CASE STUDY ON THE APPLICATION OF UNFC TO ENERGY AND MINERAL RESOURCES IN KAZAKHSTAN

Authors:
Mr. Georgiy Freiman
Mr. Kuanysh Makazhanov
Mr. Viktor Babashev

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EXECUTIVE SUMMARY

The classification of the State Reserves Committee of the Republic of Kazakhstan (GKZ RK) establishes uniform requirements for the classification of reserves and resources of oil, natural hydrocarbon gas (free gas, gas cap gas and gas dissolved in oil) and condensate, their state accounting in the bowels according to the degree of knowledge and development.

The GKZ RK classification also establishes requirements for forecasted resources and reserves of solid minerals. In addition, by the adoption of Kazakhstan as the tenth member of Committee for Mineral Reserves International Reporting Standards (CRIRSCO) in 2016, and the new Code of the Republic of Kazakhstan "On Subsoil and Subsoil Use", enacted in 2018, the Kazakhstan Code of Public Reporting on the Results of Exploration, Mineral Resources and Mineral Reserves (KAZRC Code), developed in accordance with the CRIRSCO template, received the right of official application in the Republic.

The current classification reflects the results of a phased geological study of the subsoil. A phased study of the subsoil is carried out by the implementation of relevant projects. Each project has goals, deadlines, quality requirements and certain risk levels. Similar principles for a phased study of subsurface resources and project management are laid in the UNFC.

As research objects, one solid mineral deposit ("N" deposit) located in the East Kazakhstan region and one hydrocarbon deposit ("X" deposit) located in the Kyzylorda region were taken (location of the objects is shown in Fig.1).

On the example of the exploited pyrite-polymetallic deposit "N" in the East Kazakhstan region, the socio-economic importance of the mining enterprise, which has been operating profitably for a long time and is city-forming for the region, is shown. The management of the company of the subsoil user has developed an optimal socio-economic model for the exploitation of the field, which is aimed at ensuring the longest possible period of profitable exploitation of the field. In accordance with UNFC-2009, the estimated reserves of pyrite-polymetallic ores as of 01.01.2019. can be classified as E1, F1,2, G1,2.

On the example of the "X" object, the stages of geological study of the subsoil and development of the hydrocarbon field are shown, and the results are linked to the classification according to UNFC-2009 along three main axes – E, F, G. The scope of work of the Search Stage Projects made it possible to identify a prospective structure for oil and gas exploration and to discover the "X" field. The results of the search stage are classified according to UNFC-2009 in three axes as E3.2; F2.2; G3. The implementation of the exploration phase projects confirmed the industrial significance of the field and reserves are classified according to UNFC-2009 as E2; F2.1; G3. The start of industrial development of the field allowed for additional research on newly drilled wells, to deepen the knowledge of oil deposits. According to UNFC-2009, oil reserves as of 02.01.2019 can be classified as E1.1, E2; F1.1, F1.2; G1 + 2.

According to the study, we can state the comparability of the classification of the GKZ of the Republic of Kazakhstan and UNFC-2009. Unlike other classifications, UNFC-2009 takes into account the economic and social viability of projects, market conditions and uncertainties.

Given that in the modern world the number of many resource companies operating in different countries is growing, the need for a unified classification system is obvious. UNFC-2009 is the first version of the Classification at a level where general principles are established, and which can serve as the basis for international research in the field of energy and minerals.

Mr. Georgiy Freiman is the main author of the report and lead author of the case study on application of UNFC to mineral deposit "N". Mr. Kuanysh Makazhanov and Mr. Viktor Babashev are lead authors of the case study on application of UNFC to oil and gas deposit "X".

Fig.1 – Map of the territory of the Republic of Kazakhstan, location of research objects

CASE STUDY I: APPLICATION OF UNFC TO MINERAL DEPOSIT “N”

Author: G.Freiman

Introduction

As an example of the possible use of the UNFC for assessing a solid mineral deposit, the exploited pyrite-polymetallic ore deposit “N”, which is located in the territory of the East Kazakhstan region of the Republic of Kazakhstan, was selected (Fig.1.1). The author of this part of the report is G.Freiman.

The deposit is a typical representative of pyrite type ore objects, widely known in the world and in Kazakhstan. The practical value of the ores of deposits of this type are five useful components – copper, lead, zinc, gold and silver. Ores of the deposit are represented by both continuous (predominantly) and disseminated varieties. Most of the ore substance (especially in solid ores) is pyrite.

Like many other ore objects in Kazakhstan, the “N” field was discovered more than 100 years ago, and was subsequently explored in stages, with a gradual increase in the detail of exploration work, which was carried out in parallel with exploitation, first by a quarry, and later by an underground method.

During the discovery of the deposit, ore bodies came to the surface and were partially (to a small extent) mined by ancient miners. In the wake of such developments, the “N” field was discovered. At the first stage (1950-s), the exploration of the upper horizons of the field was carried out by digging ditches, deep pits with cuts and wells of great depth (up to 100 m). The upper part of the ore bodies was composed of oxidized ores, which spread from the surface to a depth of 30 m, which were replaced with depth by sulfide ores. The next stage of exploration – deeper horizons of the field (mid-1960-s) was carried out in parallel with mining operations. Exploration was carried out by drilling wells to a depth of 300-500 m.

The “N” field is medium in scale. According to the latest recalculation of reserves of 2018, taking into account the movement of reserves (production and additional exploration), as of 01.01.2019, the reserves of the field are as follows:

- ore: 5672.0 thousand tons;
- copper: 141.8 thousand tons, with an average grade of 2.5%;
- lead: 62.4 thousand tons, with an average grade of 1.1%;
- zinc: 238.2 thousand tons, with an average grade of 4.2%;
- gold: 5104 kg, with an average grade of 0.9 g/t;
- silver: 158.8 tons, with an average grade of 28.0 g/t.

Fig.1.1 – Map of the "N" field region

National Classification system for mineral resources

Classification of reserves of deposits and forecast resources of solid minerals of the Republic of Kazakhstan (classification of GKZ RK, and classification by the KAZRC code) is considered.

Description and details of the national classification and management system

Predicted resources of solid minerals according to their degree of geological knowledge are divided into categories P3, P2, P1. Each of these categories clearly indicates the degree of reliability of the calculated values.

Reserves of solid minerals according to their degree of knowledge are divided into two groups:

1. pre-estimated reserves of category C2;
2. confirmed (explored) reserves of categories C1, B, A.

The principles for applying the classification of forecast resources and solid mineral reserves are given in Fig.1.2.

Exploration Stage and Substage	Exploration Results						
	Forecast potential	Field Reserves and Forecast Resources					
		Forecast Resources			Reserves		
	P	P3	P2	P1	C2	C1	B+A
Stage 1 Regional geological exploration of mineral resources							
Substage 1 Consolidated and survey (1: 500000 and smaller) geological mapping							
Substage 2 Medium (1: 200000) geological mapping							
Substage 3 Large-scale (1: 50,000) geological mapping							
Stage 2 Search work							
Stage 3 Search and assessment work							
Stage 4 Geological exploration							
Stage 5 Operational exploration, production							

Fig.1.2 – Application of classification of reserves and forecast resources according to the GKZ RK standard

Reserves of categories A, B, C1 belong to industrial reserves, category C2 to previously explored. Reserves of categories A, B, C1, C2 are classified as reserves – economically viable for production. In addition, off-balance reserves are also distinguished, which are currently unprofitable for

mining by the contents of useful components, or by the conditions of occurrence, or by technological properties, but may be of practical interest in the future.

Both reserves and forecast resources, their definitions and application are fully consistent with the classification in force in the former USSR.

In 2016, Kazakhstan became the 10th member of CRIRSCO. With the introduction of the new Code "On Subsoil and Subsoil Use", the practical implementation of the KAZRC Code, which fully complies with the CRIRSCO template (Fig.1.3), began.

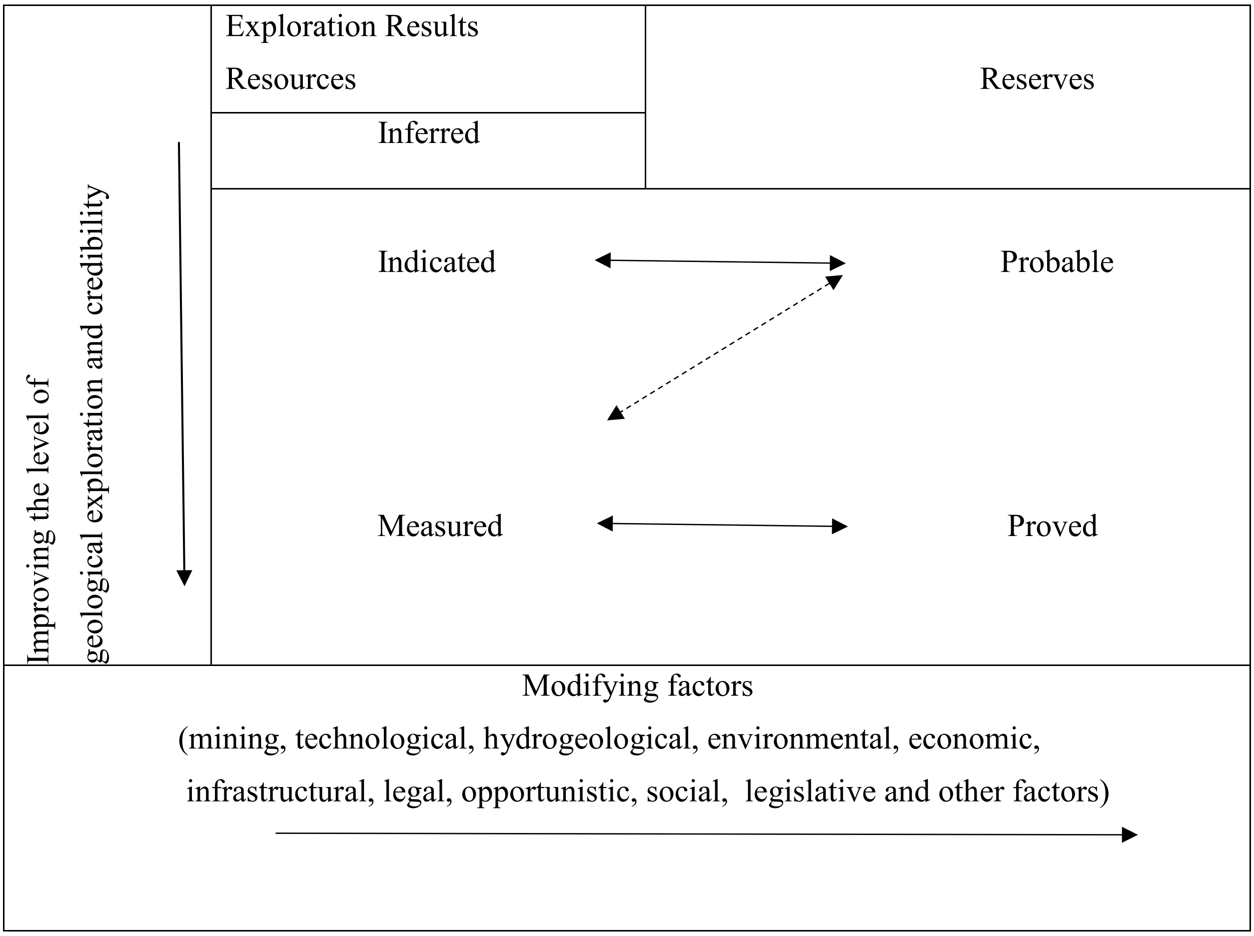


Fig.1.3 – Categorization of resources and reserves in accordance with the CRIRSCO template (including the KAZRC Code)

In accordance with the KAZRC Code, since 2019, subsoil users began to submit reports of Competent persons on the assessment of resources and reserves of deposits to the Committee of Geology and Subsoil Use of the Republic of Kazakhstan.

Comparison of the GKZ RK classification for solid minerals with UNFC

A comparison of the classification of reserves and forecast resources of solid minerals of the Republic of Kazakhstan (in the absence of a bridging document with UNFC) can be represented as follows (Fig. 1.4).

<table>
<tr><td colspan="7">UNFC Classes defined by categories and sub-categories</td><td rowspan="5">GKZ reserves and forecasted categories</td></tr>
<tr><td rowspan="14">Total commodity initially in place</td><td rowspan="2">Extracted</td><td colspan="5">Sales Production</td></tr>
<tr><td colspan="5">Non-sales Production</td></tr>
<tr><td colspan="2" rowspan="2">Class</td><td rowspan="2">Sub-class</td><td colspan="3">Categories</td></tr>
<tr><td>E</td><td>F</td><td>G</td></tr>
<tr><td rowspan="8">Known Deposit</td><td rowspan="3">Commercial Project</td><td>On Production</td><td>1</td><td>1.1</td><td>1,2,3</td><td>A, B, C1</td></tr>
<tr><td>Approved for Development</td><td>1</td><td>1.2</td><td>1,2,3</td><td>B, C1, C2</td></tr>
<tr><td>Justified for Development</td><td>1</td><td>1.3</td><td>1,2,3</td><td>C1, C2</td></tr>
<tr><td rowspan="2">Potential commercial Project</td><td>Development Pending</td><td>2</td><td>2.1.</td><td>1,2,3</td><td>C1, C2</td></tr>
<tr><td>Development On Hold</td><td>2</td><td>2.2</td><td>1,2,3</td><td>C1, C2, P1</td></tr>
<tr><td rowspan="2">Non-Commercial Projects</td><td>Development Unclarified</td><td>3.2</td><td>2.3</td><td>1,2,3</td><td>C2,P1</td></tr>
<tr><td>Development Not Viable</td><td>3.3</td><td>2.3</td><td>1,2,3</td><td>P1,P2</td></tr>
<tr><td colspan="2">Additional quantities in place</td><td>3.3</td><td>4</td><td>1,2,3</td><td>P2,P3</td></tr>
<tr><td rowspan="2">Potencial deposit</td><td>Exploration Projects</td><td>[No sub-classes defined]</td><td>3.2</td><td>3</td><td>4</td><td>P3</td></tr>
<tr><td colspan="2">Additional quantities in place</td><td>3.3</td><td>4</td><td>4</td><td>P</td></tr>
</table>

Fig.1.4 – Estimated ratio of UNFC and GKZ RK classification (solid minerals)

The main difference between the UNFC and the GKZ RK classifications is the absence of the E axis factors in the latter. The GKZ RK classification (as a two-dimensional system) focuses only on the degree of geological exploration of deposits and the feasibility of projects.

When evaluating deposits according to the GKZ RK classification, the main emphasis is on the significance of the project for investors, often the socio-economic and environmental component is simply ignored. When planning the development of the mineral resource base of Kazakhstan, state bodies do not take into account, to the necessary extent, the needs of the population, the creation of new jobs in the raw materials sector of the economy, and the ecological state of the regions. The lack of necessary attention to the socio-economic and environmental aspects of projects is determined by the fact that too little attention is paid to the requirements of GKZ RK standards.

The approximate ratio between the UNFC and the GKZ RK classification shown in Fig.5 can be used as the basis for a binding document between the two classifications. However, the GKZ RK classification will remain a conceptually two-dimensional model of an outdated approach to the planning and development of the mineral resource sector of the economy of Kazakhstan.

Since the classification of mineral resources and mineral reserves according to the KAZRC Code is fully consistent with the CRIRSCO template, which has a bridging document with UNFC, the classification is compared using a bridge document dated 05.01.2015 (Fig.1.5, 1.6, 1.7).

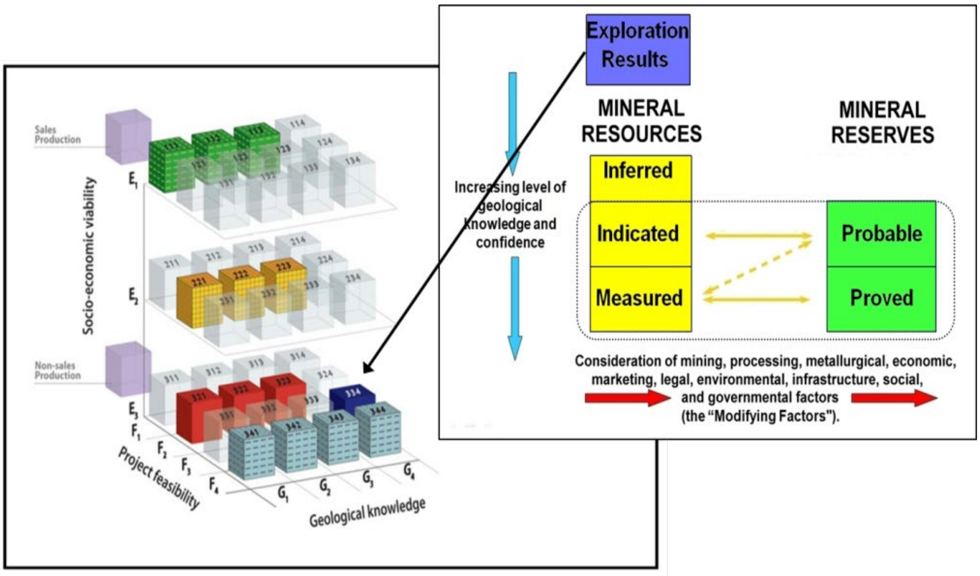


Fig.1.5 – Exploration projects

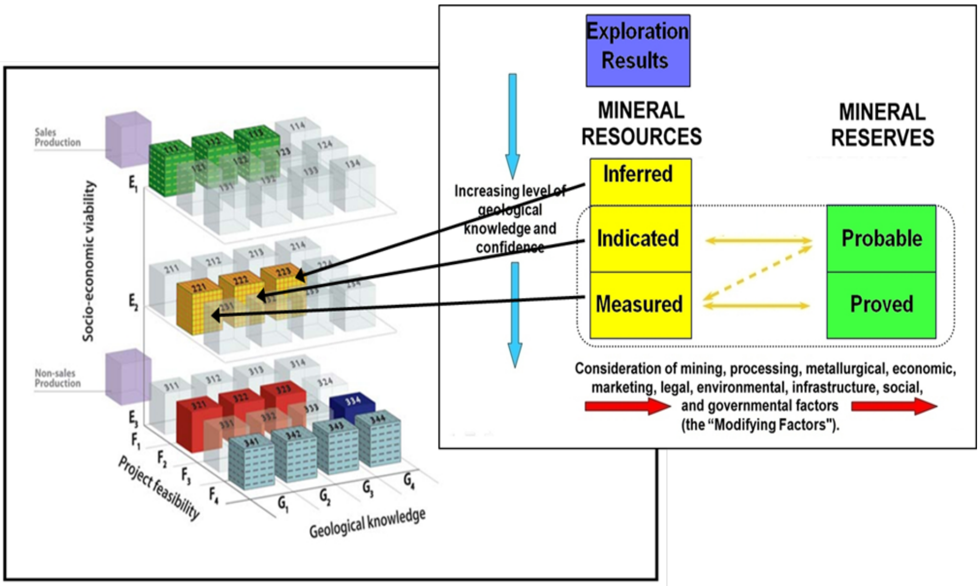


Fig.1.6 – Potentially commercial projects

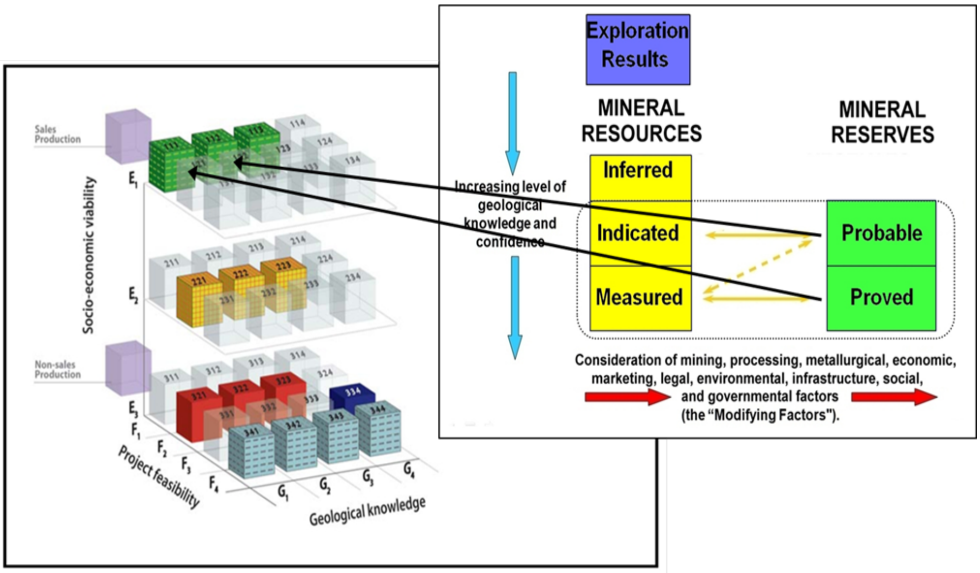


Fig.1.7 – Commercial projects

It should be noted that with significant progress in using the classification according to the KAZRC Code, this system is also significantly inferior in accounting for the maximum number of factors, compared with the UNFC. Also, the classification by the KAZRC Code is inferior to the GKZ RK classification in view of the absence of different ranks in the estimates of forecast resources.

Background information on the "N" field project

Previous work

The "N" field has been explored over a long period. In the area of the deposit, geological studies of various details were carried out, starting in 1949. For more than 20 years, more and more detailed exploration work has been consistently carried out, which has provided an increase in the reliability of reserves estimates. The main projects and stages of exploration are given below.

Search project. Exploration work at the field was carried out 1949-1952 and included ground-based geophysical exploration using magnetic prospecting and electrical exploration, as well as the drilling of individual wells on a rare network (200x400 m through) – the category of forecast resources according to the GKZ classification; according to UNFC – categories E3.3, F3, G4.

Search and evaluation project. On the basis of obtaining positive results in 1953-1954, exploratory and appraisal work was carried out by drilling wells on a 100x200 m network, as a result of which a large part of the ore deposit was discovered – a category of reserves according to GKZ C2 classification, as well as forecast resources P1; according to UNFC – categories E.2, F2.3, G2,3.

Preliminary Intelligence Project. In 1955-1960, preliminary exploration was carried out by drilling wells through a 100x100 m network and tunneling at a horizon of + 625 m with reserves estimated for categories C2 and C1; according to UNFC – categories E2, F2.1, G2.

Detailed intelligence project. In 1962-1966, a detailed exploration was carried out by drilling wells on a 50x50 m network, as a result of which, based on the development of a feasibility study, balance reserves for categories B, C1 and C2 were calculated; according to UNFC – categories E1.2, F1.3, G1,2.

In total, during the exploration of the field, 227 wells were drilled with a total volume of 99 thousand m, 2380 m of underground mine works were completed, core samples of 15.3 thousand and furrow samples of 3.8 thousand were taken.

Large volumes of exploration work carried out at the field provided a high degree of reliability of reserves. In 1968, pilot development of pilot block No. 1 was started.

Development project. Based on the results of pilot production in 1972, a project for developing the field was developed, and in 1976 the field began commercial operation. Two mine shafts were passed, and horizontal openings were opened after 60 m. With a total ore reserves of 9.5 million tons, the design capacity of the mine for ore production of 200,000 tons per year was envisaged. Ore processing is carried out at the beneficiation plant, which was built at the deposit in 1980.

Reserves categories according to GKZ – B, C1, C2; according to UNFC – E1, F1.2, G1,2.

Ore mining and processing has been carried out since 1976 with a break in 1993-2000, during the post-Soviet crisis. Since 2001, the field has been continuously operated. A total of 3.9 million tons of ore was mined during the period of the field's operation.

Current status of the project, and outlook

The current actual Mining Project was approved in 2007. For socio-economic reasons, the mine's ore production and processing capacity is 200 thousand tons per year.

Mining at the deposit is accompanied by operational exploration, which allows to detail ore bodies with the transfer of their reserves to higher categories. From category C1, reserves are transferred to category B. The density of the operational intelligence network is 12.5 x 12.5 m. Such an exploration network makes it possible to ensure the most efficient ore mining. Currently, reserves categories according to GKZ are B, C1; according to UNFC categories – E1, F1, G1,2.

The mine and concentration plant are regularly upgraded with equipment upgrades, process improvements and cost optimization in order to increase the efficiency of the enterprise.

Socio-economic and socio-environmental aspects of the project

Economic aspects

The company is a subsoil user engaged in the exploitation of the "N" deposit with ore processing at its own processing plant. The company produces several sulfide concentrates: copper, lead and zinc, which it sells to metallurgical plants.

Due to the fact that the enterprise is operating and city-forming, economic efficiency assessments were carried out in three variants of the mine's ore productivity: 200 thousand tons (option 1), 300 thousand tons (option 2), and 400 thousand tons (option 3). The ore processing plant's capabilities allow doubling the mine's productivity.

To solve this problem, a financial and economic model was calculated, which provides for the following key indicators:

- income (sale of concentrates);
- costing;
- production profit;
- income tax;
- net profit;
- capital expenditures;
- accumulated cash flow (net present value (NPV) at a discount rate of 10%);
- internal rate of return (IRR);
- life of the enterprise.

Comparison of technical and economic indicators of 3 development options are presented in Tab.1.1 (thousand US dollars):

Tab.1.1 – Comparison of technical and economic indicators of 3 development options

Indicator	Option 1	Option 2	Option 3
Income	362,8	544,2	725,6
Production costs	198,4	297,6	396,9
Production profit	164,4	248,4	328,7
Income tax, 20%	32,9	49,7	65,7
Net profit	131,5	198,7	263,0
Capex	21,5	30,1	40,8
NPV (10%)	4,9	11,2	21,5
IRR	11,6	24,3	39,6
Life of the enterprise, by year	2047	2037	2033

Despite the higher result indicators for the second and third options, given the social significance of the project, the company-subsoil user prefers the first option – the longest possible existence of the enterprise.

Social aspects

The company-subsoil user is one of the city-forming enterprises in its area. The number of employees of the enterprise (2017-2019) and the wage fund are presented in Tab.1.2.

Tab.2 – The number of employees of the enterprise (2017-2019) and the wage fund

Indicator	Unit	2017	2018	2019
Number of employees	Persons	470	481	493
Payroll	US dollars	3,615,240	4,155,840	4,295,016
Average salary	US dollars	641	720	726

As of 2019, the average salary at the enterprise is 1.6 times higher than the average salary in Kazakhstan (453 US dollars). Under the terms of the Subsurface Use Contract, the enterprise annually pays the amounts for the social development of the district as presented in Tab.1.3.

Tab.3 – Social payments of the enterprise

Indicator	Unit	2017	2018	2019
Specialist training	US dollars	35,838	41,197	48,944
Social development of the area	US dollars	1,635,405	1,879,488	2,232,921

The average annual budget of the region in which the company-subsoil user is operating over the past three years has amounted to about 15.5 million US dollars. Based on this amount, the company's payments for the social development of the district constitute a significant share of the revenue part of the district. With the total population of the region 44.3 thousand people (about 10 thousand families), more than 400 families are provided with jobs at the “N” field.

Environmental aspects

An Environmental Impact Assessment has been carried out in the “N” Ore Mining Project. In accordance with current regulations, emissions of harmful substances into the environment are calculated annually, and payments for these emissions are coordinated. The mining project provides for measures aimed at reducing emissions of harmful substances and the overall negative impact on the environment.

To prevent negative impact, careful compliance with environmental measures is necessary. In this regard, the project provided for technologies and technical solutions that minimize the negative impact on the environment, including:

- reduction of pollutant emissions into the atmosphere;
- reduction of emissions into surface and underground waters;
- reduction of soil pollution;
- reduce the impact on flora and fauna;
- reduce environmental impact in emergency situations;
- measures to improve the safety of mining;
- measures to control emissions during periods of particularly adverse weather conditions;
- reclamation of land disturbed by mining.

The measures envisaged by the project ensure minimization of the harmful environmental impact, provided that all design decisions are carefully observed.

Field projects status and feasibility

Technological feasibility aspects

Exploration projects at the “N” field have been fully implemented. The ore bodies of the deposit are fully explored. In this regard, further exploration work at the field is impractical. At the production stage, operational exploration is carried out as a result of which the reserves of the field are refined at individual sites to prepare them for production.

Reserves of the “N” field as of 2019 are:

- ore: 5672.0 thousand tons;
- copper: 141.8 thousand tons, with an average grade of 2.5%;
- lead: 62.4 thousand tons, with an average grade of 1.1%;
- zinc: 238.2 thousand tons, with an average grade of 4.2%;
- gold: 5104 kg, with an average grade of 0.9 g/t;
- silver: 158.8 tons, with an average grade of 28.0 g/t.

Over the years, the results of drilling wells by mining were verified at the field. The certification work demonstrated the consistency of the data that was obtained from the wells with the results of testing the mine works. In different years, during the operation, work was carried out to compare the exploration results with the operational data, as a result of which it was shown that in all cases the calculated ore reserves practically coincide, and, in some cases, according to the mining results, the reserves increase.

The results of many years of cost-effective mining of ores of the “N” deposit indicate the economic efficiency of the project, and design decisions suggest that the operation of this facility can be successfully continued for almost another 30 years. This fact has important socio-economic significance for the population of the region.

Detailed studies conducted

Over the past 10 years, work on technological mapping of ores and technological research is regularly carried out at the “N” deposit, in order to increase the extraction performance of useful components. Thanks to these studies, from 2017 to 2019 extraction of useful components in concentrates increased, including:

- copper to copper concentrate – from 76.3 to 81.3%;
- lead to lead concentrate – from 62.6 to 68.4%;
- zinc to zinc concentrate – from 81.7 to 83.9%.

The increase in the extraction of useful components ensured an increase in the volume of marketable products and income from its sale by 6.2%.

Level of knowledge / confidence in estimates

Geological and technical aspects

The geological features of the deposit and ore bodies have been studied in detail thanks to consistent multi-stage geological exploration, including production exploration. Geophysical studies in wells confirmed the correctness of the coordination of ore bodies, which was confirmed by the results of operation. The features of the geological structure of the “N” field are illustrated on the geological map and geological section (Fig.1.8, 1.9).

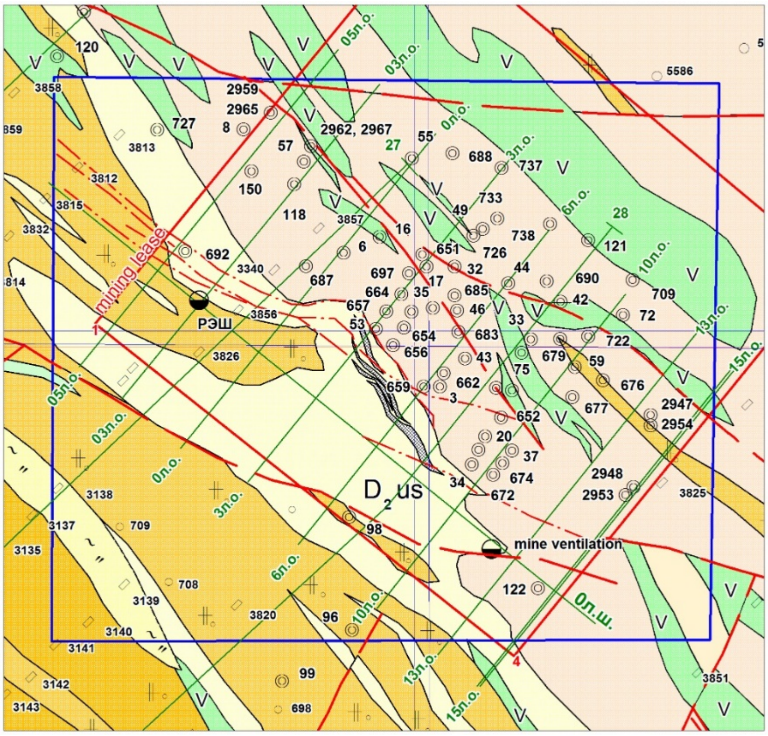


Fig.1.8 – Geological map of the field "N"

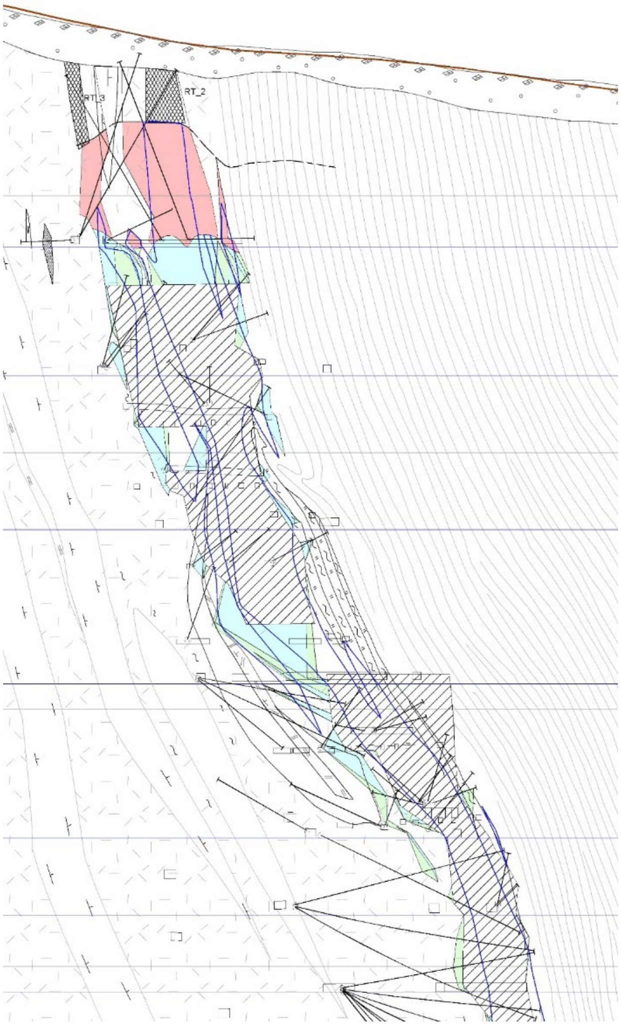


Fig.1.9 – Geological section along line 3 (the shaded areas are the worked-out space, pink and blue are the remaining ores of various types, and underground wells are shown in short straight lines)

The field was discovered by two shaft shafts at nine horizons. The ore has been mined for over 30 years. Ore processing is carried out at our own processing plant with the production of conditioned concentrates of copper, lead and zinc. The sale of concentrates is carried out at the metallurgical plants of the Kazzink LLP holding.

Estimates of quantity and volume

The latest revaluation of the "N" field reserves was carried out in 2018. All data processing, including replenishment of the database, contouring of ore bodies, construction of wireframe and block models, interpolation of metal contents into a block model, replenishment of mining (mining chambers), was carried out using the Micromine tools.

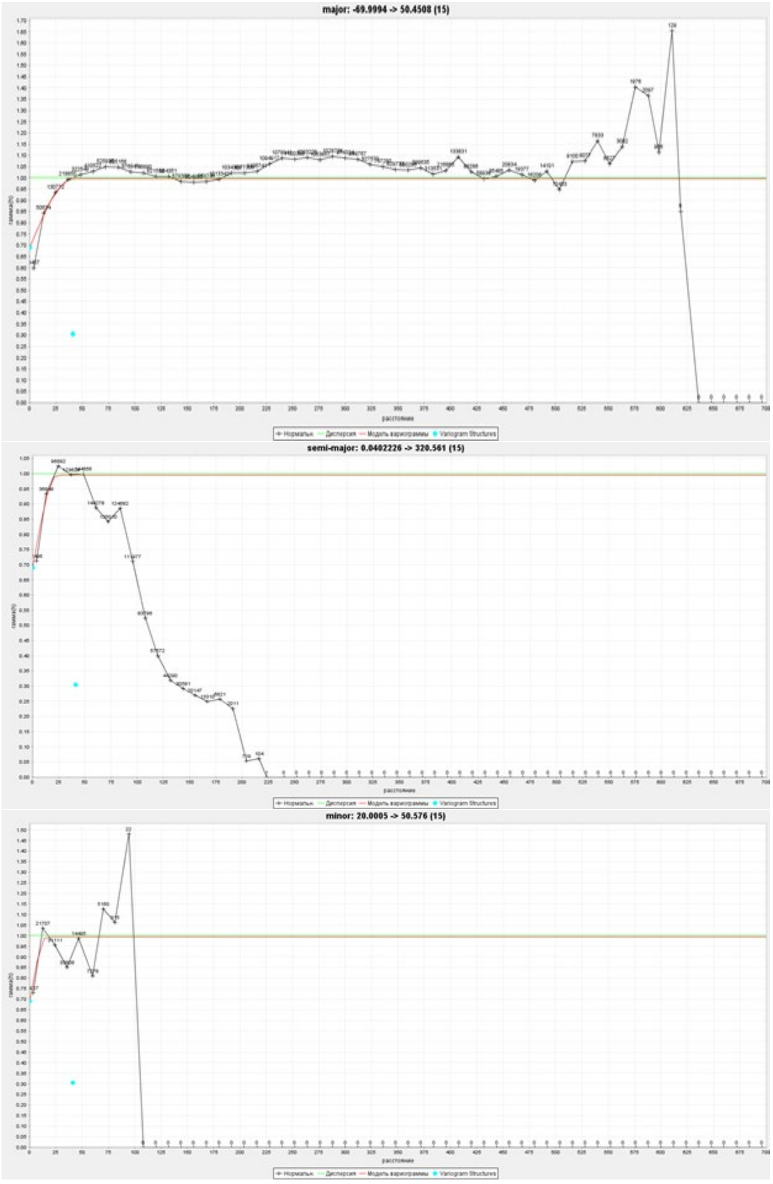
To clarify the patterns (capacity analysis, distribution of contents, etc.), statistical studies were conducted on a database of testing wells and mine workings. Histograms of the distribution of contents for all samples for five metals (copper, lead, zinc, gold, silver) were constructed and correlation relationships between the metals were determined.

When contouring ore bodies, the following principles were observed:

- The contour of ore bodies is built according to the maximum possible tracking between sections and the choice of the best option for its coordination in sections and plans in accordance with the morphology of ore bodies, as well as taking into account the available materials of the predecessors;
- The contouring of ore bodies along strike and dip was carried out using the rules of interpolation and limited extrapolation;
- Interpolation of data on the rise and fall of ore bodies was carried out in most cases at a distance of 15-20 m to 40 m, occasionally more than 50 m. Mutual linking of ore intersections at lower horizons was carried out at distances from 40-50 m to 70-75 m.
- The contouring between ore and barren workings was carried out taking into account the density of the exploration network by half the distance between the workings.

Because the ores of the deposit are complex, the conversion factors of metals into conditional copper were calculated, which were: for lead gold 0.3, for zinc 0.45, for gold 0.6, for silver 0.01.

<u>Variographic studies.</u> Variographic studies were carried out on the basis of a 1 m long file of composites. Since the ore bodies of the deposit have the same elemental composition, morphology, and due to the fact that according to the results of the study of histograms of individual populations of elements, no elements are distinguished, the same parameters of the anisotropy ellipsoid are used in the calculation of reserves for comparing exploration and exploitation data (Fig.1.10).



The copper semi-variogram is the main axis

Copper Semivariogram – Big Axis

Copper Semivariogram – Small Axis

Fig.1.10 – Variograms on the example of studies of the distribution of copper in ores of "N" deposit

Interpolation of contents. The contents were interpolated into the block model by ordinary kriging separately for each side and each ore body. After interpolation, each block was assigned a volume weight depending on the metal content. In addition, conventional metal was calculated (Fig.1.11, 1.12). To assess the quality of content interpolation, verification was carried out in two ways:

1. Visual certification. Correspondence of the tracks of composites, wireframe model of the ore body and the block model of geological reserves.
2. Statistical verification.

The certification results showed the reliability of the performed estimates of resources and reserves of the "N" field.

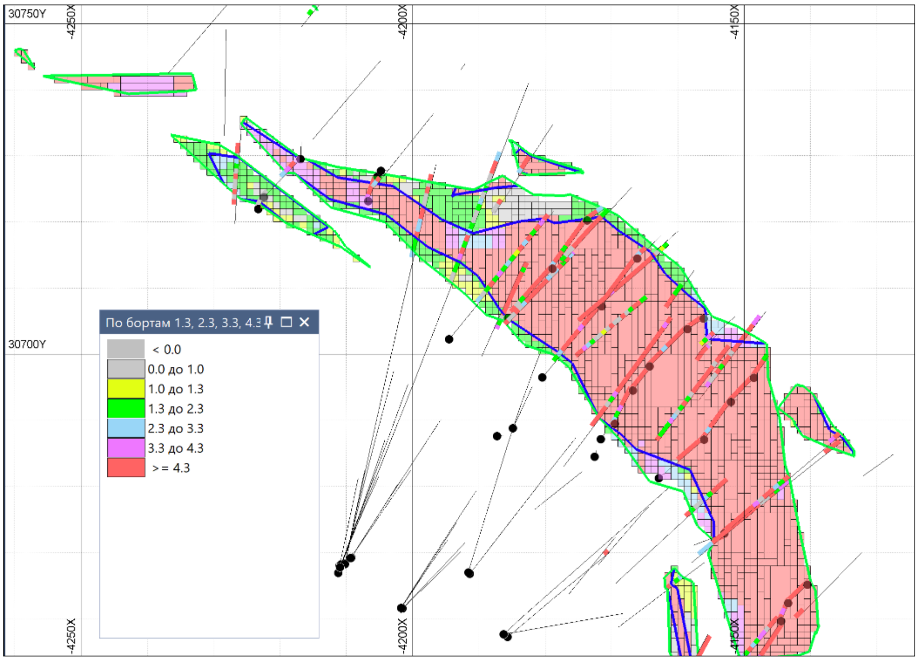


Fig.1.11 – Visual verification of the block model on the horizon 6 +630, ± 6.25m

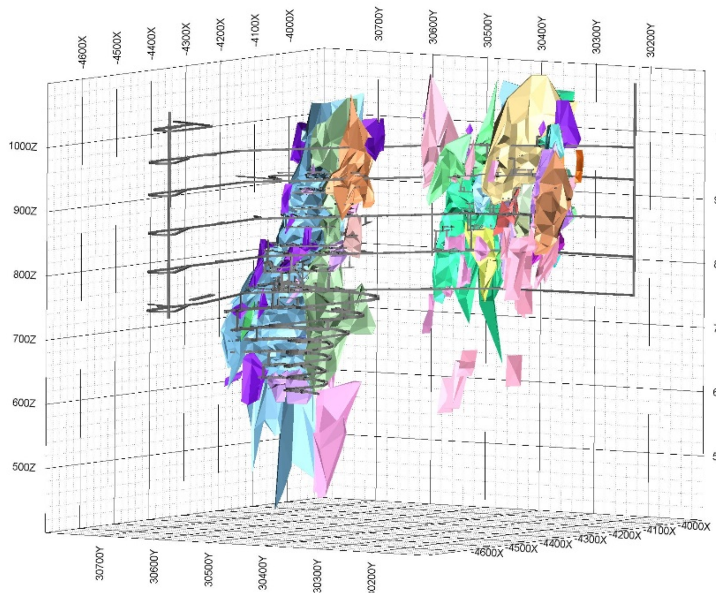


Fig.1.12 – General view of the wireframe model of ore bodies of the "N" deposit

Different colors show sections of ore bodies with different cutoff grade.

The optimum cutoff grade of reference copper for estimating reserves is assumed to be 2.0% (with a mine production and ore processing capacity of 200 thousand tons per year) based on a comparison of the technical and economic indicators of various stock options calculated at the cutoff grade of reference copper 1.6, 2.0, 2.4 and 2.8%.

Classification of the "N" field project using UNFC

Review of socio-economic information including social and environmental (E-axis)

The pyrite-polymetallic ore deposit "N" has been operating profitably for more than 30 years. The subsoil user company is a city-forming enterprise that provides work for almost 500 workers and specialists. In general, the work of the enterprise is important for the socio-economic development of the region. The company's management deliberately chose the option of annual ore production

and processing capacity of the enterprise (200 thousand tons), which ensures the maximum life of the enterprise (28 years). A significant part of the district's budget is formed by the enterprise in the form of taxes.

Therefore, the socio-economic feasibility of ore mining, production of concentrates and their marketing can be classified according to UNFC-2009 by category E1.

Review of project feasibility information (F-axis)

The high quality of ores of the "N" deposit, the compactness of the ore bodies, the high degree of their exploration, continuous field exploration at the deposit, and the stable sale of products (concentrates) ensure a stable economic position of the enterprise with satisfactory IRR performance of 11.6% and average annual profit for the entire period of development of 4.7 million US dollars. Some of the reserves of the deep horizons of the field (about 20%) that have not yet been discovered by underground mining are characterized only by preliminary technical and economic assessments.

Therefore, the feasibility study of ore mining, production of concentrates and their marketing can be classified according to UNFC-2009 in category F1.2.

Review of geological knowledge / confidence in estimates (G-axis)

The latest assessment of the field's reserves (as of 01.01.2019), made by 3D modeling using Micromine, while ensuring proper quality control of testing and analytical work, confirmed by studies comparing exploration and production data, provide a high degree of confidence in the estimates.

At the same time, on the deep horizons of the deposit, where production exploration has not yet been carried out, some of the reserves have been studied with a lower degree of detail than on those horizons where ore is mined. This part of the reserves is characterized by less confidence in valuations.

Therefore, the degree of geological exploration and confidence in reserves estimates of the "N" field can be classified according to UNFC-2009 into F1.2 categories.

Classification of the project using UNFC scheme

Based on the above review of the "N" project on the axes of the UNFC-2009 classification, stocks of pyrite-polymetallic ores as of 01.01.2019 can be classified as E1, F1,2, G1,2.

CASE STUDY II: APPLICATION OF UNFC TO OIL AND GAS DEPOSIT “X”

Authors: K.Makazhanov, V.Babashev

Introduction

Administratively, the “X” field is located in the Kyzylorda region of the Republic of Kazakhstan. Geographically, the field is located in the southwestern part of the Torgai Trough (Fig.2.1). Details are presented in Fig.2.2-2.3.

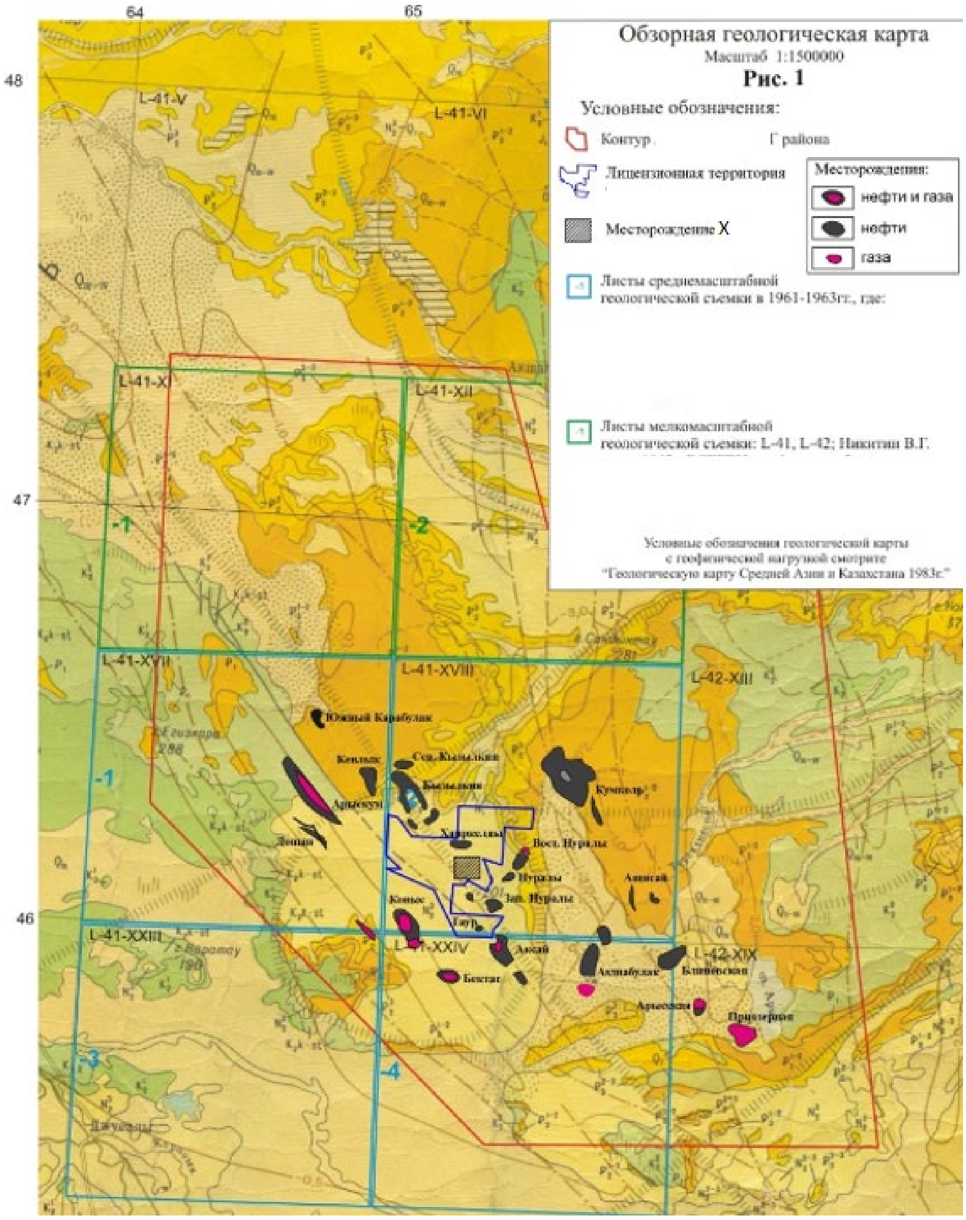


Fig.2.1 – Regional map, “X” field

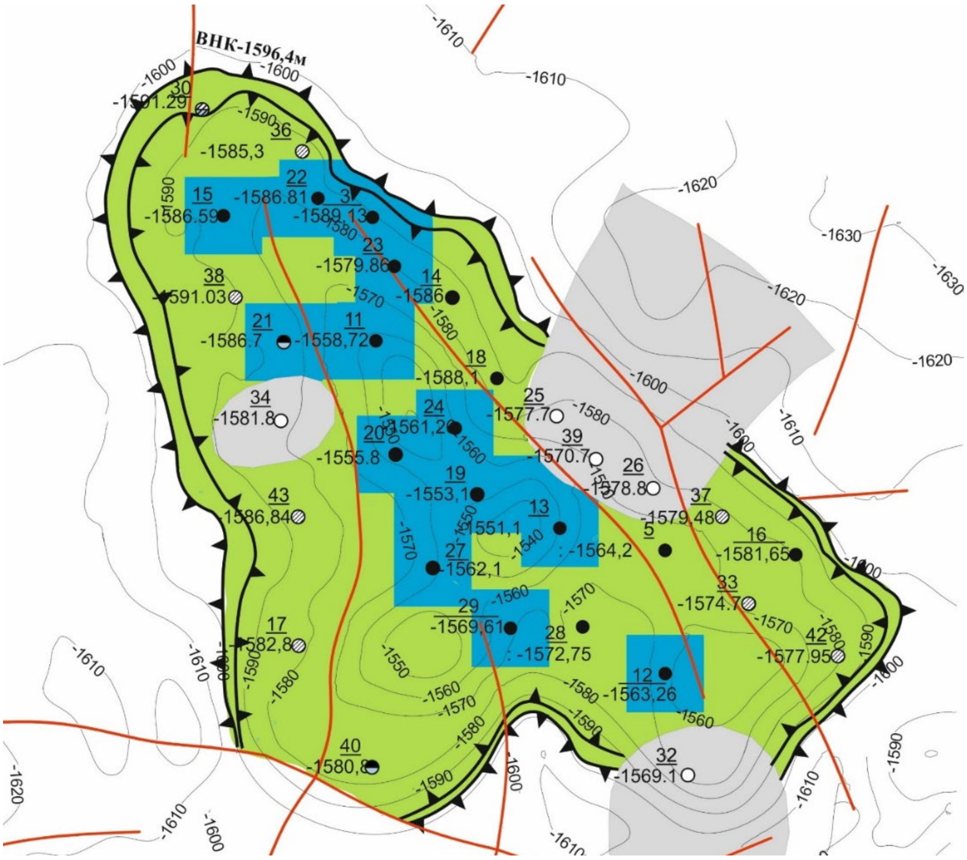


Fig.2.2 – Structural map on the roof of the collector of the productive horizon M-II-1 (I object of development)

Fig.2.3 – Structural map for the collective productive horizon U-0-3 (II development object)

Proceeding from the regional nomenclature of productive horizons at the “X” field, oil deposits were revealed in the lower neocomial deposits K1nc1 (horizons: M-II-1; M-II-2; M-II-3) and in the upper Jurassic J3 (horizons U-0-1, U-0-2, U-0-3, U-0-4, U-I).

In 2019, the report “Recalculation of oil reserves at “X” field as of 02.01.2019” was prepared. Initial geological and recoverable oil reserves are approved according to the GKZ RK classification in the following quantities and categories:

- B: 929 thousand tons of geological, including recoverable – 346 thousand tons;
- C1: 2064 thousand tons of geological, including recoverable – 741 thousand tons;
- C2: 316 thousand tons of geological, including recoverable – 92 thousand tons.

As of 02.01.2019, total oil production at the “X” field amounted to 315 thousand tons.

For “X” field, as of 02.01.2019, the remaining recoverable oil reserves calculated according to the GKZ RK classification are as follows:

- B+C1 categories: 2678 thousand tons;
- C2 category: 92 thousand tons.

In terms of recoverable oil reserves, according to the GKZ RK classification, “X” field belongs to the category of small fields with reserves of up to 3 million tons.

National classification system for reserves of fields, prospective and forecast oil resources and natural hydrocarbon gas

Classification of reserves of fields, prospective and forecast oil resources and natural hydrocarbon gas of the Republic of Kazakhstan (GKZ RK classification) is considered.

Description and details of the national classification and management system

The GKZ RK classification establishes uniform requirements for the classification of reserves and resources of oil, natural hydrocarbon gas (free gas, gas caps and gas dissolved in oil) and condensate, their state accounting in the bowels by the degree of study and development. Basic concepts of reserves categories and resource categories are used in the GKZ RK classification.

Oil, gas and condensate resources are divided into prospective (category C3) and forecast (categories D0, D1 and D2) according to their degree of substantiation and timeliness.

The resources are predictable:

- Category D2 – predicted resources of lithology-stratigraphic complexes, estimated within large regional structures, the industrial oil and gas bearing capacity of which has not been proved yet.
- Category D1 – Projected resources of lithology-stratigraphic complexes, estimated within large regional structures with proven industrial oil and gas bearing capacity.
- Category D0 – Estimate of inferred resources at identified local sites within the region with D1 resources and used to plan geophysical surveys to identify and prepare structures for exploratory drilling.

Resources are promising:

- Category C3 – prospective resources estimated on structures and areas prepared for deep exploratory drilling within the oil and gas bearing area. Prospective resources are used when planning prospecting works.

Stock categories (reserves of oil, gas, condensate and associated components are divided into proven categories A, B, C1 and preliminary estimated (undiscovered) categories C2. Proven reserves include those under development (categories A and B) and those explored (category C1)):

- Category A – reserves are calculated on the basis of the deposit (or part of it) drilled in accordance with the approved field development project and serve as a basis for optimizing the system and process of oil, gas and condensate reserves development.
- Category B – reserves are calculated on the basis of the deposit (or its part) drilled in accordance with the approved technological scheme of field development and serve as the basis for the development project.
- Category C1 – reserves of a deposit (its part), the oil and gas content of which is determined on the basis of commercial oil, gas and condensate inflows received in wells and positive results of geological and geophysical studies in untested wells.[1]
- Category C2 – reserves of the deposit (its part), the presence of which is justified by the data of geological and geophysical studies.[2]

Comparison of the GKZ RK classification for oil and gas resources with UNFC

The classification of field reserves, prospective and inferred oil and natural gas resources reflects the results of a step-by-step geological study of the subsoil.

The subsoil study stages are carried out through the implementation of relevant projects. Each project has objectives, timelines, quality requirements and specific risk levels

The presented scheme (Fig.2.4) highlights 4 main stages of subsoil studies, while each stage of the subsoil study has a specific resource and reserve estimate by category:

- regional,
- a search stage,
- exploratory
- industrial development.

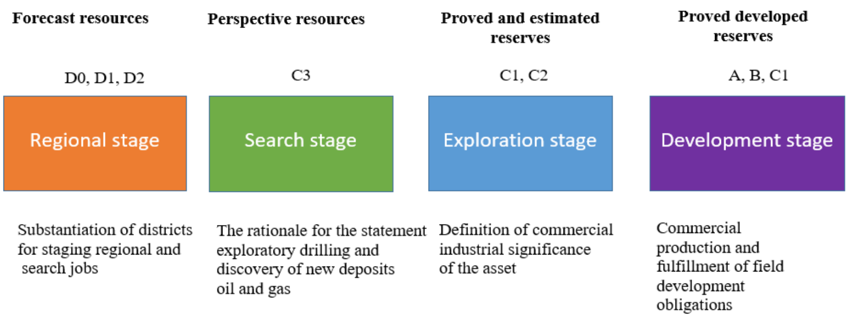


Fig.2.4 – The phased study of asset based on project management

[1] Category C1 reserves are calculated on the basis of the results of geological exploration and production drilling and should be studied to the extent that they provide the initial data for the development of the technological scheme of the field. Category C1 reserves can be allocated to new areas based on drilling and testing of single wells, provided that commercial oil and gas inflows are received.

[2] Category C2 reserves are calculated in unexplored parts of the deposit adjacent to areas with higher categories of reserves. Category C2 reserves are used to determine the prospects for the field, to plan exploration work or geological and field studies and, in part, to design the development of a deposit.

Similar principles of step-by-step subsoil study and project management are laid down in the UNFC. For example, from the G4 category, where only estimated quantities of a potential field are determined through the G3 category, where the quantities are already discovered, but determined with a low degree of certainty and through the G2 category, where the quantities are determined with a medium degree of certainty reach the G1 category, where the quantities at the known field are determined with a high degree of certainty.

At the same time, with a certain degree of conditionality it is possible to compare the categories of geological study under the UNFC with the GKZ RK classification so, for example, G4 is comparable with the category of resources D0, C3, category G3 – with the estimated category of reserves C2, category G2 – with the categories of reserves C1 and C2, category G1 – with the categories of reserves A, B.

It is also tentatively possible to compare the criteria of the status and feasibility of the field development project under the UNFC with the stage-by-stage subsoil study projects in Kazakhstan. F4 category under the UNFC is comparable to regional stage projects, F3 category under the UNFC is comparable to exploration stage projects, F2 category under the UNFC is comparable to exploration stage projects, F1 category under the UNFC is comparable to the projects of the field development stage.

The study of a specific field under the G1 category and the economic feasibility of production and sales under the E1 category under the UNFC is achieved by phased implementation of projects from F4 to F1 category.

Background information on the “X” field project

Previous work

In 2009, field seismic works were carried out in the Contract area with a total area of 90 km2 of 3D seismic data.

Since 2011, exploration work has been carried out on the basis of the “Prospecting Works Project”. In 2011, additional 3D seismic work was carried out in Area X with an area of 175 km2, and the materials obtained were interpreted and structural maps of the main reflective horizons were constructed. Additionally, the processing of 2009 seismic data was reworked. In 2012, wells 3 and 5 were drilled in accordance with the exploration project.

Field “X” was discovered in 2012 by obtaining oil inflow in well 3 during testing of the interval 1885-1891 m (horizon – U-I). The oil flow rate was 26.5 m^3/day at a 7 mm connection.

In 2013, based on the results of the work performed, the “Operational calculation of oil reserves and dissolved gas reserves at the “X” field” as of 15.05.2013 was performed. In 2013, the “Trial Operation Project of “X” Field” was drawn up.

In 2014, the “Calculation of oil reserves, dissolved gas and associated components of “X” field” as of 01.07.2014 was performed. Inventories are calculated in the following quantities and categories:

- 742 thousand tons of geological, including 279 thousand tons extracted,
- S1, 2249 thousand tons geological, including 808 thousand tons extracted.
- C2, 315 thousand tons geological, including 89 thousand tons recoverable.

In 2014, the “Technological Scheme for Development of the “X” Field” was drawn up, providing for the drilling of 19 production wells from 2015 to 2018. In 2016, the “Author's supervision over the implementation of the technological scheme of “X” field development” was performed. In 2017, based on the results of production drilling, the company increased and clarified the reserves of oil dissolved in oil, gas and associated components of the “X” field as of 05.01.2017.

Current status of the project, and outlook

In 2018, the "Analysis of "X" field development" was performed with specified development indicators until 2021.

As of 02.01.2019, 28 wells were drilled in total at the "X" field, of which 22 wells were drilled in the operating well stock, 5 wells were inactive, and 1 well was under development (under injection). Wellbores of the operating fund work in fountain and mechanized ways. Flowing wells at the field 2 are operated by mechanized method with 20 wells, including 15 wells with sucker rod pumps, 4 wells with electric submersible pumps and 1 well operated by means of a compressor gaslift.

Socio-economic and socio-environmental aspects of the project

Economic aspects

As part of this assessment, the economic efficiency of the proposed 3 development options was conducted not only to assess the economic performance of the contractor as an investor, but also the share of the Republic of Kazakhstan in the form of taxes and contributions to staff training and social development.

This project has created an economic model that takes into account the following points:

- gross revenue (oil sales);
- accounting for all refundable and non-refundable mandatory payments;
- tax;
- the subsoil user's cash flow;
- cash flow of the Republic of Kazakhstan.

To make a decision on the efficiency of economic indicators of development options, integral indicators such as cash flow, NPV with a discount rate of 10% were calculated. These figures were calculated on the basis of net cash flows.

Comparison of technical and economic indicators of 3 options of development is given in Tab.2.1.

Tab.2.1 – Economic indicators of field development (thousand US dollars)

Indicator	Option 1	Option 2	Option 3
Net sales revenue	165,100	264,644	253,872
Capital expenditures	0	3,416	20,581
Operating expenses	34,304	59,391	53,452
Taxes and payments to the budget	64,146	103,476	98,391
Income tax	11,407	17,749	14,366
Excess profits tax	0	0	0
Accumulated cash flow	55,244	80,612	67,082
Contractor's NPV (10%)	35,084	48,824	41,454
Revenue of the Republic of Kazakhstan	75,553	121,224	112,757
Life of the enterprise, by year	2038	2040	2035

As can be seen, the implementation of the project under the recommended option 2 will bring the Republic of Kazakhstan about 121.2 million US dollars. The Advisory Committee recommends that the General Assembly approve the establishment of an additional amount of 100,000 US dollars in budgetary revenue in the form of taxes and contractual obligations.

Social aspects

To understand the significance of the above figure, it can be compared with the data of the Civil Budget of the city of Kyzylorda (hereinafter referred to as the Budget) for 2017-2019 on social projects (Fig.2.5).

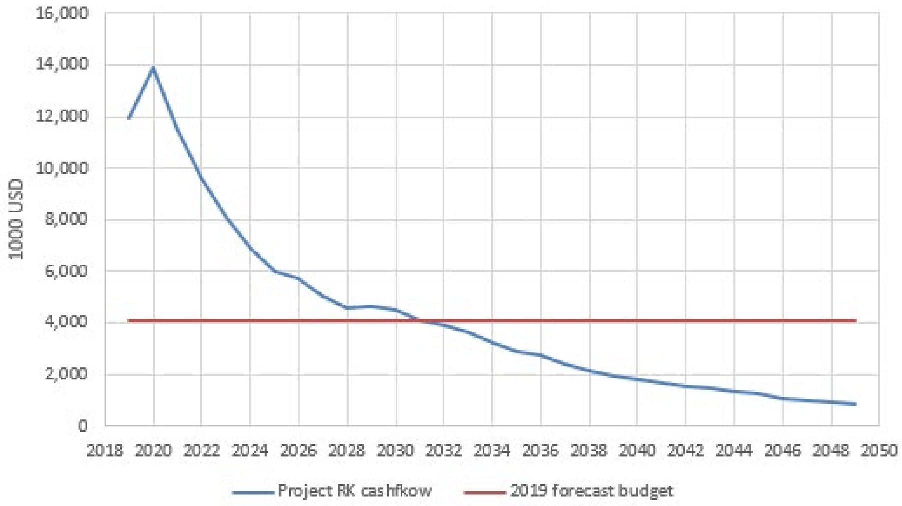


Fig.2.5 – Comparison of the Republic's cash flow from social needs

In general, according to the Budget, for 2019, the projected allocations for the social sphere of the city of Kyzylorda should be about 1.58 billion tenge or approximately 4.1 million US dollars. If to result on years of receipt of the Republic of Kazakhstan from the present project and to compare these receipts with the sum (4.1 million US dollars) allocated for 2019 only on social sphere it is visible that only from realization of the present project the Republic of Kazakhstan can "close" requirements on social sphere of the city of Kyzylorda till 2031.

On the subsoil-user level, the company "X" is engaged in the search, exploration, development of oil and gas fields and oil production, with the further sale of commercial oil in the domestic and foreign raw material markets. Company "X" is not a city-forming enterprise.

The number of employees starting from 2017 is presented in Tab.2.2.

Tab.2.2 – Payroll fund

Indicator	Unit	2017	2018	2019
Employees	people	209	232	233
Payroll	thousand US dollars	2,236	2,851	2,863
Average salary per employee	US dollars	891	1024	1023

As can be seen, as a whole, "X" employs 233 people as of 2019, with an average salary of 1,000 US dollars, which is on average 3 times higher than the average salary in the area. In general, over the past 4 years, social commitments have been total as shown in Tab.2.3 below.

Table 2.3 – Social obligations of "X" Company

Indicator	Unit	2016	2017	2018	2019 (plan)
Training of specialists	thousand US dollars	22,167	132,331	112,183	174,384
Social development of the region	thousand US dollars	2,248,472	1,123,034	1,597,255	497,261

Environmental aspects

As part of the development of the Technological Scheme for field development, a preliminary environmental impact assessment was developed.

The area of the planned activity is confined to the sensitive zone of anthropogenic impact in which minor changes as a result of economic activity may cause undesirable changes in individual components of the environment. In order to prevent negative impact on the environmental components it is necessary to carefully observe environmental protection measures.

In this regard, the project included technologies and technical solutions that would have had the least impact on the environment. The main components of the environment affected are the air basin, water areas, subsoil, flora and fauna of the area, and the social environment (Fig.2.6).

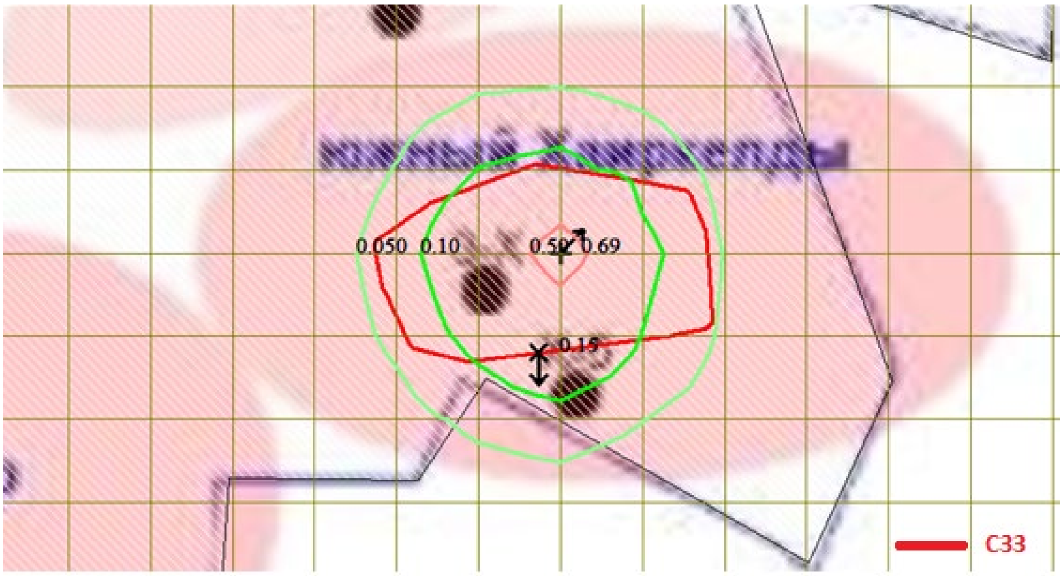


Fig.2.6 – Calculation of the dispersion of the concentration of pollutants in the field

On the basis of the analysis of the current situation, the adopted design decisions and their predicted consequences the maps of calculation of dispersion of pollutants in the surface layer of the atmosphere were additionally modeled. Emissions of pollutants do not exceed Maximum Permissible Norms (MPCs) (Tab.2.4).

Thus, the analysis of the component and integral impact on the environment allows us to conclude that the implementation of the project, subject to compliance with the design technological solutions will not have a significant negative impact on the environment. At the same time, the implementation of the project will have a significant positive impact on the socio-economic sphere and will lead to an improvement in the standard of living of a significant group of people.

The planned implementation of the project is desirable from the socio-economic point of view and is possible without consequences from the point of view of the environmental situation development.

Tab.2.4 – MPC table for "X" field project

Code	MPC maximum once, mg/m^3	MPC maximum per day, mg/m^3	Safe exposure level, mg/m^3	Hazard Class	Substances taking into account cleaning, g/s	MPC maximum once, mg/m^3
0123	Iron (II, III) oxides (diGeleSo trioxide, Iron oxide) /Iron equivalent/ (274)		0.04		3	0.02
0143	Manganese and its compounds /in terms of manganese (IV) oxide/ (327)	0.01	0.001		2	0.002
0304	Nitrogen (II) oxide (Nitrogen oxide) (6)	0.4	0.06		3	0.4
0328	Carbon (Soot, Black Carbon) (583)	0.15	0.05		3	0.35
0330	Sulphur dioxide (sulphur dioxide, sulphur dioxide, sulphur dioxide (IV) oxide) (516)	0.5	0.05		3	0.50
0337	Carbon oxide (Carbon monoxide, Carbon monoxide) (584)	5	3		4	4.76
0410	Methane (727*)			50		0.17
0415	Mixture of hydrocarbons limit C1-C5 (1502*)			50		0.004
0416	Mixture of hydrocarbons limit C6-C10 (1503*)			30		0.0004
0602	Benzene (64)	0.3	0.1		2	0.00001
0616	Dimethylbenzene (mixture of o-, m-, p-isomers) (203)	0.2			3	0.000001
0621	Methylbenzene (349)	0.6			3	0.000002
0703	Benz/a/pyrene (3,4-Benzpiren) (54)		0.000001		1	0.00001
1325	Formaldehyde (Methanal) (609)	0.05	0.01		2	0.04
2754	Alkanes C12-19 /C/ (Hydrocarbons limit C12-C19 (C); RPK-265P solvent) (10)	1			4	1.00
2902	Weighted particles (116)	0.5	0.15		3	0.02
2907	Inorganic dust containing silicon dioxide in %: more than 70 (Dynas) (493)	0.15	0.05		3	0.13

Field projects status and feasibility

Technological feasibility aspects

The technical project of 2009 for field seismic works in 3D modification (90 km2) is related to prospecting projects to identify promising structures for oil and gas exploration. Based on the results of the seismic survey, promising structures for oil and gas exploration were identified, but area “X” was not covered by these studies.

Detailed studies conducted

Additional 3D seismic work was carried out under the prospecting project, covering an area of 175 km2. The obtained materials made it possible to identify and preliminarily delineate promising hydrocarbon deposits, to construct structural maps of the reference reflective horizons and to determine the points of location of exploration wells to confirm the identified prospective structures.

Exploration wells 3 and 5 were drilled in 2012 under the above exploration project. Geophysical surveys were carried out in the wells drilled, and oil-saturated thicknesses, porosity and oil-saturated reservoirs were determined for each productive horizon. The properties of oil have been studied. The work on this project was carried out at the search stage.

On the basis of operational reserves calculation, the “Project of trial operation of “X” field” was drawn up, which provides for drilling of 7 new wells, including 4 production and 3 exploration wells. The total number of wells during the trial operation reached 9.

Based on the results of the trial operation of field “X”, the following tasks were solved:

- parameters of oil-saturated reservoirs in new wells were determined, and oil properties in formation and surface conditions were studied;
- the operating modes of productive deposits were studied, and the elastic energy potentials of the formation system were assessed;
- productive characteristics of deposits were studied according to the data of long-term well operation at different modes;
- the productivity of producing wells and the optimal underbalance on productive formations were specified;
- assessment of problems related to well operation and oil production.

In 2014, the “Calculation of oil reserves, dissolved gas and associated components of “X” field” as of 01.07.2014 was performed. The “Trial Production Project for “X” Field” is part of the exploration phase. In 2014, based on the results of reserves calculation, the “Technological scheme of “X” field development” was drawn up. Further, in 2016, the “Author’s supervision over the implementation of the technological scheme of “X” field development” was performed.

During the implementation of the technological scheme for the development of the “X” field, 19 producing wells were drilled, and the field development and preparation of oil quality for sales and distribution began. In 2017, based on the new data on 19 wells drilled and geological and field studies conducted, a report was prepared on “Growth and clarification of oil reserves, dissolved in oil gas and associated components of “X” field” as of 05.01.2017. The implementation of the Technological Scheme for the development of the “X” field belongs to the commercial development stage.

In 2018, the “Analysis of the development of “X” field” was completed, according to which the field is currently being developed.

In 2019, based on the results of the implementation of the recommendations of the project “Analysis of the development of “X” field”, the “Recalculation of oil reserves of field “X” as of 02.01.2019” was carried out, in which there was a change in the categories of reserves as a result of a more detailed study of the field. The project “Analysis of the development of “X” field” is a part of the Technological scheme of development, and also refers to the stage of commercial development.

Level of knowledge / confidence in estimates

Geological and technical aspects

As a result of the interpretation of MOGT 3D seismic data, both structural and non-structural objects have been identified in the contract area, and the provisions of tectonic disturbances and the contours of the foundations' protrusions have been clarified. Structural maps of all productive horizons were constructed based on the results of interpretation of seismic surveys and taking into account wells drilled at the “X” field.

A total of 28 wells were drilled at field “X”, where a full range of geophysical studies were carried out. Productive horizons were identified by correlation of well sections. All wells have oil-saturated thicknesses, porosity and oil-saturated coefficients. Water-oil contacts (WOC) in all oil reservoirs have been justified.

In total, 284.8 m of core sinking was achieved at the field, with a total linear flow of 260.2 m or 91.36% of sinking. A total of 166 core samples from nine wells were selected and analyzed along the section. Out of this amount, 150 samples of them were studied within the limits of productive deposits. The number of conditioned samples is 124.

Based on the results of petrophysical core studies, the following dependencies for chalk and Jurassic deposits were constructed:

- dependence of the porosity parameter on the porosity coefficient;
- saturation parameter dependence on water saturation coefficient;
- determination of the limit value of the porosity coefficient;
- dependence of permeability coefficient on porosity coefficient;
- dependence of volume density on porosity coefficient;
- dependence of permeability coefficient on volume clayiness;
- dependence of porosity coefficient on volume clayiness;
- dependence of permeability coefficient on the total content of clayey and carbonate cement;
- dependence of porosity coefficient on the total content of clayey and carbonate cement;
- histogram of distribution of granulometric fractions.

All wells within the B and C1 categories are in operation. All of them have measured formation and bottom-hole pressures, studied different modes of operation. At field “X”, the properties of oil in reservoir conditions were studied by 26 studies of deep samples from 14 wells. Properties of degassed oil are determined by 29 samples from 14 wells.

The component composition of oil in all productive horizons is highly paraffinic, low-tar and low-sulfur. The density of formation oil changes 701 -720g/cm^3, gas content 98-123m^3/t, volume factor 1,244-1,31d.unit, viscosity 0,66-0,8mPa*s.

Estimates of quantity and volume, and confidence in grades

The boundaries of productivity areas for each horizon are:

- the contours of the adopted provisions of WOC. SOCs were adopted based on well testing data consistent with the results of the GIS interpretation;
- boundaries;
- correlation;
- petrophysics.

Logs parameters were determined in Interactive Petrophysics software package. The selection of collectors was carried out at a qualitative level and linked by reasonable boundary values. Productivity areas, reservoir volumes, pore volumes and saturated reservoir volumes within the limits of the accepted productivity circuits and categories were determined in a 3D model in the Petrel software according to the existing guidelines for calculating reserves (Fig.2.7, 2.8).

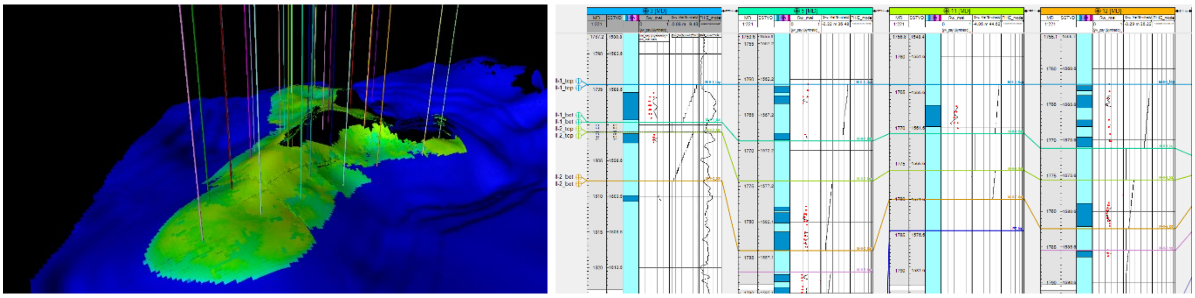


Fig.2.7 – Model grid and cross section of the well section Fig.2.5 – Model grid and cross section of the well section

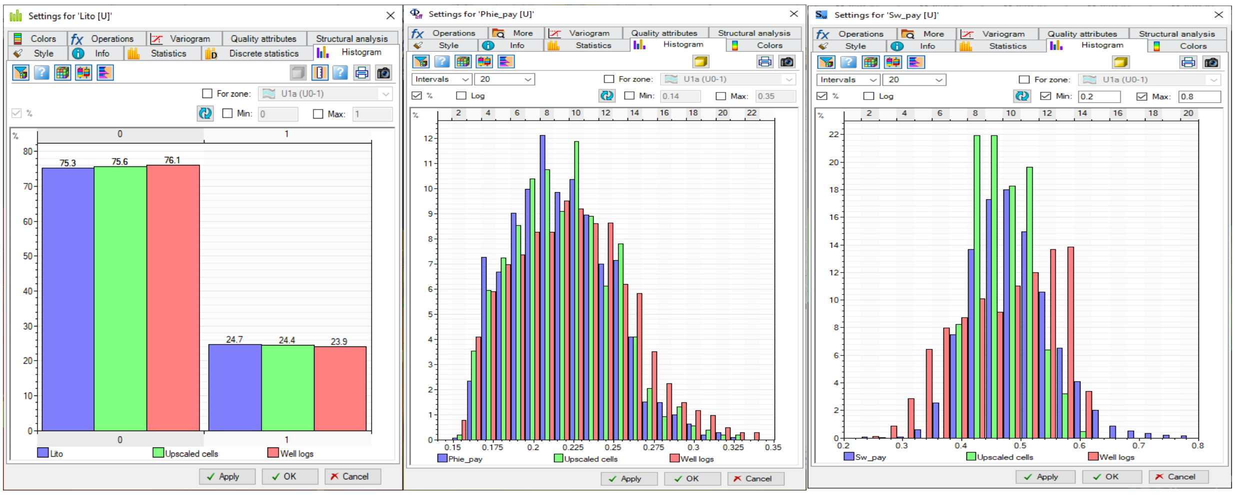


Fig.2.8 – Comparison of input parameter distributions (fraction of collector, porosity, water saturation) based on modeling results and initial data

On the basis of laboratory studies of oil samples, a fluid model was constructed from which, according to field conditions of separation, oil density, conversion factor and gas content were determined. The main oil properties of the field based on the modeling results are shown in Fig.2.9.

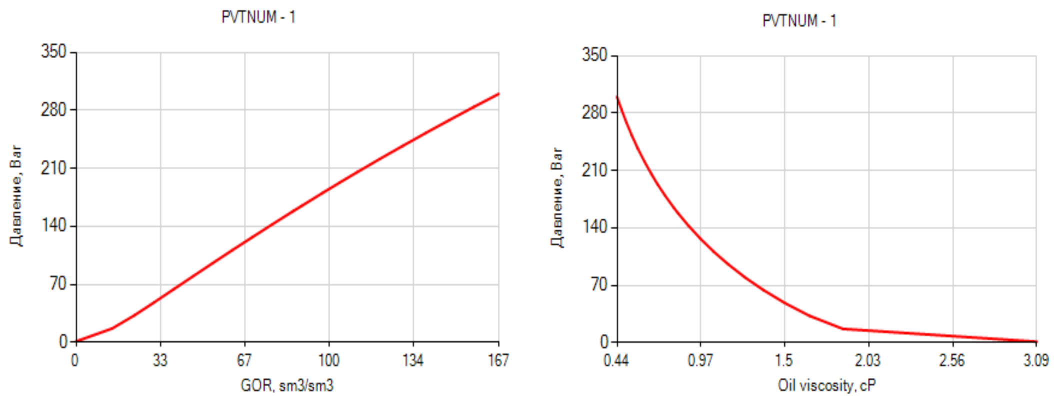


Fig.2.9 – Dependence of gas content and viscosity of formation oil on pressure

According to the results of SCAL, the phase permeability curves were constructed and the water displacement coefficient of oil was derived (Fig.2.10).

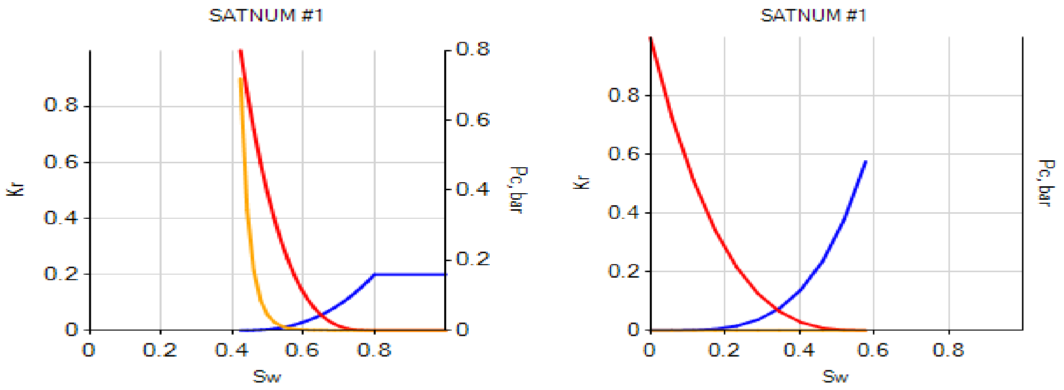


Fig.2.10 – Phase permeability of oil-water by the result of modelling

Based on the results of interpretation of the total volume of geological and field data, two hydrodynamic models for each development object were built in the t-Navigator software package. Tab.2.5 shows the main parameters of the models, illustrated in Fig.2.11 and 2.12.

Tab.2.5 – Model parameters

Indicator	Object 1	Object 2
Measuring system	METRIC	METRIC
Griddle type	Single	Single
Free phases in the model	GAS&OIL&WATER	GAS&OIL&WATER
The water horizon	Aqufer	Aqufer
Start date of calculation	1.01.2012	1.01.2012
Platform	tNavigator	tNavigator
Dimension, I	202	202
Dimension, J.	250	250
Dimension, K	17	48
Number of active cells	198 610	415 635
Number of equilibrium regions	4	6
Number of filtration regions	3	5
Number of PVT regions	4	6
Number of reported regions	7	6

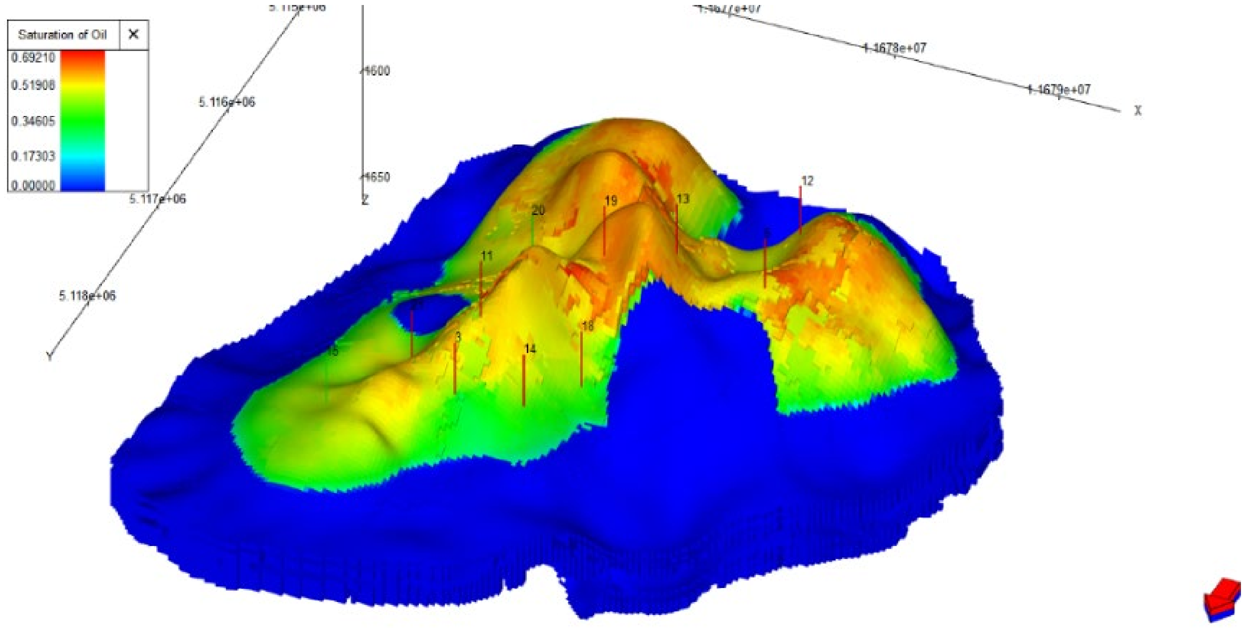


Fig.2.11 – Dynamic grid model of Object 1

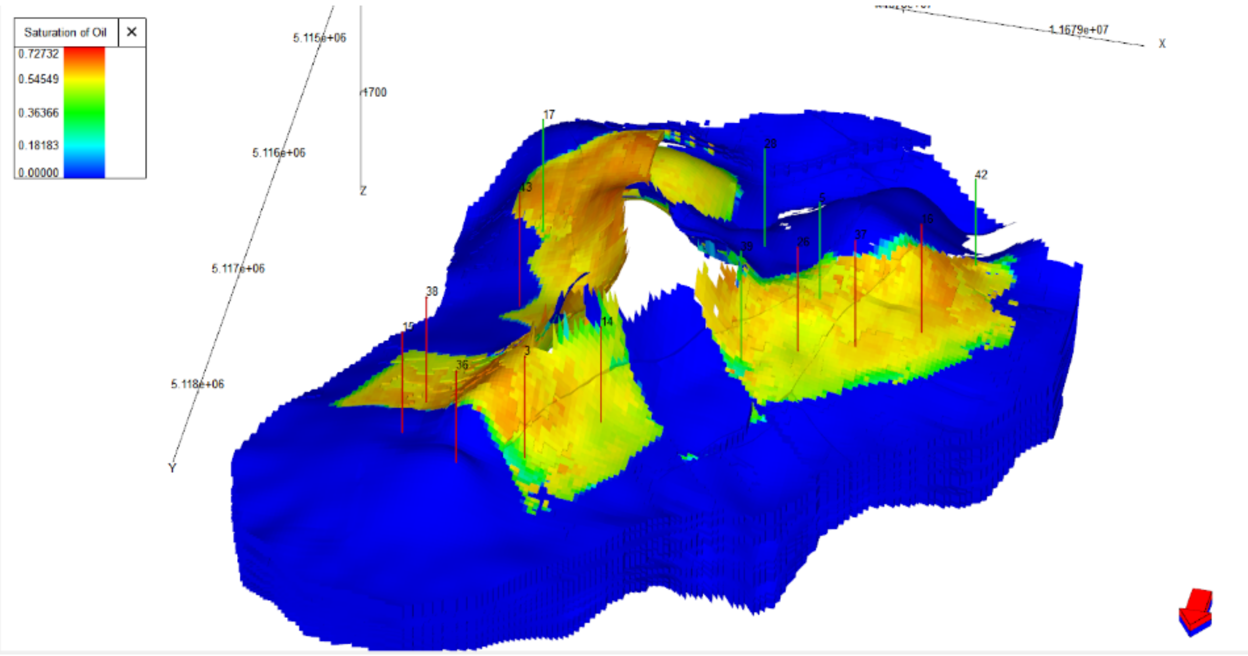


Fig.2.12 – Dynamic grid model of Object 2

Adaptation was carried out for each horizon both at the development site and at the wells. Adaptations for oil sampling in general at the facility are shown in Fig.2.13-2.19.

It should be noted that the constant pressure in Regions 5 and 6 is a category of C2 reserves that needs to be further explored before commercial development.

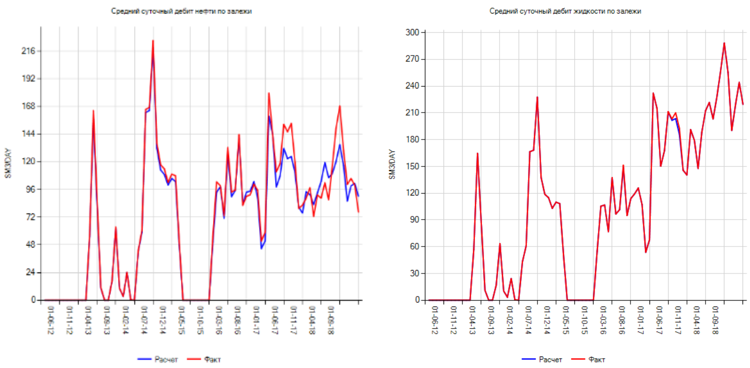


Fig.2.13 – Adaptation of oil and liquid rates by Object 1

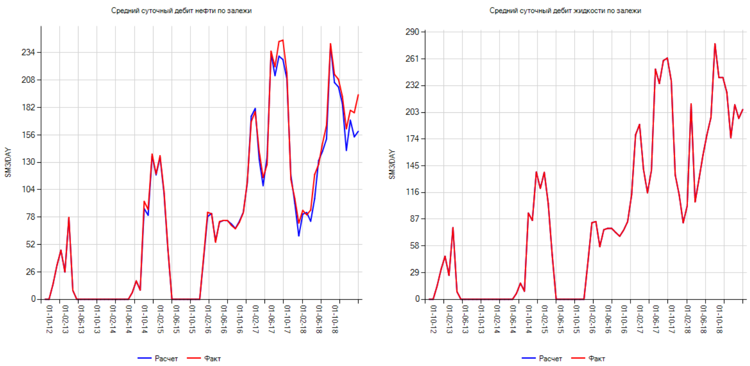


Fig.2.14 – Adaptation of oil and liquid rates by Object 2

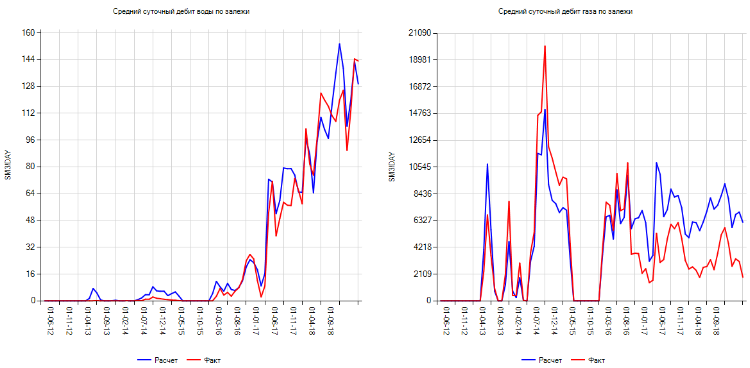


Fig.2.15 – Adaptation of water rates and GOR of Object 1

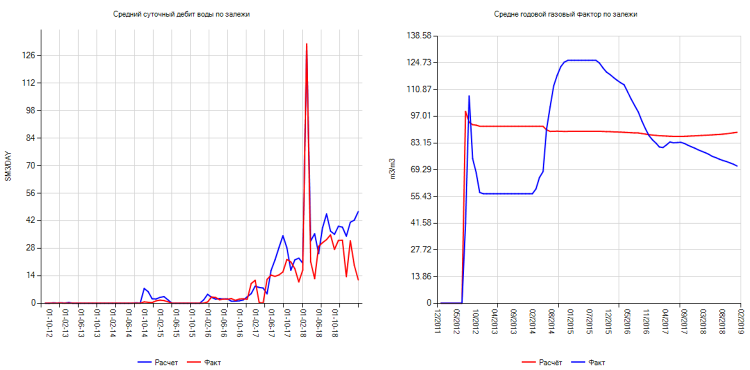


Fig.2.16 – Adaptation of water rates and GOR of Object 2

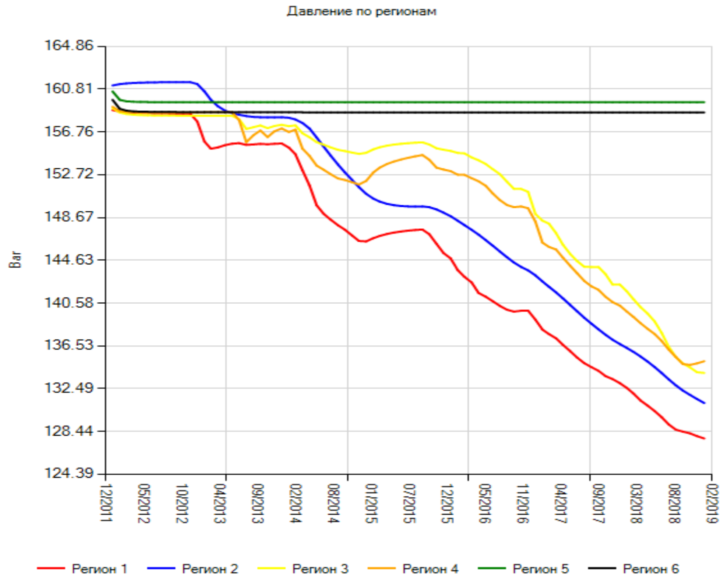


Fig.2.17 – The reservoir pressure dynamics along the horizons of Object 1

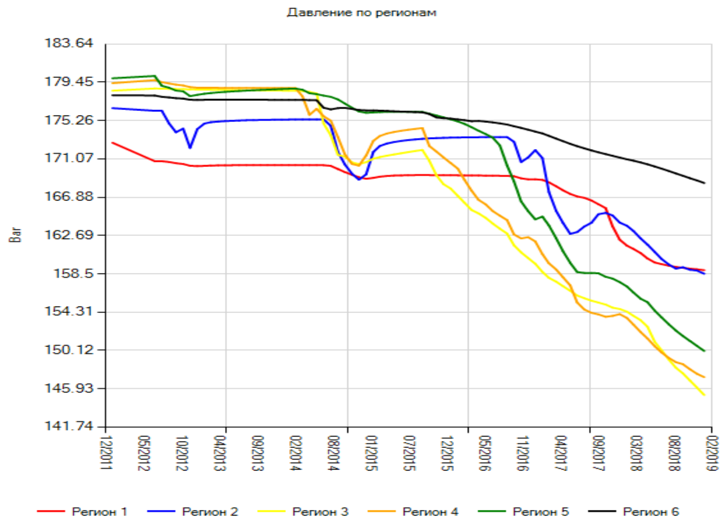


Fig.2.18 – The reservoir pressure dynamics along the horizons of Object 2

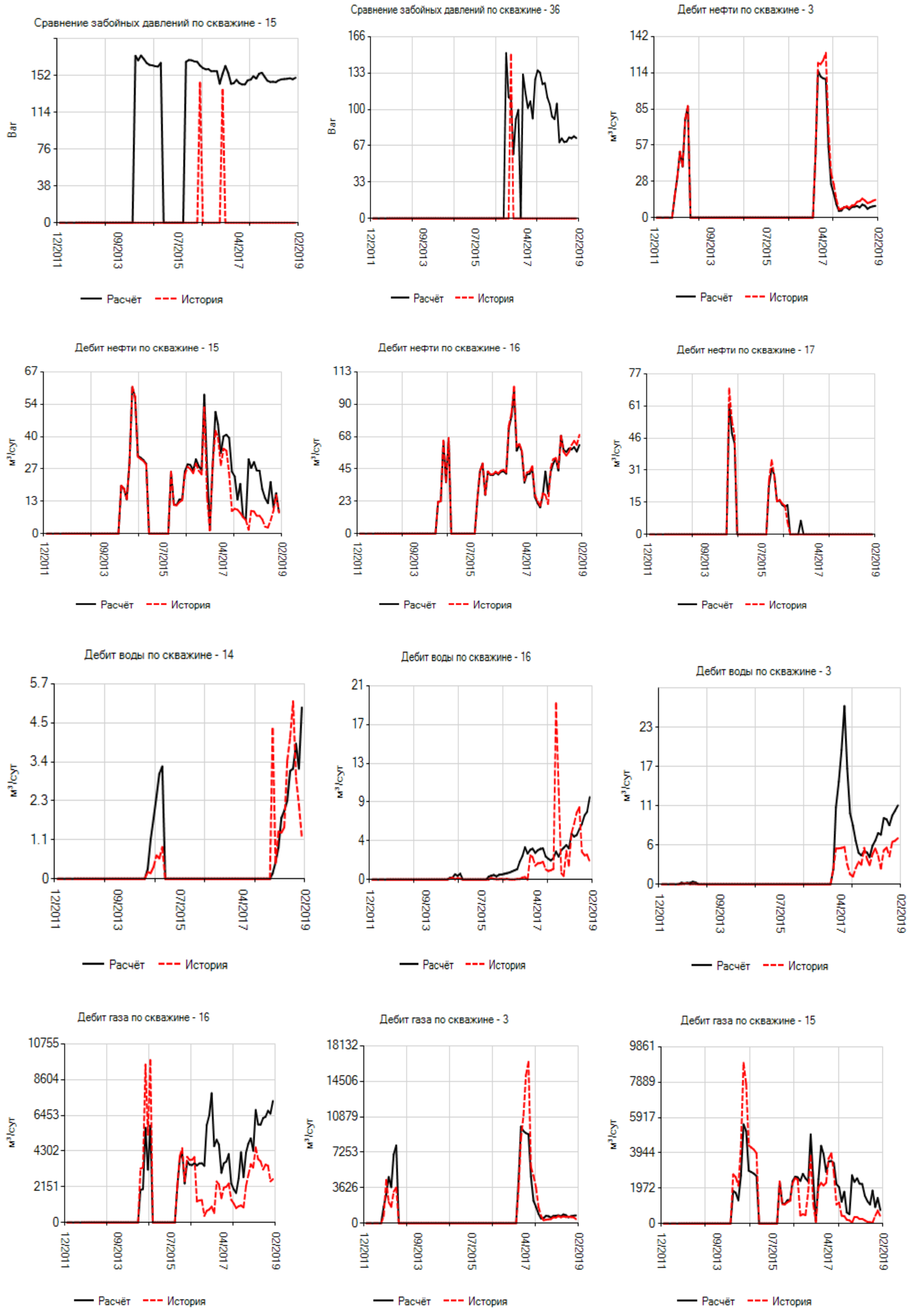


Fig.2.19 – The reservoir pressure dynamics along the horizons of Object 2Adaptation of well performance indicators for the period of history

In general, the obtained model satisfactorily reproduces the historical data on fluid sampling and reservoir pressure dynamics not only for the objects of development in general, but also for wells.

On the basis of the obtained adaptation of calculations for the period of history 3 variants of further development were calculated and the most efficient project from the point of view of economy was chosen. The following table summarizes the main technical and economic indicators of field development options.

Table 6. Technical and economic indicators of field development

Technological indicators	**Option 1**	**Option 2**	**Option 3**
Accumulated oil production since the beginning of development, thousand tons	816	1,111	1,106
Crude oil recovery factor (CEP), %.	27.3	37.1	37.0
Oil gas production since the beginning of development, mln m^3	106	134	137
Dissolved gas recovery factor (DGR), %.			
Accumulated water injection, thousand tons	8,994	28,943	20,003
Accumulated compensation of withdrawals, %	45	65	78
Drilling of production wells, total	0	4	24
Transfers of wells between facilities, total	0	7	6
Integral economic indicators.	**Option 1**	**Option 2**	**Option 3**
Last profitable year	2038	2040	2035
Net sales revenue, thous.	165,100	264,644	253,872
Capital expenditures, thous.	0	3,416	20,581
Operating expenses, thous.	34,304	59,391	53,452
Taxes and payments to the budget, thousand USD	64,146	103,476	98,391
Income tax, thousand USD	11,407	17,749	14,366
Excess profits tax, thous.	0	0	0
Accumulated cash flow, thous.	55,244	80,612	67,082
Contractor's NPO (10%), thousand USD	35,084	48,824	41,454
NRR, %.	n/a	n/a	n/a
Payback period, year	2019	2019	2019

In terms of technical and economic evaluation, Option 2 is the most advantageous option for both the Contractor and the Republic.

According to the indicators of Option 2 of the development and as of the date of 02.01.2019 studies, the oil reserves of field X are approved in the following quantities and categories:

- B - 929 thousand tons of geological, including recoverable 346 thousand tons;
- C1 - 2064 thousand tons of geological, including recoverable 741 thousand tons;
- B+C1 - 2993 thousand tons are geological, including 1,087 thousand tons recoverable;
- C2 - 315 thousand tons of geological, including 92 thousand tons extracted.

Classification of the “X” field project using UNFC

Review of socio-economic information including social and environmental (E-axis)

The results of the prospecting phase of the 3D Modification Field Seismic Design (90 km2) and the Adjacent Exploration Project have not been able to determine the economic viability of oil extraction due to lack of information.

Therefore, the economic feasibility of oil production and sales at the exploration stage can be classified under the UNFC-2009 subcategory E3.2.

Aims, objectives and scope of work performed under the Trial Field Development Project are given in Section 4, paragraph 4.3 of this report. The results of the trial operation of field “X” allowed us to assume profitable production and sales of oil in the foreseeable future.

The economic viability of oil production and sales under the Trial Operation Project can be classified under UNFC-2009 under category E.2.

Commercial production of oil at field “X” is carried out on the basis of 2 projects “Technological scheme of “X” field development” and “Analysis of field “X” development”. The scope of work performed, and the results obtained are presented in sections of this report.

As of 02.01.2019, the economic feasibility of oil production and sales during the period of commercial development can be classified under the UNFC-2009 into categories and subcategories E1.1 and E2.

Review of project feasibility information (F-axis)

The works carried out in 2009-2010 under the Technical design for field seismic surveys in 3D modification (90 km2) at the search stage under the UNFC-2009 in terms of project feasibility (F-axis) belong to the F3 category. In order to confirm the presence of a deposit (or deposits) on the identified prospective structures it was necessary to conduct additional research and prospecting and exploration work.

As noted, the Exploration Project has resulted in the discovery of the “X” field. Additional 3D seismic work (175 km2) has been carried out, exploration wells 3 and 5 have been drilled, and the first oil spouting flow has been obtained. Following the implementation of the Prospecting Works Project, the field has not been further explored and additional studies were required to justify commercial production and therefore, under the UNFC-2009, the feasibility of the project (F-axis) corresponds to the F2.2 subcategory.

The Trial Production Project of “X” Field was completed in 2013-2014. Field “X” was at the exploration stage in terms of its degree of exploration. The purpose of the Trial Operation was to evaluate the discovered oil deposits, prepare them for commercial development and further exploration of promising areas. The tasks set out in the Trial Operation Project have been implemented. The necessary amount of information was obtained, which allowed to conduct the first reserves calculation with a feasibility study of oil recovery coefficients (FS EOR). Calculations of the Feasibility Study of the IEP have confirmed the necessity of drawing up the Technological scheme of development and implementation of the project in the foreseeable future.

Based on the above, according to the UNFC-2009 classification, the feasibility of the project (F-axis) corresponds to subcategory F2.1.

As of 02.01.2019, the majority of the field area was drilled by production wells, and commercial oil production was in progress in accordance with the approved project documents (industrial development stages are described above). In view of the above, the feasibility of the UNFC-2009 project should be classified under subcategories F1.1 and F1.2.

Review of geological knowledge / confidence in estimates (G-axis)

The 3D (90 km2) field seismic surveys in 2009 revealed promising structures. The estimation of the resources of the structures as potential deposits was based on indirect data. Such data, which is largely similar to that of the region, is characterized by a significant range of uncertainty and risk of non-confirmation. Therefore, according to UNFC-2009, geological exploration and confidence in estimates (G-axis) corresponds to G4 category.

Additional 3D seismic work and drilling of wells under the 2011 Prospecting Project resulted in the discovery of field X. Types and volumes of work are provided in the report.

In 2013, oil reserves in industrial category C1 amounted to 1272 thousand tons of geological and 383 thousand tons of recoverable oil and estimated category C2 reserves of 3870 thousand tons of geological and 1161 thousand tons of recoverable oil.

The operational calculation of reserves performed without a feasibility study of the oil recovery factor allows to classify the geological study and confidence in the estimates as G3 under the UNFC-2009, as the recoverable quantities are estimated with a low degree of reliability.

The purpose of the trial operation is to clarify the initial geological and field data for calculating reserves and drawing up the Technological Development Scheme. Tasks solved during trial operation are presented above. The reserves estimation report based on the results of trial operation became the basis for drawing up the Technological scheme of “X” field development.

In 2014, oil reserves in industrial category C1 amounted to 3460 thousand tons of geological and 1257 thousand tons of recoverable oil and in appraisal category C2 – 1508 thousand tons of geological and 404 thousand tons of recoverable oil.

The results of the Trial Operation Project allow to classify the geological study and confidence in the estimates under the UNFC-2009 as G2.

Commencement of commercial development of the field made it possible to conduct additional research on newly drilled wells and to deepen the study of oil deposits. The scope of work on the Technological Scheme of development is described earlier in the report.

In 2019, recalculation of oil reserves at X field as of 02.01.2019 was performed, where reserves and categories were clarified. As of 02.01.2019, oil reserves at the “X” field were, by category:

- B+C1 – 2993 thousand tons of geological, including recoverable – 1087 thousand tons;
- C2 – 316 thousand tons of geological, including recoverable – 92 thousand tons.

As of 02.01.2019, the geological exploration and confidence in the estimates under the UNFC-2009 at field “X” can be attributed to the G1+2 categories.

Classification of the project using UNFC scheme

Based on the above review of project, against the three axes of the UNFC-2009 oil reserves at “X” field (as of 02.01.2019) can be classified as follows: E1.1, E2, F1.1, F1.2, G1+2.

The oil reserves of industrial categories B+C1 correspond to the categories and subcategories E1.1, F1.1, G1 according to UNFC-2009. Oil reserves of the estimated categories C2 correspond to the categories and subcategories E2, F1.2, G2 according to UNFC-2009.

ALIGNMENT TO SUSTAINABLE DEVELOPMENT GOALS IMPLEMENTATION

National approaches

The Sustainable Development Goals (SDGs) fully coincide with the priorities and objectives of Kazakhstan. For Kazakhstan, the implementation of the SDG methodology and indicators provides the opportunity for systematic adaptation of strategic planning and monitoring to world standards, taking into account the harmony of Kazakhstan's policy documents, primarily the “Strategy-2050” and the resulting industry programs, to global development goals.

The mission of international experts from UNDP in order to quickly comprehensively assess Kazakhstan’s readiness for the implementation and monitoring of the SDGs, held in November 2016, revealed a rather high degree of inclusion of the SDG targets in national and sectoral plans - 61% of the SDG targets are already covered by national strategic documents.

Kazakhstan is part of the High-level Group for Partnership, Coordination and Capacity-building for the provision of statistics for the 2030 Agenda for Sustainable Development (HLG), composed of Member States, including regional and international UN agencies, as observers.

The first national technical meeting on SDG statistics was held in Kazakhstan with the participation of representatives of all government bodies, NGOs, research organizations, various trade unions and associations, national companies, UN agencies and international experts in various sectors. The main goal of the meeting was to assess the readiness of the national statistical system to produce global indicators for monitoring the SDGs, as well as to identify additional national indicators that would be relevant for Kazakhstan. A specially created interdepartmental Working Group on the implementation of indicators for monitoring the SDGs is developing a system of indicators that includes both global and national indicators, taking into account the priorities of Kazakhstan.

In general, the systematic implementation of the SDGs in Kazakhstan will undoubtedly give a positive multiplier effect, in particular: facilitating the process of becoming one of the 30 most competitive states in the world by achieving the indicators of the Organization for Economic Cooperation and Development (OECD) through the implementation of the SDGs, and; giving an additional impetus to processes such as enhancing human potential, attracting foreign technologies and experience, advanced training in the field of processing large data arrays (Big Data). Implementation of SDGs is becoming one of the factors of investment attractiveness for large international corporations, for which the model of socially responsible business and its relevance to the SDGs is an important component of their image.

Industry approaches

The economy of Kazakhstan is heavily dependent on mining activities. Attracting private investment in subsoil use is one of the priority tasks in the extractive industries. The objective of economic growth can be solved by sustainable development programs. For example, Kazakhstan’s subsoil users working in the fields of solid minerals, oil and gas pay to the oblast budget, in addition to tax payments, also targeted payments for arranging infrastructure, building and repairing schools and preschool institutions.

During the development of new oil and gas fields in the Kyzylorda region of Kazakhstan, thousands of new jobs were created. Many residents of the region working in oil and gas fields received special technical education at the expense of subsoil users. Subsurface user companies are constantly involved in projects that provide social support to the population.

CONCLUSION ON UNFC CLASSIFICATION OF ENERGY AND MINERAL PROJECTS IN KAZAKHSTAN

Advantages of UNFC at national and project-level decision making

An important task of the development of the mineral resource complex of Kazakhstan is to increase the resource base of solid minerals and hydrocarbons. UNFC-2009 can create the most favorable conditions for investors.

The special significance of UNFC-2009 is that this classification is based on three fundamental criteria – the economic and social viability of the project (E), the status and validity of the field development project (F) and geological exploration (G) – using numerical and linguistic independent coding schemes. It is noteworthy that unlike other (numerous) classification systems, the UNFC is applicable to any emissions of mineral raw materials, as well as to renewable energy sources and anthropogenic resources.

This is due to the fact that the UNFC takes into account the maximum number of factors when evaluating any objects.

Given that in the modern world the number of multi-resource companies operating in different countries is growing, the need for a unified classification system is obvious. UNFC-2009 is the first version of the Classification at a level where general principles are established, and which can serve as the basis for international research in the field of energy and minerals.

UNFC can be a tool for global accounting of mineral resources, which ensures the comparability and compatibility of various classifications used today in Kazakhstan and other countries. Of course, it will be advisable to use the UNFC at the level of state planning and subsoil management. In this case, taking into account national characteristics, it is necessary to take into account international experience in integrating the national system in the UNFC, in particular the experience of the Russian Federation, which was the first to implement the integration process in the UNFC, while they did not blindly copy and implement this system, but adopted the so-called transitional document taking into account its specifics and the internal unified system for estimating reserves already existing there.

Constraints in the use of UNFC

Limitations in the use of the UNFC include the need for significant adjustment of national legislation both in Kazakhstan and in other countries. And this process, as you know, always happens very slowly.

A difficult question is the responsibility of the Competent Person for the results of his evaluations. There are unclear questions about the methods of verification of reliability, as well as the system of responsibility for inaccurate assessments of objects by Competent persons.

The legal provisions existing in Kazakhstan today, enshrined in the Constitution of the Republic of Kazakhstan, speak of the ownership of minerals, described as “the property of the people”. Therefore, for the implementation of the UNFC, it is also necessary to develop mechanisms of state control in this area.

In this case, it is necessary to take into account precisely the national interests of our country, first of all, to increase environmental and environmental requirements, as well as the norms of social responsibility of subsoil users.

Also, when introducing and unifying systems, it is desirable to establish the priorities of national legislation over the proposed international legal provisions in this area.

Given the lengthy work of state bodies in the field of improving legislation and creating a base of by-laws, the introduction of a new system may take a long period of time.

Benefits in using UNFC for alignment to SDGs

The advantages of using the UNFC to estimate mineral reserves include the possibility of using it to increase the investment attractiveness of our country in the eyes of the world community within the framework of common reporting standards.

It should also be noted that using the UNFC reporting system is able to ensure the transfer of stocks and resources from one system to another, for example, from the SCPC system to the SPE PRMS system.

The UNFC can also serve as the basis for harmonizing national valuation systems and national regulatory systems with international systems and help integrate the national system in the international market. Moreover, reporting on the basis of the principles of socio-economic feasibility will ensure the construction of rational consumption and production models.

Improving the level of scientific and technological development is achievable by introducing the best world experience in this area through the introduction and integration of the UNFC.

Also, in the context of globalization, the UNFC can serve as a system for harmonizing the global exchange of information, since, being an integral set of common rules, it will facilitate the paths of global communication, will lead to the revitalization of global partnership mechanisms for sustainable development.

General principles and reporting mechanisms will help to significantly increase the efficiency of development of the sphere of mining by increasing investment attractiveness.

All this should lead to a significant development of the exploration and mining sectors, and this, in turn, to the sustainable development of the country's economy, increase the level of employment and welfare of the population.

Thus, the benefits of using UNFCs are fully consistent with the Sustainable Development Goals. and will help ensure that four of the seventeen SDGs are achieved: on promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all; on creating a solid infrastructure, promoting inclusive and sustainable industrialization and innovation; on providing rational patterns of consumption and production; on strengthening the means to achieve sustainable development and revitalizing global partnership mechanisms for sustainable development.

REFERENCES

1. Reservoir Evaluation Services LLP "Report on Operational Calculation of Oil and Gas Reserves at Field X" as of 15.05.2013.
2. Smart Engineering LLP Project of prospecting and exploration works in the growing areas of KAZPETROL GROUP LLP. Approved by the Central Committee of the Republic of Kazakhstan (Minutes No. 172 of 13.06.2011)
3. Timal Consulting Group LLP "Recalculation of oil reserves, dissolved gas and associated components of the X field of the Kyzylorda region of the RK as of 01.07.2014
4. Timal Consulting Group LLP "Increase and specification of oil reserves, dissolved gas and associated components of the “X” field of the Kyzylorda region of the RK as of 05.01.2017
5. Report on the results of detailed exploration with the calculation of reserves of the N field in the East Kazakhstan region. 1970.
6. Report on the recalculation of reserves of the N field in the East Kazakhstan region as of 01.01.2019.
7. Bylinkin G.P., Guzhikov P.A. "Dependence of formation oil properties on the type of degassing." Moscow. Oil and Gas Geology, No.3, 2008
8. Daukeyev S.J., Uzhkenov B.S., Votsalevsky E.S., et al. "Deep structure and mineral resources of Kazakhstan. Oil and Gas", Volume III. Almaty 2002
9. Amix J., Bass D., Whiting R. "Oil reservoir physics." 1962
10. Sh.K. Himatudinov, A.I. Shirkovsky "Oil reservoir physics." Moscow "Nedra" 1982.
11. Wendelstein B.Y. et al. "Methodical recommendations for determining the estimated parameters of oil and gas deposits based on the materials of geophysical studies of wells with the use of the results of core analysis, sampling and testing of productive formations. Kalinin. 1990.
12. Dakhnov V.N. "Geophysical methods of determination of reservoir properties and oil and gas saturation of rocks" 1975
13. "Technical instruction for geophysical survey in wells". M.: Nedra, 1985.
14. Kovalev A.G., Kuznetsov V.V., Kuznetsov A.M., Frolov A.I. "Experimental determination of oil displacement factor by water on samples of productive deposits". Proceedings of KazNIPIneft, issue 7, 1980.
15. Petersilje V.I. "Methodical recommendations on calculation of oil and gas reserves by volume method", Moscow-Tver, 2003
16. All-Union Research and Design Institute of Geophysical Methods of Investigation, Testing and Control of Oil and Gas Exploration Wells (VNIGIK) "Determination of capacitive properties and lithology of rocks in incisions."
17. Dakhnov V.N. "Geophysical methods for determination of reservoir properties and oil saturation of rocks", Moscow, "Subsoil", 1985
18. Latyshova M.G., Wendelstein B.Y., Tuzov V.P. "Processing and Interpretation of Well Geophysical Survey Materials", Moscow. "Nedra, 1990.
19. M.G. Latyshova "Practical Guide to Interpreting Geophysical Well Diagrams"
20. "Classification of reserves of prospective and forecast oil and natural hydrocarbon gas resources.", Almaty, 1997.
21. "Instruction on execution of reports on geological study of subsoil of the RK...", Kokshetau, 2004.
22. "Requirements for the content and volume of geological and geophysical materials for calculation of oil, gas, condensate and associated components reserves submitted for state expertise. 2007г.

23. Kartoatmodjo, Trijana, Schmidt. "New Correlations for Crude Oil Physical Properties", SPE 23556
24. J. Velarde, T.A. Blasingame, W.D. McCain “Correlation of Black Oil Properties at Pressures below Bubble point Pressure—A New Approach”, JCPT, Special Edition, 1999, Vol. 38, No. 13
25. S.A. Khan, M.A. Al-Marhoun, S.O. Duffuaa and S.A. Abu-Khamsin “Viscosity Correlations for Saudi Arabian Crude Oils”, SPE 15720. Fifth SPE Middle East Oil Show, Manama, Bahrain, 1987