ATLANTIS PRESS

Advances in Engineering Research, volume 177

International Symposium on Engineering and Earth Sciences (ISEES 2018)

Deep Structure and Oil and Gas Content of Submerged Zones of Western Part of Terek-Caspian Trough

Daukaev A.A.
Laboratory of Geology and Geoecology
R&D Institute RAS
Chechen State University
Grozny State Oil Technical University
Grozny, Russia
daykaev@mai.ru

Bachaeva T.Kh.
Laboratory of Geology and Geoecology
R&D Institute RAS
Chechen State University
Grozny State Oil Technical University
Grozny, Russia bachaeva@bk.ru

Abubakarova E.A.
Laboratory of Geophysics
R&D Institute RAS
Grozny, Russia
eliza_ggni@mai.ru

Aidamirova Z.G.
Department of Applied Geology
Grozny State Oil Technical University
Grozny, Russia
lizi_68@list.ru

Elzhaev A.S.
Laboratory of Geology and Geoecology
R&D Institute RAS
Grozny, Russia
e-mail aslambek.elzhaev@mail.ru

***Abstract* — The article is devoted to the issues of the structure of deep submerged zones and oil and gas potential of Terek-Sunzhensk folded zone. Information on the study history of the region under consideration by deep drilling, CDP seismic reflection method and other geological and geophysical methods is presented in the article. Besides, the modern structure of the basement and sedimentary cover of Terek-Caspian trough is described. The main prerequisites for the deep genesis of oil are listed with an assessment of oil and gas potential of the studied area.**

Keywords* — *Terek-Sunzhensk folded zone, deep structure, hydrocarbon deposits, oil and gas content, basement, faults

I. INTRODUCTION

The Terek-Caspian trough and one of its regions associated with Sunzhensk and Terek frontal folds is one of the most important oil and gas regions of the North Caucasus. Due to the fact that in recent years the stock of anticlinal structures in Upper Cretaceous deposits suitable for exploration drilling for oil and gas has sharply increased, there was raised a question of oil and gas content of deeply submerged horizons, in particular, subsalt Jurassic, the geological structure of which is poorly studied due to a number of objective reasons. Today there is a great amount of material that has been accumulated on various aspects of geological structure, tectonics and the history of the development of Terek-Sunzhensk region, in particular, and the trough in general, including geophysical data. Despite the abundance of diverse geological and geophysical materials, there are many unresolved and unclear questions about the structure of Terek-Sunzhensk region, the method and time of its formation, and specifically the question about the structural plan of deep horizons of the trough, in particular, “subsalt” Jurassic, which is associated with the prospects for the discovery of new deposits.

For many decades (over 120 years), the oil on the territory of the Chechen Republic was mainly produced from the Miocene and Cretaceous sediments within the Starogroznensky, Oktyabrsky, Eldarovsky, Bragunsky and other fields. At present, the depletion of hydrocarbon deposits of the listed and other fields, which were discovered later, amounts to 80-95% and naturally they cannot result in an oil production increase. Therefore, there is an acute problem of studying deep-seated horizons and predicting potential for oil and gas reserves at great depths.

The aim of this work is to assess the current state of the study and the oil and gas potential of deep-seated zones of the western part of the Terek-Caspian trough (TKT).

The main objective of the study is the analysis and synthesis of available materials on various aspects of geology and oil and gas potential of the western part of the TKT. A significant amount of materials accumulated over a long history of studying the region is used.

II. METHODOLOGY

The studies of this region were carried out in the following manner: collection and analysis of actual and library material on the geological structure of the region. A great attention was paid to poorly studied monoclinal and synclinal zones.

III. HISTORICAL ASPECTS OF STUDYING DEEP STRUCTURE

The study of the deep structure of the region began mainly in the second half of the twentieth century. The first structural diagram of the pre-Jurassic foundation of the TKT was compiled by E.E. Milanovsky in 1963. After the basements were opened in the Zolskaya and Baksanskaya areas, a more detailed map of the pre-Jurassic basement of the western part of the Terek-Caspian trough was constructed at a scale of 1:500,000 (M.N. Smirnova, V.A. Stanulis, T.V. Yakovleva).

In 1967, the same team compiled a diagram of the pre-Jurassic basement of the TKT, including Northern Dagestan.

In 1970-1972 (M.N. Smirnova, V.A. Stanulis), a more substantiated structural map at a scale of 1:500,000 was compiled and an influence of the deep structure on the formation of sedimentary cover and fluid migration was revealed.

In 1973, M.N. Smirnova, V.M. Brazhnik drawn up a schematic structural map of the basement of the Chechen Basin at a scale of 1:100,000. In 1975, M.N. Smirnova summarized the materials on the pre-Jurassic basement for the entire territory of the TKT and structured maps and the internal structure diagram of the pre-Jurassic basement were made, where the North Caucasian ophiolite belt was highlighted. At the same time, by extrapolating capacities, the structural diagrams of the basement were developed by B.K. Lotiev, Yu.A. Sterlenko [9].

Many publications are devoted to the study of deep faults: (E.E. Milanovsky, G.D. Azhgirey, N.Yu. Uspenskaya, 1964; B.G. Sokratov, 1965; M.N. Smirnova, 1968; B.K. Lotiev, U. A.A. Sterlenko, I.A. Kerimov, V.D. Talalaev, 1965-1980; I.M. Krisyuk, and others).

In the 70s the works on the analysis of deep faults with the reference to oil and gas exploration appeared [4].

In 1983-1985, with the purpose to study the deep structure, an earthquake converted-wave method was applied along the Datykh-Druzhba line. According to the results of processing and interpretation of geophysical materials, six wave exchange boundaries were identified. The basement surface was fixed at the depths of 8 and 14 km, respectively, in the south and north, a complex folded-block foundation structure was noted with the immersion of blocks from the central part [1].

Basing on the data of deep drilling of wells and the materials for interpretation of time sections of CDP seismic reflection method made it possible to significantly clarify ideas about the structure of the sedimentary cover, the transition complex (Permian-Triassic) and the basement surface. For a large part of the territory, a map of the basement isochrones was constructed using seismic survey materials; besides, large gaps and suture zones were traced, separated by a set of geological and geophysical data. According to the regional seismic profiles of the submeridional strike, temporary paleoreconstructions were completed for later the Eocene time making it possible to compare the history of the geological development of various sections and the formation time of the main tectonic elements. According to the analysis of the results of exploration work in recent years, a tectonic map of the basement surface of the Eastern Pre-Caucasian region has been compiled, specifying the tectonic zoning of the territory. The tectonic elements were highlighted on the map, such as the buried Karpinsky Ridge, the East-Manychsky and Kizlyar trough, the Nogai-Tarumovsky wall and the TKT. The structures have a sublatitudinal strike, are limited by large suture zones and are complicated by numerous ruptures and elements of smaller order [11].

IV. MODERN VIEW ON TEREK-CASPIAN TROUGH

Current data on the deep structure of the TKT is based on the results of geophysical (DSS, CDP, CWM, etc.) and geodynamic studies, as well as deep drilling. The Terek-Caspian trough is located between the Nogaysko-Tarumovsky wall and mega anticlinorium of the Greater Caucasus. It extends in a sublatitudinal direction from Mineralovodsk protrusion in the west up to the Caspian Sea in the east and has the size of 400x120 km. In the Caspian Sea, the trough acquires a submeridional strike and is traced southwards to the Absheron threshold. At the latitude of the city of Derbent, it is complicated by the Samursk protrusion with the basement depth of 7-8 km. Due to the complexity of the geological structure and the significant thickness of the sedimentary cover (9–12 km), the ideas about the structure of its basement are based mainly on materials of geophysical studies (CMPW, CWM) and drilling. The basement was opened by wells only within the limits of Mineralovodsk protrusion, and the stratification of the reflecting horizons of the Jurassic age on the temporary sections is possible on the sides of the trough edges.

The TKT basement is composed of deployed and metamorphosed sedimentary and volcanogenic strata, broken through by the magmatic intrusions. The Late Paleozoic age (Middle Devonian-Upper Carboniferous) of the basement was established by drilling. In the axial part of the TKT, the development of a strip of the pre-Hercynian melanocratic basement, processed during the Hercynian time, is possible [5].

When drilling the well Burunnaya-1 (5,972-7,501 m) the volcanogenic-sedimentary strata of the Triassic age was revealed on the northern side of the TKT. On the southern side of the trough on the Varandi anticline in the allochtonous bedding, the carbonate sediments of about 1,000 m of Upper Permian (Lower Triassic?) age were crossed. 10 km to the north, in the autochthon of the Varandi fold, variegated terrigenous-carbonate rocks were found (Bass-1, 4520-5350 m) related to the Cuman group of the Upper Permian. Earlier, in the Miatlinsk and Talginsk arches of the Dagestan wedge, in the sub-Jurassic section, the dislocated rocks were also revealed, their age was previously determined as Permian or even more ancient. In this regard, the Triassic dating of the stationed strata of rocks (well No. 47 in the arch of the Benoist offset in the interval 4,114-5,373 m) is incorrect. The tectonic position of the Benoist offset predetermines a small depth of the basement within its limits, and the age of the sub-Jurassic section, (well. No. 47) is logical to assume Permian.

There are different, often opposite, points of view on the geological history of development and mechanisms for the formation of the TKT structure, and in particular of the Terek-Sunzhensk folded zone. In accordance with the first point of view, the Terek- Sunzhensk folded zone is considered as a structural element of the southern side of the TKT (as the zone of the frontal folds) formed as a result of common Caucasian orogenic movements in the Neogene and Quaternary time [6]. According to other researchers who support mobilistic views, the Terek and Sunzhensk anticlinal zones arose “as a result of the general advance of the eastern part of the Greater Caucasus to the Terek-Caspian folded zone”. There are also views on the epiphytic nature of the Terek-Sunzhensk folded zone. [3, 8] The current structural features of the TKT are determined by powerful phases of the inversions of mode and folding (East Caucasian, Pliocene and the newest) with the predominance of tangential compression stresses. Comprehensive studies have revealed large sublatitudinal faults (suture zones) of an ancient foundation 5-7 km wide: Chernogorska, Sunzhensk, Terek, Krai, Nogaisk. These fragmented zones during the periods of stretching of the earth’s crust had greater sizes, and under the influence of powerful tangential compression during the periods of Alpine tectogenesis, they sharply decreased in width (N.I. Kononov, V.D. Talalaev and others). The imbricated overthrust, as well as extended and elevated basement blocks were formed within the suture zones, which determined the formation of the structure of the sedimentary cover. The picture was complicated by the influence of fault zones opposite to Caucasian directions. The tangential stresses of the northern orientation caused a breakdown and displacement to the north of large basement plates and sedimentary cover within the southern edge of trough, which is reflected in the structure of the Dagestan wedge and the Montenegrin tectonic zone [3].

In the modern structural plan of the trough, the surface of the basement seats from west to east from 3 to 12 km and on the sides from 6 to 11 km in the axial part. It is complicated by faults of various orientations, anticlinal and synclinal zones, depressions and protrusions or offsets forming mainly sublatitudinal folding. The northern side of the trough, bounded by the Nogai and Regional faults, has a width of 20-25 km, tilted to the south and southeast with a submerged basement of 6.5 to 9 km. In the west, the slope is complicated by the Stepnovsk trough. In the east the presence of the Shelkovsk and Babayurt paleo-arches is assumed, in the area of which the absence of the Paleocene-Eocene and Upper Cretaceous sediments was revealed by seismic exploration and drilling (disruption and slipping to the axis of the trough). Within the northern border, a powerful volcanogenic and sedimentary stratum of the Triassic age was discovered; a regional pinching to the north of the Jurassic sediments occurs [7].

To the south of the Krai fault, the anticlinal zone with the size of 75X (5-10) km and the height of 0.5 km is singled out, bounded from the south by a narrow extended Pre-Territory depression zone with the basement marks of 8.5-9 km. In the axial part of the TKT, the basement surface is complicated by the linear anticlinal zones (Terek, Grozny-Kharbizhinsk and Sunzhensk) with the size of (120-195) x (5-15) km and the height of 0.5-1 km.

Sublatitudinal anticlinal zones in the south are associated with local isometric depressions (Petropavlovsk, Chechen, Ossetian) within which the basement sinks to the level of 10 to 11 km. The western closure of the trough is represented by the Kabardian basin and the Baksan-Ardon monocline, complicated by the Argudan offset. In the eastern part the Sulak basin is identified with the basement mersion to 12 km. Its southern side is complicated by the Kizilyurt anticlinal zone with the size of 85x8 km and its height of up to 500 m. This zone is vividly observed in the sedimentary cover near the front of the Dagestan wedge, basing on the seismic exploration works.

The southern side of the trough, located at the junction with the alpine folding region of the Greater Caucasus, has a complex tectonic structure and is least studied by drilling and seismic exploration. The surface of the basement to the Montenegrin deep fault is up to 5.5 km, forming a sublatitudinal system of protrusions and blocks bounded by the fractures of the opposite to Caucasian directions. Obviously, in the structure of the basement (similar to the sedimentary cover) the southern side of the trough is complicated by imbricated overthrust, and the distinguished tectonic elements are located in the allochtonous occurrence. The Montenegrin tectonic zone of 120x (10-25) km in size is complicated by a series of faults (Datykh-Akhlovsk, Argunsk, Aksaysk, etc.) and two offsets (Datykh and Benoysk). The latter is the most elevated and is characterized by an ancient foundation. There are no deposits of the lower, middle Jurassic in its arch and the thickness (up to 415 m) of the upper Jurassic is sharply reduced.

As a result of studying the deep structure, the fault-block structure of the basement was noted, as well as the leading role of deep faults in the formation of the structure of the sedimentary cover. There is much room for improvement in the degree of study of the Paleozoic base. The compiled structural maps can be considered only as schematic or presumptive. The situation is much better with the case of separation of deep faults, which are largely based on anomalies of geophysical fields, confirmed by facial analysis, and their current activity is revealed by repeated leveling and migration of the earthquake focus.

At the same time, the study of modern structure of the TKT basement is an urgent task both in theoretical terms for cognition of endogenous processes of marginal deflections, and in practical aspect in order to study the lower horizons of the Triassic and Jurassic (including subsalt Jurassic) covering it. Such studies are also important from the point of view of justification of oil and gas prospects at great depths.

The issues of the deep structure of the territory are closely intertwined with the problem of the oil genesis. In this regard, the historical and contemporary aspects of this problem are described below.

V. Deep Oil Issues

In the second half of XVIII and XIX centuries a number of hypotheses, concepts and theories about the genesis of oil — organic, mineral, cosmic, volcanic, etc. — were described. The fundamentals of the *organic concept* were outlined by M.V. Lomonosov. In his work On the Layers of the Earth, he expressed a number of new ideas, including the origin of oil as a result of distillation of the same organic matter (plant residues) being part of the coal [3]. In the beginning of XIX century A. Humbolt expressed the idea of the *mineral* origin of oil. In the future, this idea was developed in the theoretical and experimental studies of domestic and foreign chemists M. Berthelot, G. Biasson and D.I. Mendeleev. Based on the study of chemical composition of oil, conditions of occurrence and placement of hydrocarbon accumulations, Mendeleev D.I. developed a theory of the inorganic origin of oil. In his book the Oil Industry in Pennsylvania and the Caucasus, published in 1877, he outlined the widely known carbide hypothesis that oil is formed in the depths of the Earth as a result of interaction of water with iron carbide. In order to prove his assumptions, he conducted an experiment in the processing of cast iron enriched with carbon, as a result of which he obtained a product similar to oil. Another confirmation of the deep origin of oil was the location of oil fields in the Caucasus and Pennsylvania on the surface of the Earth [4]. After reviewing the oil sources of the North Caucasus and partly of the Transcaucasus (Georgia), he concluded the following: "We can say that the Caucasus oil fields with their common position clearly justify the new hypothesis about oil, because they are located just along the ridge, parallel to it, and in that very place where the presence of deep cracks is possible and which were formed during the ascent of the Main Ridge" [4].

American geologist J. Costa is considered the author of the modern-time volcanic hypothesis, who most fully described it in 1905. This theory was further developed in the works of the Professor E.A. Steeber, who suggested that oil is formed in volcanic vents at a depth of about 10 km as a result of the reaction between oxide, carbon dioxide and hydrogen, at a temperature of 300-400 °C. The final hypothesis was described by E.A. Shteber in his work On the Origin of Oil from the Products of Emanation of the Earth in 1924 (the Emanational Hypothesis).

In the beginning of 1920s of XX century there were many in-depth studies carried out to learn the patterns of distribution, the conditions of formation and the genesis of oil. These studies were conducted under the guidance of a number of outstanding domestic scientists, among which there was N. D. Zelinsky, A.D. Arkhangelskogo, V.I. Vernadsky, and others.

In the 50s and 60s, both domestic and foreign scientists among which there was N.A. Kudryavtsev, V.B. Porfiriev, P.N. Kropotkin, G.N. Dolenko, F. Hoyle, and others revived various hypotheses of the abiogenic and deep genesis of oil - volcanic, cosmic, and magmatogenic. So, Professor N.A. Kudryavtsev proposed the *magmatic hypothesis* of oil formation, as a new version of the mineral hypothesis, according to which in the Earth's mantle, under very high temperatures, carbon and hydrogen form hydrocarbon compounds - CH, CH2 and CH4. Due to the pressure differential, these radicals move along the mantle material into the zones of deep faults (into the low pressure region) and rise along them. N.A. Kudryavtsev and his followers noted numerous cases of finding hydrocarbons in igneous rocks and associated deposits of oil and gas, as well as traces of oil in kimberlite pipes.

In the 60s of XX century, the detailed thermodynamic studies were carried out to substantiate the possibilities of the formation and existence of hydrocarbon compounds in the deep interior of the earth. These studies were carried out by E.B. Chekalyuk, who, on the basis of the obtained research, concluded that thermal decomposition of hydrocarbons (decomposition of chemical elements into radicals) under high temperature conditions is impeded by high pressure (AHPP) of the Earth's mantle [2]. At great depths, the AHPP contributes to an increase in the lower temperature limit of the existence of oil, which is proved by the discovery of oil deposits in the depths above 6,000 m in a number of oil and gas regions. The research results obtained by E. B. Chekalyuk served as another scientific rationale for the deep origin of oil. In 1971, his monographic work entitled Thermodynamic Bases of Theory of Mineral Origin of Oil was published.

Thus, after almost 300 years of controversy, there has not yet been an end to the debate about the origin of oil. Perhaps this is due the lack of common views on the formation of the Earth itself and the geological processes in its depths. The problem of the genesis of oil is particularly relevant today, when oil reserves, calculated on the basis of the classical biogenic model, are on the verge of depletion. The current stage is characterized by a number of concepts of the origin of oil of mixed or polygenic types [1,2], which are characterized by the convergence of polar views of supporters of organic and abiogenic genesis of oil. According to these concepts the development of complementary theories and hypotheses is possible. These include the so-called mixed or polygenic hypotheses of the origin of oil, based on the theory of tectonics of lithospheric plates, according to which the biogenic substance is drawn into the deep subduction zones. A well-known English organic chemist R. Robinson and the author of the concept of polygenic naftidogenesis Academician A.N. Dmitrievsky, and others supported the idea of dual genesis of oil (partly biogenic, partly abiogenic) [2].

Among the main prerequisites for deep genesis of oil the following are distinguished: oil migrating from the deep zones is under increased pressure, which is confirmed by the fact that it penetrates into the thinnest fractures of rocks, the presence of AHPP within hydrocarbon deposits of many oil-bearing regions of the world, etc.; production of oil flow from the deep horizons of the sedimentary cover and the crystalline basement; obvious irregularity in the distribution of oil clusters and their focal concentration in the zones of active deep faults development within the boundary, foothill, and intermountain ridges and platforms and the their absence in the central parts of the mountain-folded structures; the presence of margins of desalinated, condensing bottom waters within the oil pools, which significantly distinguish from the underlying highly mineralized formation waters, the formation of which is explained by the phase differentiation of gas-liquid fluid mixtures of deep-seated foci; the composition of oil, in particular, the presence of significant quantities of paraffin in it, which could be formed as a result of synthesis from CO and H2.

The study of the conditions for the formation of hydrocarbon accumulations in the framework of geological exploration (GE) is based on the genetic concept that consistently covers the history of the tectonic development of basin, generation of oil and gas, processes of migration, accumulation and preservation of hydrocarbons in the deposits. This concept is generally accepted, and, according to many domestic and foreign researchers, contributes to reducing the risk and optimizing the exploration of oil and gas.

VI. Oil and Gas Potential of Deep-Seated Zones of TKT

Based on the analysis and classification of geological and geophysical materials and drilling data on the oil and gas potential of deeply submerged horizons, the patterns of distribution of hydrocarbon deposits in various geodynamic settings, as well as features of the development of oil and gas formation and oil and gas accumulation of great depths were established.

Within the Terek-Sunzhensk oil and gas region in the context of Mesocenozoic sediment complex, several dozen hydrocarbon fields were identified.

The introduction of geophysical methods and deep drilling made it possible carry out geological prospecting and exploration of oil and gas at great depths since 1980s. More than 75 wells were drilled with the depth of more than 4,500 m, including 35 of them with the depth of 5,500 - 7,500 m.

As a result of targeted geological exploration of deeply submerged Mesozoic deposits for the period of 1958-1993, more than 29 oil, 3 gas and 2 gas condensate deposits were identified in the Terek-Sunzhensk oil and gas bearing area. In the junction zone of the Terek and Sunzhensk anticlinal zones, and the Dagestan wedge, at the depths of 4.5-5.7, the following hydrocarbon deposits were established: Koshkeldinsk (gas), Mesketinsk (transition oil), Benoisk (oil and gas condensate), Novolaksk (gas condensate), etc.

VII. Conclusion

The review of materials indicates a lack of knowledge in the field of deep structure of the territory under consideration as a whole and the unequal geological study of individual zones - the Terek and Sunzha anticlinal zones, the Montenegrin monocline and syncline zones. According to the data of geophysical studies and single wells of deep drilling, the crystalline basement and lower horizons of the sedimentary cover are characterized by complex fault-block structure. According to preliminary data, the deep-submerged zones of this territory are characterized by the significant potential for the discovery of new hydrocarbon accumulations, primarily gas and oil and gas condensate.

First of all, the study aimed at the search of oil and gas accumulations requires the near edge parts of the anticlinal zones, the Priterechnaya zone, the Montenegrin moncline, and the structures of western and eastern parts of the TKT, such as Khayan-Kortovsk, North-Bragunsk, West-Khankalsk, Starogroznensk, Western and Eastern Gudermessk, etc., with the depths of the roof of the subsalt Jurassic with an approximate depth of 7.5 x 8.5 km. In the long-term future plans, it is necessary to bear in mind the study of deep-seated horizons of synclinal zones.

In terms of the method of work, an integrated approach should be envisaged, due to the diversity and interrelationships of geological processes; therefore, the attempts to consider a single phenomenon or process without communication with others are unlikely to succeed [10]. For example, the mechanism of formation of a folded structure at a depth and the nature of the structure itself cannot be understood without clarifying not only the structural plan and the way it is formed in the higher horizons of the section, but also the general geological history of the trough. Different research methods complement each other and make it possible to understand different aspects of the same problem.

References

[1] A.A. Daukaev, “Problems of development and oil and gas potential of great depths”, In Modern problems of geology, geophysics and geoecology of the North Caucasus. T.V. Kerimova I.A., Shirokova V.A. Eds. Grozny: Grozny Worker, 2016. pp. 74-79.

[2] B.L. Alexandrov, Abnormally high reservoir pressure in oil and gas bearing basins, Oil industry. Moscow: Oil industry, 1987. p. 216.

[3] B.A. Sokolov, Yu. L. Korchagina, D.A. Mirzoev et al., Oil formation and oil and gas accumulation in the Eastern Ciscaucasia. Moscow: Science, 1990, p. 206.

[4] V.A. Stanulis, V.F. Khludnev, “Some problematic issues of geology and petroleum potential of the Terek-Sunzhensk region”, In Geology and mineral resources of the Greater Caucasus. Moscow: Nedra, 1987. pp. 246-254.

[5] L.I. Lebedev, I.A. Alexina, L.S. Kulakova et al., The Caspian Sea in the book Geology and Petroleum Potential. Moscow: Science, 1987.

[6] N.V. Koronovsky, A.I. Gushchin, M.Yu. Nikitin et al., “Geological development and formation of modern structure of the Terek-Caspian advanced deflection”, In Tectonics of orogenic structures in the Caucasus and Central Asia. Moscow: Science. 1990. pp. 4–35.

[7] P.A. Petrenko, N.T. Kopylov, Features of the structure of the surface of the Jurassic deposits of the Eastern Pre-Caucasian region in connection with their oil and gas content, Proceedings of SevKavNIPIneft, Issue 57 Grozny, 1992, pp. 11-14.

[8] S.I. Dotduev, On the integumentary structure of the Greater Caucasus, Geotectonics, 1986, No. 5, pp. 94-106.

[9] S.S. Gatsayeva, A.S. Elzhaev, L.S. Gatsayeva, “Analysis of the study of foundations of the TKE”, Proceedings of the Scientific Research Institute of the Russian Academy of Sciences, No. 8, Grozny, 2015, pp. 199-207.

[10] F.S. Sean, A.N. Ivanov, V.Yu. Kholodilov, E.V. Frolova, “Comprehensive Approach to the Substantiation of Exploration Drilling”, Oil Industry, Moscow: Oil industry, 2015, pp. 38-39.

[11] I.A. Kerimov, E.A. Abubakarova, S.V. Badaev, Tridimensional analysis of gravitation and magnetic fields of the Terek-Caspian trough, Conference Series: Earth and Environmental Science, vol. 87, 2017, no. 052011, pp.1-6.