilovi Alij.*, etc.

In Hochaz trough the Upper Santonian section (***Tulusdagh suite***) usually starts with basal conglomerates and passes upward to alternating gravelite, muddy and sandy limestones, carbonate gravelites, sandstones and tuffites (130-260 m). The age of the sediments is confirmed by a typical faunal complex including *Gryphaea vesicularis vesicularis Lamarck, G. vesicularis valaticus Chal., Praesorites moureti Douv., Orbitoides tissoti Schlumb., O. tissoti var. douvillei Silvestri*, etc.

Campanian deposits (***Tulakdagh suite***) occur in the Aghjakend and Aghdara troughs (Lok-Garabagh zone). Sediments are composed of pelitomorphic, sandy, muddy limestones interbedded with marls, shales, bentonite shales and sandstones (30-410 m). Presence of typical fauna in some Campanian sections allows dividing the stage into upper and lower substages. In some outcrops only Lower Campanian sediments have been preserved.

In Ganjachay-Kurakchay interfluves mandelstone containing porphyrites, tuffs and tuff breccias are recorded at the base of limestones.

In Khojavand trough the stage is represented by its lower (***Dahraz suite***) and upper (***Asgaran suite***) substages. Besides the basal conglomerates Dahraz suite is expressed in carbonate facies (limestones and marls) intercalating with by sandstone-siltstone-argillite beds (250-580 m). Middle portion of the section contains volcanic strata, which are composed of andesite and andesitic - basaltic tuffs, tuff conglomerates and tuffaceous sandstones rarely interbedded with pelitomorphic limestones (130-150 m). Less developed Asgaran suite contains a layer of basal conglomerates, and consists of the alternation of carbonate tuffites and sandy limestones (35-80 m). Following faunal complex have been recovered from the Campanian section in Lok-Garabagh zone: 1) Lower Campanian *Pseudofaster caucasicus L.Dru., İnoceramus decipiens Zitt., İn. agdjakendensis Aliev, İn. gandjaensis Aliev, İn. bulgaricus Tsag., Micraster schroederi Stoll., M. coravium Posl.* etc.; 2) Upper Campanian *Pseudoffaster caucasicus Dru., Orthaster alapliensis Lamb., İnoceramus cf. convexus Hall. et Meek., İn. regularis Orb., İn. lingua Goldf., Bostrichoceras aff. sohlcenbachi Faure., Hoplitoplacenticeras coesfeldiense Schl., Galeola papillosa Klein*, etc.

Within the Toraghaychay trough located in the Goycha-Hakari zone Campanian succession is recorded in Shahdagh range beyond the Garabagh territory. In this area the stage is represented by the ***Darvadagh suite*** that is divided into two portions. The lower subsuite that contains fossils (*Micraster coravium Posl., Echinocorys ovatus*) in its section, is composed of gravelitic, sandy and detrital limestones (20-90). The upper subsuite is represented by siliceous and sandy limestones with tuffaceous material in their composition (140-150 m). These limestones contain the Upper Campanian fossils *Najdinothyris bakolovi Bonc., Pseudoffaster caucasicus Dr., İnoceramus balticus Boehm., İ. Salisburgensis Fugg. et Kasth., İ. pertenius Meek, Micraster schroederi, Globotruncana arca*, etc.

In Saribaba trough the Campanian sediments are recorded together with Lower Maastrichtian deposits, where they form the ***Gonur suite*** built by the alternation of sandy and siliceous limestones rarely interbedded with medium conglomerates and andesite beds (200-470 m). The suite's limestones contain fossils *Cunulus matesovi Mosk., Coraster cubanicus Mosk., C. caucasicus Mosk., Seunaster gillieroni Lor., Echinocorys pyramidatus Portl., İsomicraster cyliensis, İnoceramus balticus Boehm., İ. regularis Orb., İ. aff. bara bini*, etc.

In Gafan zone Campanian deposits are mainly composed of carbonate facies (***Gubadly suite***). Represented by the Lower Campanian sediments in the central and southeastern parts of the Hochaz trough the suite consists of limestones and marls (*Micraster cf. schroederi, Echi-*

nocorys marginatus, inoceramus) in the lower, and sandy and pelitomorphic limestones in the upper portion of its 15-70 m thick section (Figure 15). Foraminiferas *Globotruncana arca, Heterohelix globulosa* and sea urchins are recorded in the pelitomorphic limestones. Complete section of the suite is observed in the trough's southwestern segment on the right bank of Bargushadchay river (Gubadly town's vicinities). The lower subsuite is composed of alternating pelitomorphic, sandy limestones, shales, marls and sandstones (45-65 m). The upper subsuite includes tuffs and tuff breccias as well as sandy, sometimes pelitomorphic limestones and marls with the interlayers of porphyrites (40-50 m). Following fossils have been recorded in the suite's section: *İnoceramus brancoi Wegn., I. azerbaidjanensis Aliev, I. balchiiHayd et Meek., I. balticus Boehm., Paronaster cf. cupiliformis Aur.*; üst yarımlay dəstəsi – *Galeola pappilosa Kleinş, G. cf. senonensis d'Orb., Ornithaster cf. sokolovi Mosk., Isomicraster poslavskajae Mel., Conulus azerbaidjanensis Mel. et Ask.*, etc.

Maastrichtian series have been found in carbonate facies within the Lok-Garabagh zone's boundaries. Being less occurring than the Campanian succession, Maastrichtian stage is represented by its Lower (***Gargarchay suite***) and Upper (***Aghjakend suite***) substages.

In Aghjakend and Aghdara troughs the Gargarchay suite contains the massive limestones with thin carbonate shale and tuff interlayers (35-90 m). In the basin of Ganjachay river the suite contains basal conglomerates, and transgressively overlaps the Campanian succession. In Khojavand (Figure 16) and Hadrut troughs marls and marly limestones prevail in the suite's bottom portion, whereas the upper part of the section is mainly composed of gravelite limestones and carbonate tuffites (55-60 m).

The Upper Maastrichtian Aghjakend suite occurs in Aghjakend and Aghdara troughs, and is built by gravelite and sandy dense limestones (35-100 m). In Khojavand trough the suite is constituted of muddy, sandy limestones with the tuffite and argillite interlayers (75-290 m).

The age of the Maastrichtian complex in Lok-Garabagh zone is determined accordingly to the following fauna recorded in its section: 1) Lower Maastrichtian *Seunaster altus Seunes, Homocaster tunetanus Pomel., Galerites vulgaris minor Schulz, Austinocrinus erkerti Dames, Pseudoffaster caucasicus Prieq., İnoceramus regularis Orb., Verneulina kelleri, Tritaxia jarvisi, Pullenia coryelli*, etc.; 2) Upper Maastrichtian *Eohinocorys ciplensis Lanel., Cyclaster cf. integer Seunes, Coraster vilasovae Cotteau, Homocaster evaristel Cotteau, Seunaster lamberti Seunes, Schinocorys arnoidi Seunes, Pycnodonta vesicularis,* etc.

Figure 15. Outcrop of Campanian succession: Hochaz trough, to the east from Aghbulag village (the cliffs on the left bank of Ildidimsu river)

Figure 16. Outcrop of Maastrichtian deposits: Khojavand trough, Khanabad village on the left bank of Gargarchay river

Within the Toraghaychay trough (Goycha-Hakari zone) Maastrichtian outcrops are recorded mainly the Garabagh's territory (area of north-western Shahdagh), and sometimes on the trough's southeastern margin on the left coast of the Sarsang water reservoir. Accordingly to lithologic and faunistical characteristics the ***Gojadagh suite*** is separated from the Maastrichtian succession. The lower portion of the suite consists of pelitomorphic and sandy limestones (35-40 m), and the upper portion is built by limestones with multiple beds of detrital and gravelite limestones and carbonate tuffites (25-30 m). Age of the suite is determined accordingly to the following recovered fauna: *Belemnetella langei Schatsk., Simploorbites gensacieus secaus Leum., S. gensacieus popaniformis Reng., Orbitella apiculata segmentoides Reng., O. apiculata aplanta Reng., Lepidorbitoides socialis regularıs Leum.*, etc.

In Saribaba trough the Upper Maastrichtian sediments (***Chichakli suite***) are recorded in the various parts of the structure (Figure 17). This 40-170 m thick suite is mainly composed of gravelite and pelitomorphic limestones with numerous fossils *Orbirhynchia vespertilio, Pseudopyrina bourgeoisi, Echinocorys vulgaris, Lepidorbitoides socialis, İnoceramus regularis Orb.*, etc.

Figure 17. Outcrop of Maastrichtian deposits: Saribaba trough, Tutgunchay canyon

In the Hochaz depression located in the Gafan zone the stage comprises the ***Aghgaya suite*** containing gravelite, sandy pelitomorphic and siliceous, sometimes organic-detrital limestones (30-280 m). The suite's age is confirmed by the following faunal assemblage: *Orbitella apiculata, Orbitoides tissoti Schumb., Seunasteu georgious Rouch., Homocaster sls Fugg. et Kasta., Diplamoceras cylinduaceum Defz. var. ivevensis Mic., İnoceramus aff. barabini Mortin., İn. balticus Bohm.*, etc.

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QARABAĞ. SRTATIQRAFIK ESSE
Oçerk I: Mezozoy

T.N. Kəngərli, A.D. Babazadə

Məqalədə Azərbaycanın qərb regionlarından olan Qarabağ diyarının geoloji quruluşunda iştirak edən Yura və Təbaşir struktur-maddi komplekslərinin litoloji-stratiqrafik kəsilişlərinin Azərbaycan geoloqları (həm elm xadimləri, həm də keçmiş Geologiya və Təbii Ehtiyyatlar Komitəsində çalışan mütəxəssislər) tərəfindən uzun müddət ərzində öyrənilməsinin nəticələri əks olunur. Bu nəticələr müəllif tərəfindən Azərbaycanın stratiqrafiya kodeksinə əsaslanaraq təftiş edilmiş və ümumiləşdirilmiş, nəticə olaraq müasir Ümumi və Beynəlxalq Stratiqrafik Cədvəllər əsasında adı çəkilən komplekslərin yerli stratiqrafik bölgüsü, ayrılan stratiqrafik vahidlərinin (lay dəstələrinin) təsviri və paleontoloji əsaslandırılması verilmişdir. Bu məlumatlar ilk dəfə olaraq ingilis dilində təqdim edilir və geoloji kəsilişlərin stratiqrafik korrelyasiyası və regional ümumiləşdirmələr məqsədilə Cənibi Qafqazda yer səthinə çıxan Mezozoy kompleksinin litoloji-stratiqrafik xüsusiyyətləri ilə maraqlanan xarici geoloqlar üçün yığcam və dolğun məlumat bazası kimi qəbul edilə bilər.

КАРАБАХ. СТРАТИГРАФИЧЕСКОЕ ЭССЕ
Очерк I: Мезозой

Т.Н. Кенгерли, А.Д. Бабазаде

В статье освещены результаты изучения литологии и стратиграфии юрского и мелового структурно-вещественных комплексов, участвующих в геологическом строении Гарабага - одного из западных регионов Азербайджана, осуществлявшихся большой плеядой азербайджанских геологов (как деятелей науки, так и специалистами бывшего Комитета по геологии и природным ресурсам) на протяжении многих лет. Автор взял на себя смелость осуществить ревизию и обобщение этих во многом разрозненных материалов, основываясь на Стратиграфическом кодексе Азербайджана. При этом осуществлено структурно-фациальное районирование региона с описанием стратиграфических подразделений, а также выделением и палеонтологическим обоснованием местных стратиграфических единиц (свит) на базе современных Общей и Международной Стратиграфических Шкал. Эти данные, впервые представляемые на английском языке, могут послужить сжатой, но насыщенной базой данных для представителей международной геологической общественности, интересующихся литологией и стратиграфией мезозойского комплекса Южного Кавказа в целях осуществления региональных обобщений и стратиграфической корреляции геологических разрезов.

SULFIDE MINERALIZATION OF THE MUD VOLCANOS IN AZERBAIJAN

The article discusses conditions of formation of the iron sulfides recorded in the breccia of 19 mud volcanoes within the Azerbaijan territory, and represented by pyrite, marcasite, chalcopyrite, sphalerite, wurtzite and millerite. The detailed characterization of pyrrhotine is also given in the paper.

Keywords: mud volcano, iron sulfides, mineralization

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Introduction

Sulfide mineralization in the mud volcanic breccia is a well-known fact in Azerbaijan. Mud volcanic breccia appears to contain multiple inclusions of pyrite and marcasite. These minerals were recorded during one of the first mineralogical surveys conducted by P.P.Avdusin (1939, 1948). As it was stated by the survey, occurrence of pyrite and marcasite is accompanied by release of the amorphous forms of hydrotroilite. Another sulfide that was recorded during this survey is chalcopyrite, but its origin hasn't been discussed. Pyrrhotine was not mentioned in the publication on the Avdusin's survey results.

Methods

Our studies covered 19 mud volcanos of Azerbaijan (Figure 1) selected by Ad.A.Aliyev. From each mud volcano breccia 30-35 kg weighing samples were collected, and cleaned from mud fraction. Remaining after cleaning material was disintegrated in bromoform (d=2.9 g/cm^3). Heavy fraction was consecutively divided in a magnetic field, and the electromagnetic fraction was produced. Light fraction was studied separately by using the methods of electronic microscopy and microprobe analysis. Implemented by V.V.Permyakov at the laboratory of the Institute of Geological Sciences, NASU (National Academy of Sciences of Ukraine) these studies deployed the electronic microscope SEM JSM 6490ZV Jeol (Japan) with integrated electron-probe analysis system of JNCA Energy.

Abundance of pyrite's manifestations, saturation of breccia by a pyrite, diversity of its appearance and variability of pyrite's' chemical composition make it necessary to develop separate and detailed description of this mineral in connection with the genesis of ore minerals in the volcanic breccia.

According to A.G.Betekhtin (1950), ferrous disulfide (pyrite) emerges under high H_2S content of the original fluids, meanwhile reduced H_2S content leads to creation of monosulfide - pyrrhotine FeS. In our opinion, pyrrhotine is a higher-temperature analogue of pyrite.

It ought to be noted that during our volcanic breccia research, we recorded pyrrhotine in many of the studied volcanos. Presumably, H_2S content in the mud volcanic fluids was far from being homogenous, and different areas and spots with low H_2S content must have episodically emerged, causing the development of pyrrhotine in a limited number of spots within the breccia of various volcanos. Often pyrrhotine forms separate isolated grains (Figure 2), but sometimes it creates framboidal conglomerations (Figure 3) or spherules of the lamellar crystals (Figure 3, b).

When studying this mineral, our attention was attracted to the crystallographically well expressed hexagonal-like thin lamellas of pyrrhotine, most frequently developed on Durovdagh and Ayrantokan volcanoes (Figures 4-8). Such lamellas are quite large and may reach 250 microns by a long axis and 10 microns in thickness. They have sharp edges and hexagonal lamella-like forms. Initially it was even assumed the pseudomorphosis of pyrrhotite on biotite, but later this hypothesis was repudiated as the discovered lamellas were clean and contained no signs of alteration. Sometimes, obviously younger sediments of cubical-shaped pyrite are developed close to the lamellar pyrrhotine conglomerations.

Figure 1. Map of mud volcanoes covered by sampling (Ad.A. Aliyev et al., 2004).

1 – Damirchi, **2** – Kichik Maraza, **3** – Pirakashkul, **4** – Deveboynu, **5** – Bozdagh-Guzdak, **6** – Nardaranakhtarma, **7** – Cheyildagh, **8** – Aghdam group, **9** – Shakikhan, **10** – Dashmardan, **11** – Akhtarmaardi, **12** – Boyuk Harami, **13** – Pilshila-Garadagh, **14** – Ayrantokan, **15** – Dashgil, **16** – Bahar, **17** – Durovdagh, **18** – Duzdagh, **19** – Neftchala Pilshilasi

According to their chemical composition, all of the described lamellas, except for one particular case, are typical monosulfides containing more sulfur than the iron. Framboidal pyrrhotine has a formula of $Fe_{0,80}S$; pyrrhotine lamellas are described by formulas of $Fe_{0,95}S$; $Fe_{0,83}S$; $Fe_{0,83}S$; $Fe_{0,99}S$; $Fe_{0,89}S$; $Fe_{0,9}S$; $Fe_{0,986}S$. One, the most likely contaminated sample, has a formula of $FeS_{0,89}$, and its excessive iron content might be explained by native iron admixture.

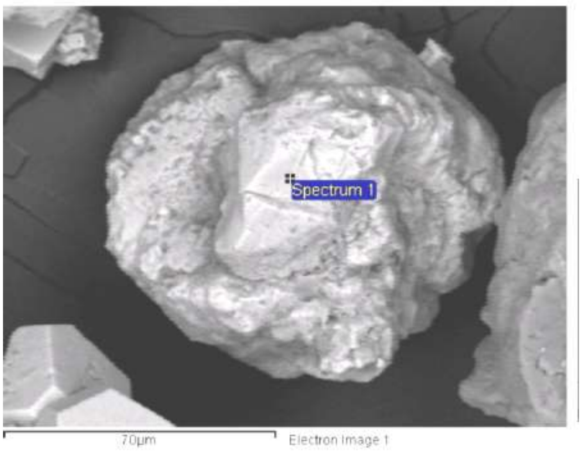
In a number of instances, insignificant admixtures of Ni and sometimes Cu were recorded in the collected samples of pyrrhotine. For example, one sample collected from Pirakashkul volcano contained up to 1.77% of Cu. Extra sulfur and deficit of iron are explained by the fact that a pyrrhotine's lattice contains voids instead some iron. Iron deficit is therefore known to be a sign of pyrrhotine.

Guidelines developed by D.Dena et al. (1951) and A.G.Betekhtin (1950), assert the pyrrhotine's hexagonal syngony as well as its tabular appearance. Marcasite is also tabular shaped, but in our case, it has different chemical composition and crystal habitus.

According to P.Ramdor (1962), pyrrhotine is a hexagonal mineral with FeS formula, mostly characterized by the excessive sulfur that reaches 1/6 of its quantity. Excessive sulfur is interpreted as due to iron deficit. Iron can be replaced by nickel (less than 1%, and up to 13% under laboratory environment), cobalt and manganese. As recorded, lamellas are often formed as a result of solid solutions' decomposition into the twinned forms.

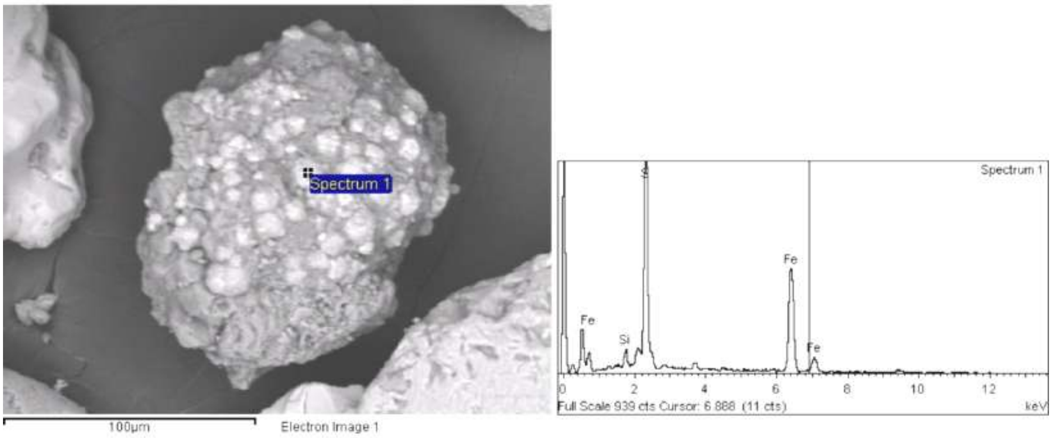
Pyrrhotine was synthesized from iron and sulfur through heating of pyrite to 550ºC in the H_2S atmosphere (Dir and etc., 1966). Monoclinous pyrrhotine was synthesized through the treatment of hexagonal pyrrhotine by sodium bicarbonate with tº = 175–200º. Under all circumstances, this mineral is typical for the endogenous processes. Its casual occurrences in the Kerch's sedimentary iron ores can be characterized as rare exception (Лазаренко, 1970). The author also stated that monoclinous and hexagonal pyrrhotine is usually recorded together, where monoclinous pyrrhotine forms lamellas and narrow veinlets inside the hexagonal one. It is fair to assume that tabular pyrrhotine is apparently the form of monoclinous pyrrhotine.

Solution to the problem was found by recent researches implemented by J.F.W.Bowles and others (2011). It has been revealed that pyrrhotine is a monoclinous (pseudohexagonal) mineral. It's to be supposed that the abovementioned pyrrhotine's pseudohexagonal lamellas record the quite long development stage of cooling deep fluids.



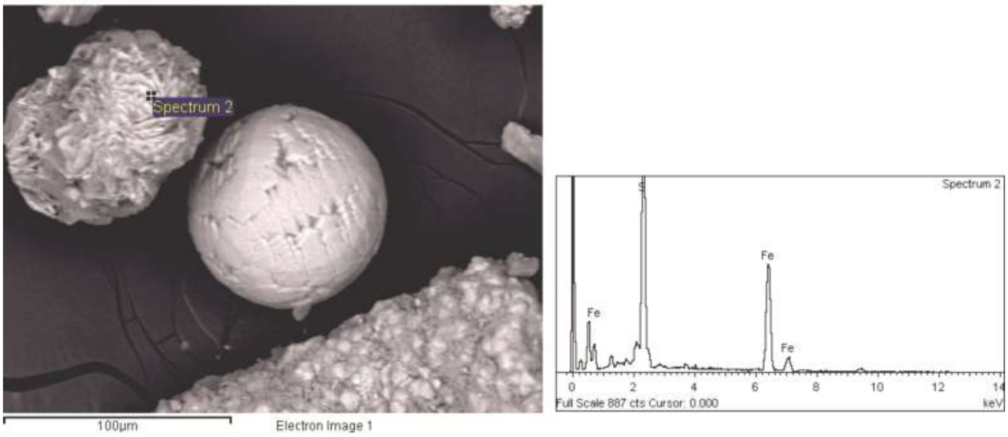
Element	Weight%	Atomic%
S K	43.30	57.08
Fe K	56.70	42.92
Total:	100.00	

Figure 2. Isolated grains of pyrrhotine. Ayrantokan volcano



Element	Weight%	Atomic%
Si K	2.23	3.40
S K	38.20	50.97
Fe K	59.57	45.64
Total:	100.00	

Figure 3, a. Framboidal conglomerations of pyrrhotine. Bahar volcano

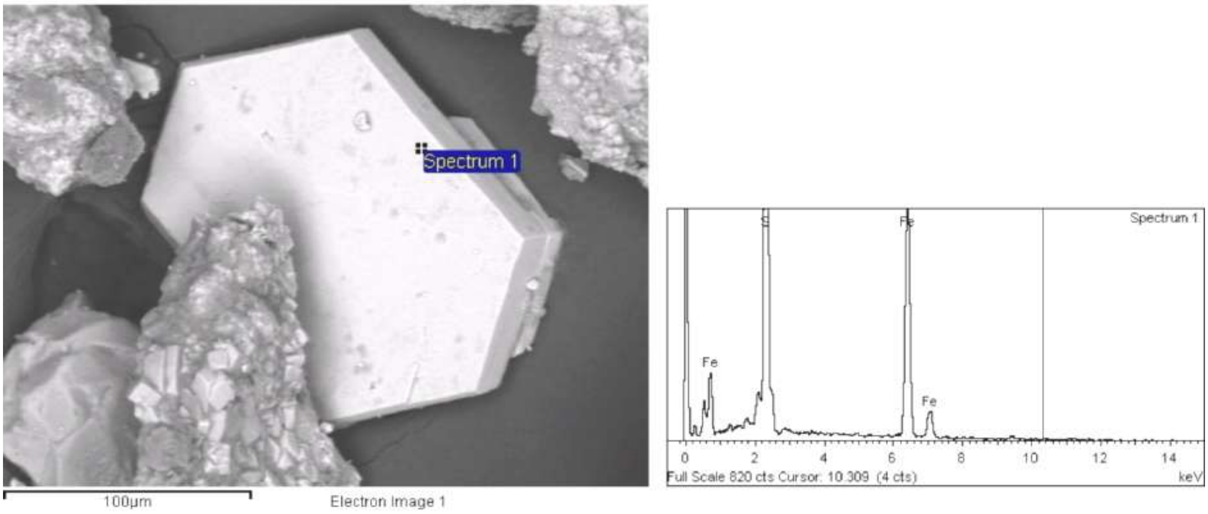


Element	Weight%	Atomic %
S K	41.38	55.15
Fe K	58.62	44.85
Totals	100.00	

Figure 3, b. Spherules of ductile crystals of pyrrhotine. Pirakashkul volcano

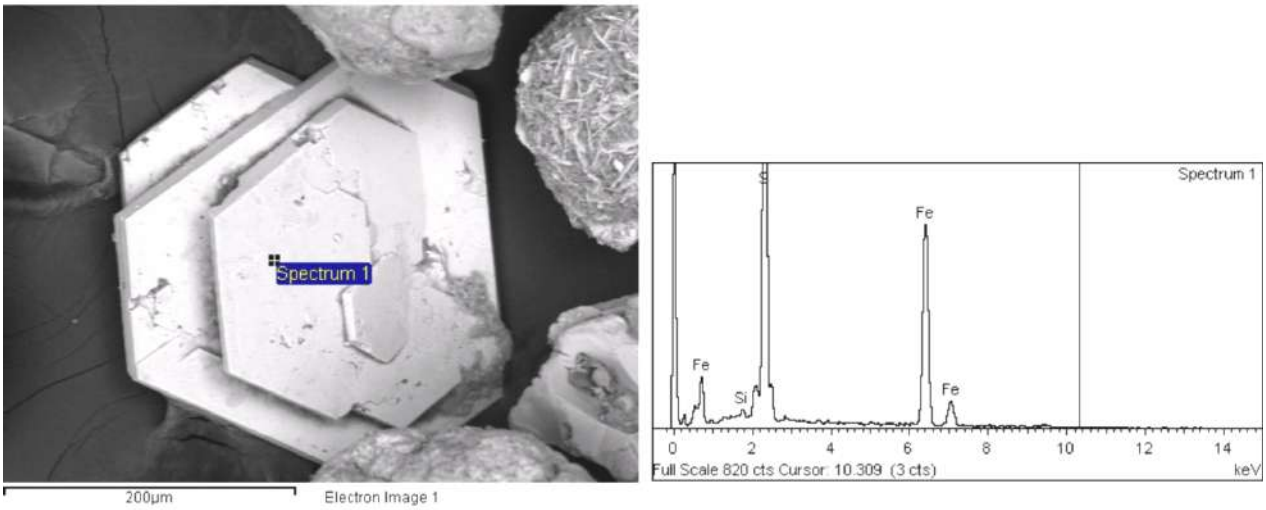
Earlier we spoke about chalcopyrite discovered by P.P.Avdusin (1939) in the mud volcanoes in Azerbaijan. Knowing that this mineral is quite rare in Azerbaijan, we have discovered chalcopyrite in the volcanic breccia of Cheyildagh, where the described mineral forms rounded conglomerations of crystals (Figure 9). Formula of some chalcopyrites is characterized by deficit of Fe.

In Shakikhan volcano, grains are recorded to form a conglomeration of slightly rounded and up to 250 micron large crystals of sphalerite with small admixture of iron (1.35%). Sulfur content in this mineral is little higher than the summary content of Zn and Fe (Figure 10). One fragment of sphalerite crystal is recorded in the volcanic breccia of Pirakashkul, reaching 150 microns by its long axis (Figure 11).



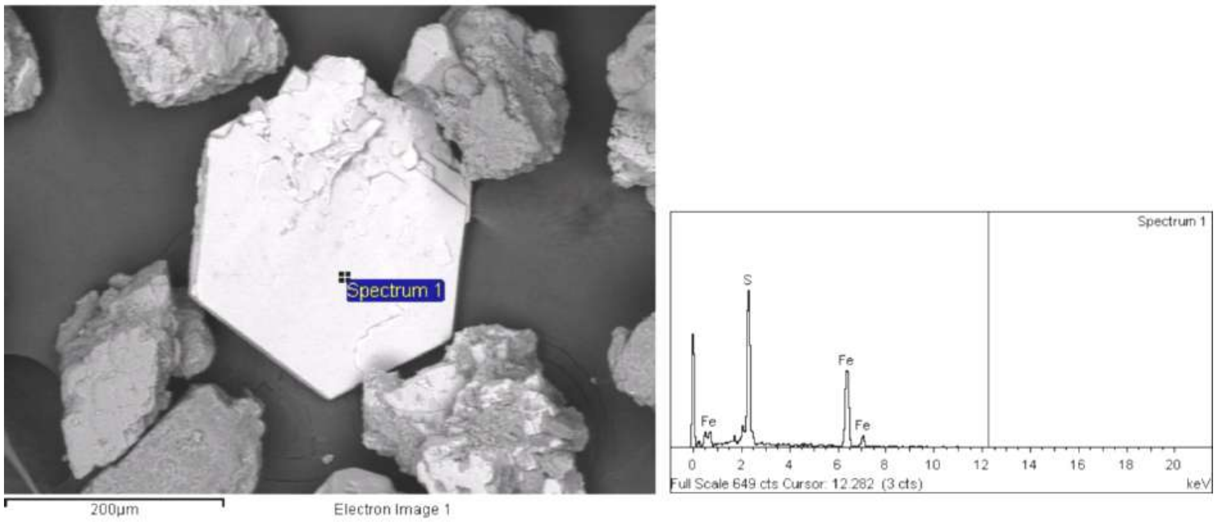
Element	Weight%	Atomic%
S K	39.31	53.01
Fe K	60.69	46.99
Total	100.00	

Figure 4. Pyrrhotine. Durovdagh volcano



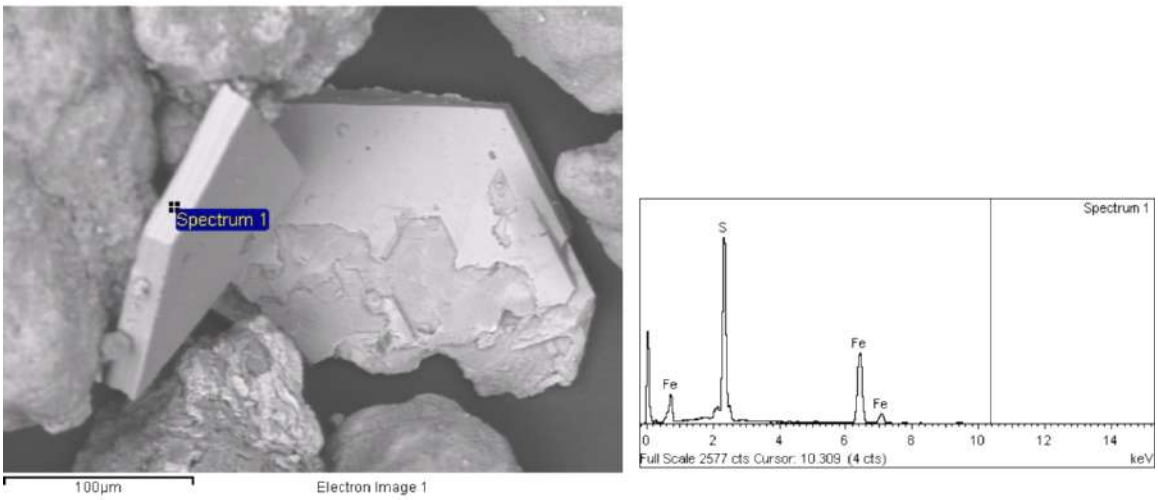
Element	Weight%	Atomic%
Si K	0.57	0.87
S K	39.31	52.78
Fe K	60.13	46.35
Total:	100.00	

Figure 5. Lamellas of pyrrhotine. Durovdagh volcano



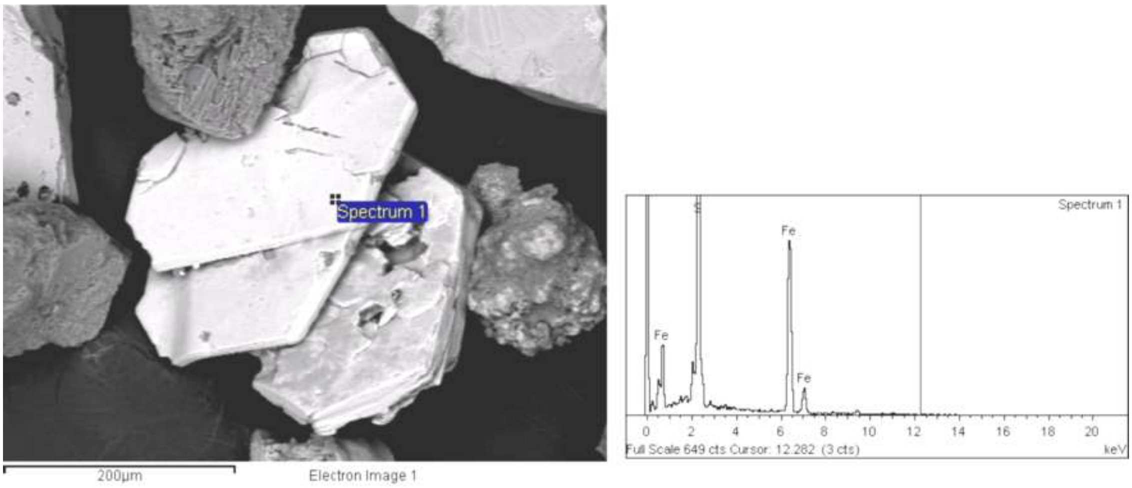
Element	Weight%	Atomic%
S K	37.11	50.68
Fe K	62.89	49.32
Total:	100.00	

Figure 6. Pyrrhotine. Ayrantokan volcano



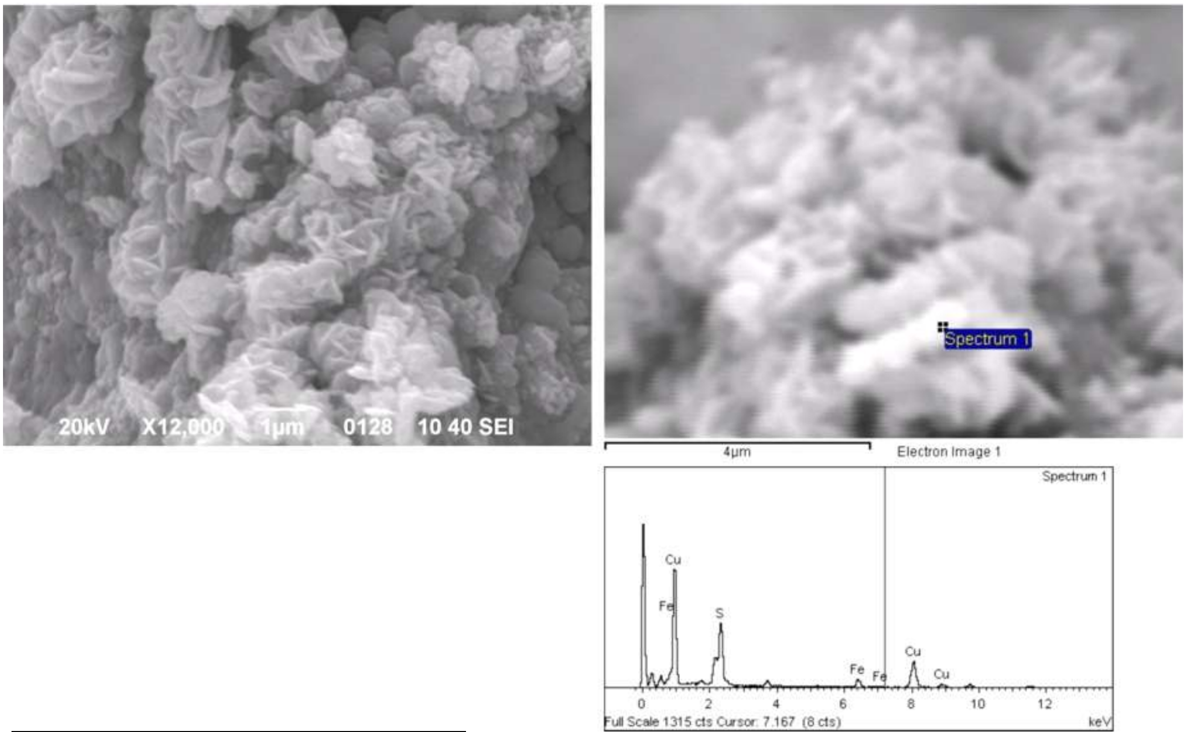
Element	Weight%	Atomic%
S K	41.86	55.64
Fe K	58.14	44.36
Total:	100.00	

Figure 7. Pyrrhotine. Durovdag volcano



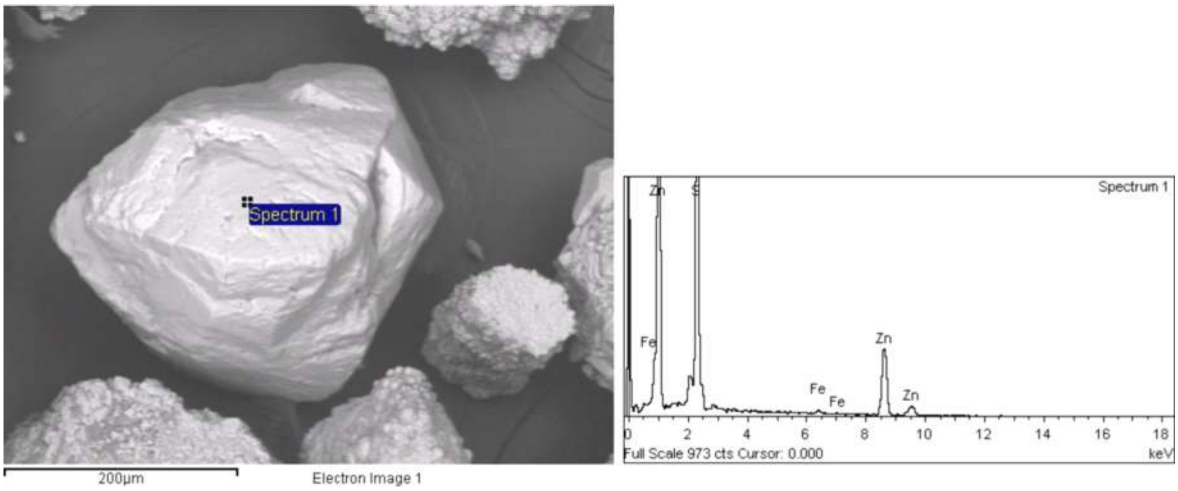
Element	Weight%	Atomic%
S K	41.43	55.19
Fe K	58.57	44.81
Total:	100.00	

Figure 8. Pyrrhotine. Ayrantokan volcano



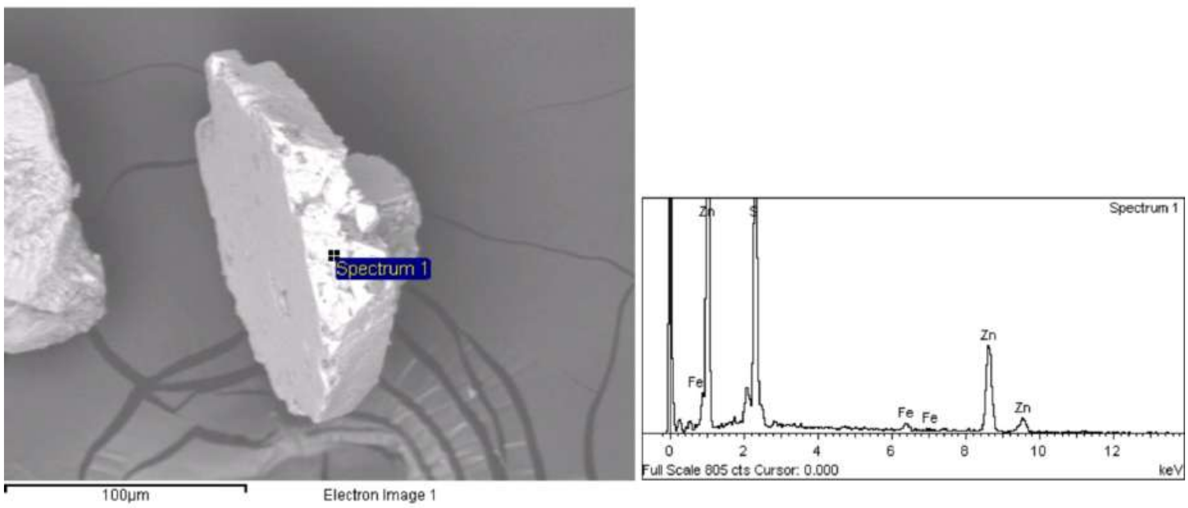
Element	Weight%	Atomic%
S K	37.93	54.34
Fe K	7.96	6.54
Cu K	54.11	39.12
Total:	100.00	

Figure 9. Conglomerations of chalcopyrite crystals. Cheyildagh volcano



Element	Weight%	Atomic%
S K	39.06	56.56
Fe K	1.35	1.12
Zn K	59.59	42.32
Total:	100.00	

Figure 10. Sphalerite. Shakikhan volcano

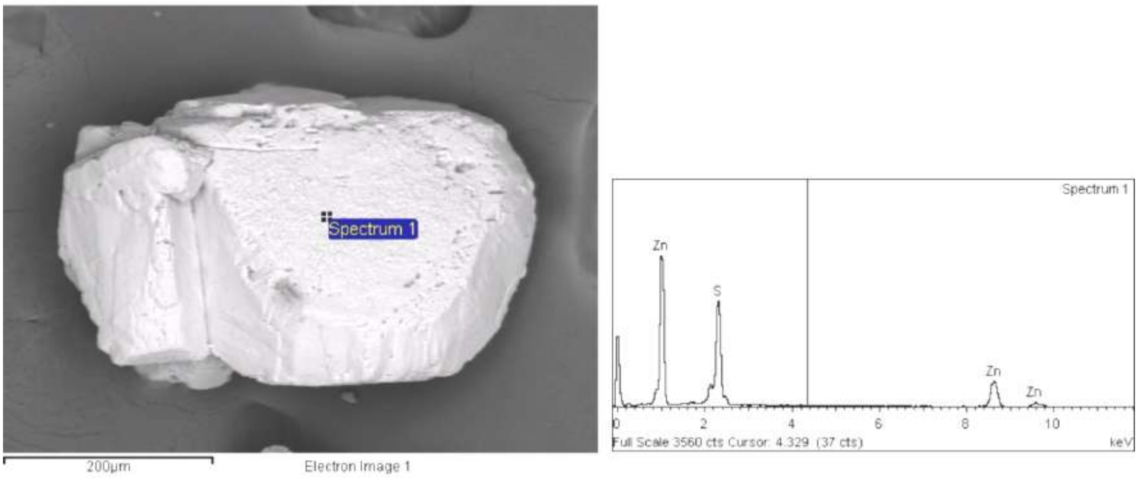


Element	Weight%	Atomic%
S K	31.63	48.43
Fe K	1.77	1.56
Zn K	66.60	50.02
Total:	100.00	

Figure 11. Fragment of sphalerite crystal. Pirakashkul volcano

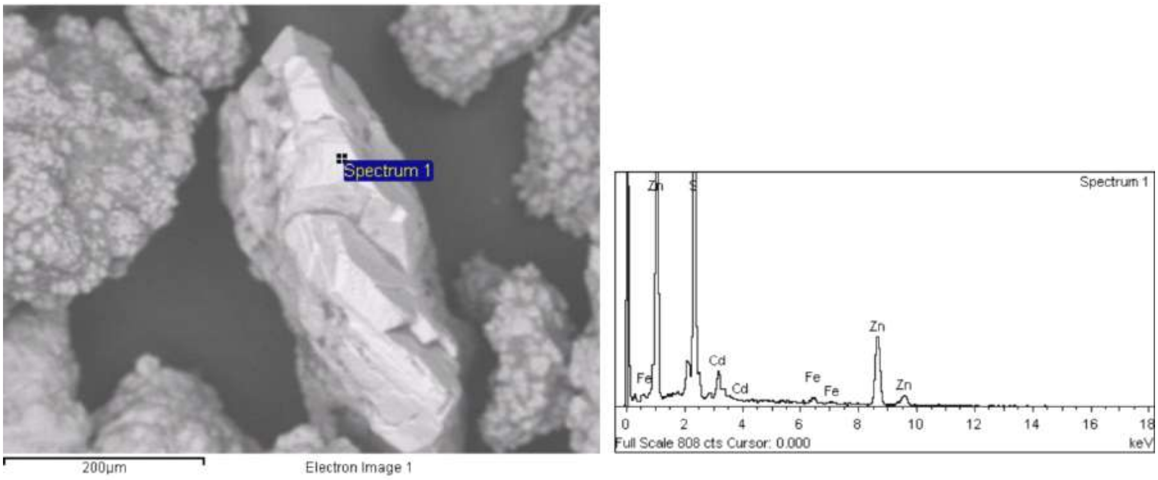
Flattened sprout of sphalerite crystal reaches 250x100 microns (Figure 12).

Wurtzite – cadmium containing hexagonal modification of ZnS, was recorded in the Aghdam volcano's breccia. Its cadmium content is anomalously high. As stated by mineralogical reference books, the cadmium content in wurtzite doesn't normally exceed 3.66%. This is a druse of fine accreted crystals with individual sizes of nearly 300 microns by a long axis (Figure 13).



Element	Weight%	Atomic%
S K	45.03	62.55
Zn K	54.97	37.45
Total:	100.00	

Figure 12. Aggregates of sphalerite crystals. Nardaranakhtarma volcano



Element	Weight%	Atomic%
S K	34.30	52.91
Fe K	1.69	1.50
Zn K	55.04	41.64
Cd L	8.97	3.95
Totals	100.00	

Figure 13. Nodule of interlocked small crystals of wurtzite. Aghdam volcano

Encountered are the roundish concretions of native copper, zinc, iron and nickel. All of them contain sulfur, which is an indicator of presence of copper and zinc sulfides (Figure 14).

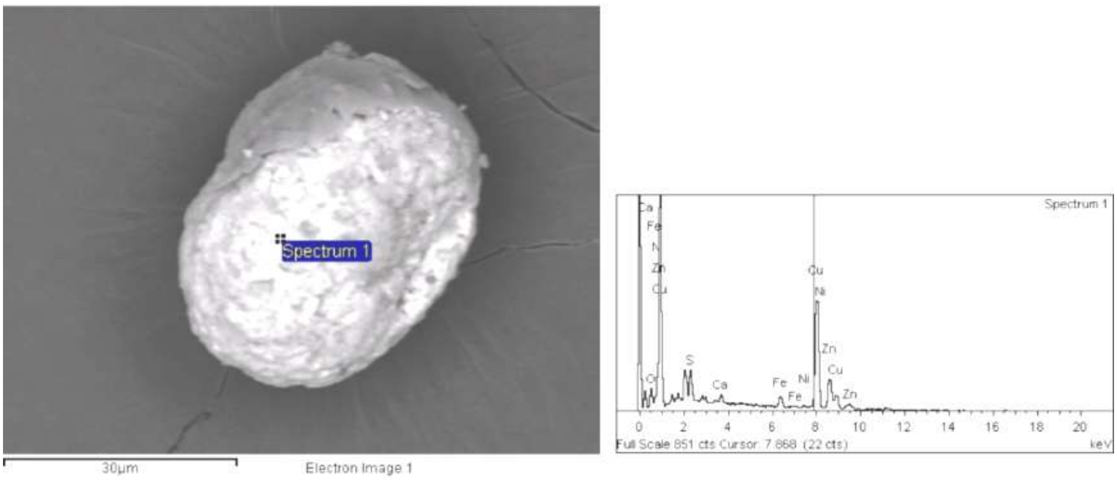
The epitaxic aggregates of lamellar crystals of biotite and wurtzite (Nardaranakhtarma volcano) are also observed.

In the volcanic breccia of Cheyildagh, native nickel together with small crystals of millerite developed on its surface were recorded.

In general, the list of sulfides recorded in mud volcanoes in Azerbaijan is quite modest and inferior to a sulfide mineralization of mud volcanoes in the Black Sea region (Shniukov, 2016). However, it should be noted that only one tenth of the country's mud volcanos have been studied so far, and that it's likely that there are more discoveries ahead.

Meanwhile, conspicuous is the fact that there were no findings of low-temperature hydrothermal minerals like sulfides of Hg, Sb and As, which are typical for the Kerch-Taman region (Shnyukov, 2016). Supposedly, it speaks for specificity of mud volcanic processes in Azerbaijan.

In the meantime, mercury isn't a geochemically alien element for the hydrocarbon sediments and mud volcanoes in Azerbaijan. There is a number of literature data that show presence of mercury in the mud volcanic gases, although to a lesser content than in the gas-oil accumulations. Active mud volcanos are characterized by mercury anomalies in the near-surface atmosphere. Mercury's local gas aureoles (0,1–0,2 mkg/m^3 at a height of 1,5 m) are confined to the mud volcanic structures and their active channels (Mashianov и др., 1991). Most significant mercury concentrations are registered on the mud volcanoes Gaynarja (pre-Caspian region) – <0,4×10^{-6} g/m^3, Cheyildagh – <0,69×10^{-6} g/m^3, Dashgil (Southern Gobustan) – <0,3×10^{-6} g/m^3 and Lokbatan (Absheron peninsula) – <1,0×10^{-6} g/m^3 (according to N.A.Ozerova). Increased mercury concentrations are correlated with high mantle helium content (1,2%) (Машьянов и др., 1991). On Damirchi volcano, rise of the mercury content just before earthquake has been recorded by Ad.A.Aliyev et al. (1989).



Element	Weight%	Atomic%
O K	4.69	15.79
S K	3.70	6.21
Ca K	0.79	1.06
Fe K	2.89	2.79
Ni K	0.94	0.87
Cu K	66.08	56.04
Zn K	20.92	17.24
Total:	100.00	

Figure 14. Native copper with an admixture of zinc. Shakikhan volcano

Unlike the Kerch-Taman region, mercury hasn't been recorded yet in the mud volcanic breccia of Azerbaijan. At the same time, pyrite from a number of studied volcanos is to a certain extent enriched by the mercury ($n\times10^{-5}$%) (Karasik, Morozov, 1966).

In general, study of sulfide mineralization of the country's mud volcanos allows acknowledging the wide development of sulfides and points at the important role played by H_2S in the mud volcanic fluids.

Therefore, sulfide mineralization of the mud volcanos of Azerbaijan is mainly represented by iron sulfides, especially pyrrhotine. Reportedly, the variety of sulfides is limited to pyrite, marcasite, pyrrhotine, chalcopyrite, sphalerite, wurtzite and millerite.

Low-temperature sulfides that are typical for the Black Sea region (cinnabar, auripigment and realgar, antimonite wasn't recorded yet) haven't been yet discovered. This fact is presumably preconditioned by specificity of the mud volcanic processes in the discussed region.

It is important to continue the mineralogical studies of the mud volcanic breccia as it is obvious that these volcanoes are enriched with sulfide minerals.

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СУЛЬФИДНАЯ МИНЕРАЛИЗАЦИЯ ГРЯЗЕВЫХ ВУЛКАНОВ АЗЕРБАЙДЖАНА

Е.Ф. Шнюков, Ад.А. Алиев, А.М. Агаев, В.В. Иванченко

В статье рассмотрены условия образования сульфидов железа, обнаруженных в сопочной брекчии 19 грязевых вулканов Азербайджана, представленных пиритом, марказитом, халькопиритом, сфалеритом, вюртцитом и миллеритом. Подробно охарактеризован пирротин.

AZƏRBAYCANIN PALÇIQ VULKANLARININ SULFİD MİNERALLAŞMASI

Y.F. Şnyukov, Ad.A. Əliyev, A.M. Ağayev, V.V. İvançenko

Məqalədə Azərbaycanın 19 palçıq vulkanlarının sopka brekçiyasında tapılmış dəmir sulfidlərinin (pirit, markezit, xalkopirit, sfalerit, vyurtsit, millerit) əmələ gəlməsinə baxılmışdır. Pirrotin ətraflı xarakterizə olunmuşdur.

GAS-OIL RATIO IN PETROLEUM FIELDS OF SOUTH CASPIAN BASIN: REGULARITIES OF SPATIAL CHANGES

In the paper the scope of generation of hydrocarbon (HC) gases and the conditions for their preservation were estimated based on about 750 gas-oil ratio (GOR) determinations for 46 deposits of the South Caspian basin (SCB). It has been established that the values of GOR vary a wide range of 2.5 to 80000 m^3/t, averaging at 1751.4 m^3/t. Spatially, GOR values increase from elevated side of depression (zone with low temperatures and pressures) towards its central deeply buried side (zone with relatively high temperatures and pressures). In the change of GOR with depth, its lowest values are observed in the range 0-2 km, which is explained by unfavorable conditions for gas preservation. A characteristic dependence of GOR on the thermodynamic parameters, the density of oil and properties of reservoir rocks was also revealed.

Keywords: deposit, gas, oil, gas oil ratio, depth, temperature, pressure, Southern Caspian Basin

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Introduction

At early stages of prospecting in the South Caspian Basin (SCB), conducted in its continental part, SCB was referred to the oil province. This was due to both the shallow occurrence of discovered hydrocarbon (HC) accumulations, unfavorable for the preservation of their gas component, and the lack of data on the HC content and its phase state on the deep part of the basin. The results of further exploration, the wide occurrence introduction of modern geochemical studies of organic matter (OM), oils and gases, as well as the wide occurrence development of mud volcanism, served as the basis for assignment SCB to the oil and gas province (Feyzullayev, Tagiyev, 2001; Feyzullayev, 2012).

In this paper, the an analysis of the spatial change of values of the gas-oil ratio (GOR) in SCB first time is given, which is the informative indicator of the scope of gas saturation of the rock-fluid system.

Database

As is known, GOR is the ratio of the volume of gas (in m3) to the amount of oil (mass or volume, in tons or m3) at atmospheric pressure and temperature of 20° produced by a development well (Large.., 2004).

750 gas-oil ratio (GOR) determinations for 46 petroleum fields of the SCB, as well as the information about depth occurrences, formation pressures and temperatures, oil density and properties of reservoir rocks. Analysis of these data included statistical processing and investigation of the relationship between the parameters, as well as consideration of the regularities of spatial changes of GOR values in SCB.

Results and discussion

The change of notions about the phase ratio of hydrocarbons in SCB is based on the following facts.

Firstly, discovery of a number of new large gas-condensate fields within the deeply buried part of SCB, including Shahdeniz, Absheron and Umid fields with up to several hundreds of billions cubic meters of gas reserves.

Secondly, the wide occurrence development of mud volcanoes in the SCB, which continuously discharges a significant volumes of gases.

And finally, the revealed qualitative features of OM of source rocks as a result of modern geochemical studies performed in latest years. It was established (Bailey et al., 1996; Feyzullayev et al., 2001) that the OM from the Oligocene-Lower Miocene (Maikopian series) and Middle-Upper Miocene (Chokrak and Diatom suits) source rocks belongs to the types II-III, capable of generating considerable volumes (over 70%) of gaseous hydrocarbons.

A generalization of a large bulk of data on GOR of the Azerbaijani oil-gas fields identified that its values vary within very wide range: from 2,5 to 80000 m^3/t, (average is 1751,4 m^3/t).

The highest GOR values are recorded in the major oil-gas reservoir of Azerbaijan – Productive series (PS-lower Pliocene), which content more than 80% of the country's total HC resources. Relatively high values are also characteristic of Oligocene-Miocene source rocks (Figure 1).

Characteristic feature is observed in GOR variations by depth (Figure 2). Lowest ratio values are registered up to 2 km depth. In this depth interval the GOR values (from 362 measurements) vary within 2,5-575 m^3/t (average is 67,4 m^3/t).

Such a phenomenon is probably explained by unfavorable gas preservation conditions caused by strong dislocation of rocks and high seismicity of the Azerbaijan territory (Feyzullayev et al., 2008).

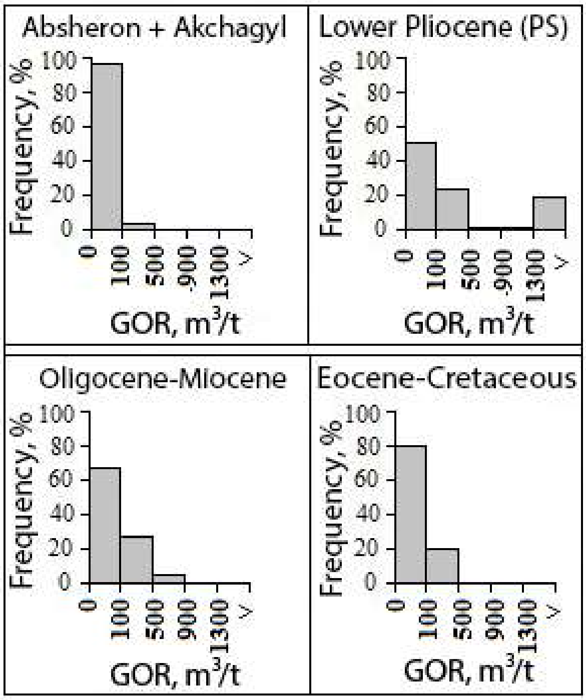

Figure 1. GOR values distribution histograms for different stratigraphic complexes of Azerbaijan

Characteristic feature is observed in GOR variations by depth (Figure 2). Lowest ratio values are registered up to 2 km depth. In this depth interval the GOR values (from 362 measurements) vary within 2,5-575 m^3/t (average is 67,4 m^3/t).

Such a phenomenon is probably explained by unfavorable gas preservation conditions caused by strong dislocation of rocks and high seismicity of the Azerbaijan territory (Feyzullayev et al., 2008).

Below 2 km GOR gradually increases and reaches its peak values at depth interval 3,2-5,2 km. To the same interval of depth, the largest values of daily oil and gas production are corresponded.

A characteristic feature is observed in the change GOR as a function of the thermodynamic parameters: low values of the GOR correspond to low values of the formation temperature (less than 68 ^{0}C) and pressure (less than 28 MPa). Above indicated values of thermodynamic parameters, a sharp increase in GOR is observed (Figure 3).

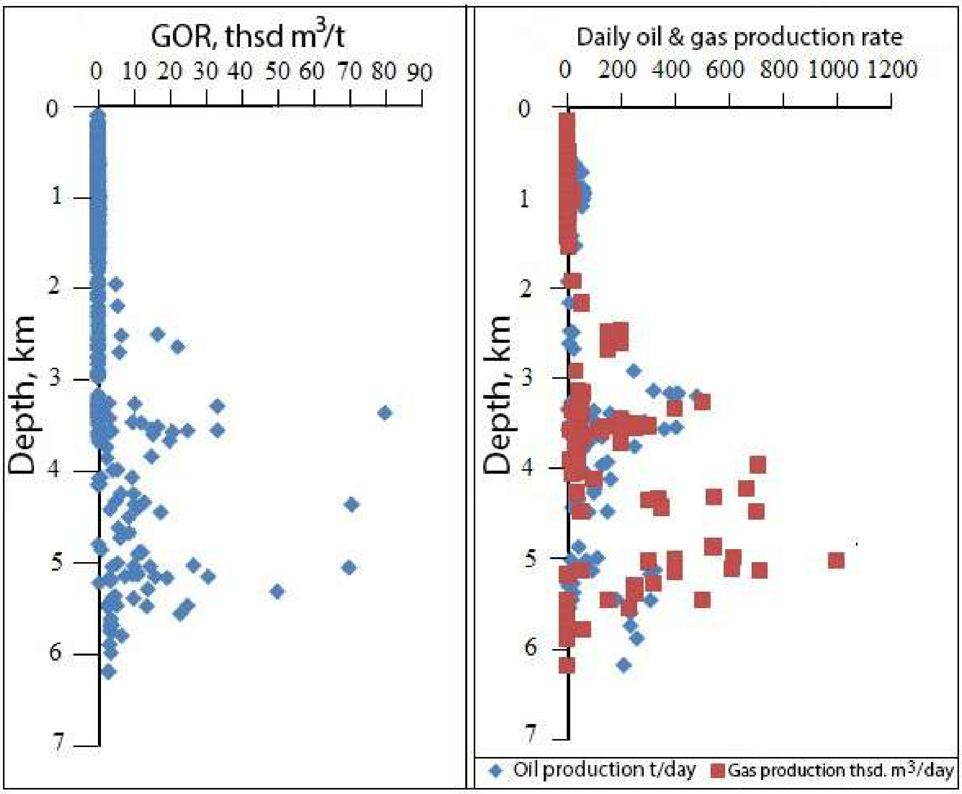

Figure 2. Dependence of GOR and daily production of oil (t) and gas (m^3) vs. depth

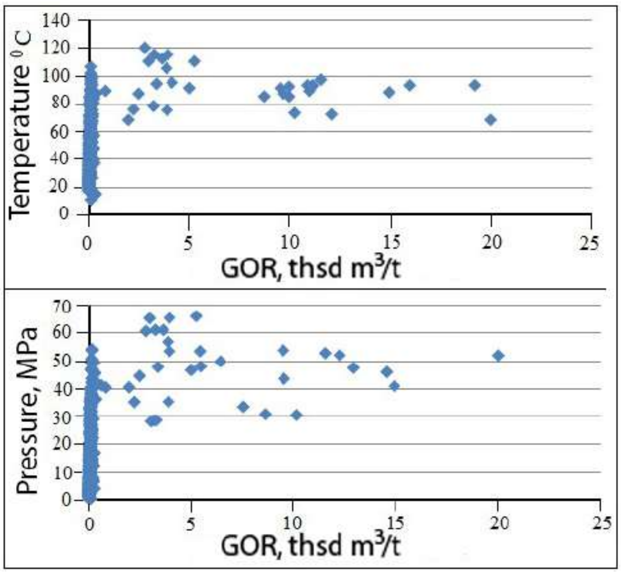

Figure 3. Dependence between GOR and thermodynamic parameters (reservoir temperature and pressure)

The revealed character of the change of GOR (as well as the productivity of rocks) with depth and depending on the thermodynamic parameters is in good agreement with the previously proposed concept of the Golden Zone (Buller et al., 2005; Nadeau, 2011), according to which the distribution of HCs in sedimentary basins is the result of their migration from mature source rocks, as well as remigration from reservoirs with abnormally high pressures (overpressures).

The features of the spatial change of the average GOR values calculated for individual fields (mainly developing PS) are also considered. To exclude the effect of preservation conditions on the value of the mean values, data for a depth below 2 km were used.

The analysis of the scheme shows that the GOR values naturally increase from the elevated edges of depression towards its deeply buried central part. In other words, GOR increases from zone with low temperatures and pressures towards the zone with increased thermodynamic stress of the subsurface.

It was also established that the highest GOR values are typical for oils that have relatively less density values (750-800 kg/m^3) (Figure 5).

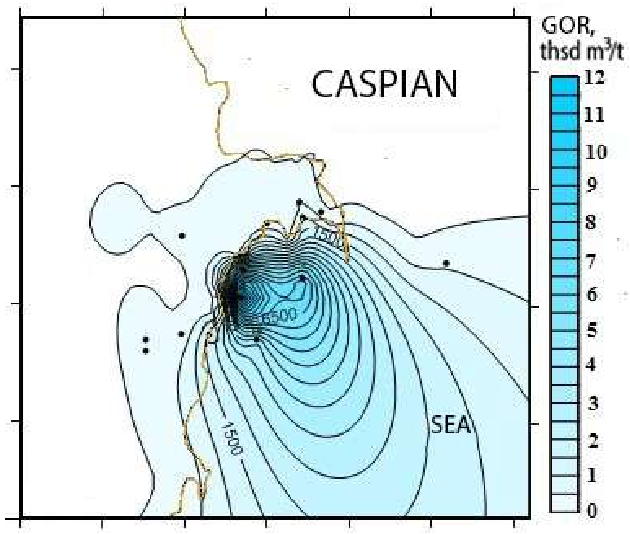

Figure 4. Spatial distribution of average values of GOR in PS

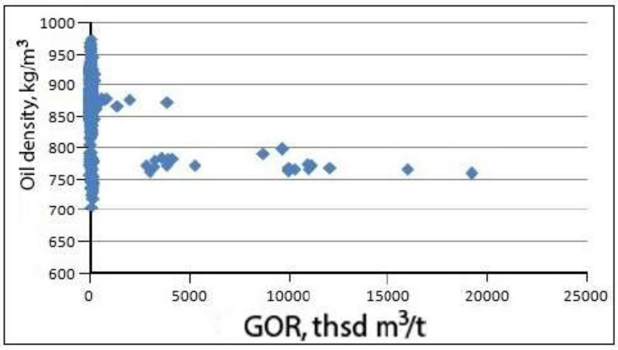

Figure 5. GOR vs. the density of oil

Significant interest arouses also the dependence of GOR on the reservoir properties of rocks (porosity and permeability). The nature of the relationship of these parameters obviously displays the graph shown in Figure 6.

Based on the graphs presented in Figure 6, it can be concluded that the dependence of GOR on the properties of reservoir rocks is appear in the confinement of its peak values to certain intervals of porosity and permeability values. These intervals are characterized by relatively low values of porosity (13-18)% and permeability (0,01-0,08) μm^2. This is most likely due to the closer interrelationships in the rock-fluid system in this range of values that, due to the action of capillary and adsorption forces, contribute to the retention of gas in the rock.

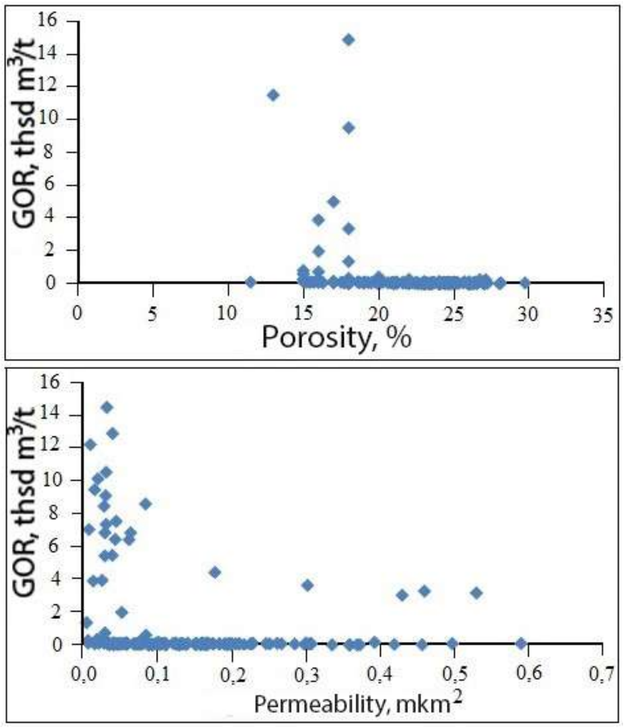

Figure 6. Diagrams of dependence of GOR on filtration-capacity properties of rocks (porosity and permeability)

Conclusion

Based on a complex of modern geological and geochemical studies, SCB can be classified as an oil and gas bearing basin, where significant gas generation rates determine their decisive role in the migration and formation of HC fields. A obvious evidence of the considerable scales of gas generation in SCB is the wideoccurrence development of mud volcanism here.

The quantitative estimation of GOR in SCB, based on a statistically significant amount of data, confirms the high gas content of its sedimentary cover. The basin's GOR varies from 2,5 to 80000 m^3/t and averages at 1751,4 m^3/t, which is typical for the GOR values of oil, oil-gas and gas-condensate fields (Katz, 1965; Shurupov, Belousova, 2010; Generalized …, 2013; Kingston, 1990; Mark, Yunke, 2010; Maclay et al., 2013). In this connection, GOR can serve as a criterion for estimating the phase state of HC accumulations in the subsurface and the regularities of its variation in space.

The values of GOR increase from its marginal parts of basin towards its deep-buried part. This agrees well with the change in this direction of the phase state of hydrocarbons, which is manifested by the successive replacement of oil fields by oil-gas and gas condensate fields.

The characteristic dependence of GOR on the thermodynamic parameters, the density of the oil, and the properties of reservoir rocks was revealed.

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CƏNUBİ XƏZƏR HÖVZƏSİ YATAQLARININ QAZ AMİLİ VƏ ONUN SAHƏ ÜZRƏ DƏYİŞMƏ QANUNAUYĞUNLUĞU

A.A. Feyzullayev, A.Z. Həsənov, G.H. İsmayılova

Məqalədə Cənubi Xəzər hövzəsi (CXH) yataqlarının qaz amili (QA) haqqında olan böyük həcmli materiallar (46 yataqdan 750-yə qədər qaz amili təyini) əsasında karbohidrogen qazarının iri həcmli generasiyası və onların saxlanılması qiymətləndirilmişdir. Müəyyən edilmişdir ki, qaz amilinin orta qiyməti 1751.4 m3/t olduğu halda o 2.5-dən 80000 m3\t-a kimi geniş intervalda dəyişir. Sahə üzrə qaz amilinin qiyməti hövzənin yan qalxımlarından (aşağı təzyiq və temperatur zonası) mərkəzə, yəni hövzənin dərin yatan hissəsinə tərəf (nisbətən yüksək tempeatur və təzyiq zonası) qanunauyğunluqla artır. Qaz amilinin 0-2 km dərinlik intervalında dəyişməsinə baxanda onun ən aşağı qiyməti qeydə alınır, bu da öz növbəsində qazın saxlanılması üçün şəraiin pisliyi ilə izah edilir. Eləcə də qaz amilinin termodinamik parametrlərdən, neftin sıxlığından, süxurların həcm-keçirilicik xüsusiyyətlərindən xarakterik asılılığı göstərilmişdir.

ГАЗОВЫЙ ФАКТОР НЕФТЕГАЗОВЫХ МЕСТОРОЖДЕНИЙ ЮЖНО-КАСПИЙСКОГО БАССЕЙНА И ПРОСТРАНСТВЕННЫЕ ЗАКОНОМЕРНОСТИ ЕГО ИЗМЕНЕНИЯ

А.А. Фейзуллаев, А.З. Гасанов, Г.Г. Исмайлова

В статье на основании большого объема данных о газовом факторе (ГФ) месторождений Южно-Каспийского бассейна (ЮКБ) (около 750 определений по 46 месторождениям) дана оценка масштабам генерации углеводородных (УВ) газов и условиям их сохранения. Установлено, что значения ГФ изменяются в очень широких пределах, от 2,5 до 80000 м3/т, составляя в среднем 1751,4 м3/т. По площади значения ГФ закономерно увеличиваются от приподнятых бортовых частей впадины (зона с низкими температурами и давлениями) в сторону центральной глубокопогруженной ее части (зона с относительно высокими температурами и давлениями). В изменении ГФ с глубиной в интервале 0-2 км отмечаются самые низкие его значения, что объясняется плохими условиями сохранения газа. Выявлена также характерная зависимость ГФ от термодинамических параметров, плотности нефти, емкостно-фильтрационных свойств пород.

STRATIGRAPHIC AND LITHOFACIES PECULIARITIES OF THE MIOCENE DEPOSITS OF WESTERN ABSHERON AND SHAMAKHI-GOBUSTAN REGION, SOUTH-CASPIAN BASIN

Known as the country's second largest oil-gas bearing sediments, Miocene deposits are of a special importance in implementation of wide-scale research and assessment of oil and gas content. This article provides complex analysis of the outcomes of geologic-geophysical researches (including drilling data), which have been carried out to study the depositional environment, reservoir properties and oil-gas perspectives of the Miocene sediments.

Keywords: western flank of the South Caspian basin, Miocene deposits, stratigraphy, lithofacies, petrography.

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Introduction

Miocene sediments are widely developed within the western flank of the South Caspian Basin (SCB), and are present in the structure of the whole range of structures, including Garadagh, Solakhay, Ajivali, Umbaki, Guzdak, Binagadi, Masazir, Sulutapa, Shabandagh, Rahim, Klij, Suleyman-Akhtarma, etc. (Figure 1).

Thickness of Miocene sediments increases from 0.5 km in the northwest to 7-8 km in the southeast of the Southern Caspian Basin.

Hydrocarbon potential of Miocene sediments is proven on many of the Basin's structures, including Umbaki, Hajivali, Garadagh, Sangachal, Duvanny, Lokbatan, Sulutapa and Chakhnaglar structures, some of which are already covered by commercial development. At the same time, testing of the many other areas of SCB had produced negative results.

This article aims to study the lithofacies peculiarities of Miocene sediments, as criteria for determining their reservoir properties.

Geological structure of the studied region

Surrounded by the mountain systems of the Greater Caucasus, Talysh, Elburs and Kopetdagh, the South Caspian Basin (SCB) is a part of the Caspian sedimentary megabasin and the Alpine-Himalayan mobile belt (International Tectonic Map…., 2002).

Key tectonic feature of the Shamakhi-Gobustan region is the development of sublatitudinally trending structures composing different anticlinal belts. These structural units are separated by regional deep faults that are often expressed in the imbricated overthrusts, which are recorded in a stepped southeastward immersion of tectonic blocks from the Greater Caucasus towards the Caspian Sea where they are subsided to a depth of over 4 km. Within the boundaries of Southeastern and Central Gobustan, occurrence depth of the top of Miocene sediments varies from 0 to 2-2.5 km.

Miocene sediments are stratigraphically divided into lower and upper portions. Lower Miocene is represented by the Maikopian Series, which constitute its upper portion. Upper Miocene sediments include the following stages (bottom-upwards): Chokrakian, Karaganian, Konkian, Sarmatian, Meotian and Pontian. Karaganian-Meotian sediments constitute the Diatom Suite.

In the north and the northeast of the region (Suleymanakhtarma, Guzdak, Binagadi, Masazir), 40-50 m thick Pontian sediments overlie the Meotian sand-shale series in the crestal parts of the anticlines (location of structures is shown on Figure 1). At the same time, no Pontian sediments were recorded in the crests of anticlines in the south (Garadagh, Lokbatan-Puta-Gushkhana). In some parts of Gobustan Oil-Gas Region, 75-275 m thick Pontian shaly sediments transgressively overlie the Miocene sediments.

Although shaly facies prevail in the lithological section, there are some variations in the lithological composition of sediments observed throughout the studied area.

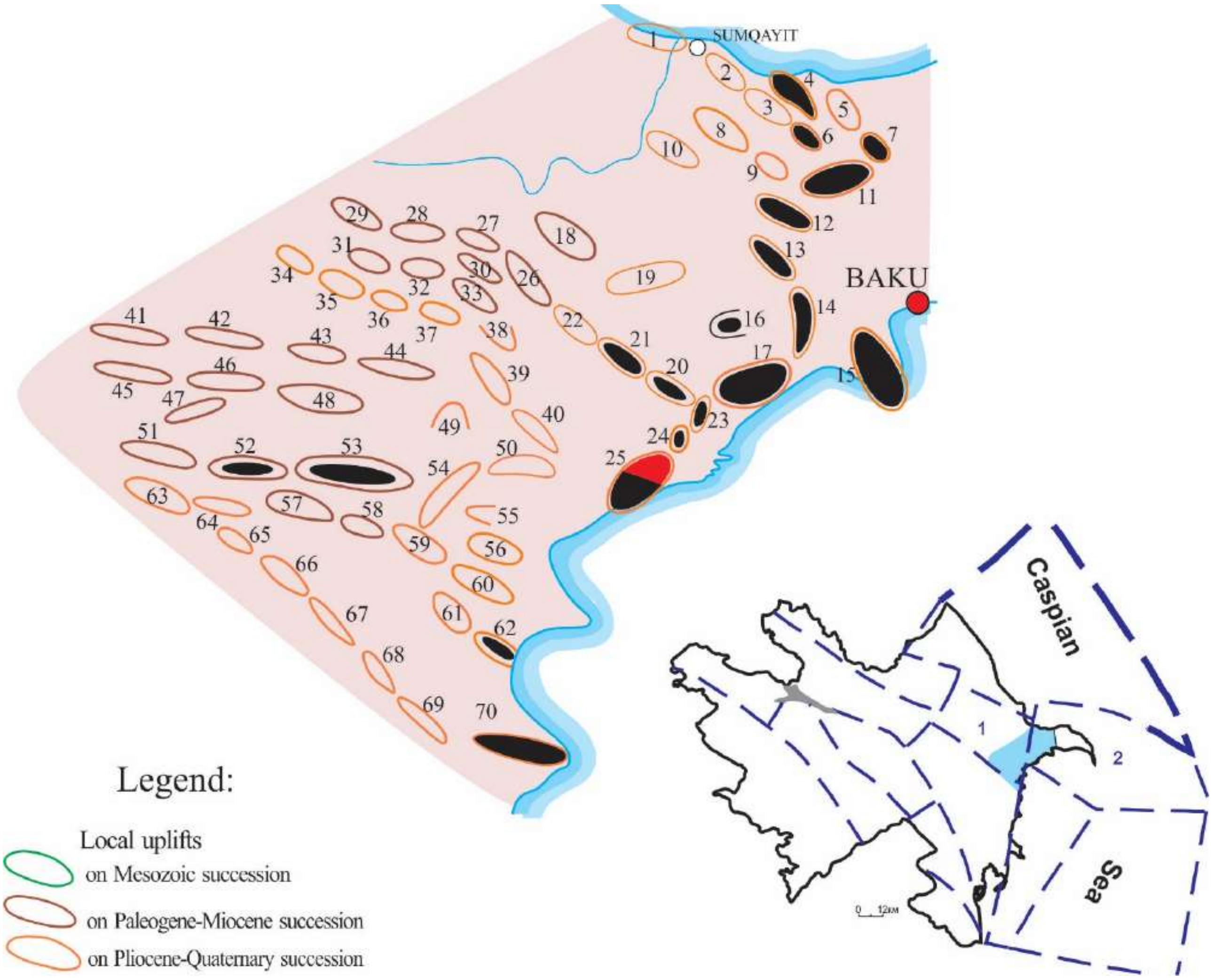

Figure 1. The locality scheme of the Gobustan and Western Absheron anticline structures

1-Sarigayabashi; **2**-Jorat; **3**-Novkhani; **4**-Fatmayi; **5**-Digah; **6**-Sianshor; **7**-Kirmaki; **8**-Sara; **9**-Kechaldagh; **10**-Goytapa; **11**-Binagadi; **12**-Sulutapa; **13**-Shabandagh; **14**-Shubani; **15**-Bibiheybat; **16**-Güzdak uplift; **17**-Lokbatan; **18**-Otman-Bozdagh; **19**-Garaheybat; **20**-Shongar; **21**-Sarinja-Gulbakht; **22**-Shorbulag; **23**-Korgoz-Qiziltapa; **24**-Northern Garadagh; **25**-Garadagh; **26**-Boyansiz-Boyanata; **27**-Sarıdash-Julga; **28**–Southern Gishlag-Ala; **29**–Baygushtu; **30**–Girdagh; **31**-Garagishlag; **32**–Galachalar; **33**–Girgishlag; **34**–Donguzluq; **35**–Garghabazar; **36**–Kaftaran; **37**-Aghzigir; **38**–Northern Shikhigaya; **39**–Shikhigaya; **40**–Anart; **41**-Gijaki-Akhtarma; **42**–Nardaranakhtarma; **43**–Suleymanakhtarma; **44**–Cheyilakhtarma; **45**–Sundu; 46–Northern Sundu; **47**–Ilkhidagh; **48**–Cheyildagh; **49**–Northern Utalgi; **50**-Miajik; **51**–Western Hajivali; **52**–Northern Hajivali; **53**–Umbaki; **54**-Utalgi; **55**–Southern Utalgi; **56**-Jamaladdin; **57**–Arzani-Glij; **58**–Glij; **59**–Toragay; **60**-Kanizadagh; **61**–Western Duvanni; **62**–Duvanny; **63**-Dashmardan; **64**–Shakikhan; **65**–Durandagh; **66**-Baridash; **67**–Solakhay; **68**-Ayrantokan; **69**–Goturdagh; **70**-Dashgil

Discussion

In Western Absheron, thick layer of the Maikopian Suite's (Oligocene-Lower Miocene) dark-chocolate shales is exposed on the crests of Fatmayi, Novkhani, Binagadi, Shabandagh, Shubani and several other anticlines. Complete Maikopian section is observed only in Uchtapa structure (Akhmedov, 1957: Kastrulin, Mamedov and etc., 1991).

Parts of the Maikopian Suite that are recorded to the east (Bozdagh, Shabandagh, Shubani, Gara-Heybat, Damlamaja areas) and to the northwest (Jorat, Novkhani and Saray areas) of Uchtapa, are mainly represented by shales (Figure 2). The Suite was also revealed by several exploration and prospecting wells drilled in the production and exploration sites of Jorat, Fatmayi, Girmaki, Balakhani, Shabandagh, Shubani and Guzdak structures.

Great part of the Maikopian dark-grey shales (610 m) was revealed by the wells # 109 and 308 drilled in the northern, and the well # 292 drilled in the southern limb of Garadagh structure (Salmanov et al., 2016, a,b,c).

Widely developed Maikopian Suite (Oligocene-Lower Miocene) of the Southeastern Gobustan is divided into lower and upper subsuites. Lithofacies and thickness of the Suite are shown in the lithofacies map in Figure 2. Lower subsuite is represented by the alternation of sandy marls, shales and tight sandstones. Thin beds of sandstones and siltstones are recorded in the lower Maikopian section of Nardaranakhtarma, Sundu, Cheyildagh, Umbaki, Arzani, Hajivali and several other localities. Lower Maikopian section of Gobustan is generally represented by shaly lithofacies, whereas its thin beds of sandstone-siltstones are practically unimportant. Thickness of Lower Maikopian sediments in Gobustan reaches 60-100 m in the north, 500-600 m in the southwest and even 1600-1800 m in the southeast within the depression that opens towards the sea.

I.M.Gubkin divided Miocene sediments of the Absheron peninsula into the Spirialis and the Diatom Suite. Forming wide strips over the areas of Paleogene occurrence on the northwestern Absheron, these sediments are cropping out on the southeastern limbs of Aghburun and Goytapa anticlines, as well as on crests and near-crest parts of Jorat, Novkhani, Saray, Binagadi and several other structures. Such sediments were also revealed by the exploration wells drilled in Shabandagh, Shorbulag, Binagadi and Sulutapa fields of the Southwestern Absheron. (Salmanov et al., 2011; Salmanov et al., 2016, a,b,c)

It was determined by later microfaunistic investigations that the stratigraphic age of Gubkin's "Diatom Suite" covers an entire range of Chokrakian-Pontian stages, including Karaganian and Konkian horizons, as well as Sarmatian and Meotian stages.

Now it is both lithologically and faunistically proven that the section of Western Absheron Miocene sediments contain Tortonian, Sarmatian and Meotian stages. As it's often impossible to distinguish these stratigraphic units on the Absheron peninsula, the term "Diatom Suite" is widely used in practical work. As a result of microfaunistic research of the Miocene sediments done on core samples from numerous wells drilled in Binagadi, Chakhnaglar and Sulutapa fields, Diatom Suite was divided into Meotian, Sarmatian and Tortonian stages. Tortonian stage consists of Konkian, Karaganian, Chokrakian and Tarkhanian horizons (Maharramov, 2006; Maharramov, 2008).

Researchers failed to locate the Tarkhanian horizon in a number of the Absheron peninsula's exploration fields, and the main reason for this could be that the section yet wasn't investigated in sufficient details, or that during pre-Chokrakian erosion, these thin sediments might had been eroded in elevated parts of the anticlines.

Chokrakian horizon in Absheron is composed of shaly and sandy-shaly sediments (Figure 3). Shaly facies with dolomite and marlstone interbeds are developed on the peninsula's northwestern, northern and eastern segments, whereas the sandy-shaly sediments with marlstone interbeds are dominating on the peninsula's center and southwest.

In Fatmayi structure, where the shales are prevailing, up to 1.5 m thick dolomite beds containing the Spirialis fauna are occurring in both bottom and top of the Chokrakian horizon. It's worth mentioning that similar beds were recorded in the structures dominated by Chokrakian sandy-shaly sediments as well (Saray anticline, etc.) (Kastrulin and etc., 1991; Salmanov et al., 2016, a,b,c).

Within the central part of Western Absheron, Chokrakian sediments are developed on the eastern limb of Ateshgah anticline, western limb of Shabandagh anticline and the southeastern pericline of Ziyilpiri-Masazir anticline. In this area, the horizon is dominated by the alternating dark-grey, greenish-grey and grey shales with the interbeds of dolomites, marls and fine-grained sands. As stated by the analysis of borehole log diagrams and core samples collected from wells that have been drilled in Binagadi and Chakhnaglar fields, the share of sandstones and sands makes up 17-18%, and reaches 23% in Shabandagh. True thickness of the Chokrakian horizon in these structures varies between 50-134 m.

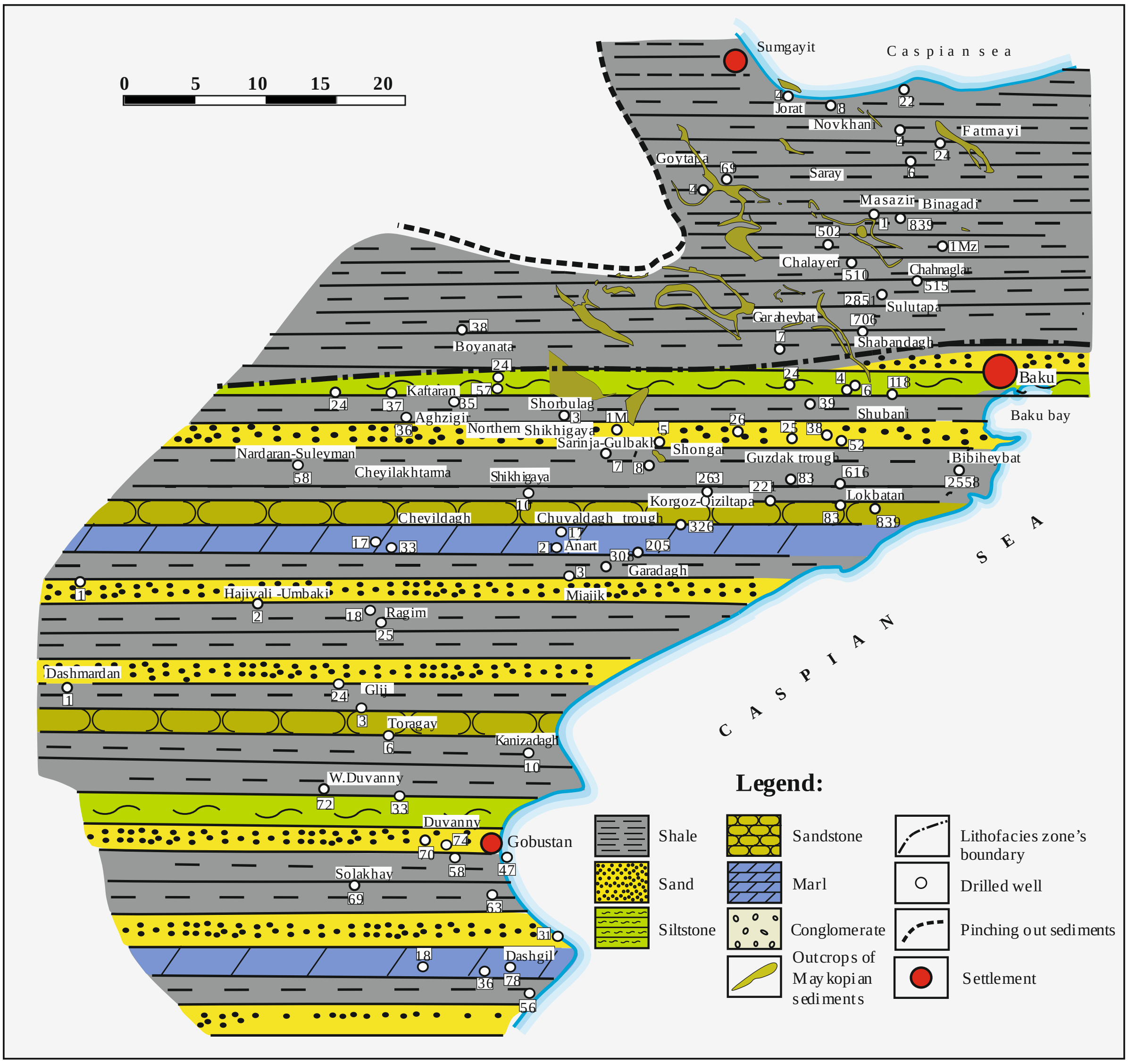

Figure 2. Lithofacies map of the Maikopian sediments of Western Absheron and Shamakhi-Gobustan region

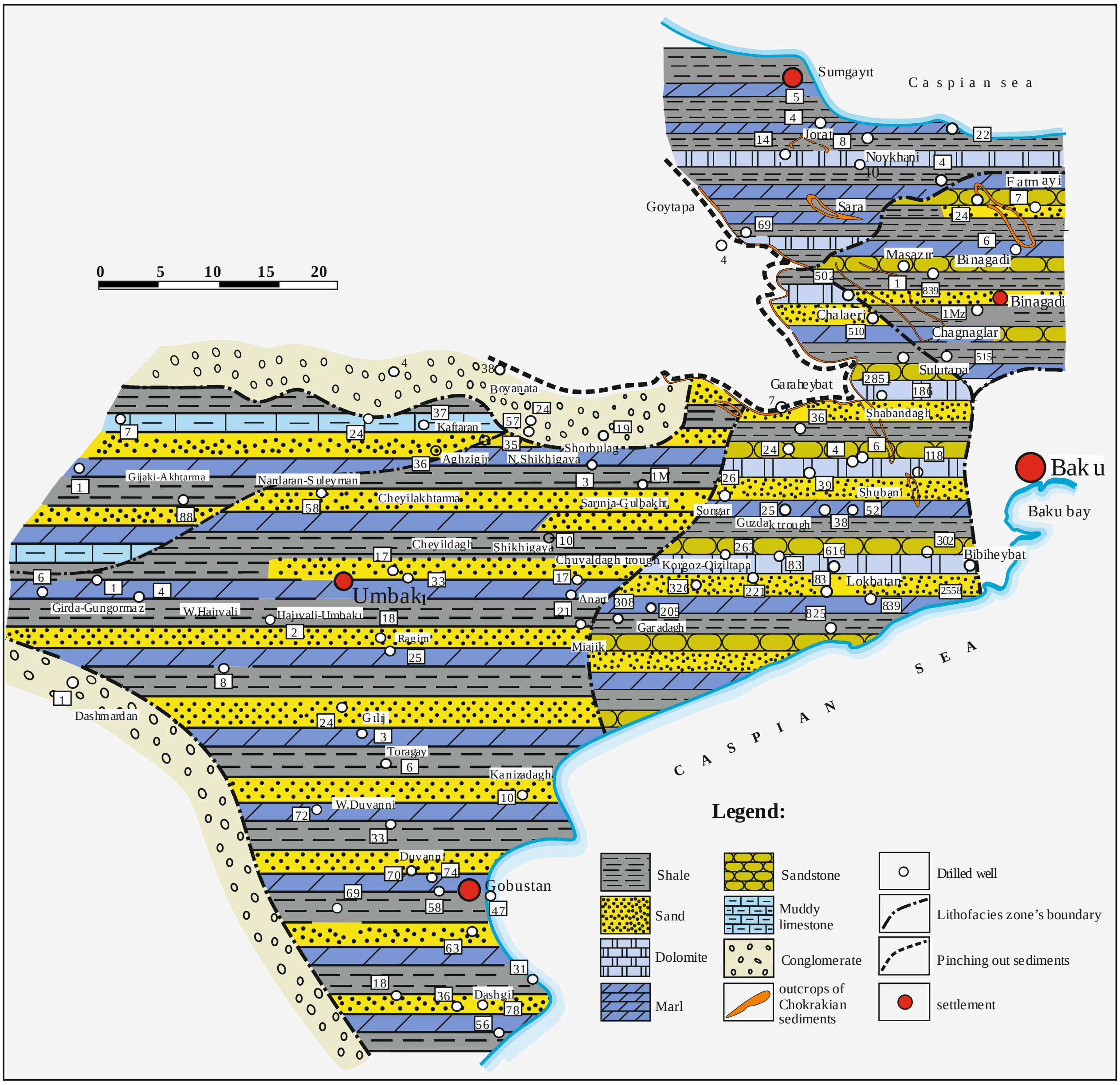

Figure 3. Lithofacies map of the Chokrakian sediments of Western Absheron and Shamakhi-Gobustan region

In many parts of the Western Absheron, Chokrakian horizon is composed of dark-grey shales with sand and marlstone interbeds, and characterized by slight (up to 40 m) reduction of its overall thickness.

Chokrakian horizon of Garadagh area in the Northeastern Absheron is composed of the alternating brownish-grey sandy shales with sandstones and siltstones, revealed by a number of prospecting wells. Miocene sediments occur in 2400-4350 m depth interval on the northern limb of the structure. In the same structure's crestal part, overall thickness of Miocene sediments reaches 895 m, 160 m of which fall to the Chokrakian horizon (work report..., 1975, Yusifov et al., 2004). It should be noticed that the occurrence of dolomites in the horizon's section allows distinguishing it from the underlying Maikopian Suite. Chokrakian horizon differs from Eocene Govundagh and Maikopian Suites by a presence of the group of thin and elongated (sword-shaped) peaks in the resistivity log diagram reaching 5-7 Om/m of resistance.

Represented by sandy-shaly lithofacies in the studied localities (Akhtarma, Cheyildagh, Sundu, Girda, etc.), Chokrakian sediments are widely developed on the territory of Gobustan (Figure 3). Thickness of sandy sediments reaches 170 m, which makes 40% of the horizon's 400-500 m thick section composed of the alternating shales, sandstones, marls and partly dolomites. Section of Chokrakian horizon in the Southwestern Gobustan (Nardaranakhtarma, Cheyildagh, Ilkhichi, Umbaki, Hajivali and Arzani areas) contains (from the bottom upwards) distinguished beds of sandy-shaly (120-200 m), shaly (100-125 m), sandy (20-65 m) and shaly-sandy (50-150 m) sediments.

Total thickness of Chokrakian sediments reaches 300-350 m in the north (Gijakiakhtarma, Nardaranakhtarma and Sundu), and 400-500 m in the south (Hajivali, Cheyildagh, Umbaki, etc.) of Southwestern Gobustan. Thicknesses of separate beds are provided in Table 1.

Information on occurrence, lithological patterns and thicknesses of the Chokrakian horizon in the Southwestern Gobustan is provided below.

In Umbaki area Chokrakian horizon is composed of shales with marlstone and dolomite interbeds. The section also contains thin beds of sands, sandstones and siltstones. Dominating sediments in the horizon's upper portion are sands and sandstones. Thickness of individual beds of these sediments varies between 4-8 m with thickness of sands reducing at higher stratigraphic depth. Sands are usually fine-grained and weakly carbonated, characterized by a larger (68-70%) share of the quartz (Salmanov et al., 2011; Salmanov et al, 2016).

Thickness of sand and siltstone beds doesn't exceed 1.2-2.5 m in the bottom of Chokrakian horizon. In general, horizon can be divided into the following 3 subhorizons. Shales amount to 82-85% in the deep 360-380 m thick shaly-sandy succession. Here, the maximum thickness of separate sand beds reaches 1.5-2.0 m. 75% of the 65-70 m thick middle portion of the horizon are consisting of sands and sandstones. Upper portion of the section is dominated by 75-85 m thick beds of muddy marls and sands.

Table 1

The thicknesses of different lithologies in the Chokrakian horizon

Thickness, m				
Areas	Sandy shales	Shales	Sands	Shaly sands
Gijakiakhtarma	75-100	100-125	20-25	100-125
Nardaranakhtarma	80-85	85-110	30-35	100-115
Cheyildagh	200-250	75-80	50-60	75-100
Sundu	215-250	75-85	45-65	85-110
Ilkhiji	200-215	70-85	55-65	85-120
Umbaki	200-210	65-75	60-70	85-100
Hajivali	200-220	70-80	60-65	80-105
Arzani	215-225	75-80	55-65	75-100

Chokrakian horizon is also occurring in southern and western parts of Cheyildagh area. The horizon is cropping out along the Cheyildara ravine. Its bottom is composed of grey and dark-grey shales and marlstones. Upper part of the section contains several beds of sand, one of which is 50 m thick “Horizon I” that occurs 60 m below the horizon’s top and has unique lithological composition. Important role in its section is played by the beds of grey and light-grey, fine and medium-grained quartzy sands and siltstones. Thickness of the separate beds of siltstones constitutes 2-10 m, while the thickness of shaly interbeds varies within 0.5-5 m. Total thickness of the Chokrakian horizon reaches 580 m.

In Eastern Hajivali, the Chokrakian horizon occupies the northern limb of the fold. Chokrakian sediments were also revealed by structural mapping and exploration wells. Horizon’s lithological composition consists of the irregular interbedding of light-brown, greyish-brown shales with the interbeds of sands, sandstones, marls and dolomites. Alike Umbaki area, local Chokrakian sediments are divided into three subhorizons according to their lithological composition. 200-220 m thick bottom portion of the section is mainly composed of the uneven alternation of grey and greenish-grey shales, light-grey marls and extremely thin interbeds of sands. Middle portion of the section contains 50-60 m thick sandy-shaly horizon, which corresponds to “Horizon I” studied in some parts of the Southwestern Gobustan (Umbaki, Cheyildagh, Nardaranakhtarma structures). Here the sands and sandstones are from fine to medium grained, and by 70-75% consist of the quartz. 75-85 m thick upper portion of the section is composed of the alternating greenish-grey shales and fine-grained sands.

In Arzani-Gilij area, the Chokrakian horizon was studied by structural mapping and exploration drills on the northern limb of the fold. The section is shale prone. Upper portion of the section includes up to 60 m thick bed of sands and shales with slightly prevailing sands. Total thickness of the horizon equals 550 m.

In Western Sundu, Chokrakian horizon is developed in the near-crest segment of the fold, where it transgressively overlaps Maikopian sediments. The horizon’s section is composed of grey, greenish-grey shales, marly shales, sands, sandstones, marls and dolomites. Alike all of the neighboring areas (Hajivali, Umbaki, Nardaranakhtarma, etc.), 45-50 m thick layer of sands and sandstones occurs 100 m below the horizon’s top. Total thickness of the Chokrakian sediments here is 400-450 m.

In Eastern Sundu, the Chokrakian horizon is occurring over the northern and southern parts of the structure. Its lithological composition is represented by the interbeds of grey, carbonate sandy shales, as well as grey, fine grained sands and sandstones. Between shales, there are the interbeds of dolomites and marls with remnants of plants and fishes recorded in the section. The horizon’s thickness reaches 250-300 m.

On Ilkhiji structure, Chokrakian horizon is exposed as a narrow strip in the near-crest zone of the structure, and gets revealed by structural mapping and exploration wells. Horizon’s section is 475-490 m thick and represented by the uneven alternation of grey, fine and medium-grained, poorly sorted sands and marlstones.

Chokrakian sediments are also developed in the center of Gijakiakhtarma area, where the horizon’s lithology mainly consists of grey and carbonated shales, while its 170-300 m thick section contains up to 1.5-2 m thick beds of lenticular sands and thin interbeds of marlstones.

In Sheytanud structure, the Chokrakian sediments are exposed in its northern segment, and revealed by the wells. Lithological composition of 100-150 m thick horizon is consisting of dark-grey carbonate shales with marly interbeds.

In Nardaranakhtarma, the Chokrakian horizon similarly to Hajivali and Umbaki fields lithologcally is divided into three portions. 100-150 m thick bottom portion is composed of grey, greenish-grey, firm and laminated shales with thin sandy interbeds. 30-50 m thick middle portion consists of cemented fine and sometimes medium-grained poorly sorted sands with sandstone interbeds. 80-110 m thick upper horizon is composed of grey, coffee-grey and greenish-grey sandy shales with 0.1-0.5 m thick sand and marl interbeds. Here, the total thickness of the Chokrakian horizon doesn't exceed 310 m.

Covering the stratigraphic interval of Miocene's Karaganian, Konkian, Sarmatian and Meotian stages, Diatom Suite is characterized by the variable facies and thickness of its sediments both in Western Absheron and Southwestern Gobustan.

Diatom sediments have been thoroughly studied by boreholes drilled in the Shabandagh, Shubani, Shorbulag, Garadagh, Binagadi, Ziyilpiri structures, etc. The Suite is mainly composed of the beds of shales, limestones, marls and sands. Thickness of its sandy beds gradually increases from the south to the west (Yusifov et al, 2008).

Karaganian sediments are widely occurring in central, northwestern and northern parts of the Western Absheron. Alike the Chokrakian sediments, Karaganian horizon is composed of the alternation of carbonate, brown and greenish-grey shales with normal and brecciform dolomites, dolomitic marls, sands and siltstones. The difference between these two successions is that the Karaganian horizon contains no spirialis. With that in mind, the bottom of Karaganian succession is defined based on the occurrence of the last spirialis-containing dolomite bed. Within the described area, the Karaganian horizon conformably overlies the Chokrakian sediments (Figure 4).

In Sulutapa and Shabandagh areas, up to 2-3 m thick beds of sandstones and siltstones form major part of the Karaganian section, total thickness of which varies between 25-40 m, and begins with thin beds of sands and siltstones in Shorbulag field and towards the Southeastern Gobustan.

As determined by drilling data, Karaganian horizon in Garadagh is composed of sandy shales and silty marls, as well as thin but multiple beds of sands. In general, increase of sand proportion is observed towards the southwest. 85% of terrigenous material are composed of lithic fragments. The share of quartz and feld spars is miserable, rarely reaching 10%. Heavy fraction is mainly represented by pyrite and iron oxide. The relatively small amounts of magnetite, ilmenite and garnet, as well as the individual grains of amphibole, pyroxene and anhydrite are also recorded.

The fact that sand proportion is equals to 50% in Ziyilpiri, 20-25% in Jeyranbatan and 7% in Damlamaja areas, brings us to a conclusion on worsening of reservoir properties towards the south-southwest. As argued by some scientists (work report.., 1975) these sediments (known as Binagadi facies) are traced through Baku archipelago in the south.

Complete section of the Karaganian horizon has been studied in Gijakiakhtarma-Nardaran zone, southern limb of Umbaki and Cheyildagh structures and the northern limb of Arzani fold. In all these areas, the horizon is represented by fine grained sands as well as weakly carbonated sandstones. Quantity and thickness of sand beds increases towards the south and the southeast, reaching maximum in the east of Umbaki and in Arzani-Gilij folds. Thickness of the horizon's sandy-shaly lithofacies varies between 20-225 m.

In general, the horizon's shaly facies that are occurring in the north are replaced by the sandy-shaly facies in the southwest, and this is in concordance with the horizon's thickness increase trend.

Sediments of the Konkian horizon are recorded in the geological structure of Western Absheron. Lithofacies composition of these sediments is very similar to the Karaganian series. A distinguishing feature of the Konkian horizon is the wide occurrence of diatomaceous shales in its sections. Konkian sediments were studied mainly in the areas of Karaganian and Chokrakian horizons' occurrence. Characterized by similar-to-Karaganian lithofacies, the described horizon lithology is constituted by grey, brown, laminated and carbonate mudstones with interbeds of shales. Sometimes, the Konkian section contains dolomite and volcanic ash interbeds. Additionally, very thin interbeds of siltstones and sands occur in it in the southwest (Figure 4).

In the structures of Orjundagh and Fatmayi, Konkian sediments are represented by the alternation of grey, ashy, lamellar shales with rare 10-15 cm thick interbeds of light-yellow marlstones. In Binagadi area, the horizon contains thin interbeds of the light-grey, fine and medium-grained sands.

In the other parts of the Absheron peninsula, it's hardly possible to distinguish the Konkian horizon from Karaganian sediments, as in this part of the region they both have similar faunistical and lithological characteristics. Feld spar and quartz content of the shales varies between 3.0-12.0%. Heavy fraction is typically characterized by presence of pyrite (up to 40%) and other minerals (up to 44%). Sandy siltstone and carbonate sediments of both horizons are distinguished for weakness of their reservoir properties. In spite of high total porosity varying from 9.3% to 34.6%, permeability is ranging from 0,0013x10^{-3} mkm^2 to 0,003x10^{-3} mkm^2 (Yusifov et al., 2004).

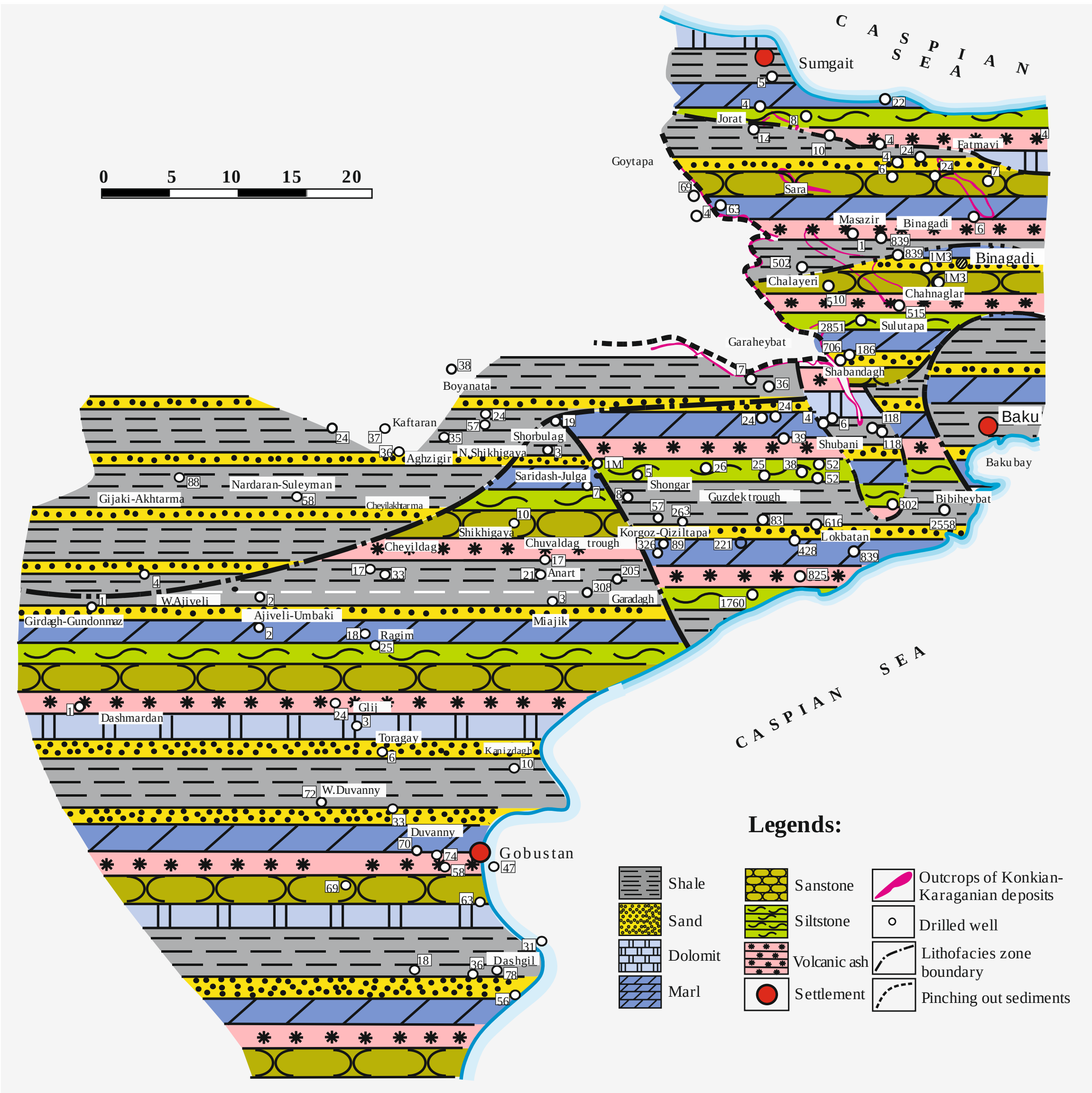

Figure 4. Lithofacies map of Konkian-Karaganian deposits in Western Absheron and Shamakhi-Gobustan

According to electrical log diagrams, Konkian sediments are less occurring and more variable in thickness than the Karaganian succession. For example in Sulutapa field, 10 m thick sandy sediments that have been revealed in the upper section of well #2593, get replaced by more than 20 m thick sandy sediments in well #1524 occurring little to the north.

Complete section of the Konkian horizon has been revealed by drilling on the southern limb of Cheyildagh anticline, as well as on the northern limbs of Umbaki, Arzani and Ilkhiji anticlines. This section is mainly consisting of shales, thin sandstones, sands and siltstones (0.5-2.5 m). In Arzani and Umbaki structures, lower part of the horizon contains up to 3.5 m thick bed of wet sand. In the Southwestern Gobustan thickness of the Konkian horizon varies between 125-200 m.

Karaganian sediments exposed in the different parts of Cheyildagh fold, where they are represented by the alternation of laminated shales and marlstones with thin interbeds of sand. Total thickness of the horizon is 200-250 m. At the same time, nearly 200 m thick Konkian horizon has few sand beds in its section.

Karaganian and Konkian horizons are exposed on the northern, and recorded by boreholes on the southern limbs of Eastern Hajivali fold. Their lithological composition consists of grey, brownish-grey shales, fine grained sands and marlstones, with sands not exceeding 0.15-0.25 m in thickness.

Karaganian and Konkian sediments are occurring in the northern limb of Ilkhiji fold. Here, the horizons are mainly composed of homogenous grey shales with thin interbeds of sands, sandstones and marls. The total thickness reaches 500 m.

Sarmatian succession is represented by grey, greenish mudstones, thin interbeds of sands and shales. Upper portion of the section contains the thin beds of volcanic ash as well. Thickness of the stage is 140-150 m.

In Gijakiakhtarma, Karaganian horizon was revealed by structural mapping and boreholes in the northern and southern limbs. Here, the Karaganian sediments are represented by grey, greenish-grey and laminated shales, grey and light-grey marlstone interbeds, marly shales and up to 1 m thick fine grained sands. Shales contain remnants of fishes and plants. Horizon's thickness is 300 m.

Karaganian horizon is cropping out in the north of Nardaranakhtarma fold. Its lithological composition is dominated by grey carbonate mudstones, shaly sandstones, shales, marls and dolomites. Thickness of the local beds of sand rarely reaches 2-3 m. These sands are often saturated with oil. Horizon's thickness varies within 300-400 m.

80-100 m thick Konkian horizon is represented by shales and brecciform dolomites.

Sarmatian succession is composed of grey shales, sheets of oil-saturated sands and interbeds of marls and dolomites.

Sarmatian sediments are widely developed in the northwestern, northern and central parts of Western Absheron. They are recorded in Uchtapa and Khosmalidagh folds, and represented by greenish-grey and greenish-brown shales with fish fossils, as well as the individual beds of marlstones.

In many localties across Western Absheron, only Lower and Middle Sarmatian sediments are occurring in the section. Most complete Sarmatian section is recorded on the northeastern limb of Orjundagh anticline and on the southeastern pericline of Saray and Fatmayi folds. Here Sarmatian sediments are composed of the alternating yellowish-brown, yellowish-grey and greyish-brown shales with yellow sandy marlstone interbeds (0.4 m). Section contains 10-15 cm thick beds of dolomitized limestones as well. Total thickness of the Sarmatian sediments is 95-108 m (Figure 5).

Wells # 323 and 324 drilled in the near-crest part of Garadagh structure, revealed 1190 and 1300 m thick Diatom sediments at the depths of 3010 and 3050 m. The section is entirely composed of Sarmatian sediments. It includes four 80-120 m thick subsuites accordingly to the log diagrams.

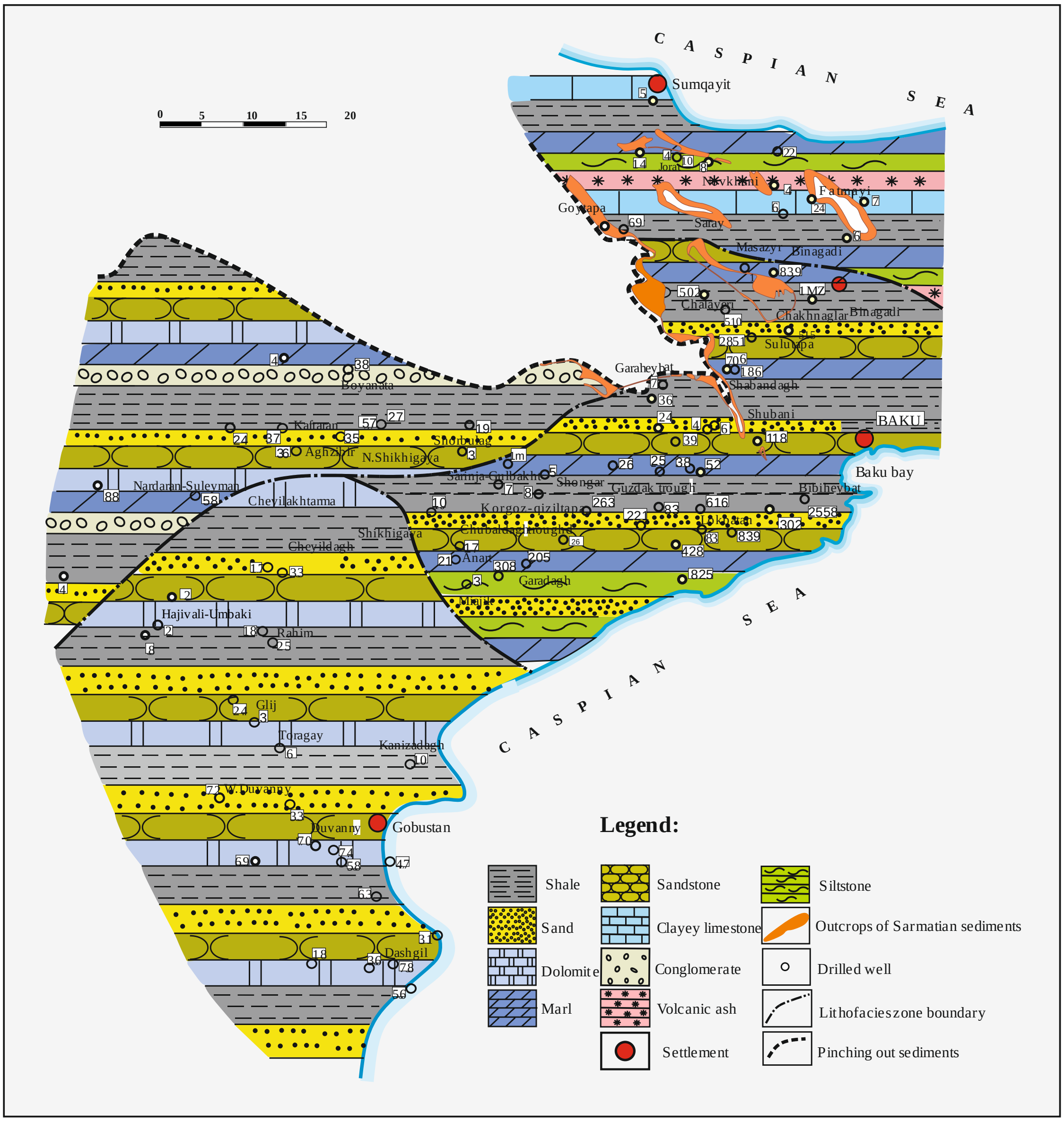

Figure 5. Lithofacies map of the Sarmatian deposits of Western Absheron and Shamakhi-Gobustan region

The degree of Miocene sediments' erosion reduces from the crest towards the northern limb of the structure. At the same time, the thickness of Miocene succession grows to 1500-1600 m, and the section becomes composed of sandy and carbonate (dolomites, marlstones) rocks.

Steeply dipping (up to 50^0) Pontian-Maikopian shales were recorded at the depth interval of 2670-4020 m on the southern limb of the Garadagh fold. According to borehole data obtained in well #214, the Pontian sediments are underlaid by the Sarmatian succession, and the thickness of local Miocene sediments reaches 470 m.

Within the Garadagh structure's boundaries, Middle and Upper Miocene sediments (Diatom Suite) were recorded by the wells # 3, 103, 106, 107, 109, 129, 205, 308, 324, 508, 510 and 512. Their revealed section reaches 1410 m in thickness (well # 323) and consists of light-grey shales, shaly marlstones, fine sands, sandstones and siltstones. In wells # 103, 129, 323 and 512, revealed section of the Miocene sediments reaches 770 m in thickness and includes two sandy horizons. At the same time, Miocene section of well#323 is 1410 m thick with four sandy horizons recorded in its structure. Sandstones from 100-150 m thick Horizons I and II demonstrate the electric resistance of 5-10 Om/m. Sandstones revealed at the depth interval of 3102-3015 m in the Horizon II of well # 308 show the electric resistance of up to 15-17 Om/m. 567 m thick strata of Diatom sediments were penetrated by the well # 292 at the depth interval of 2658-3225 m. These strata include two 50-60 m thick highly argillised Sarmatian successions. Electric resistance of the existing 1-2 m thick beds of siltstones doesn't exceed 2-3 Om/m.

Sarmatian sediments are more widely occurring in the Southern Gobustan, where they are composing the synclines and local elevations. Thickness of the section grows to 700-800 m from the north to the south. The Sarmatian stage here is represented by its lower, middle and upper portions. Thickness of shaly horizons of the Lower Sarmatian section reaches 375-400 m in Ilkhidagh, Hajivali, Umbaki and Arzani areas. Middle Sarmatian is occurring in a number of structures (Nardaran, Suleyman, Sundu, Hajivali, etc.), where it is composed of up to 160-165 m thick sandy-shaly sediments. Upper Sarmatian sediments were revealed by boreholes on the southern limb of Umbaki anticline and on the northern limb of Arzani anticline. Its section is represented by argillo-arenaceous, dolomitic and marly sediments. Sometimes, conglomerates are also recorded in the section. Amount of sandstones grows in Umbaki and Arzani structures. In the Southwestern Gobustan, thickness of Sarmatian sediments varies within 175-260 m interval.

Sediments of the Meotian stage are widely occurring in the Western Absheron. Revealed in Uchtapa, Khosmalidagh and Ilkhidagh structures, these sediments are composed of the yellowish-grey thinly bedded shales, marlstones and white volcanic ashes. In the northern part of the Western Absheron (Orjundagh, Fatmayi and Saray areas), Meotian sediments are represented by thinly bedded shales, sometimes marly, as well as several interbeds of volcanic ash and marlstones. In the Southwestern Absheron (Garadagh, Korgoz, Gobu and Damlamaja areas), thickness of the Meotian stage changes from 50 to 350 m. The local thicknesses as well the number of its reservoir beds grow from the south to the west (Figure 6).

Within the boundaries of Southwestern Gobustan, Meotian sediments are recorded on the limbs of Nardaran, Umbaki, Galandartapa anticlines, and on the local synclines. These sediments are lithologically represented by a section of shales, breccias, marls and dolomites. Thickness of the Meotian succession reaches 300-350 m.

In Eastern Hajivali area, Sarmatian stage is 750 m thick and represented by the interbedding light-grey and dark-grey shales, dense marlstones and fine sands. The mudstones and shales contain a lot of the fossils of fish. The stage's thickness is 250 m.

In Arzani-Gilij area, Sarmatian section is constituted of grey, dark-grey mudstones, interbeds of marlstones and shales. Thickness of these sediments is 1050-1100 m.

In Eastern Sundu, Sarmatian sediments are composed of the alternating grey, light-grey and thinly bedded shales, marlstones and dolomites. A layer of volcanic breccia was revealed by the well # 79 drilled in the northern part of the area. The succession is 400-550 m thick.

Meotian stage is represented by the beds of grey, greenish-grey and thinly bedded mudstones, thin and poorly sorted interbeds of lenticular sands, as well as the beds of shales and volcanic ash. Shales contain numerous fossils of fishes and plants. These sediments overlie the eroded surface of the Karaganian horizon. Thickness of the revealed part of the section is 150 m.

In Sheytanud area, stratigraphic units of the Miocene's Diatom Suite (Karaganian and Konkian horizons, Sarmatian and Meotian stages) are widely developed in the area's northern and eastern segments. These 280-300 m thick sediments are represented by mudstones, shales, marls and brecciform dolomites. Amount and thickness of sand beds occurring in the Diatom section increases towards the south and the east.

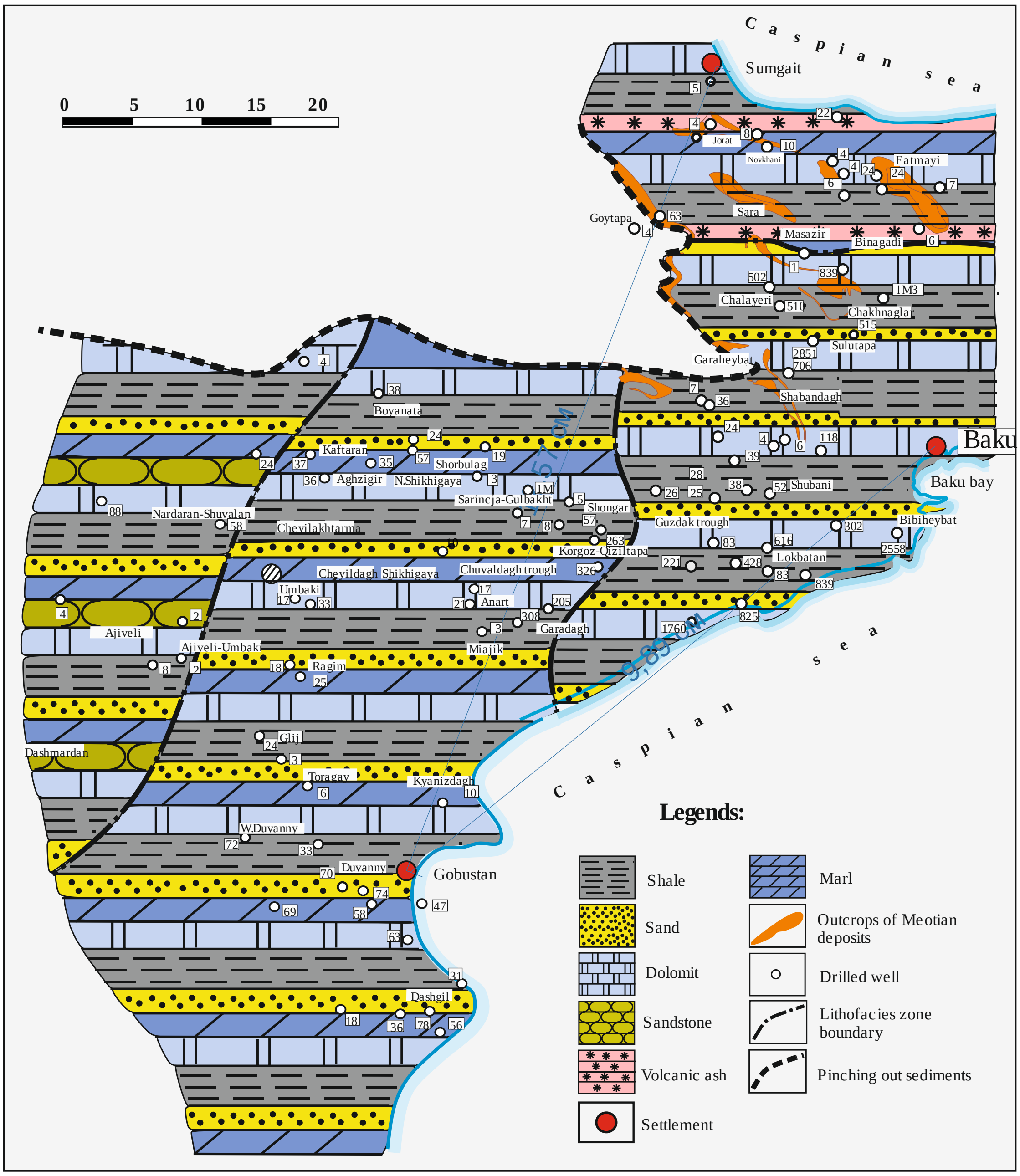

Figure 6. Lithofacies map of the Meotian deposits of Western Absheron and Shamakhi-Gobustan

Based on the above stated, we can conclude that the Oligocene-Miocene sediments widely occurring in the area under study had undergone considerable lithological changes both at the regional and local scales. Thickness of these sediments significantly increases both from the north-northeast towards the south-southeast of the region, and from the near-crest parts of the anticlines towards their limbs and periclines.

Conclusions

Miocene sediments are represented by shale facies in the north and the northeast, and by shale-sand facies in the southwest of the Absheron peninsula. Higher sand content is recorded in Chokrakian and Karaganian horizons, as well as in the top of Sarmatian and bottom of Meotian successions.

In the central and southwestern parts of Western Absheron (Binagadi, Chakhnaglar, Sulutapa, Gara Heybat, Shabandagh, Korgoz-Giziltapa and Garadagh areas), Meotian, Sarmatian, Karaganian and Chokrakian sediments are either pinching out or tectonically screened in the near-crest parts of the anticlines.

In the Southern Gobustan, Oligocene-Miocene sediments have different lithological composition and thickness varying both lateraly and in the section. The reservoir properties of the Maikopian, Chokrakian and Diatom sediments improve and their thicknesses increase from the north to the south and from the west to the east (towards Jeyrankechmaz depression) of the region.

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CƏNUBİ XƏZƏR HÖVZƏSİNDƏ QƏRBİ ABŞERON VƏ ŞAMAXI-QOBUSTAN ƏRAZİSİNDƏ MİOSEN ÇÖKÜNTÜLƏRİNİN STRATİQRAFİK VƏ LİTOFASİAL XÜSUSİYYƏTLƏRİ

K.F. Mustafayev

Azərbaycanda ikinci neftli-qazlı çöküntülər sayılan Miosen çöküntülərinin geniş tədqiqatı və neft-qazlılıq xüsusiyyətlərinin öyrənilməsi xüsusi əhəmiyyət kəsb edir. Miosen çöküntülərinin toplanma şəraiti, kollektor xüsusiyyətləri və neft-qazlılıq perspektivlərini öyrənmək məqsədilə aparılmış geoloji-geofiziki işlərin nəticələri və qazılmış quyu məlumatları kompleks şəkildə təhlil edilmişdir. Bu çöküntülərinin stratiqrafiyası, litologiyası, struktur-tektonik xüsusiyyətləri, geoloji inkişaf tarixi, petroqrafik və litofasial xüsusiyyətləri öyrənilmiş, kollektorluq xassələri geniş tədqiq edilmiş və neft-qazlılıq perspektivlikləri proqnozlaşdırılmışdır. Neft-qazlılığı öyrənmək məqsədilə hər hansı bir ərtazidə geniş tədqiqat aparan zaman həmin sahədə tədqiq olunan çöküntülərin stratiqrafiyasi və litofasial xüsusiyyətlərinin öyrənilməsi xüsusi əhəmiyyət kəsb edir. Məqalədə tədqiqat apardiğimiz ərazidə Miosen və maykop çöküntülərinin stratiqrafik və litofasial xesusiyyətləri geniş təhlil edilmişdir.

СТРАТИГРАФИЧЕСКИЕ И ЛИТОФАЦИАЛЬНЫЕ ОСОБЕННОСТИ МИОЦЕНОВЫХ ОТЛОЖЕНИЙ ЗАПАДНОГО АБШЕРОНА И ШАМАХЫ-ГОБУСТАНСКОГО РАЙОНА, ЮЖНО-КАСПИЙСКИЙ БАССЕЙН

К.Ф. Мустафаев

Изучение миоценовых отложений, второго нефтегазоносного комплекса в Азербайджане, и их нефтегазоносных свойств имеет особое значение. Результаты геолого-геофизических исследований и анализов керна скважин были проинтерпретированы с целью изучения стратиграфии, литолого-фациальных свойств и качества коллекторов миоценовых отложений Южно-Каспийского бассейна. Полученные выводы имеют научно-прикладное значение и могут быть использованы при проведении поисково-разведочных работ на нефть и газ.

LONG-TERM MANTLE PLUME-TRIGGERED SUBSIDENCE: A NEW FRAME FOR GEOLOGICAL JUDGEMENTS?

Geodynamic modeling provides a lot of interesting thoughts for field geology that should not be ignored. For instance, it has been proposed recently that mantle plume emplacement triggers long-term (~20 Ma) subsidence and subsequent short-term (~5 Ma) uplift, after which flood volcanism start. Of interest is whether this idea facilitates interpretation of the geological information available from some regions. Theoretically, one should consider the noted duration of subsidence and uplift phases before flood volcanism and also the motion of lithospheric plate(s) above the rising plume in order to make judgements. Two case examples illustrate what do these considerations mean for interpretation of geological information. The mantle plume related to the Cameroon hotspot could trigger hypothetically the long-term subsidence in West Africa in the first half of the Mesozoic. In the late Cenozoic, the emplacement of the plume that is presently located beneath the Caucasus could lead hypothetically to the Neogene subsidence in the Caspian tectonic domains. The both hypotheses face with some contradictory lines of evidence. However, the hypothesized mechanism of subsidence cannot be rejected totally. At least, the basins are found almost exactly there, where subsidence is expected from the available information about mantle plumes and plate motions.

Keywords: mantle plume, sedimentary basin, subsidence, Mesozoic; Cenozoic; West Africa; Caucasus

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Introduction

The history of science and, particularly, geoscience knows a lot of examples of when brilliant or, at least, interesting hypotheses sank in the "sea" of other ideas. Such a problem with scientists' awareness has become even stronger in the modern geoscience with its unprecentedly broad and dense information flows (e.g., Ruban, 2011, 2016). There are also examples of when concepts were well-appreciated, but almost not used for further solution of particular problems. This is especially dangerous in those cases when theoretical advances based on calculations, modeling, and simulations allow practical applications.

A few years ago, Leng and Zhong (2010) published results of their modeling of topography reactions to mantle plume emplacement. They challenged the classical view of mantle plumes as triggers of significant uplifts and demonstrated that plumes may be responsible for significant surface subsidence on a long time scale. This echoes some considerations by Kumagai et al. (2008) expressed a bit earlier. Moreover, Leng and Zhong (2010) insisted on the possibility of use of their results for the purposes of interpretation of field geological data. Although their work was cited multiply (according to scopus.com), it appears the authors' ideas have not been used appropriately for in-depth discussions of real geological situations. This is disappointing because the so-called "dynamic topography" and some relevant concepts of tectonic influences on the Earth's surface are on the top of the present-day research (Heine et al., 2008; Moucha et al., 2008; Conrad and Husson, 2009; Braun, 2010; Lovell, 2010; Jones et al., 2012; Spasojevic and Gurnis, 2012; Conrad, 2013; Rowley et al., 2013; Zorina et al., 2013; Gvirtzman et al., 2016; Plyusnina et al., 2016;

Ruban, 2016; Ruetenik et al., 2016; Schiffer and Nielsen, 2016). In the other words, if the arguments of Leng and Zhong (2010) are correct, the research community misses chance to extend the vision of topographical effects of the mantle plume dynamics.

The main objective of the present brief paper is to return to the original idea of Leng and Zhong (2010) from the "pure" geological point of view. Of interest is whether this idea facilitates interpretation of the available geological information. Undoubtedly, this paper may be judged debatable itself because it does not address critically the idea of Leng and Zhong (2010), but it seems to be more preferable to start debating than to ignore something potentially very important.

Simple interpretative frame

The nature of mantle plumes and their distribution in the geological time–space are described in numerous works (Abbott and Isley, 2002; Kumagai, 2002; Anderson, 2007; Courtillot, 2007; Kumagai et al., 2008; Yoshida, 2014; French and Romanowicz, 2015; Pirajno and Santosh, 2015; Cagney et al., 2016; Hastie et al., 2016). It has been accepted widely that mantle plumes ascending from the deep interiors of the Earth push the planetary surface upward to produce large uplifts (e.g., Griffith and Campbell, 1991). E.g., according to Hallam (2001), the probably global end-Triassic regressive episode resulted from the plume emplacement in the Central Atlantic; Lindsay (2002) explained the major uplift in central Australia at ~900 Ma by the rising superplume.

The modeling of Leng and Zhong (2010) suggested that mantle plumes may produce topography uplifts for only a few millions of years before flood basalt eruption. Before this, plumes also influence the surface, but in the opposite way. Moving upwards, mantle plume experiences ringwoodite –perovskite phase change at the depth of 660 km with negative buoyancy that causes significant subsidence during a couple of dozens of millions of years (Leng and Zhong, 2010). In the other words, the long-term mantle plume-triggered subsidence precedes the relatively short-term uplift. This simply-sounding idea (although based on high-tech modeling) may explain formation of some large sedimentary basins, including those cratonic (in addition to the other explanations – e.g., see Heine et al. (2008), Armitage and Allen (2010), Wangen (2010), Busby and Azor (2010), and Xi et al. (2014)). If so, this idea may be linked to the old-fashioned idea of epeirogeny (Zorina et al., 2013).

The idea of Leng and Zhong (2010) can be applied as a kind of frame for "pure" geological judgements about sedimentary basins (Figure 1). First of all, it is necessary to understand that the emplacement of mantle plume may explain large subsidence "above" this plume during n*10 Ma. Leng and Zhong (2010) indicate 20 Ma-long subsidence, but exact numbers matter in the models only. In reality, plume morphology, state of the mantle, thickness and tectonic regime of the lithosphere, and many other factors may lead to shorter or larger duration of the relevant subsidence. The magnitude of the plume-triggered subsidence depends on the Clapeyron slope for the phase change (the gradient of the variation of pressure with temperature). As it is impossible to establish this slope for each real situation, it is necessary to take into account the possible variations of the subsidence duration and strength. Generally, any subsidence on the territory "above" the plume within the time frame of ~5–30 Ma before massive eruptions may be attributed hypothetically to the mechanism described by Leng and Zhong (2010). Such a subsidence can be documented easily with usual geological data when basin analysis and/or palaeogeographical reconstructions are attempted. As for the post-subsidence and before-eruption uplift, it also can last more or less than 4 Ma calculated by Leng and Zhong (2010).

Plate motions are active, and the lithosphere has been re-organized multiply through its entire evolution. Global reconstructions illustrating such a dynamics are available for the Phanerozoic (Scotese, 2004; Seton et al., 2012; Stampfli et al., 2013) and the Precambrian (Pesonen et al., 2004), although they are much less precise in the latter case. When mantle plume is emplaced during several dozens of millions of years, plates move above it, and, thus, the subsidence may "migrate" accordingly. When interpretations of long-term mantle plume-triggered subsidence are made, such a "migration" should be taken into account (Figure 1). Fortunately, the history of many mantle plumes and plate motions is more or less known for the Mesozoic–Cenozoic (Golonka and Bocharova, 2000; Seton et al., 2012), although much work is yet to be done to obtain the similarly clear knowledge of the earlier intervals of the geological time.

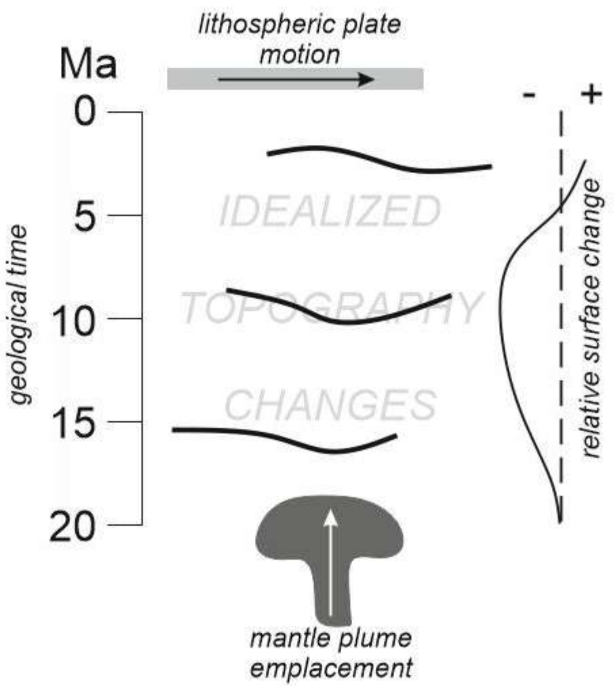

Figure 1. General interpretative frame of the long-term mantle plume-triggered subsidence based on the model of Leng and Zhong (2010)

Case examples should be considered in order to understand how well can work the proposed interpretative frame (Figure 1). These examples should not be "ideal", but "ordinary", i.e., when the mantle plume-triggered subsidence was not considered earlier. Additionally, each example should be discussed with the only very general geological data (the available palaeogeographical reconstructions are of utmost importance for this purpose) to demonstrate the clarity of the approach and its utility for all situations and without some additional/highly-specific analyses.

Case example 1: Mesozoic subsidence in West Africa

In the Mesozoic, several mantle plumes rose beneath Africa, which resulted in effusive volcanism and rifting (Golonka and Bocharova, 2000; Guiraud et al., 2005; Ngako et al., 2006; Seton et al., 2012). One of these plumes can be related to the Cameroon hotspot that was located in West Africa. The history of this hotspot is described comprehensively by Golonka and Bocharova (2000). In the Mesozoic, it occupied position on the territory of actual Niger, and it shifted southwards in the Cenozoic to reach what is now the coast of Cameroon. Significant volcanic eruptions and development of the relevant extensional tectonic structures (first of all, the Benue Trough) took place in the Late Jurassic–Early Cretaceous (Golonka and Bocharova, 2000; Guiraud et al., 2005). These can be understood as a kind of culmination of the plume activity. The plate tectonic reconstructions of Seton et al. (2012) show generally the same history of hotspots as presented by Golonka and Bocharova (2000). Ngako et al. (2006) proposed a more complex model of the geodynamic evolution of West Africa, although it anyway suggests the Mesozoic mantle plume activity beneath Africa.

The considerations presented above can be interpreted with the idea of Leng and Zhong (2010) (Figure 1). The noted culmination of the plume activity in the Late Jurassic–Early Cretaceous might have been associated with certain uplift at the Middle–Late Jurassic transition, which does not contradict the palaeogeographical reconstructions of Guiraud et al. (2005). Earlier, long-term subsidence might have taken place. Taking into account the Mesozoic geological time scale (Gradstein et al., 2012), the hypothesized start of this subsidence can be dated as Late Triassic. An important question is about the location of this subsidence in the African palaeospace. The global geodynamic reconstructions by Seton et al. (2012) imply that the position of the plate changed relatively to the Cameroon hotspot during the first half of the Mesozoic, but not very significantly. Supposedly, the risen plume was located a bit northward from where volcanism and rifting occurred later.

Surprisingly, there was the area experienced long-term subsidence that was located almost exactly at the same place as predicted above (Figure 2). The accurate palaeogeographical reconstructions of Guiraud et al. (2005) depict a large continental basin in the midst of the uplifted cratonic domain. As it is possible to judge on the basis of the noted reconstructions, this area corresponds to the Tim Mersoi Basin located between Hoggar in the north and Air in the east. Its Paleozoic–Mesozoic geology is relatively well-known (Clermonte et al., 1991). Since the beginning of the Mesozoic, this basin occupied chiefly the same area with minimal changes in the palaeospace (Figure 2). Generally, this is consistent with the position of the African plate relatively to the plume (Seton et al., 2012). If so, it is possible to hypothesize that the mantle plume activity triggered long-term subsidence as this may be predicted with the idea of Leng and Zhong (2010).

The above-presented hypothesis, however, cannot be verified fully. The contradictory lines of evidence are as follows. First, the basin subsidence started much earlier than the Late Triassic. The contours of the continental basin can be recognized since the Carboniferous (Guiraud et al., 2005) (Figure 2), and sedimentation on this area started even earlier (Clemente et al., 1991). Second, the basin continued to evolve in the Cretaceous (Guiraud et al., 2005). Third, there is

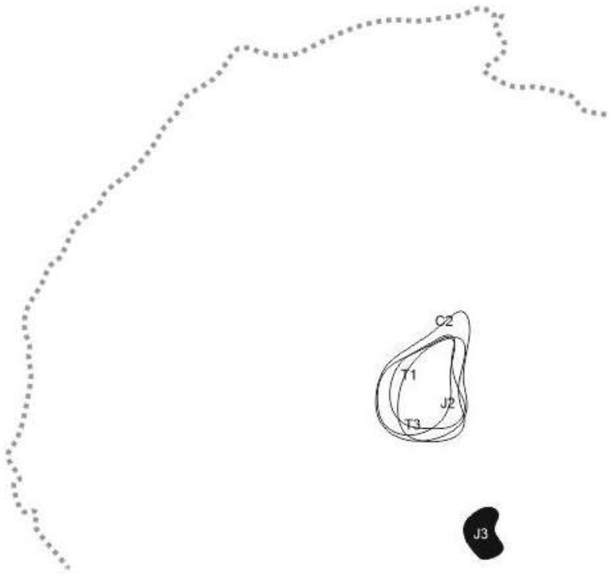

Figure 2. The late Paleozoic–Mesozoic dynamics of the contours (thin black lines) of the continental sedimentary basin and the location of effusive volcanism (black-filled area) on the basis of the series of reconstructions by Guiraud et al. (2005). Geological ages (epochs) are abbreviated. The modern shoreline of Africa (dotted grey line) is given for reference

an alternative explanation of the basin formation and evolution that links them to fault activity and strike-slip displacements (Clemente et al., 1991). The two last lines of evidence can be challenged. The existence of the basin in the Cretaceous can be explained by inheritance of the earlier-formed features under stable tectonic regime after the southward motion of the plume activity. As for the alternative explanation of the basin origin, this does not confront the idea of the mantle plume-triggered subsidence because the influence of mantle plumes on the lithospheric structures could be realized through old-lived weak zones in the crust (Ngako et al., 2006). Therefore, there is the only evidence, namely the early basin formation, that does not fit the hypothesis of the long-term mantle plume-triggered subsidence proposed above. Three possibilities exist:

1) the hypothesis is wrong,
2) the hypothesis is correct (e.g., the

mantle plume initiated subsidence yet in the Paleozoic),

3) the hypothesis is partly correct (e.g., the mantle plume provided only supplementary support of subsidence that occurred because of any other reason).

Anyway, the considerations presented above imply that making hypothesis about the sedimentary basin evolution with the idea of Leng and Zhong (2010) is sensible: at least, the subsided area is found exactly where it is predicted.

Case example 2: Cenozoic subsidence near the Caucasus

The Caucasus is a large mountainous region stretching between the Black Sea in the west and the Caspian Sea in the east; it consists of two major domains, namely the Greater Caucasus and the Lesser Caucasus. Its geological history has been highly complex, and the present stage of its development (late Cenozoic orogeny) is comparable to that of the Alpine tectonic units, even if it differs in timing a bit (Gamkrelidze, 1986; Ershov et al., 2003; Saintot et al., 2006; Tawadros et al., 2006; Adamia et al., 2011; Vincent et al., 2011; Vezzoni et al., 2014). It has been argued that a mantle plume has existed beneath this the Caucasian-Arabian Synthaxis since the late Cenozoic and caused volcanism (Sharko et al., 2015). Although this is a mere proposal (although well argued), it permits to hypothesize mantle plume-triggered subsidence near the Caucasus.

The application of the interpretative frame (Figure 1) makes possible to state that if the Caucasian plume activity culminated near the end of the Cenozoic (Sharko et al., 2015) the relevant subsidence started at ~20–30 Ma and ended just a few millions of years ago. With regard to the geological time scale (Gradstein et al., 2012), this interval corresponds generally to the Miocene (embracing probably the Oligocene and a part of the Pliocene). The Eurasian Plate drifted quite slowly to the northeast through the Neogene (Seton et al., 2012), and this permits to predict location of the subsided area to the northeast of the Caucasus, i.e., in what is now the Precaspian Lowland (a vast plain rimming the Caspian Sea from the north). Since the Oligocene and until the very end of the Pliocene, the large Paratethys Sea stretched between the rising Alpine structures (including the Greater Caucasus) in the south and the "stable" platforms in the north. Its evolution is described in detail in numerous works (Rögl and Steininger, 1983; Rögl, 1998, 1999; Golonka, 2004; Popov, 2006, 2010; Krijgsman et al., 2010; Ruban et al., 2010; Rybkina et al., 2015; van Baak et al., 2016). The part of this sea between the Greater Caucasus and the Russian Plain is known as the Eastern Paratethys. If there was the mantle plume proposed by Sharkov et al. (2015) and if the idea of Leng and Zhong (2010) is valid, there was subsidence in the northeastern part of the Eastern Paratethys. Nonetheless, the entire Eastern Paratethys cannot be explained by the plume influence because this was a typical foreland basin.

The highly-accurate reconstructions of the Eastern Paratethyan palaeogeography (Popov et al., 2006, 2010) demonstrate that the sea was not a kind of stripe between the Caucasian island in the south and the Russian Plain in the north. In fact, it often penetrated to the northeast where formed a large shallow embayment in between of topographic highs (Figure 3). Transgression was especially large there in the Pliocene when the Akchagilian Basin was formed and the shoreline moved far to the north. The large territory affected by this transgression corresponds well to that where the mantle plume-triggered subsidence is predicted (see above). It is established that the shoreline shifts in the Eastern Paratethys were controlled significantly by the water balance in the basin and the development of tectonic barriers that isolated the sea from the south and limited the water discharge to the Mediterranean and the remnants of the former Tethys (Popov et al., 2006, 2010). Therefore, the northeastward transgression might have been not induced by the only subsidence. However, it is clear that the noted territory

1) remained topographically very low throughout the entire Neogene to allow multiple broad transgressions (Figure 3),

2) really subsided in the Akchagilian time (at least), i.e., in the second half of the Pliocene (Nevesskaja et al., 2004; Ruban, 2009), as suggested by some geological data (Volozh et al., 2009) and the comparison of the thickness of the Akchagilian sediments (Nevesskaja et al., 2004) with the absolute rise of the sea level (Popov et al., 2010).

Figure 3. The late Pliocene contours (thin black lines – shoreline, thick grey lines – topographic highs) of the Eastern Paratethys and its approximate maximum northern limit (thin dashed line) at the Middle–Late Miocene transition based on the reconstructions by Popov et al. (2006, 2010)

Therefore, the above-made hypothesis of the mantle plume-triggered subsidence near the Caucasus in the Neogene is sensible. It cannot be excluded that this mechanism explains the absence of the desiccation of the Caspian Sea related to the Messinian salinity crisis established recently by van Baak et al. (2016).

The poposed hypothesis faces some contradictory lines of evidence. First, there are not good stratigraphical data (Nevesskaja et al., 2004) that permit to judge about the subsidence in the northeastern edge of the Eastern Paratethys before the Akhchagilian times – the only shorelines are delineated (Figure 3) on the basis of various interpretations (Popov et al., 2010). Probably, the sedimentary successions accumulated during the Miocene transgressive phases of the Eastern Paratethys were eroded during its regessive phases that alternated rapidly. Second, if the interpretations given above are correct, the plume-related uplift and volcanism that occurred in the Caucasus in the Pliocene–Quaternary overlapped with the subsidence of the Akchagilian Basin in the Pliocene. This is a serious controversy. It can be resolved if to imagine that the Akchagilian Basin inherited the earlier-developed structure, whereas the mantle plume affected directly the Caucasus in the Akchagilian times because of the northeastward motion of the Eurasian Plate. Alternatively, the modern plume-related Caucasian volcanism does not mean the culmination of the plume activity. Third, of significant interest is a strong (and only tentatively explained) increase in the subsidence in the South Caspian Basin in the Pliocene–Quaternary when up to 10 km of sediments accumulated (Brunet et al., 2003). It can be hypothesized that the mantle plume started to influence the other region (neither the Precaspian nor the Caucasus) together with the motion of the Eurasian Plate. The unusual morphology of the plume proposed by Sharkov et al. (2015) may give a proper explanation, although this requires further investigations. Generally, the considerations presented above suggest that it is sensible to apply jointly the plume model proposed by Sharkov et al. (2015) and the idea of Leng and Zhong (2010) to the late Cenozoic evolution of the Caucasus and the nearby territories, although much work to verity the hypothesis of the plume-triggered subsidence there is yet to be done.

Conclusions

The analysis presented in this paper permits three general conclusions.

1) The idea of the long-term mantle plume-triggered subsidence of Leng and Zhong (2010)

permits to propose a simple interpretative frame for "pure" geological judgements.

2) The activity of the Cameroon hotspot may explain the presence of the early Mesozoic sedimentary basin in West Africa, although only hypothetically.

3) The activity of the Caucasian mantle plume provides some insights into the mechanism of subsidence of the Caspian domains, although with significant uncertainty and questions yet to be answered.

It should be stressed that the case examples chosen for the purposes of the present work are not "ideal", and, thus, the absence of clarity in the interpretations is both expected and permitted. Thus, the idea of the long-term mantle plume-triggered subsidence cannot be rejected totally. The present hypothetical considerations coupled with the observations in the "ideal" situations (Leng and Zhong, 2010) imply that such a subsidence appears to be possible mechanism of sedimentary evolution, which should be considered seriously when field geological data are interpreted.

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MANTİYA PLYUMALARININ TƏKANI İLƏ UZUNMÜDDƏTLİ ÇÖKMƏ: GEOLOJİ MÜHAKİMƏLƏR ÜÇÜN YENİ BİR ƏSASDIR?

Dmitriy A. Ruban

Geodinamik modelləşdirmə çöl geologiyasında istifadə olunmaq üçün gözardı edilməyəcək qədər çox maraqlı ideyalar təqdim edir. Məsələn, bu yaxınlarda göstərildi ki, mantiya plyumalarının tətbiqi uzunmüddətli (~20 milyon litr) çökməyə və sonra qısamüddətli (~5 milyon litr) yüksəlməyə kömək edir. Bu da pilləli vulkanizmin baş verməsinə səbəb olur. Bu fikrin müxtəlif bölgələrdən olan geoloji məlumatların təfsirinə nə dərəcədə kömək etdiyini bilmək maraqlı olardı. Nəzəri olaraq müvafiq hökmlər üçün pilləli vulkanizmin baş verməsinə səbəb olan çökmə və yüksəlmələrin faza müddətinə, litosfer plitəsinin (plitələr) yüksələn plyuma üzərində hərəkətinə olduğu qədər diqqət yetirilməlidir. İki nümunə bu mülahizələrin geoloji məlumatların interpretasiyası üçün əhəmiyyətini göstərir. Kamerun isti nöqtəsi ilə əlaqəli mantiya plyuması hipotetik olaraq Mezozoyun birinci yarısında Qərbi Afrikada uzunmüddətli çökməyə səbəb ola bilərdi. Hal hazırda Qafqaz “altında” yerləşən və gec kaynozoyda tətbiq olunan plyuma isə hipotetik olaraq Xəzərin tektonik domenlərinin neogen çökmələrinə səbəb ola bilərdi. Hər iki fərziyyə bir sıra ziddiyyətli faktlarla üzləşir. Lakin təxmin edilən çökmə mexanizmi tamamilə istisna edilə bilməz. Ən azından çökmə hövzələri ən çox mantiya plyumaları və litosfer plitələrinin hərəkətləri sayəsində yaranması təxmin olunan çökmələrin olduğu yerlərdə tapılır.

ДОЛГОВРЕМЕННЫЕ ОПУСКАНИЯ, ВЫЗВАННЫЕ МАНТИЙНЫМИ ПЛЮМАМИ: НОВАЯ ОСНОВА ДЛЯ ГЕОЛОГИЧЕСКИХ СУЖДЕНИЙ?

Дмитрий А. Рубан

Геодинамическое моделирование предоставляет множество интересных идей для использования в полевой геологии, которые не должны игнорироваться. Например, недавно было показано, что внедрение мантийных плюмов способствует долговременными (~20 млн. л.) опусканиям и последующим кратковременным (~5 млн. л.) поднятиям, после чего начинается трапповый вулканизм. Представляет собой интерес выяснить, насколько эта идея способствует интерпретации геологической информации из некоторых регионов. Теоретически для соответствующих суждений необходимо принять во внимание отмеченную длительность фаз опусканий и поднятий, предшествовавших трапповому вулканизму, равно как и движения литосферной плиты (плит) над поднимающимся плюмом. Два примера иллюстрируют значение этих соображений для интерпретации геологической информации. Мантийный плюм, связанный с Камерунской горячей точкой, гипотетически мог способствовать долговременным опусканиям в Западной Африке в первой половине мезозоя. В позднем кайнозое внедрение плюма, который в настоящее время располагается "под" Кавказом, гипотетически могло способствовать неогеновым опусканиям в каспийских тектонических доменах. Обе гипотезы наталкиваются на некоторые противоречащие факты. Однако предполагаемый механизм опусканий не может быть исключен полностью. По меньшей мере, осадочные бассейны обнаруживаются непосредственно там, где такие опускания предполагаются на основе информации о мантийных плюмах и движениях литосферных плит.

HISTORY OF THE OIL-GAS COOPERATION BETWEEN BAKU AND UKHTA

Cooperation of the oil workers of Ukhta with oil engineering professionals from Azerbaijan had begun since early years of discovery and commercial exploitation of the Timan-Pechora oil-and-gas province. First specialists from Azerbaijan arrived in Ukhta on their own accord, dedicated many years of their lives to the province and made great contribution to a discovery and development of its rich resources. Highly professional cooperation and devotion to work is widely known to be a passport to success in the different types of human activities, including search and exploration of mineral deposits. Direct contribution of the Azerbaijani specialists into development of Timan-Pechora oil-and-gas province is an indicative of great advantage of such fruitful cooperation.

Keywords: cooperation, Ukhta oil workers, search and exploration, specialists of Azerbaijan.

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One of the first Azerbaijani envoys in Ukhta was **Andrey Krems** (Born in July 17, 1899, in Kulchuk). Right after his graduation from the Baku Polytechnic University, A.Krems had started his engagement with oil prospecting activities in Azerbaijan. In 1931, he completed correspondence courses at the Azerbaijan Institute of Oil and was awarded the order of Lenin in recognition of his merits in oil exploration. In 1932, he became chief geologist at "Azneft" (Azerbaijan State Oil Production Concern), and in 1934-1938, worked as chief geologist of "Glavneft" (Chief Oil Industry Administration under the People's Commissariat of Heavy Industry). In 1936, A.Krems and a group of his colleagues have visited US, where they learnt how to use geophysical methods during exploration oil and gas sediments, and then tried to apply these methods in the oil-gas exploration in USSR. In 1938, A.Krems was taken into the custody and in 1939 exiled to Ukhta, where he was hired as a reservoir specialist for the design stage of the Union's first heavy oil production mine (Демченко, Зыков и др., 2007; Ухтинский государственный…, 2008).

In 1947, Krems gained an audience by Stalin and informed him on status and perspectives of the Republic's oil-gas economy. In 1960, he was appointed a chief geologist of the recently established Ukhta Territorial Geological Administration and served there as deputy-head of geological department for the rest of his life.

A.Krems had initiated organization of mini-academy for the secondary school students of Ukhta and its Region, where the children have had an opportunity to familiarize themselves with different professions and to decide on their path of life. At the Academy, A.Krems read the lectures on geology and helped schoolchildren learn more about the profession of geologist. Also, he was the one of key persons to initiate the establishment of Ukhta Industrial Institute with the faculty of oil and gas. During fledging years of the Institute's functioning, he headed its first geological department. Krems was a doctor of science in geology and mineralogy, professor.

Merits of A.Krems have been highly appreciated by the state: he was twice laureate of the Stalin's prize, Hero of the Socialist Labor, chevalier of the orders of Lenin (triple), Red

Banner of Labor (double) and the Red Star, as well as the holder of a number of USSR medals. He received honorary degrees of the "Eminent science and technology professional of RSFSR and Komi ASSR" and the "Honorary Citizen of Ukhta".

A.Y.Krems died on May 31, 1975. His name is assigned to one of the streets in Ukhta, and to the University's geological museum. Commemorative tablet was attached to a wall of the house, where Krems used to lived, and the division of Ukhta Local History Museum was opened in his apartment.

Mikhail Bernstein was born on November 15, 1911, in the Ramana settlement of Azerbaijan. In 1938, that same year that A.Y.Krems was arrested, a warrant has been issued to detain Bernstein when he was a student of Azerbaijan Institute of Oil. After his arrest and exile, Mikhail started working in the integrated plant of Ukhta, managing the Union's first gas field in Krutyansk and supervising the design of local lampblack plants. In 1942, Bernstein was released conditionally but decided to continue his work in Ukhta, first as a head of department, then as deputy chief engineer and deputy-manager of the Ukhta combine. In 1952, he was completely rehabilitated, and in 1960 became chief of the Ukhta department of "PechorNIUI" (Pechora Scientific Research Institute of Coal), which was renamed in 1963 into the Ukhta Oil and Gas Division of "VNIIGAS" (Research Institute for Natural Gases and Gas Technologies). In 1965, Bernstein, who had demonstrated himself as highly qualified specialist, was transferred to Moscow to the Ministry of Oil and Gas Industry of USSR. Later he managed a sector at the Fundamental Research Laboratory of Complex Oil-Gas Industry Development, functioning at I.M.Gubkin Moscow Institute of the Petrochemical and Gas Industry.

For discovering the new oil sediments in Timan-Pechora oil and gas province, M. Bernstein was given the Stalin's award (1947) and the award pin *"Standout of the Socialistic Competition of RSFSR"*. In 1981, he was merited the award pin "Standout of the Oil Industry" and the certificate of the Committee of Inventions under the Soviet of Ministers of USSR. M.A.Bernstein died in Moscow in 1984 (Векшина, Матросова и др., 2009.).

Semyon Zdorov was born on December 17, 1910, in the Akhmetka village of Krasnodar Krai. In 1936, pending his completion of Baku Oil Institute named after M.Azizbekov, he had moved to Ukhta, and in 1940-1948 has worked there as chief geologist of the Geological exploration department of NKVD (People's Commissariat of Internal Affairs). In 1948-1950, Zdorov used to supervise rare metal exploration activities in Middle Timan. In the following years he worked as deputy chief geologist and chief of geological exploration department of the Ukhta Combine. In 1958-1960, Zdorov served as chief of the Central Scientific Research Laboratory, and in 1960-1973 – as the Combine's deputy chief and chief geologist.

In recognition of his merits in the oil field development, S.F.Zdorov was awarded the Stalin's Prize of USSR, Order of the Bridge of Honor, medals for the "Distinguished Labor" and the "Victory over Germany in the Great Patriotic War 1941-1945". He was also given the titles of "Honored Oil Worker of USSR" and "Eminent Science and Technology Professional of Komi ASSR (1954)". S.F.Zdorov died in Ukhta in 1980.

Georgy Kuznetsov was born in 1915 in Baku. Having graduated from the Azerbaijan Industrial Institute named after M.Azizbekov in 1939, he started working at the Ukhta Combine, in which he became chief engineer in 1956 and manager in 1958. In 1960-1963, G.Kuznetsov worked at the recently established Ukhta Territorial Geological Administration. In 1950, G.Kuznetsov has been awarded the Stalin's Prize of USSR for development of new chemical product. In recognition of his merits to the Republic and to the Soviet Union, he received the Order of the Bridge of Honor as well as the medals for "Distinguished Labor" and "Valorous Labor n the Great Patriotic War 1941-1945", and the award pin of USSR Ministry of Interior for the "Exploration of Pechora Basin" (1947). G.A.Kuznetsov died in 1976 (Боровинских, Герасимов и др., 2014, page 405).

Konstantin Mashkovich was born in 1903 in the Stepnoye village of Stavropol Governorate. After completing the Azerbaijan Polytechnic Institute in 1930, he had worked at different exploration and oilfield organizations in Baku, and represented "Aznefterazvedka" (Azerbaijan Oil Exploration Organization) at XVII International Geological Congress held in Moscow in 1937. In 1940, K.Mashkovich has been arrested and since May, 1943, started serving his sentence in Ukhtidzemlag (Ukhta-Idzemsk Forced Labor Camp), but soon was deconvoyed. Mashkovich was recognized as oil geologist, tectonics specialist, doctor of geology and mineralogy, professor, Honored scientist of RSFSR. In 1951, he received the Stalin's Prize of USSR for his contribution to discovery of Voyvozh oil-gas deposit. He has held the positions of the chief geologist at "Voyvozhneft" Trust after his release, and the chief geologist at "Saratovneft" since his final rehabilitation in 1954. In 1961-1963, Mashkovich served as director of newly established Nizhnevolzhsk Scientific-Research Institute of Geology and Geophysics in Saratov. In 1963, he became the Institute's deputy director on geology and worked there until his retirement in 1971. Died in 1974 (Боровинских, Герасимов и др., 2014, page 406).

Faig Mammadov was born in 1935 in Fuzuli, Azerbaijan SSR. He had started his work career in 1956 at "Azneft", and since 1962, has worked at "Ukhtaneftegazogeologiya" (Ukhta Oil and Gas Geology), occupying the positions of engineer at the production department of "Pechorneftegazrasvedka" Trust (Pechora Oil-Gas Exploration), chief geologist at Oil Exploration Expedition (NRE)-2, section supervisor of well tryout and casing section at NRE-5 (Naryan-Mar), supervisor of wellbore testing section at NRE-5, and chief of Ukhta expedition. In 1985, he was appointed the general director of "Ukhtaneftegazgeologiya" Production Geological Association. F.Mammadov has been awarded the honorary title of "Deposit Discoverer" for discovering the Upper Vozey oil deposit. He was also mandated the titles of "Honored Geologist of RSFSR" and "Honored Worker of the National Economy of Komi ASSR", as well as the Order of the Badge of Honor (Дорогами надежд и сомнений, 2000, attachment. 1; 4, page 418).

Asif Sayadov was born on June 6, 1951, in Gazanchy village of Azerbaijan. In 1974, he had completed the Azerbaijan Institute of Oil and Gas, and in 1977-1990, worked as the head of department of organization and introduction of scientific-technical developments under the All-Union Oil Scientific Research Institute of Accident Prevention in Baku. In 1990-1997, A.Sayadov worked as manager of the Ukhta base "PTO & K" under Federal State Unitary Enterprise "Ukhtaneftegazgeologiya". In 1997-2005, he was general director of the same-named public corporation and the State Unitary Enterprise "Seversnabsbyt". In 2006-2008, A.Sayadov has headed the "Intaneft" LLC, and since July 2008 became general director of the Public Corporation "Ukhtaneftegasgeologiya". A.K.Sayadov owns the titles of "Honored Geologist of Russian Federation", "Honored Geologist of Komi Republic", and the award pins for his merits in studying Ukhta's mineral resources, as well as his merits to Ukhta and Komi Republic (Боровинских, Герасимов и др., 2014, page 422).

In 2014, A. Sayadov was arrested, accused of wasting and power misuse and sentenced to 4 years of prison. The trial is not completed yet.

Aleksandr Dyakonov was born on July 15, 1927 in Krasnodar. He had started his working career in 1943 at the geological exploration organizations of "Krasnodarneftegaz". In 1955, he completed the Azerbaijan Industrial Institute named after M. Azizbekov with qualification of mining geological engineer. Since 1959, he worked as research officer at the Krasnodar branch of VNIPIneft (Research and Project Institute for Oil Producing and Oil Chemical Industries). In 1963, he defended PhD in geology and mineralogy, and started managing the laboratory of regional geology. Since 1970, he used to managed the geological exploration and surveying laboratory under the Krasnodar branch of VNIPIneft. In 1978, A.Dyakonov defended his doctoral dissertation. In 1979, he became the oil and gas search adviser in the People's Republic of Angola. In 1983, A.Dyakonov started working at the Engineering Survey Administration. Dyakonov was a dissertation committee member at Ukhta State Techinical University, Geological Institute and the Komi branch of Russian Academy of Sciences, as well as a full member of Russian Academy of Natural Sciences. In recognition of his professional achievements, A.Dyakonov has been awarded the titles of "Honored Scientist of RF", "Honored Worker of Komi Republic" and "Excellent Oil Industry Worker". He also received medals for the "Valorous Labor in the Great Patriotic War 1941-1945", "Valorous Labor in commemoration of Lenin's 100 anniversary", and the commemorative medal of the Russian Academy of Natural Sciences. A.I.Dyakonov died in April, 2010, in Krasnodar (Демченко, Зыков и др., 2007, pages 32–35; Ухтинский государственный…, 2008, page 171; Боровинских, Герасимов и др., 2014, page 377).

Rudolf Ter-Sarkisov was born in Baku on October 19, 1939. In 1970, he had completed Baku Oil Technical College under the Azerbaijan Institute of Oil and Chemistry named after M.Azizbekov. In 1973, he became PhD in technical sciences and since 1979, worked as deputy-director of VNIIGAS (Research Institute for Natural Gases and Gas Technologies) for scientific research.

In 1985, Ter-Sarkisov defended his doctoral thesis in technical sciences. In 1998, he became head of the oil and gas deposit development and exploitation department at Ukhta State Technical University. Ter-Sarkisov had supervised more than 20 scientific candidates and doctors. He was full member of Russian academies of natural and mining sciences, and holder of the titles of "Honored Scientist of the Russian Federation" and "Honored Worker of the National Economy of Komi Republic". Died on November 29, 2016 (Ухтинский государственный..., page 153).

Zafar Yagubov was born in 1945 in Azerbaijan. In 1967, he had completed the automatics and computation faculty of Azerbaijan Polytechnic University. In 1971, he had first visited Yarega, and has moved to Ukhta in 1983. It was upon Yagubov's initiative that the postgraduate training program was opened in Ukhta Research Institute. Since 1996, Z.Yagubov manages the department of electrification and automatization of technological processes. He has worked as director of the Institute of Management and International Business in 1996-2000, and as dean of the information technologies department in 2000-2001. Z.Yagubov is the doctor of technical sciences, professor and member of the dissertation committee of Ukhta State Technical University.

Z.Yagubov holds the titles of "Honored worker of higher professional education" and "Honored Worker of Higher Education of the Russian Federation" (Ухтинский государственный…, 2008, page 208).

Boris Gene was born in Tbilisi, on July 27, 1913. In 1939, he had completed the Azerbaijan Industrial Institute and started working as local inspector and then as deputy chief of the Azerbaijan State Mining-Technical Inspection of SCOI (State Commissariat of Oil Industry). Later, he became deputy chief of Sevzheldorlag (Northern Railway Corrective Labor Camp) for labor.

Since 1943, B.Gene has worked at the Ukhta Combine as well-sinker, gas exploitation engineer and chief of the Nibel gas field. In 1950, he became chief engineer of the "Voyvozhneft" Trust's gas field, and started leading it since 1952. B.Gene was chief engineer of Voyvozh Oil Field Administration (1953-1965) and Mingazprom's (Ministry of the Gas Industry of USSR) Field Infrastructure Development Directorate in Komi ASSR. In 1968-1969, he worked as chief engineer of "Komigazprom" Production Enterprise, and then managed its technical department until 1973. For his merits, B.Gene has been awarded the Order of the Red Banner of Labor, and the titles of "Excellent Worker of the Ministry of the Gas Industry of USSR" and "Distinguished Worker of the National Economy of Komi ASSR" (От «Сияния Севера»…, 2015, pages 18–19).

Helmut Reitenbach was born on January, 10, 1919, in Khanlar, Azerbaijan. On May 21, 1941, 15 days before defending his diploma at the oil-field faculty of Azerbaijan Industrial University, Reitenbach has been arrested and exiled to Ukhtidzemlag (since 1943 - Ukhta Combine of NKVD). There, he has worked as engineer, engineering team leader and senior engineer of the design-and-survey office, and in 1950, became the equipment engineer in coal-pit #29 of "Vorkutaugol" Combine. Released on April 4, 1952 and completely rehabilitated on September, 28, 1956, Reitenbach resumed his work at the design-and-survey office of Ukhta Combine, working there as leader of the oil-field group since August 1952. In 1955, he became chief engineer of the oil field development projects. In 1958, H.Reitenbach completed the All-Union Correspondence Polytechnic Institute with the specialty of "development of oil and gas sediments" and qualification of mining engineer. Since 1961, he worked at the Ukhta oil and gas department of "PechorNIUI" (Pechora Scientific Research Institute of Coal) and passed his PhD defense. In 1966-1968, he worked as deputy-head of the scientific research department, and retired in 1981.

In recognition of his professional merits, H.Reitenbach has been awarded the titles of "Excellent Worker of the Ministry of the Gas Industry of USSR" and "Eminent Science and Technology Professional of Komi ASSR". Died in 2003 (Векшина, Матросова, 2009, pages 86–87).

Igor Ametov was born on January 31, 1947. In 1970, he had graduated from the Azerbaijan Institute of Oil and Chemistry with distinction, and since 1972, started his work at Ukhta Industrial Institute (now Ukhta State Technical University), holding positions of assistant and senior teacher. In 1973, he defended his PhD dissertation titled "Studying the Gravity Effect on Motion of Two-phase Systems as applied to some Problems of the Oil-field Mechanics". Leading the Institute's hydraulics department since 1974, I.Ametov defended his doctoral dissertation in 1979. In 1984, I.Ametov moved to Moscow to become chief of laboratory at the All-Union Oil-Gas Scientific Research Institute. Since 1997, he has also lead the department of development and exploitation of oil and gas sediments in Ukhta. I.Ametov made a considerable contribution to both theory and practice of high-viscosity oil development. Awarded the title of "Honored oil worker", he was the full member of Russian Academy of Mining Sciences and International Eastern Oil Academy. Died in 1997 (Ухтинский государственный…, 2008, page 145).

Azad Mirzajanzadeh was born in 1928. Graduated from Azerbaijan Industrial Institute, he had started his teaching activities, and lectured at the Azerbaijan State University in 1952-1960. A.Mirzajanzadeh led the theoretical mechanics department in the Azerbaijan Institute of Oil and Chemistry in 1959-1962, and the department of oil deposit development and exploitation in the Azerbaijan Oil Academy in 1962-1977. Since 2000, A.Mirzajanzadeh started his part-time employment in Ukhta, working there as professor and rendering consultancy to local teaching staff and postgraduates. A.Mirzajanzadeh is the author of more than 370 scientific papers and multiple scientific breakthroughs, including fundamentals of well drilling under complicated conditions. Being a doctor of technical sciences, he was elected the correspondent and then the full member of Azerbaijan National Academy of Sciences. Died in 2006 (Ухтинский государственный…, 2008, pages 151–152).

Anna Moliy was born in Baku on February 16, 1909. In 1933, she had completed the Azerbaijan Industrial Institute with the specialty of oil refining. In 1932-1938, she has worked as engineer-on-duty and chief of the deparaffination workshop at Baku Oil Refinery. In 1938-1940, A.Moliy worked as engineer and senior engineer at "Azneftezavodproject" (Azerbaijan Oil Factory Design Institute). Since November 1940, she has started her career in Ukhta as engineer at the production department of Ukhtizhemlag. In 1942-1951 she worked as director and chief engineer of the Ukhta Oil Refinery. In 1955, A.Moliy completed the Moscow Oil Industy Academy and continued her work as director of Ukhta Oil Refinery. Since 1967 until last she used to manage the laboratory "Study and Refining of Gas and Condensate".

A.Moliy has been awarded the Lenin's order (twice) as well as the orders of Red Banner of Labor and the Badge of Honor, and multiple Soviet medals. She was also given the honorary titles of "Eminent Science and Technology Professional of Komi ASSR", "Honored Oil Worker of Komi ASSR", "Honored Worker of Science and Culture", "Shock worker of the 9th Five-year", "Honorary Freeman of Ukhta" and "Ukhta Citizen of the Century". A.Moliy died on April 12, 1979, 4 years after the death of her husband – A.Krems (Теплинский, 2009, pages 103–118).

Gulnara Krimcheeva was born in Tbilisi on July 18, 1942. In 1964, she had completed the physics department of Azerbaijan State University with the specialty of "Physics". After her graduation she has worked as engineer in Penza oblast (1964-1966), Energy Institute in Baku (1966-1975) and the All-Union Scientific Research and Design Institute of Natural Gas Development, Transportation and Refining (since 1975). Since 1998, G. Krimcheeva serves as professor at the gas main operation department of Ukhta State Technical University (Портрет Интеллекта, 2015, page 87).

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25 - 29 June, 2018, Syros - Mykonos, Islands, Greece

Email: isplab@uth.gr
Website: http://2018.geomapplica.eu/

ERAD 2018 – 10TH EUROPEAN CONFERENCE ON RADAR IN METEOROLOGY AND HYDROLOGY

01 - 06 July, 2018, Reehorst, Netherlands

Website: https://www.erad2018.nl/

3RD VIRTUAL GEOSCIENCE CONFERENCE (VGC)

22 - 24 August, 2018, Queen's Universty, Kingston, Canada

Website: http://virtualoutcrop.com/vgc2018

CLIMATECONF 2K18

30 - 31 August, 2018, Bali, Indonesia

Tel: +91 9087388294

Email: climateconf@bioleagues.com
Event website: https://bioleagues.com/conference/Climate-Change/

MAGMATISM OF THE EARTH AND RELATED STRATEGIC METAL DEPOSITS

03 - 07 September, 2018, Moscow, Russia

Email: alkaline.conference@gmail.com
Website: http://magmas-and-metals.ru

Tel: +79104736108

2ND CONFERENCE ON GEOPHYSICS FOR MINERAL EXPLORATION AND MINING

09 - 13 September, 2018, Porto, Portugal

Website: https://events.eage.org/en/2018/2nd Conference on Geophysics for Mineral Exploration and Mining

GEOMODEL 2018 — 20TH CONFERENCE ON OIL AND GAS GEOLOGICAL EXPLORATION AND DEVELOPMENT

10 - 14 September, 2018, Gelendzhik, Russia

Website: https://events.eage.org/en/2018/Geomodel 2018

SECOND EAGE WORKSHOP ON GEOCHEMISTRY IN PETROLEUM OPERATIONS AND PRODUCTION

01 - 04 October 2018, Muscat, Oman

Website: https://events.eage.org/en/2018/Second EAGE Workshop on Geochemistry in Petroleum Operations and Production

SEG 18 ANNUAL MEETING – SOCIETY OF EXPLORATION GEOPHYSICISTS INTERNATIONAL EXPOSITION & 88TH ANNUAL MEETING

14 - 19 October 2018, Anaheim, United States

Email: bdonica@seg.org
Website: http://seg.org/am

Tel: 918-497-5547

GIMS14 – 14TH INTERNATIONAL CONFERENCE ON GAS IN MARINE SEDIMENTS

14 - 20 October, 2018, Haifa, Israel

Email: giuliana.panieri@uit.no
Website: http://gims14.haifa.ac.il

THE GEOLOGICAL SOCIETY OF AMERICA (GSA) 2018 ANNUAL MEETING

04 - 07 November, 2018, Indianapolis, United States

Website: http://www.geosociety.org/meetings/

FOURTH AAPG/EAGE/MGS MYANMAR OIL & GAS CONFERENCE

13 Nov 2018 - 15 Nov 2018 • Yangon, Myanmar

Website: https://events.eage.org/en/2018/Fourth AAPG_EAGE_MGS Myanmar Oil and Gas Conference

FOURTH EAGE EASTERN AFRICA PETROLEUM GEOSCIENCE FORUM

03 - 05 December, 2018, Nairobi, Kenya

Website: https://events.eage.org/en/2018/Fourth EAGE Eastern Africa Petroleum Geoscience Forum

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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