Starogroznensky oil and gas field: historical background and current status

A A Daykaev¹, Z G Aydamirova², E A Abubakarova¹,², A A Shaipov², A M Movlaeva², T Kh Bachaeva¹,², Kh I Zakriev² and R Z Dzharnagaliev²

¹ Department of the Issues of Fuel and Energy Complex, Complex Research Institute, RAS, Grozny, Russia
² Grozny State Oil Technical University named after Academician M.D. Millionshchikov, Grozny, Russia

E-mail: daykaev@mail.ru, lizi_68@list.ru, eliza_ggni@mail.ru, a.shaipov@gmail.com, amovlaeva@bk.ru, bachaeva@bk.ru, gpf-pg1920@mail.ru, dzharnagaliev@mail.ru

Abstract. The paper is devoted to one of the largest deposits of the North Caucasus, i.e. Starogroznenskoye field. There are identified the main development stages of this field, i.e. well production, development of the Miocene and Mesozoic deposits, and the current stage. Well production continued almost until the end of the 19th century. At the Miocene stage, the production was carried out from thrust and subthrust sand formations of Karagan and Chokrak. The paper also mentions the experimental adit on Mamakayevskaya gill. Which was headed by mining engineers A.A. Klushin and A.E. Yeronin. The beginning of the Mesozoic stage dates to the end of the 1940s. The main production was associated with the Upper Cretaceous sediments. At the end, an assessment of the current state of the structure of proven reserves is given. In conclusion, an assessment of the opportunities aimed at further development of the field associated with the additional exploration and additional development of the Miocene and Lower Cretaceous deposits is given.

1. Introduction
Starogroznenskoye gas and oil field is located within the Grozny ridge in the area of front ranges of the Eastern Fore-Caucasus on the territory of Staropromyslovsky district of Grozny. There are villages of Neftemaysk, Ivanovo, Katayama, etc. near the field the establishment of which is directly related to the development of Starogroznenskoye field. The northern slope of the Grozny ridge is crossed by ravines and gills, the most significant of which are Solenaya, Mamakaevskaya and Groznenskaya. The River Sunzha flows to the south-east of the field.

2. History of development of miocene deposits
Well oil production on the territory of the Grozny region began in the historical period of the late 18th century. The first information about oil sources near Grozny in the region of Mamakayevskaya and Grozny groups was presented by R.I. German at the beginning of the 19th century [1, 5].

The first geological studies date back to 1865 when the work of academician G.V. Abrikh was published. By the mid-1970s, there were more than 100 wells, and 10 years later the oil wells had increased 2 times. After that, the geologists F.G. Koshkul (1879), Andrusov N.I studied geological setting of the area. In 1888, a geological section of Karagan horizon was designed.
A new stage in a detailed geological study of the Grozny region began in the early 1892 when A.M. Konshin proved the fact of opportunities regarding this territory [2].

In the summer of 1893, the company Akhverdov & K sank a steam well No. 1 in the Alkhan-Yurt section, in which a powerful oil fountain was obtained from the second layer of the Karagan horizon from a depth of 134 m. The well was in operation until 1902; the total oil production amounted to 80.7 thousand tons.

According to Yushkina E.M. in the period from 1893 to 1894 three more flowing wells with small flow rates were drilled. The next well – 7/977 was sank in February 1895, which revealed the oil layer II of Karagansk horizon at a depth of 141 m, which produced a powerful oil gush with a flow rate of 16 thousand tons per day. The well had been flowing for three years and produced more than 710 thousand tons of oil.

Such results made the Grozny region attractive for large oil producers. Besides, Starogrozensky oil-bearing area has become known all over the world. After the flowing in the well – 7/977 there were many published works, which expressed completely different opinions about further development of Grozny oil industry [4].

Since 1901, the Geological Committee of Russia initiated the study of the geological structure and oil and gas potential in connection with unsuccessful drilling results and ever-increasing demand for oil. The work was carried out by a number of famous geologists under the supervision of N.A. Sokolova (G.P. Mikhailovsky, K.P. Kalitsky, I.N. Strizhov, E.M. Yushkin, D.V. Golubyatnikov, etc.) [6]. Studying the structure of Starogrozensky fold I.N. Strizhov and E.M. Yushkin, revealed the presence of a longitudinal gap along the northern wing, overturned anticline to the north, which was confirmed by subsequent detailed exploration. K.P. Kalitsky and E.M. Yushkin performed work in Grozny oil-bearing region [3,7]. Strizhov I.N. (1904) made up a normal section of Karagan horizon.

In 1905, he also performed the first calculation of oil reserves in Starogrozenskoye field on the basis of geological analogies (comparative analysis with oil already produced). The initial balance reserves of oil in the field amounted to 23.3 million tons. Starogrozenskoye oil field workers were among the first in the world to apply various methods of stimulating the formation. So, I.N. Strizhov proposed the use of air injection in Karagan formation in order to increase oil recovery.

In 1906, Kalitsky K.P. compiled the first geological map of Starogrozenskaya area. The works of geologists of that period were not very regular with the exception of the works of Kalitsky and Strizhov.

In 1918, the balance reserves of oil were calculated by S.I. Charnotsky using volumetric and statistical methods, which amounted to 40.2 million tons. However, based on the revaluation of reserves performed in 1923 by V.A. Selskiy the balance reserves in the field amounted to only 20.1 million tons. [11].

During 1921–1922. A.P. Shapovalov compiled a generalized section of the productive strata for Starogrozensky district for the first time in the Grozny region. This work was so thorough that it had been used for 15 years.

At the end of the restoration work in the field, a small amount of exploration work was initiated, which resulted in the discovery of new high-yield deposits in Solenaya gill in Starogrozenskaya area in May 1922. It is also specific that geological conditions that caused the existence of many high-yield deposits in the periclinal part of the anticline remained unclear due to the imperfection of geological documentation of that time. It was found out that the deposits of Solenaya gill had a water pressure regime, while those located directly to the west in the uplifted pool of Starogrozensky anticline were characterized by the dissolved gas regime.

On the example of conditions for the development of oil deposits of Solenaya gill and their comparison with the deposits of the rest of Starogrozensky area, N.T. Lidtrop defined the concept of a water pressure mode. His research on this issue played a very important role in the development of further production not only in the Grozny region, but also in other oil and gas fields.

The geologist Lednev N.M. (1925, 1926, 1927), with the participation of Vossoevich in 1928, began a detailed study of the geological structure of Makhachkalinskaya areae and Starogrozensky anticline.
As a result of studying the structure of Starogroznensky anticline N.A. Kudryavtsev in 1925 made the assumption that Tashkalinsky site is an independent anticlinal fold located echelon-like in relation to Starogroznensky brahianticlinal. At the same time A.P. Shapovalov and (1924) and, somewhat later, I.N. Strizhov (1926) suggested that the northern wing of Starogroznensky fold is complicated by longitudinal thrust.

A detailed study of the structure of Starogroznensky fold begins in the late 1920–1930s. During that period the wells were sunk in Maykop formation (15 exploratory wells) to a depth of 2000–2400 m, none of them discovered Maykop deposits, which, as it became known, lie much lower. At the same time, the drilling results proved the presence of oil in the sub-thrust beds of Karagan. In 1932, the first industrial oil was obtained from well – 5–79 from a depth of 1245 m with a flow rate of 5–10 tons/day. As soon as the next year, dozens of wells have been sunk for sub-thrust.

In 1932, an experimental adit was sunk in the section 975 of the old field in Mamakayevskaya gill. The work was headed by mining engineers A.A. Klushin and A.E. Yeronin. The adit horizontally passed through bedrock more than 500 m, revealing productive sandstones of the Tertiary age. The adit was intended to carry out research work aimed at creating an industrial oil mine for the development of the upper layers of spaniodontella formation using secondary methods of oil production. The research and experimental production works were carried out in this mine until 1936 [8–10].

In a well – 24/40, drilled in 1934 in Starogroznenskaya fold (sub-thrust) an oil gush was obtained from a depth of 1200 m with a flow rate of 40 tons per day from Karagan (stratum III–IV) layer. Thus, a high productivity of these formations was finally proved.

The difficulties of studying the structure of the thrust part of Starogroznensky fold were noted by engineer V.S. Starzhinsky: All the wells in the sub-thrust are either sandstone or clay, without crossing the strata, which is one of the reasons that impede normal lighting of the sub-thrust structure. Wells drilled with oriented north-south curvature would have a significant advantage. In this case, several layers can pass through one well and a marking horizon can be detected.

The first graphical constructions for sub-thrust layers were performed by G.M. Sukharev and V.A. Tilyupo in 1935. In 1937, the geologists N.V. Frolov and V.A. Golyakov developed a special methodology of structural constructions. Since the beginning of the 1930s a great attention was paid to the issues of oil recovery increase and rational development of the Miocene deposits. The importance of using secondary operating methods was proved.

In 1944, due to the problems of development of sub-thrust layers, a special group for well development was created. In the same year, drilling of directional exploratory wells began on the XII and XVI sub-thrust beds of Starogroznenskoye field, and in 1945 they resumed this work on Tashkalinsky site. In the same year, the gushs of oil were produced in several wells drilled within Tashkalinskaya area. This was the largest achievement of geological exploration during the war on the territory of the Chechen Republic. The discovery of Tashkalinskoie field contributed to an increase in oil production and provision of hydrocarbon refineries with raw materials. In general, from 1943 to 1945, approximately 2.5 million tons of oil were produced. [11]

In 1948, in order to select the area for the mine field, an attempt was made to drill 7 appraisal wells in Starogroznensky site in the sections 62, 56, 53, 52, 50, 48 and 146. Based on the analysis of the production materials of the appraisal wells, the eastern field was recommended as more promising in relation to the possibility of its mine method. The total oil area of this field is 82.1 ha. The depth of 2° formation is 65–200 m. The initial oil reserves in the 2nd reservoir – recoverable – make up 475.1 thousand tons, geological reserves constitute 1218 thousand tons, and 3b make up recoverable reserves, 426.6 thousand tons, and geological reserves make up 969.5 thousand tons. An exploration project for the selected mine field was drafted in accordance with the temporary instruction for the assessment and exploration of oil fields for open pit mining, in relation to fields with disturbed discharges and well-lit production wells.

The object for development was the main 2° layer of Karagansky horizon, as well as 3° and I layers. The distance between the exploration profiles is 350 m and between the individual wells in the profile
is 125 m. In total, it was planned to drill 21 Craelius wells. In total, about 5000 wells were drilled – the Miocene deposits, Starogroznenskoye field – and cumulative production amounted to about 52.3 million tons of oil. Karagan-Chokrak deposits are at the final stage of development; the degree of development is 99.8 %. Tashkalinskiy site has been fully developed.

3. History of development of mesozoic deposits

In the postwar period (1950–1960) Groznefterazvedka – the geological exploration organization – had worked extensively in the area of geological prospecting and exploration throughout the entire Eastern Fore-Caucasus, including Sunzhensky district. An experienced geologists A. Ragulin compiled geological exploration projects for chalk deposits where he encompassed such oil fields as Starogroznenskoye, Oktyabrskoye and others. An exploration of the Upper Cretaceous reservoir was carried out according to the project since 1958, but the first two wells were liquidated for technical reasons without opening the project horizon.

In total, 37 wells were drilled in the Upper Cretaceous deposit. 27 wells were the productive deposits. The industrial influx of oil from the Upper Cretaceous limestones on the Starogroznenskaya Square was first obtained in 1963 with an open flowing of well – 641.

The structure along the roof of the Upper Cretaceous is an asymmetric fold of the brachiform type of sub-latitudinal strike. The materials of the geological interpretation of detailed gravimetric surveys made it possible to identify a number of features of the gravity field. Sunzhenskaya linear zone includes Starogroznensky maximum, which corresponds to the anticlinal zone within which the Starogroznensky uplift is distinguished. Starogroznensky maximum stretching east to the city of Grozny in the form of a narrow strip is characterized by a restriction from the north with a highly gradient zone and from the south by a less gradient zone of the anomalous gravitational field.

The dimensions of the structure along minus 4250 m enclosing isogypsum are 29.3×3.2 km with an amplitude of 650 m. The Upper Cretaceous section is composed of carbonate deposits; the foraminiferous layers are represented by fractured marls; and the Upper Cretaceous rocks are represented by fractured limestone. The Upper Cretaceous reservoir is classified as a cavern-fractured type. Due to the cracks dissecting the thick strata of the foraminiferous and Upper Cretaceous deposits, the reservoir represents a single hydrodynamic system. The deposit refers to a massive reservoir type. The size of the Upper Cretaceous deposits is 30x3.2 km; the oil floor is 791 m.

An oil deposit in Aptian deposits was found in 1973 when they were testing the well – 701. In subsequent years, the Aptian deposits were tested in 16 more wells in which inflows of anhydrous oil were obtained. According to the Lower Cretaceous (Aptian) sediments, a rise corresponding to the shape of the Upper Cretaceous fold was established. The Aptian layer-uplifted deposit. The size of the deposit is 29.7 x 3.1 km with the height of 825.

The Lower Cretaceous Aptian section is represented by terrigenous formations, i.e. sandstones, siltstones and clays. A distinctive feature of the productive Aptian reservoir is the presence of two types of reservoirs, i.e. cavernous-fractured and porous.

In 1989, a hydrocarbon deposit of Valanginsk deposits was found (well – 728). The presence of hydrocarbons by testing Valanginsk deposits in well – 729 where gas inflows with a high content of hydrogen sulfide were obtained from the interval 5405–5535 m, and therefore the reservoir was mothballed [12]. A free gas deposit of Valanginsk reservoir lies at a depth of 4900–5300 m; the dimensions are 17.0 x 1.0 km; the gas content floor is 67 m.

The study of the structure of the field by geophysical methods. On the territory of the area under study the materials of detailed gravimetric surveys were processed and their geological interpretation was performed. The analysis of gravimetric maps within the described territory made it possible to identify a number of features of the gravity field. Sunzhenskaya linear zone includes Starogroznensky maximum, which corresponds to the anticlinal zone within which Starogroznensky uplift is distinguished. Starogroznensky maximum stretching east to the city of Grozny in the form of a narrow strip is characterized by a limited gradient zone from the north and a less gradient zone from the south.
Table 1. State of the raw material base of starogroznenskoye field

| Deposit               | Stratigraphic horizon | Residual reserves of category A + B1, thousand tons Recoverable | Reserves depletion % | Production, thousand tons Accumulated | Annual |
|-----------------------|-----------------------|---------------------------------------------------------------|----------------------|---------------------------------------|--------|
| Starogroznenskoye field | Miocene               | 49584                                                          | 91                   | 99.8                                  | 52284  12 |
|                       | Maikop                | –                                                              | –                    | 8                                     | 0      |
|                       | Up. Cretaceous        | 16846                                                          | 0                    | 100                                   | 32702  0 |
|                       | L. Cretaceous         | 21335                                                          | 273                  | 92.8                                  | 13825  42 |

4. Current state of raw material base and opportunities

The state of the structure of hydrocarbon reserves and resources is an important element in the exploration planning. Short- and medium-term oil and gas exploration planning is usually based on the information from previously estimated reserves and resources of C2 and C3 categories, and long-term planning is based on the total volume of unexplored part of the ultimately recoverable oil resources along the analyzed area. The table shows the figures for current oil reserves state (01/01/2018), as well as for the depletion and production of Starogroznenskoye field.

5. Conclusion

Future prospects are associated with the additional development of the Lower Cretaceous deposits of Starogroznenskoye field, with the widespread application of modern technologies aimed at maximum extraction of oil and gas from the interior of the earth; additional extraction of oil from Karagan and Chokrak deposits by drilling additional production and exploration wells or by a shaft method. Certain prospects are associated with additional exploration of the Miocene deposits. The resumption of additional exploration of these layers is due to a number of favorable prerequisites for high efficiency of this direction, i.e. favorable hypsometric position of Karagan and Chokrak horizons relative to the lower Upper Cretaceous deposits and higher than Sarmatian deposits, which demonstrated favorable signs of oil and gas deposits; high reservoir properties of sand formations, etc.

One of the topical issues of our time is considered the problem of renewability of oil and gas resources. There are various factors in the renewability of resources. One of the important factors is the excess of the total volume of oil produced over the approved reserves. At the very beginning of the industrial development of the field, mining engineer L.I. Baskakov noted that the volume of trap for Karagan reservoir was exceeded. The first estimation of reserves was done at the end of the 19th century. Subsequently, the oil reserves of the Miocene deposits were calculated repeatedly. There are known facts of the resumption of oil manifestations from the annulus at a number of wells mothballed in the 1990s. Such processes were also observed in other deposits of deeper horizons. There are several ways to determine the beginning of the formation of oil and gas deposit, i.e. paleogeological, historical, geological, geochemical, lithological, gelargon, etc. However, all of them do not record the completion time of the formation of hydrocarbon deposits, i.e. it can be assumed that they are formed at the present stage, which is established by the following criteria: by the potentiometric method, trap occupancy, gas saturation of formation water (for gas deposits). The potentiometric method proposed by N.A. Eremenko, I.M. Mikhailov in 1972, suggests that the energy balance in the reservoir under a nonequilibrium hydrogeological situation can exist only in the presence of hydrocarbon flows, and, consequently, the formation of their clusters. Trap filled with hydrocarbon oil: If the trap is completely filled with oil or gas (full-layer), it is believed that its formation continues at the present time. In 1968, gas saturation of formation water was justified for gas deposits by V.I. Korzenstein. It is assumed that gas deposits surrounded by formation water with maximum gas saturation are in a state of growth at the present stage. Some other criteria also testify to the replenishment of reserves, i.e. the presence of an abnormally high pore pressure in the deposits, the pulsating nature of operation of the production wells, high gas factor, etc. Based on everything stated above, it can be concluded that the oil and gas potential of Starogroznenskoye field and other fields of the Tersko-Caspian trough is significant.
The development of Starogroznenskoye field is an example of a comprehensive study of the features of geological structure for the purpose of prospecting and exploration of complex oil and gas deposits, i.e. subthrust, tectonically shielded, structural and lithological, etc.

References
[1] German R I 1858 Large layer of asphalt in Little Chechnya Bull. of Natural Sci. 6 189–92
[2] Konshin A M 1892 Geological description of Grozny oil-bearing area and oil fields of the Terek region and the Caspian coast Mater. for the geology of the Caucasus, ser. 2, B. 6
[3] Yushkin E M 1909 The beginning of the Grozny oil industry in essays (Ekaterinodar) p 50
[4] Kolosov L N 1953 The emergence of Grozny oil industry (1893–1903) (Moscow)
[5] Ibragimova Z H 2009 Royal past of Chechens: politics and economics (Moscow: Probel-2000) 872 p
[6] Brod I O 1937 Grozny oil field, Oil fields of the Eastern Fore-Caucasus
[7] Kalitsky K P 1906 Grozny oil-bearing region Proc. of Geolcom, new. ser. 24
[8] Klushin A A 1934 Turning the experimental adit of Starogroznenskiy district into an experimental mine Grozny oilman 2-3 61–5
[9] Yeronin M A 2000 Starogroznenskaya adit Oil industry 3 78–80
[10] Ershov G A, Tonkonogov P M and Ermolenko A P 1971 A wonderful source, Essays on the oil industry of Chechen-Ingushetia (Grozny: Chechingizdat) 327 p
[11] Broda I O 1958 Geology and oil and gas potential of the Eastern Fore-Caucasus, Proceedings of Integrated Southern Geological Expedition, iss. 1 (Leningrad: Gostoptekhizdat) 621 p
[12] Daukaev A A et al 2019 Development of oil and gas research and education institutes in Grozny in 1920–1980 European Proceedings of Social & Behavioural Sciences EpSBS Conference Social and Cultural Transformations in the Context of Modern Globalism (SCTCGM 2018) pp 366–75