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Recommendations for wells drilling in the unfavorable structural-tectonic conditions

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SUMMARY

Prospects for further exploration and exploitation of hydrocarbon fields with practically exhausted potential of structural-tectonic traps have been analyzed. Appropriate approaches are proposed to identify new traps in such fields or areas. They are based on a comprehensive study of horizons promising for hydrocarbons. Such study involves the analysis of regional oil and gas horizons, the attraction of additional geological and geophysical information from adjacent fields or areas and the use of direct hydrocarbon indicators. Studying the behavior of regional productive horizons within the license area helps to identify common factors for the presence of hydrocarbons. Geological and geophysical data of adjacent areas allow us to extrapolate these data and to obtain the prerequisites for the detection of perspective fragments of structural-tectonic traps. At the same time, the use of direct hydrocarbon indicators is the most reliable way to detect hydrocarbon traps of any type. Together with the possibility of detecting oil and gas traps, the use of direct indicator technologies allows us to estimate the amount of hydrocarbon resources discovered. The above approaches have revealed areas promising for the presence of hydrocarbons in the sediments of the Moscow stage of middle carbon. It is has been recommended the well drilling for sediments of the regional production complex M-7.

Introduction

Modern oil and gas exploration in Ukraine faces the challenge of identifying new hydrocarbon traps. Under the traditional concept of exploration, the detection of structural traps is considered the most reliable way to ensure the success of oil and gas drilling. At the same time, the number of conventional structural hydrocarbon traps in the world is declining rapidly. A similar situation regarding the possibility of detecting oil and gas traps is observed in Ukraine. Conditioning structural traps are considered to have a reliable isolation, sufficient reliability of the absence of permeability of faults, economically feasible sizes and so on. An analysis of the results of modern exploration in Ukraine reveals a relatively small percentage of new conventional hydrocarbon structural traps. Therefore, the problem of exploration of not only structural but also all possible types of hydrocarbon traps is becoming more urgent. The decrease in the value of the structural factor means the need to use direct hydrocarbon indicators and to predict the porosity of rocks to evaluate the economic feasibility of developing lithological traps of oil and gas.

Successful exploration of non-structural traps also addresses the common problem that licensees for hydrocarbon exploration and production often encounter. It is necessary to make a decision to continue or end the exploration of the site in case of drilling of all detected structural traps. The complexity of making this decision depends on the size of the portion of the license area where no structural traps of hydrocarbons have been detected.

This paper examines a typical situation where a large portion of a licensed area is devoid of conditioned or reliable structural traps. Other approaches have been used to identify industrial hydrocarbon reserves in this part of the license area. They are based both on the use of direct hydrocarbon indicators and on the analysis of additional geological factors (Vyzhva et al., 2018; Vyzhva et al., 2019).

Detection of hydrocarbon traps within the license area

Figure 1 shows a fragment of a structural map corresponding to the top of the sediments of the Moscow middle carbon layer within the license area of East Yevgenyvska square. These sediments belong to the M-7 regional productive complex. Rocks of the complex are represented by sustained in the area and geological section sandstone perspective for the presence of hydrocarbons. Different approaches have been applied to determine the optimal well location in the southern part of the license area. The standard approach is to analyze the structural-tectonic model and identify structural traps of hydrocarbons. From the analysis of the structural map shown in Fig. 1 implies that the southern part of the license area does not contain structural traps formed by features of a layer surface relief or a set of tectonic faults. Therefore, additional information should be provided to obtain motivated recommendations for drilling for oil or gas wells. Data on structural-tectonic models of adjacent areas may provide some assistance. The additional information on the structural-tectonic model of the adjacent southern area suggests that the southern part of the licensed area is the western wing of a rather large anticline located on the adjacent area. Thus, the Well 1 designed well can be productive of the Moscow stage sediment if it crosses the layer above the contact of hydrocarbons with water. Such conclusions are well founded. But they do not suggest that the Well 1 designed well will be successful.

To increase the likelihood of well drilling, Well 1 requires the use of direct hydrocarbon indicators (Chopra and Castanga, 2014; Velve et al., 2018). The simplest but at the same time reliable and stable way is attribute analysis of seismic images in the target interval. One useful option for determining the presence of hydrocarbons in rocks is to use the seismic attributes Envelope and Acoustic Impedance. When it comes to analyzing the distribution of seismic attributes in a limited depth interval, the Relative Acoustic Impedance attribute can be used instead of the Acoustic Impedance attribute. This is explained by the slight changes in the low-frequency component of Acoustic Impedance at a limited depth of geological section.

The physical content of the proposed attribute analysis is as follows. Increased values of the Envelope of seismic signals correspond to significant changes in the values of the Acoustic impedance. This effect can be observed at the boundaries of the layers saturated with hydrocarbons. Increased values of seismic signals Envelope are a classic indicator of hydrocarbons.

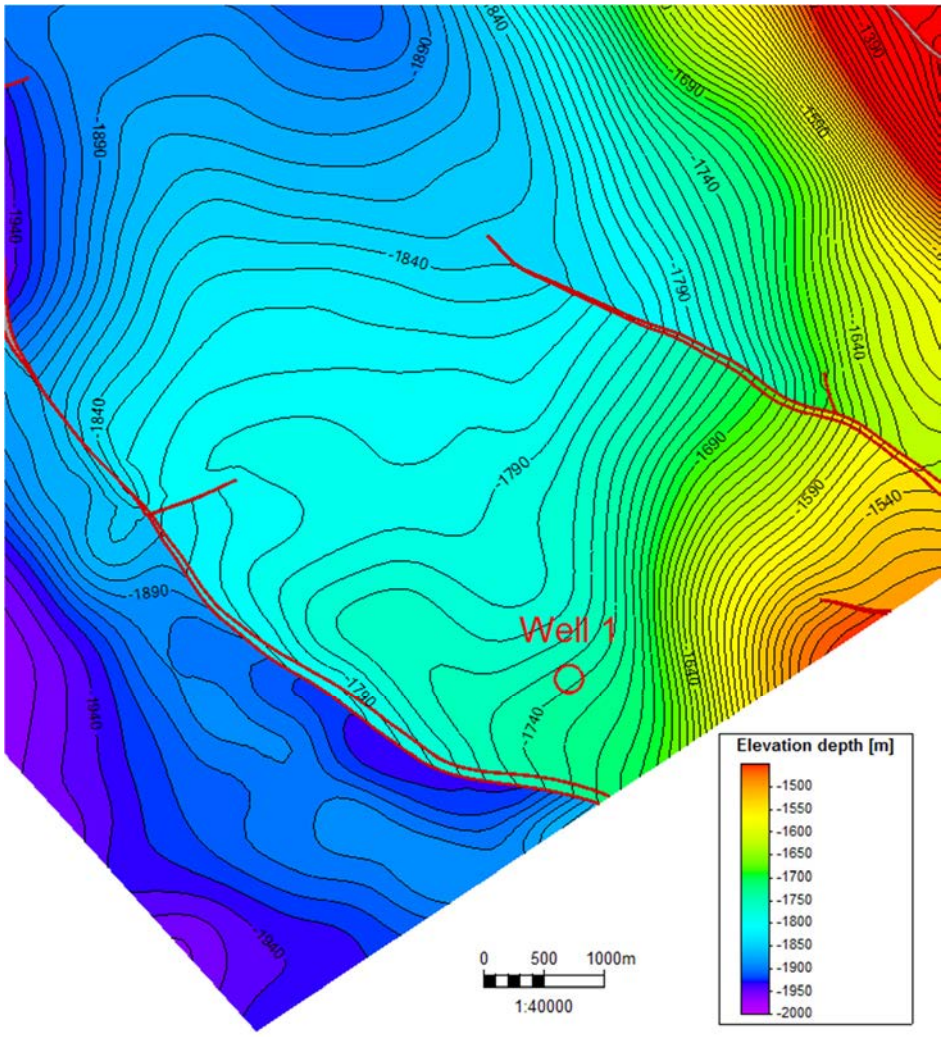

Figure 1 *Structural map of the top of the productive M-7 horizon in the sediments of the Moscow stage of middle carbon for the southern part of the license area.*

This approach is known as the bright spot method. It should also be noted that in the anticlinal traps of hydrocarbons, in the presence of tectonic faults, the reverse effect may be observed. In such cases, the Envelope intensity of the seismic signals may decrease. This can be explained by the filtration of hydrocarbons due to the tectonic movement of the reservoir saturated with hydrocarbons. Such filtration results in a smoother change in the Acoustic impedance and a decrease in the values of the Envelope of seismic signals. This effect underlies the use of another indicator of hydrocarbons, called a dim spot. Also common is the flat spot indicator. As a rule, a flat spot is a reliable indicator of water and gas contact. This paper considers the bright spot effect as a classic direct indicator of non-structural hydrocarbon traps.

A convenient approach to detecting non-structural traps of hydrocarbons is multi-parameter classification. An effective approach to multi-parameter classification using seismic attributes is implemented in geobody technology (Schlumberger). This technology allows the detection of

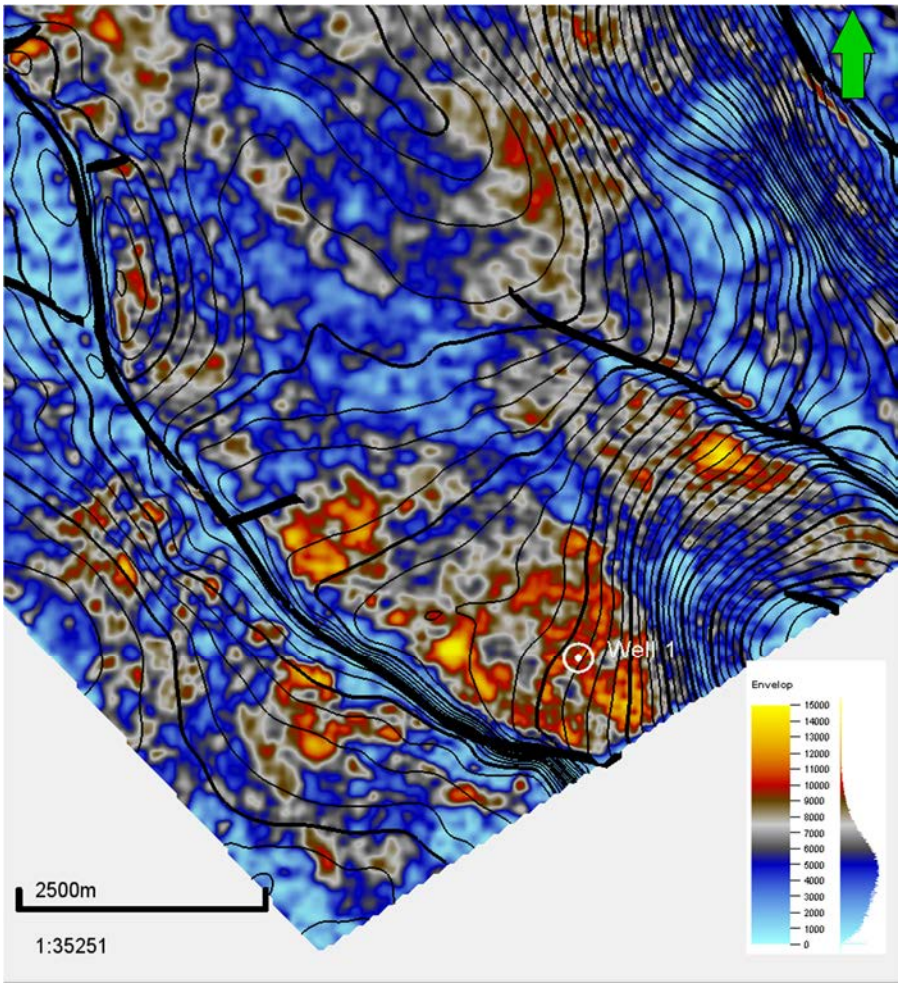

Figure 2 *Distribution of values of the Envelope seismic attribute along the top of the productive M-7 horizon in the sediments of the Moscow stage of middle carbon.*

volumetric geological bodies that correspond to specific ranges of changes in seismic attributes. The capabilities of this approach far exceed the capabilities of subjectively analyzing seismic data separately for different seismic attributes. One of the most important features of this technology is the ability to analyze and detect voluminous geological bodies with specified properties. At the same time subjective or visual analysis of the sections of volumetric seismic attribute distributions are a very complex and unreliable alternative. This approach is characterized by rather nominal and unauthentic results.

To determine the expediency of Well 1 drilling, refer to Figure 2. This figure shows the distribution of Envelope attributes along the top of the M-7 productive horizon in the Moscow stage of middle carbon sediments. Increased values of the Envelope attribute are a prerequisite for the presence of natural gas in the corresponding layer. The large values of this attribute at the boundary of the gas-saturated layer are due to the increased values of the reflection coefficient at this boundary.

Alternative results obtained by one of the Canadian exploration companies are shown in Figure 3. In this case, the figure shows the distribution of RMS amplitudes of the seismic image. The difference between this approach and the Envelope attribute distribution calculation is the averaging of the RMS amplitude over some range of the potentially productive M-7 layer. The attribute distributions in Figure 2 and Figure 3 are similar in general. This is quite natural because of the similarity of the physical meaning of both results. The question of which of the results is more appropriate for the probability of correctness of recommendations and the success of drilling is debatable and depends mainly on the distribution of the amplitudes of the output wave field of the seismic image.

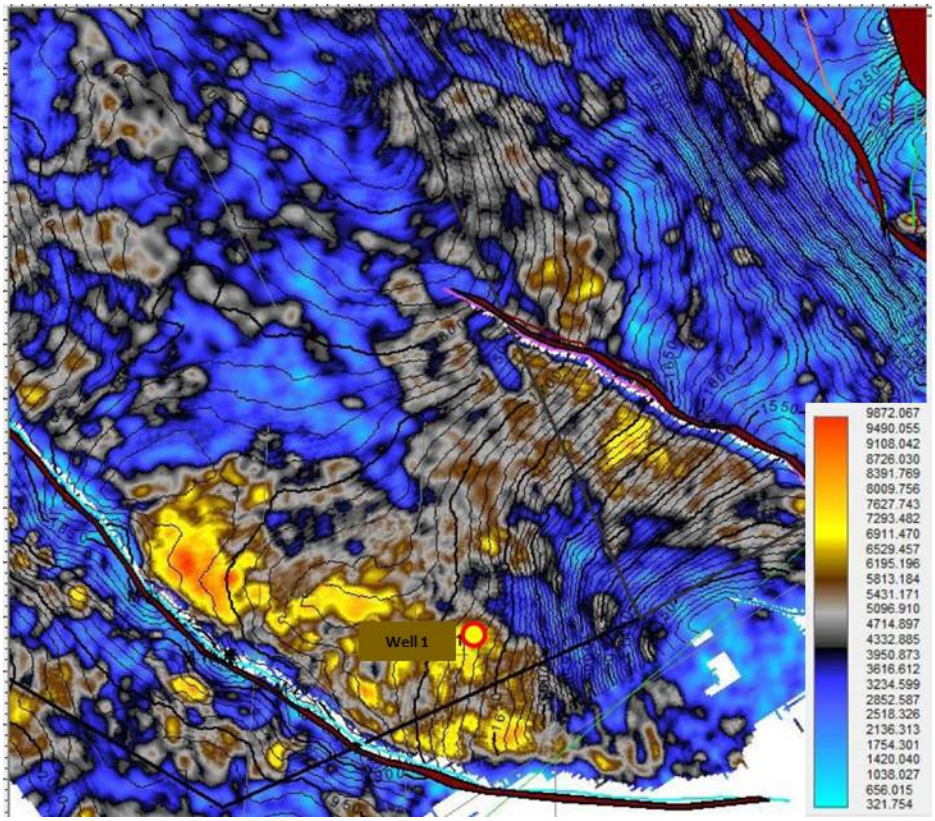

Figure 3 *Distribution of values of RMS amplitudes of seismic images for productive horizon M-7 in sediments of the Moscow stage of middle carbon.*

Conclusion

The typical problem is analyzed when all available structural and tectonic hydrocarbon traps are discovered at the oil and gas field. In this case, the expedient approach to the further development of the field is the detection of hydrocarbons traps of any type. For this purpose, a comprehensive analysis of the prospects of the productive M-7 horizon was conducted using direct hydrocarbon indicators and the involvement of geological-geophysical information from the adjacent area. As a result of the work, a non-structural type hydrocarbon trap was identified and appropriate recommendations were given for drilling Well 1 in the southern part of the license area.

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