GEOLOGICAL EXPEDIENCY FOR INCLUSION OF THE "EASY" METHODS COMPLEX INTO THE GEOLOGICAL EXPLORATION FOR OIL AND GAS

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Abstract. The article presents a triad of "easy" field methods for geological exploration of subsoil areas in the exploration and prospecting-evaluation stages of geological exploration for oil and gas. The triad of field surveys includes the following sequentially performed works: 1) remote sensing and interpretation of space images of the Earth, 2) areal helium survey (He-survey), and 3) areal microseismic survey (MC-survey) as a single triad of field surveys. Based on the results of these surveys, areal and quantitative parameters of the anomalies of registered useful signals are estimated, which are predictably associated with potentially oil and gas promising zones on the licensed area where the types and volumes of field seismic operations, and then deep exploratory drilling can be located.

Expert and automated methods based on the data of triad of field surveys can be used to assess the prospects of oil and gas potential and localized resources of each subsoil area. Their economic attractiveness is assessed taking into account geological and economic risks. The economic assessment of the licensed area uses the generally accepted indicators in the oil and gas industry for the stages of geological exploration.

In addition, the conduct of the described work by the triad of field surveys at the pre-licensing stage can be carried out in the winter, and they are appropriate to be carried out on the initiative of the state authorities on subsoil use: a complete cycle of analysis of geological and economic attractiveness will help attract new subsoil users to participate in auctions and increase the cost of initial payments at the auction.

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The modern innovation level in the oil and gas industry in Russia, as in all developed countries, presupposes the use of new technologies that are most important for geological exploration of unexplored or almost unexplored licensed areas in order to prospect and evaluate new oil and gas fields.

We present already repeatedly and successfully used in the practice "easy" field methods, such as remote acquisition and interpretation of space images of the Earth (Earth remote sensing – ERS), areal helium survey (He-survey) and areal microseismic survey (MS-survey), as a single triad of field surveys (TFS). Sequential application of the TFS methods is the most effective in the search, prospecting and evaluation stages of subsoil plots study in conditions of complete or partial absence of geological information necessary for preliminary geological ideas about the selection and placement of species, volumes and duration of costly seismic surveys of MOGT- 2D (3D) and then – deep search and prospecting drilling.

TFS of "easy" methods for preliminary geological studies of subsoil plots in order to search for oil and gas fields, includes the following sequence of surveys.

1. Selection and interpretation of space images of the Earth's surface for the subsoil plot of the required resolution in order to obtain the main geological/tectonic and structural aspects of the structure of the subsoil as a whole, which will then be used for a more conscious design of the work area of the two subsequent TFS surveys; At this stage, the largest costs are required for the purchase of space images of the required resolution, covering the entire area of the license area.

2. Implementation of He-survey using mobile high-precision instruments measuring the concentration of helium on the surface; the survey area is selected taking into account remote sensing data for some areas or (rarely) in the whole licensed area, and all points of field research form a regular network, the results of field studies on the resulting network are then interpreted and a set of special maps where anomalous helium

concentrations are indicated, predictably associated with potentially future oil and gas promising zones (in the licensed area), on which the volumes of the next MS survey will be posted.

3. Implementation of MS-survey with the use of self-contained, high-precision instruments for measuring natural quantities of microseisms on the surface; the survey area is selected taking into account remote sensing data and He survey for some areas or (very rarely) in the whole licensed area, and all points of field research form a regular network, the results of field studies on the points of the received network are then interpreted and a set of special maps received on which the anomalous magnitudes of microseisms in the infralow frequency range are indicated, which are predictably associated with potentially oil and gas containing promising zones (in the licensed area), where types and amounts of seismic data acquisition, and then deep drilling will be located.

At present, the full set of TFS methods is not applied; as a rule, one of the specified TFS methods is used, or other methods are applied.

However, Russian enterprises that are consumers of TFS information and their specialists have created their own hardware complexes, solved the problems of the technique of interpreting remote and field materials of surveys, implemented oil and gas work in practice, developed the scientific and methodological foundations of methods and their own software products, and most importantly – industries are needed that practically demonstrate high adaptability to specific areas of field research. At the same time, the results of these domestic developments are in demand among consumers-subsoil users, and on the part of sectoral state bodies this is not noted.

This position is particularly evident in the solution of the urgent geological problems of the oil and gas industry on the vast and poorly studied territory of Eastern Siberia (the Irkutsk Region, the Krasnoyarsk Territory, the Republic of Sakha (Yakutia), where the efficiency of prospecting, appraisal and exploration for oil and gas is poor. Many unexplored or poorly studied license areas that were put up by the government for auctions in 2008-2016 did not find their owners. The main reason for this is not financial crisis, but the absence of a geological-economic attractiveness of such sites for the consumer due to the provision of low-quality source products. The authors believe that in the case of the implementation at the initiative of the government in each of the completely unexplored parts of the subsoil put up for auction, a set of TFS methods, it would have risen the starting value of the subsoil plot and its geological attractiveness for the potential subsoil user.

Negative consequences from the non-use of TFS methods can be formulated as follows:

• Rates of development of new subsoil plots in order to search for and explore new oil and gas fields are low;

• Geological services of the most subsoil users who previously obtained search licenses for 5-7 years are not in a position to determine the most promising areas of work;

• Costs incurred for geological exploration work are ineffective (in the situation when the subsoil user does not have starting geological ideas);

• Actual areas of field seismic surveys are excessively increased, extended by 2-3 and more years, during one field season, operative partial sealing of the network of seismic profiles on identified prospective objects is impossible, since the subsoil user has already paid for a certain number of linear kilometers;

• As a result, inefficient volumes of deep prospecting drilling are realized, which is why investors quickly lose interest, reduce financing, or even stop design work in the plots.

In general, it can be noted that the government and subsoil users underestimate their benefits in the matter of consistent and timely exploration of subsoil (for example, in the zone of the Trans-Russian ESPO oil pipeline).

The implementation of innovative methods of hydrocarbon exploration developed to date could change this trend with a substantially low cost. For example, satellite images are still purchased and have long been the main database provided by subsoil users to regulatory authorities for assessing the environmental status of the surface of the license area at the beginning of work after obtaining a license.

From the point of relevance, the problem of increasing the efficiency of prospecting for oil and gas should not be questioned, since the complex of TFS methods makes it possible to predict structural traps and their oil and gas content, to carry out a comprehensive interpretation of the data, to assess the safety of hydrocarbon deposits, to identify areas of increased fracturing of promising oil and gas traps.

The above-mentioned difficulties arising from the development of the energy potential in the ESPO region determine the task of resource and value evaluation of the unexamined and poorly studied territories of the country. The solution to this problem may be related to the planning of geological exploration based on the TFS methods that provide prediction of hydrocarbon traps and the assessment of their oil and gas content in unexplored or poorly studied licensed areas quickly and economically, which then allows us to concentrate the design of seismic surveys on the most prospective plot of the existing licensed areas and more qualitatively prepare promising objects for deep prospecting drilling (Trofimov, Shuvaeva, 2010).

On the other hand, future auctions on granting the

right to use unexplored or poorly studied subsoil plots, for example, in the regions of Eastern Siberia and the ESPO, may arouse the interest of potential subsoil users, primarily in providing the initial integrated information on the geological and economic attractiveness of proposed subsoil plots. The geological gap in the complex of data submitted to the subsoil user can be successfully filled with the use of TFS methods, which allow performing the primary geological and economic assessment of the practical attractiveness of the subsoil plots put up for auctions.

The effectiveness of using space information from remote sensing can also be judged by the discovery of a new gas field in Yakutia, which was discovered due to the processing of space information in combination with geochemical methods.

As a rule, the package of documents for the subsoil areas submitted to the tender contains a limited amount of geological-geophysical data, often obtained many years ago, including the evaluation of non-localized resources, which does not allow the subsoil user to conduct reasonable planning of the field seismic survey profiles. In addition, in Eastern Siberia, the initial volume of information is extremely limited and does not allow to conduct an objective assessment of the oil and gas prospects, and therefore, to estimate the forecasted profitability of the licensed area development.

When using the TFS methods, it is possible to predict the structural traps in an expert and automated way, to assess the reliability of their reflection in the sedimentary cover, to assess the prospects for oil and gas potential and the forecasted localized resources of each structure, and ultimately give a conclusion on the profitability of developing license areas.

Thus, the subsoil user receives a final estimate of the geological and economic attractiveness of the area under study, taking into account the corresponding risks, which allows him, within the framework of the license agreement, to optimize the location of seismic profiles oriented not so much to identifying the search facilities as to their preparation for deep drilling.

An example of the application of the ERS method to one of the sections located within the Nepa-Botuobin syneclise near Mirny is shown in Figure 1.

In the last century six local structures were identified here, one of which was drilled with a negative result. According to the results of a structural analysis of remote materials, eighteen object were predicted on this site, four of which corresponded to previously identified uplifts. Expert automated methods were used to evaluate the prospects of oil and gas potential and localized resources. Of the eighteen predicted structures, twelve seem promising in oil and gas; among them four are priority objects (Figure 1).

As a result of the performed works, the subsoil

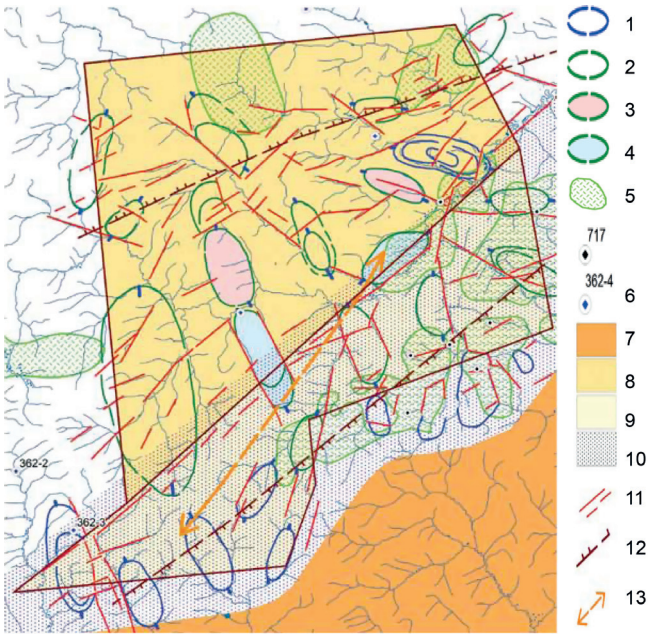

Fig. 1. The scheme for forecasting oil and gas content of a poorly studied licensed area on the Nepa-Botuobin anteclise (Eastern Siberia). 1 – Structures predicted from space data, 2 – Structures predicted from space data and reflected in geophysical materials, 3 – Structures most promising according to space data, 4 – Structures that are less promising according to space data, 5 – Uplifts identified by seismic survey, 6 – Empty wells, 7 – Oil and gas accumulation zone, 8 – More prospective area, 9 – Less prospective area, 10 – Non-productive well zone associated with deteriorated reservoir properties, 11 – Dislocations predicted by seismic data, 12 – Estimated wedging zone of basal layers in the Nepa regional horizon, 13 – axial inflexion zone, separating Nepa and Mirnensky swells

user has the opportunity to reasonably plan seismic exploration profiles and further drilling.

The method of helium photography (He-survey) is based on the fact that all hydrocarbon deposits have their surface mapping in the form of anomalous helium content in the near-surface layer. Helium comes from the depths in the only way – by migration to the Earth's surface along tectonic disturbances, fracturing zones and areas of increased permeability, accumulating in reservoirs of hydrocarbon deposits. For the prediction of oil and gas deposits from the anomalies of helium concentration, the fact that solubility of helium in oil is more extensive than in water is fundamental; the presence of portable high-precision field equipment makes it possible to record anomalous helium concentrations relative to the background contents during the investigation at the points of the regular observation network (Presentation of LLC Actual Geology, St. Petersburg, 2015). An example of field work in He-surveys is shown in Fig. 2-4 on the prospective subsoil section of Eastern Siberia, on which a prospecting well gave the inflow of gas.

An example of the method application for studying resonance effects of hydrocarbon deposits during their low-frequency seismic sounding (MS-survey)

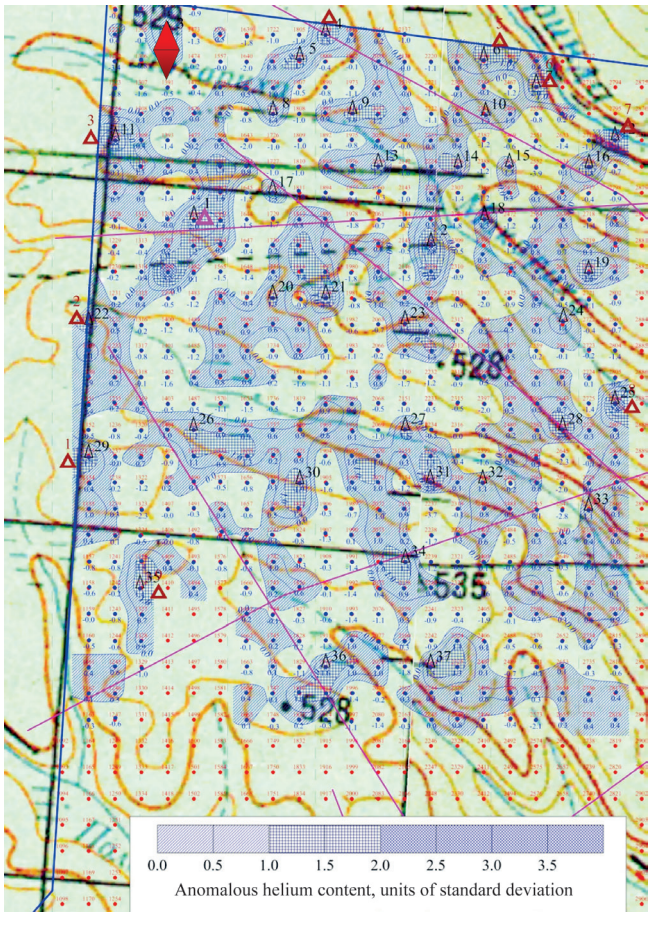

Fig. 2. Topographic base fragment of the helium survey site with its results, ◆ – a drilled search well that gave the gas inflow from the Yaraktinskian horizon

(Presentation of JSC Gradient, Kazan, 2016) is shown in Fig. 5. In this area, an MS survey was conducted, according to the results of which a productive well was drilled in the western anomaly of the resonant amplitude of the useful signal from the oil deposit (point 71 of the studies), which gave the inflow of oil.

The physical foundations of TFS methods and the results of their introduction into geological exploration

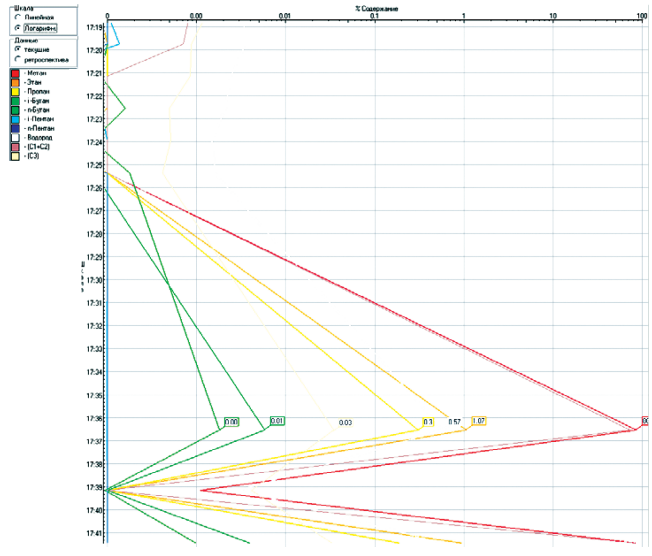

Fig. 3. The component gas composition of the Yaraktinskian horizon from the prospecting well, obtained on a field chromatograph (average for 3 samples): methane – 83-86%, ethane – 1.1%, propane – 0.3%

for oil and gas are set out in more details in field work reports done by Trofimov D.M., Shuvaeva M.K.. (LLC Resenoil, Korolev); Chistyakova K.V., Naumov K.K. (LLC Actual geology, St.-Petersburg – the first and unique company in Russia which has developed, has patented and has introduced in exploration practice a method of helium survey); Shabalin N.Ya, Feofilov S.A. (JSC Gradient, Kazan) and on the websites of these organizations, etc.

In conclusion, the authors note that the use of the triad of "easy" field survey methods (TFS) is the least costly work for the purpose of operational geological attractiveness of non-or poorly studied subsoil plots. If necessary, TFS methods can be supplemented with conventional methods of geochemical surveys in the search for oil and gas fields.

Expert automated methods based on the data of TFS

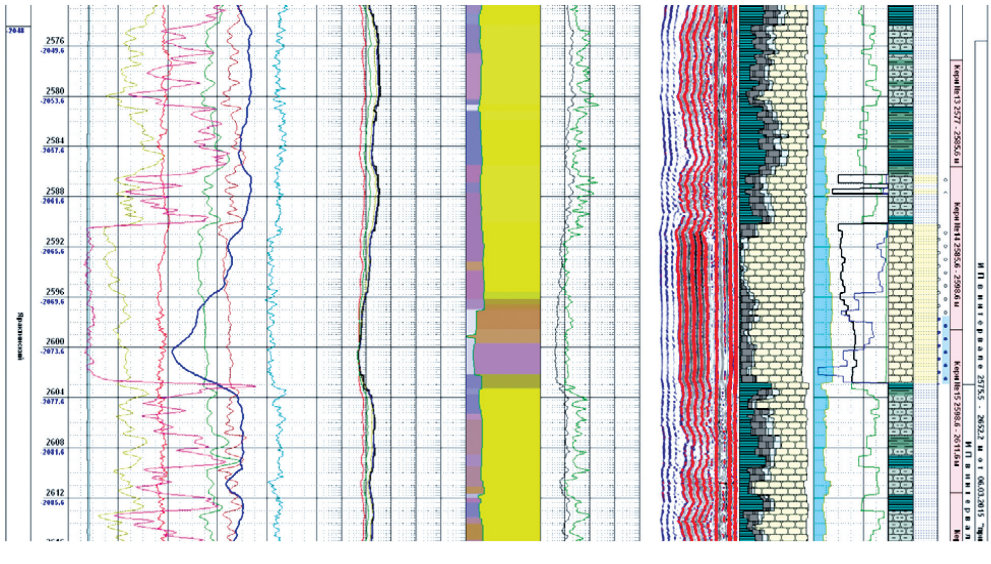

Fig. 4. According to the logging, the Yaraktinskian horizon of the search well in the depth interval 2590-2596 m is gas-saturated

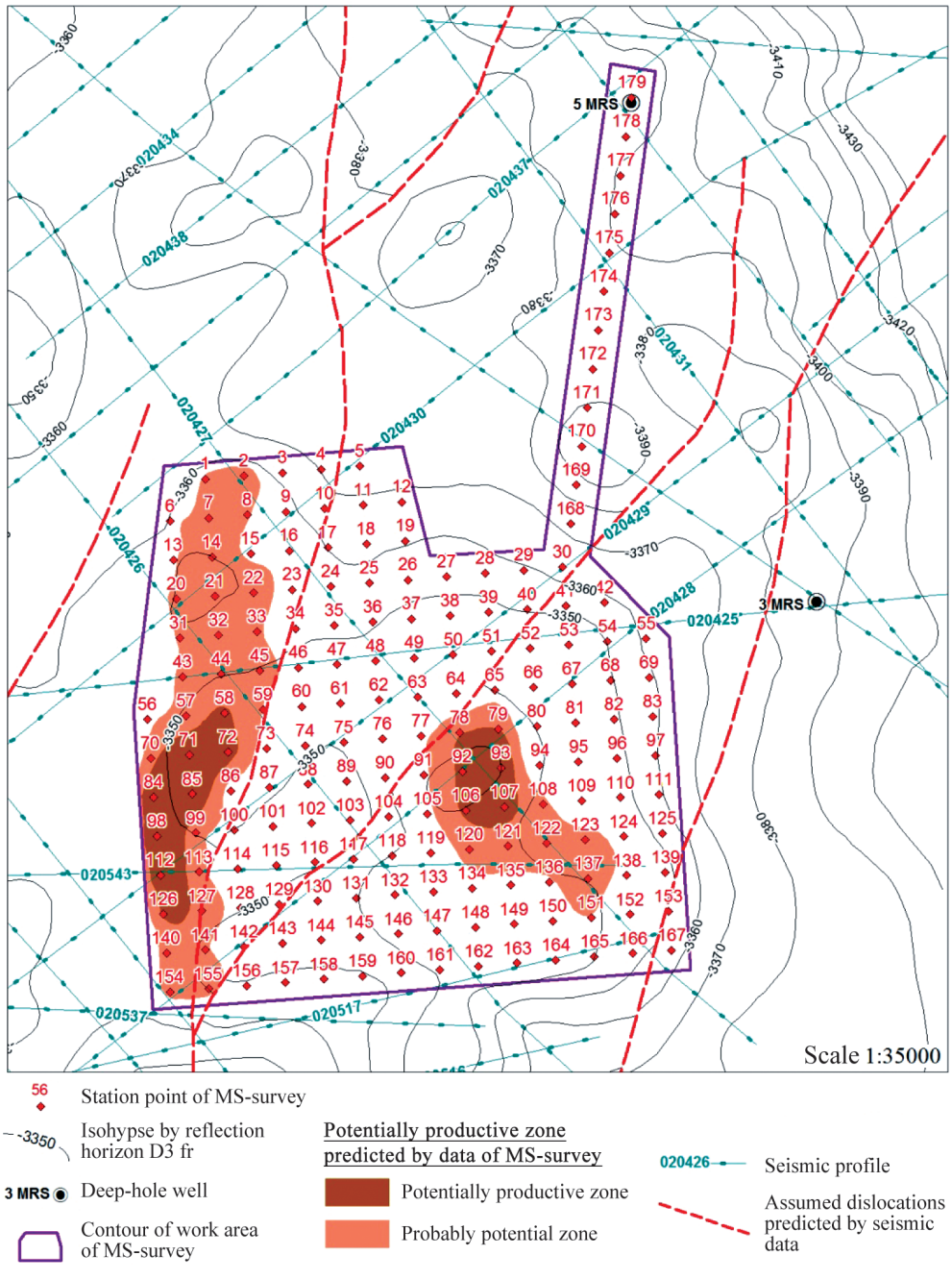

Fig. 5. A productive well No. 32 was drilled near the point No. 71 of the MS field survey

methods can be used to assess the prospects of oil and gas bearing and localized resources of each subsoil plot; their economic attractiveness is assessed taking into account geological and economic risks; the economic assessment of the licensed area is based on the generally accepted oil and gas industry indicators and parameters for the exploration stages

In addition, the conduct of the described work by the TFS methods at the pre-licensing stage can be carried out in winter, and it is appropriate to carry out them at the initiative of state bodies for subsoil use: the completed analysis cycle of geological and economic attractiveness will help attract new subsoil users to participate in auctions and increase the cost of starting payments on the auction.

References

Trofimov D.M., Shuvaeva M.K. Assessment of the reliability of predicted localized hydrocarbon resources and geological risks of poorly studied regions of Eastern Siberia in the ESPO region. V sb.: *Prognozirovanie struktur chekhla yuga Vostochnoi Sibiri kosmicheskimi metodami i otsenka ikh prognoznykh lokalizovannykh resursov v usloviyakh slaboi geologicheskoi izuchennosti* [Forecasting the structures of the cover of the south of Eastern Siberia by cosmic methods and assessment of predicted localized hydrocarbon resources under conditions of poor geological study: Coll. papers.]. Korolev: GEOS. 2010. 98 p.

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