Upper Jurassic subsalt complex of the Terek-Caspian trough due to oil content

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Abstract. The article considers a complex of factors determining the oil and gas content of the Upper Jurassic subsalt deposits of the Terek-Caspian trough. The potential resources of hydrocarbons are associated primarily with the zones of the Nazran and Harbizhsk saddles, the western end of the Terek and Sunzhensk and Soviet-Right-Bank anticlinal zones. Synclinal and near-side zones are assigned to zones with unexplained oil and gas potential, where it is recommended to conduct regional geophysical studies in conjunction with parametric drilling.

1. Introduction

Subsalt deposits in relation to their oil and gas potential were studied by many scientists. The most detailed description of subsalt deposits in connection with the prospects for their oil and gas content is given in the works of N Sh Yandarbiyev in which quantitative parameters of capacities are given in different parts of the territory under consideration, depths, resource potential, etc., as well as data on global practices of exploration for subsalt deposits [1, 2]. The tectonic features and oil and gas potential of deep-seated sediments, including subsalt, were considered in the works of A I Letavin, P A Petrenko [3], B G Voblikova, G I Lebedko and geochemical aspects are presented in the works of A A Yaroshenko [4], A N Stepanova, V V Dotsenko.

The purposeful study of Upper Jurassic deposits within the western part of the TCT has been conducted in the territory under consideration since the 60s with the laying of well No. 100 within the Karabulak area. Later, the following areas were introduced into drilling: Malgobek, Zamankul, Khayan-Kort, Dattykh and others. In the southeast, the subsalt sediments were studied by deep drilling in the Sureta, Bass, Benoy and r. Argun basins.

East of the Sharo-Argun River along the rivers of Elistanzhi, Kharachoi, Benoy-Yassi, Andy Koysu, Avarske-Koisu, a reduction in the subsalt content and a change in the lithological composition in the direction of a decrease in the amount of terrigenous material in the roof is noted. In the junction zone of the Dagestan wedge and the Montenegrin monocline, subsalt deposits were discovered by wells in areas – Benoi, Shamkhal-Bulak, Miatly, Zauzanbash, Talgi, etc. parts of dark gray layered limestone (12-15 m). The thickness of the subsalt Jurassic is reduced to 41 m in well No. 2 of Talgi and 38 m in well No. 2 of Zauzanbash.
According to the ammonite finds in the sections of the North Caucasus, the age of the subsalt layer is determined in the range of the Upper Callovian-Lower Kimeridz [5]. A large middle part of the cut is of Oxford age.

In the well sections, the upper limit of the pre-salt Jurassic region is bent on a sharp change of relict-organogenic dolomites by chemogenic rocks of Kimeridi-Titon, the signs of which are reservoirs and the inclusion of the mineral polyhalite. In the Suret area, in well No. 1, the upper Jurassic section was completely passed, including the subsalt salt thickness of 738 m, it opened the section with rocks of tires (anhydrite) and reservoir rocks (dolomite and fractured limestone).

The results of drilling at Benoy Square (well No. 47) showed the absence of a salt Jurassic stratum in the area. The well revealed a thick mass of clay-argillite deposits of presumably Triassic age below the Jurassic rocks.

On the Dattykh Square in 1987 when testing the interval of 3112-3076 m of Upper Jurassic intersalt deposits in well No. 15, an industrial flow of oil with a flow rate of 55 m³/day and gas with a flow rate of 5180 m³/day was obtained. In well No. 12, an industrial gas inflow from subsalt deposits was obtained on the same area.

Drilling operations, started in the 70s on these deposits, were suspended due to the difficult conditions of well placement and the lack of drilling equipment in anticorrosion performance. Seismic surveys carried out at the end of the 80s in the western part of the TCT traced horizons, stratigraphically confined to the top of the Oxford and more ancient sediments, were traced. In the subsalt sediments, the Nazran structure, presumably reef-like, with an amplitude of up to 500 m was established, within which the drilling of a parametric well was recommended.

Terek-Caspian trough (TCT), characterized by a complex tectonic structure and a wide stratigraphic range of oil and gas oil and gas content. The stratigraphic section is represented by a thick stratum (up to 12 km) of Permo-Triassic, Jurassic, Cretaceous, Paleogene-Neogene sedimentary rocks, in which regionally oil and gas bearing carbonate complexes (Upper Jurassic, Valanginian, Upper Cretaceous) and terrigenous (Lower Cretaceous, Karagan-Chokrak) are developed) reservoirs and rock-bearing rocks (titon evaporites, maikop and chokrak clay strata). The development of the region began at the end of the 19th century by well-oil production and the discovery of oil deposits in the Karagan-Chokrak sandy strata of Starogroznenskaya area.

At present, industrial oil and gas content has been established here from Miocene to Upper Jurassic subsalt deposits in the depth range from 200 to 5900 m, more than 150 deposits have been discovered, including more than 25 in the Mesozoic complex of rocks. Many oil deposits are confined to the Karagan-Chokrak sand beds and some of the Cretaceous deposits are practically developed.

In general, the Mesozoic sediment complex within the TCT is characterized by a high degree of exploration both by deep drilling (190 m / km² or 0.05 well / km²) and by seismic exploration (1.1 running km / km²), which predetermines the orientation of the search for new hydrocarbon deposits at great depths (5500-6100 m) in difficult temperature and pressure conditions.

One of the most promising areas with which the long-term prospects for the development of the oil and gas industry in the Chechen Republic (CR) are connected is the subsalt salt complex of the Upper Jurassic [6]. According to many researchers, the high prospects for the pre-salt Upper Jurassic complex are due to a number of factors:

- the presence of large subsalt elevations and disjunctive disorders;
- large thick carbonate rocks with favorable reservoir properties;
- availability of reliable tires;
- industrial petroleum potential subsalt deposits and high productivity of wells in several regions of the world.

2. Materials and methods

Research in this region was carried out in the following direction: collection and analysis of the actual and stock material on the geological structure of the area. Particular attention is paid to poorly studied monoclinal and near-board zones of the TCT.
3. Results and discussions
As a result of deep drilling and interpretation of seismic survey materials, it was found out that the geological structure of the Upper Jurassic sediments turned out to be more complex than expected (Figure 1).

![Geological profile of wells No. 6, 12, 13 of the Datty deposit](image)

Figure 1. Geological profile of wells No. 6, 12, 13 of the Datty deposit

The thrust structure of the Cretaceous and Upper Jurassic supersalt strata and their displacement along the gaps in the north direction relative to the subsalt salt strata has been established. In the Upper Jurassic subsalt deposits, large sub-thrust structures were noted — Bassovskaya, Korinskaya, Bamutskaya, etc. Obviously, the arches of these structures will be located to the south relative to the thrust structures. In the western part of the TCT, the following structures were fixed in the subsalt strata: Zamankulskaya, Karabulak-Achalukskaya, Severo-Zamankulskaya, Kharbizhinskaya, Akhlovskaya, Malgobek-Voznesensky-Aliyurtovskaya. The axes of these folds are displaced to the south relative to the Cretaceous by 0.5-3.5 km (Table 1).

| Name                                   | Closed isohypsum | Linear dimensions, km | Amplitude, m | Other          |
|----------------------------------------|------------------|-----------------------|--------------|----------------|
| Zamankul                               | -5600            | 17.6                  | 2.5          | 550            | asymmetric     |
| Karabulak-Achalukskaya - Pseakhskaya   | -5600            | 17.3                  | 2.6          | 900-950        | asymmetric     |
| Severo-Zamankulskaya                   | -5800            | 18.5                  | 3.3          | 500-550        | -              |
| Kharbizhinskaya                        | -5600            | 4.6                   | 1.9          | 200-250        | -              |
| Akhlovskaya                            | -5800            | 14-16                 | 2.3          | -              | -              |
| Malgobek-Voznesensko-Aliyurtovskaya    | -5800            | 39-40                 | 3            | 550            | asymmetric     |

Table 1. Morphological parameters subsalt structures of the western part of TCT

In some areas, according to the results of the method of reflected waves, the geological bodies were recorded according to the method of a common depth point and drilling, identifying developing organogenic structures in shallow areas along faults (Zamankulsky and Kharbizhinsky uplifts, etc.). Favourable geotectonic conditions of reef formation were predicted within the Sjuretsko-Akhlovskaya and Benoisko-Eldarovskaya zones of the TCT [3].
On seismic profiles, carbonate and clay-carbonate deposits are usually represented by a series of continuous and intermittent parallel reflective sites. Organogenic constructions (reefs) on time sections have a number of characteristic features: the presence of an encrustation structure in the ridge sediments with a decrease in its amplitude up the section; loss of correlation (or its deterioration) of reflecting horizons in the reef zone; the presence of diffracted waves directly under the organogenic structure.

Slope reef deposits are expressed in seismic profiles less clearly, but clearly enough, to distinguish them. Usually, at the periphery of the organogenic structure, a series of short clinoform-lying reflected sites, often crossing each other, can be traced. The slope angles of the sites gradually flatten out towards the center of the basin and acquire a subparallel pattern of wave recording.

On the territory of the TCT due to large depths of over 5500–6000 m, powerful evaporitic strata that are difficult to pass through wells, reef and bioherm structures have not been opened, with the exception of the Datykh area, where gas is obtained from a depth of 4300 m.

The Oxford Age was characterized exclusively by carbonate sedimentation. In the south of the region, sponge-algal dome-shaped bioherms of up to 60 m thick are observed at the base of the longline. The formation of such organogenic structures usually took place near the shore. On the middle and late Oxford, at the intersections of deep faults of latitudinal and meridional orientation, coral reefs were born and developed. The connection of reef formation processes with deep faults is proved by the results of the studies of V E Khaina, M S Burshtar and others [7, 8].

In the territory under consideration, similar structures were fixed in Pervomaisk, Datykh, Argun, Suret, Elistanzhinsky and Benoy districts. Everywhere reef and bioherm constructions are mainly represented by dolomites and dolomitic limestones of different-grained relict porous and fractured. In well No. 12 Datykhskaya in the range of 4300-4265 m, industrial gas flow was obtained with a flow rate of 250 thousand tons/day. Borehole No. 1 opened reef facies with a thickness of more than 700 m.

The zones of the most powerful oil and gas accumulation consider the strip of the barrier reef system surrounding the Late Jurassic basin, the predicted linear zones of biogenic sedimentation at the base of the Terek-Sunzhensk folded zone. The synclinal zones (Predtersky trough, Alkhanchurskaya syncline, Petropavlovsk and Chechen depressions) are referred to territories with unclear prospects. The areas lacking or significantly reducing the thickness of the subsalt Jurassic in the northern and south-eastern part of the TCT to 40–60 to 150 m are considered unpromising.

The thickness of the Upper Jurassic subsalt complex is comparable to the productivity of the Upper Cretaceous complex, characterized by regional oil and gas content.

Filtration-capacitive properties of subsalt carbonate rocks [9] are due to secondary processes and are improved due to partial dissolution of carbonates under the influence of high temperatures and aggressive waters that affect the formation of secondary porosity. The improvement of reservoir properties of rocks is also promoted by secondary dolomitization, which is usually characteristic of reef formations. In the reefs, a rigid skeleton (frame) preserves the free volume formed, in the process of dolomitization [10].

Some of them are presented on the upper Jurassic section and the reservoir properties of rocks give the study of natural outcrops on Mountain Rivers in particular along the river Chanty-Argun. As a result of studies of rock samples in the thickness of cavernous dolomitic limestone in the bottoms of the Oxfordian stage, high values of reservoir properties associated with secondary processes — recrystallization and elevation [11]. This made it possible to predict at great depths the favorable capacitive properties of these rocks in the study area. This was confirmed by the results of drilling well No. 12 in Dattyshskaya area.

In Dattyshskaya area, the average value of saturation porosity is 0.1–0.3%, gas permeability is 0.00204x10-3 μm², and the type of reservoir is fractured-porous-cavern. In the Sureta and Bass areas, the saturation porosity varies from 0.4 to 1.8% the gas permeability varies from 0.0306x10-3 μm² to 1.53x10-3 μm².

The subsalt sequence was traversed in a number of deep wells within the southern and western sides of the TCT and its nearest frame. This is a single carbonate, mainly dolomitic stratum, which is an analogue of the Kion and Iron suites. Sections of the subsalt Jurassic in the wells of the southern side of
the TCT are represented by dolomites with layers of dark gray clay or algal limestone. The maximum thickness is noted in the well number 1 Syuretskaya - 651 m.

Oxford sediments (subsalt Jurassic), in which reef massifs are predicted, are characterized by significant potential hydrocarbon resources. Speaking generally about global oil reserves, the researchers note a significant proportion of reserves in them associated with reef tracts. To one degree or another, such well-known, largest deposits of the Middle East as Kirkuk (2.015 billion tons), Agadzhari (1.3 billion tons), Ahvaz (1.2 billion tons) and Posa are associated with the reef structures. Rica (0.387 billion tons) in Mexico.

As for potential hydrocarbon resources, there are different figures for the pre-salt Jure TCT, according to Samoylovich and others. Initial potential resources are: oil - geological 597993 thousand tons, recoverable - 302829 thousand tons; dissolved gas - geological 368436 million m$^3$, recoverable - 185999 million m$^3$; free gas - 701765 million m$^3$.

According to N Sh Yandarbiyev [1] the total initial hydrocarbon resources generated by Jurassic oil source sediments are estimated at approximately 500 million tons of oil and 1.5 trillion m$^3$ of gas. According to a set of criteria (paleotectonic, geophysical, geochemical, technical and technological), the western parts of the Montenegrin monocline and the Sunzha anticlinal zone (Argudanskaya, Dattykhskaya, Nazranovskaya, Zamankulskaya areas) seem most promising.

In general, the upper Jurassic hydrocarbon resources (recoverable) category $D_1 + D_2$ oil are 27.8 million tons, dissolved gas is 14.3 billion m$^3$ and free gas is 55 billion m$^3$.

4. Conclusion
In order to make a comparative assessment of the degree of prospect of the Upper Jurassic subsalt complex of deposits in certain areas of the study area and the selection of priority objects for geologic exploration for oil and gas, the territory was zoned based on the use of signs favorable for the formation of local hydrocarbon accumulations in the Upper Jurassic deposits.

According to the complex of features (structural, lithofacial and depths), the prospects for the development of potential hydrocarbon resources are linked by the Nazran and Harbizh saddles zone, the western end of the Terek and Sunzhenskaya and Soviet-Right-Bank anticlinal zones.

Synclinal and near-side zones are assigned to zones with unexplained oil and gas potential, where it is recommended to conduct regional geophysical studies in conjunction with parametric drilling. The areas of high-priority drilling include: Ali-Yurt, Starogroznenskaya and Ischerskaya.

It is proposed to continue the search seismic survey by the method of reflected waves using the method of a common depth point together with high-precision gravimetric magnetometric studies that allow tracing active fault zones in the areas of Kharbizh, Arak-Dalatarek, Akhlovo, Karabulak-Achaluki. This, in particular, will allow a detailed study of the velocity characteristics of the section of the Upper Jurassic sediments.

The search for oil and gas deposits in the “pre-salt Jurassic” is possible with a clear knowledge of the section of these deposits, for which purpose it is advisable to drill a deep parametric well in the western part of the Terek anticlinal zone.

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