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APPLICATION OF SEISMIC METHODS FOR INTEGRATED RESERVOIR CHARACTERIZATION


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3D seismic survey is the undisputed leader among tools of identifying potential exploration targets and reservoir characterization. This paper shows surveys that are crucial in the exploration and development of significant amounts of hydrocarbon resources, and can be used by operator companies to map complex geological structures and select better drilling locations.

The purpose of research work is to have better understandings of formations and update previous studies in oil field of Mangyshlak Basin, Western Kazakhstan. The Main results are the acoustic impedance, Vp / Vs ratio, lithological and reservoir properties data. The quality

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controls and analysis of results show good match with well logs and good recovery of seismic signal in inversion, but it should be improved in some areas. The results, from a scientific point of view, expand the already known geological and geophysical studies of the reservoir and improve the quality of interpretation using seismic methods in studying the sedimentation environment of the site.

***KEY WORDS:** seismic interpretation, sedimentology, geological structure, productive horizons, reservoir characterization.*

КОЛЛЕКТОРЛАРДЫҢ КЕШЕНДІК СИПАТТАМАЛЫҚ СЕЙСМИКАЛЫҚ ӘДІСІ

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3D сейсмикасы – барлаудың ықтимал нысандары мен резервуардың сипаттамаларын анықтауға арналған құралдардың арасында сөзсіз көшбасшы. Бұл мақалада көмірсутектердің маңызды қорларын іздеу мен игеру үшін маңызды болып табылатын және күрделі геологиялық құрылымдарды картаға түсіру және бұрғылаудың ең жақсы учаскелерін таңдау үшін операторлар пайдалана алатын зерттеулер көрсетілген. Сейсмикалық зерттеудің нәтижесі – бұл жер асты сулары мен шағылыстырушы жыныстың орналасқан жерінен тыс ақпарат алатын сейсмикалық шағылысу деректері.

Жұмыстың мақсаты – Маңғыстау бассейні кен орнының су қоймаларының қасиеттері мен орналасуын егжей-тегжейлі зерделеу және осы учаскенің алдыңғы зерттеулерін жаңарту. ТҮЙІН нәтижелер – акустикалық кедергі, Vp / Vs қатынасы, литологиялық және резервуарлық қасиеттері. Сапаны бақылау және нәтижелерді талдау ұңғыма журналдарымен және шағылысқан толқындық сигналмен жақсы келісімді көрсетеді, бірақ кейбір жерлерде оны жақсарту қажет. Бұл нәтижелер, ғылыми тұрғыдан алғанда, резервуардың бұрыннан белгілі геологиялық және геофизикалық зерттеулерін кеңейтеді және учаскенің шөгінді ортасын зерттеуде сейсмикалық әдістерді қолдану арқылы түсіндіру сапасын жақсартады.

***ТҮЙІН СӨЗДЕР:** сейсмикалық интепретациясы, седиментиментологиялық зерттеу, геологиялық құрылым, өнімді горизонт, коллектор сипаттамасы.*

СЕЙСМИЧЕСКИЙ МЕТОД КОМПЛЕКСНОЙ ХАРАКТЕРИСТИКИ КОЛЛЕКТОРОВ

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3D сейсморазведка является бесспорным лидером среди инструментов определения потенциальных целей разведки и характеристики коллектора. В статье показаны исследования, которые имеют важное значение для поиска и разработки значительных запасов углеводородного сырья и могут использоваться компаниями-операторами для составления карты сложных геологических структур и выбора лучших мест бурения. Результатом сейсмического исследования являются данные сейсмических отражений, которые несут информацию о недрах и информацию за пределами местоположения отражающей породы.

Цель работы состоит в том, чтобы более детально изучить свойства и расположение коллекторов и обновить предыдущие изыскания данного участка месторождения в бассейне Мангышлак, Западный Казахстан. Основными результатами являются акустический импеданс, отношение Vp / Vs, данные литологических и пластовых свойств. Контроль качества и анализ результатов показывают хорошее соответствие с каротажами скважин и сигналом отраженных волн, но в некоторых областях его следует улучшить. Данные результаты с научной точки зрения расширяют уже известные геолого-геофизические исследования коллектора и повышают качество интерпретации с применением сейсмических методов в изучении седиментационной среды участка.

КЛЮЧЕВЫЕ СЛОВА: *сейсмическая интерпретация, седиментология, геологическая структура, продуктивные горизонты, характеристика коллекторов.*

Reservoir characterization is made by correlating seismic properties obtained with values measured in wells and extended wells [1]. It's a process that helps fill our knowledge gaps of properties between wells. The given reservoir characterization technique uses the following procedure: 1. Conducting detailed correlation with the division into 11 groups of oil formations of the field, followed by analysis of stratigraphy. 2. Interpretation of horizons and faults over 11 productive layers and 4 main target horizons in the Triassic and Paleozoic. 3. Compilation of structural maps of the main target horizons. 4. Perform analysis of sedimentation conditions based on updated more detailed logging and 3D seismic data. 5. Creating and performing dynamic analysis of field operation. 6. Reservoir characterization features. Evaluation of the exploration and development efficiency.

Through the petrophysical work and analysis of structural geology study [2, 3] can help us to incorporate prior knowledge of the earth model and retrieve much of the information hidden within the seismic data. Every reflection changes the information because of the amplitude change of received wave. The property controlling this change produces at the interface with impedance contrast. The information of seismic reflection amplitude can be used for an inversion to determine the relative impedance of the media on both sides of the interface [4, 5].

OIL PROPERTIES

According to the results of statistics from previous years [6], when studying the properties of oil by productive horizons in Jurassic deposits at the field, many oil samples from different intervals throughout the entire section of the drilled wells were used.

Based on to the results of the analysis, it is clear that the properties of oil within the deposits are characterized by regular variability with increasing depth.

In the upper parts of the deposits, the saturation pressure, gas factor and volumetric coefficient are the most significant, while the density and viscosity of oil are the lowest.

In the edge parts of the deposits, the gas factor and the volumetric coefficient of oil decrease, while the density and viscosity of the oil increase, and the properties of the oil deteriorate.

The properties of oil in different layers naturally change with increasing depth: from bottom to top, the saturation pressure, gas factor and volume factor gradually increase, while the saturation pressure changes within 15.7~22.3 MPa, the gas factor ranges from 76~161 m^3/m^3, the volumetric coefficient varies between 1.22~1.41, and the density and viscosity of the oil gradually decrease with increasing depth.

ANALYSIS AND RE-CHECK OF (WOC) WATER-OIL CONTACT

Since long-term development was carried out in the study area using water flooding, which leads to a very complex oil and gas complex, oil and gas complex, and mineral water treatment in this field, the result is a significant amount of work.

History data and previous studies includes: calculation of reserves, on the basis of a structural interpretation within this area of work; the results of testing and trial operation; the results of re-checking the interpretation of logging data; the dynamics scope of operation. This work was carried out to re-verify WOC and GOC on the main objects of development.

At the field, 11 development objects are divided in detail into 43 sublayers; 59 fluid contacts were identified, of which 1 GWC, 18 GOC, 40 WOC. Because of the analysis, new data on WOC in layers 6, 11 obtained. Horizon 11 is the most representative example to work with it.

WOC ANALYSIS OF HORIZON 11

According to the previous year's reserves calculation data, it was noted that WOC in the western part of the sublayer B in the horizon 11 is in the range -2158.0–2167.0 m, in the central part it is in the range of -2154.0–2216.0 m. The difference in WOC is about 60m. It is not yet clear, the reason that leads to this phenomenon. During this work, it is necessary to find relevant evidence from the perspective of seismic, collectors, and operational dynamics in order to explain this event.

Initially, using the results of interpretation of logging data and testing, the WOC was substantiated. This layer is divided into 4 zones having 4 independent oil and water systems. It is also noted that in the central and eastern parts of the field, the difference in the oil and gas concentration is about 60 m. Secondly, according to the results of structural constructions [7]. It is seen that from the central part to the east, the amplitude of the structural background decreases, while in the eastern part the low-amplitude rise disappears *(Figure 1)*.

Summarize analyse showed the changes in lithology in the central and east of the site, because of which different oil and gas deposits appeared. This leads to different levels of oil-gas concentration. The section of stratigraphic correlation in the west-east direction has a noticeable change in lithology [8] is observed between the east and central parts in the sublayers. In particular, in the central part, it was noted that possible channel sandstones are developing; in the east, in this pack channel sandstones also developed, which are characterized by sandstones with thin clays. The central part, areas of wells show a lithological substitution zone. Lithology is represented by mudstones with thin interlayers of sandstones. This proves that a remarkable lithological substitution occurred between the east and central parts, which led to a change in lithology, sand bodies are not communicated over the area. In addition, from the stratigraphic correlation along the meridional direction, near the lithological substitution zone, mudstones with thin interlayers of sandstones prevail in terms of lithology, therefore, sand bodies in underwater branched channels developed in the east and central part, between them are deposits on a branched bay.

The seismic attribute [9, 10] in area also reflects well the characteristic of lithological variability [11]. According to the Vp/Vs attribute, it was noted in the B formation by area that in the central and eastern parts there is a high attribute anomaly expressed by "red" tones, respectively, "blue" tones are present between the eastern and central parts, which is, in its turn, a zone of lithological variability. This significantly coincides with the drilling data *(Figure 2)*, therefore, using the Vp/Vs attributes in terms of area, it is possible to describe the zone of lithological variability, which provides the prerequisites for the analysis of WOC [12].

As a result of the above complex analysis, the oil deposits in pack B are divided into 4 zones by area, of which they are very different in the central and eastern parts of the WOC, and the oil deposits in the central part (areas of wells 2~3) are mainly limited by structures. Oil deposits in the eastern part (areas of well 4~5) are mainly controlled by lithology and structures *(Figure 3)*.

RESERVOIR CHARACTERIZATION BY CLASSIFICATION

Using the sections of deposits and distribution maps of oil and gas regions, we analyzed the features of 11 oil-bearing objects *(Figure 4)*.

Based on the data on reserves calculation, in accordance with the interpretation of the structure, results of testing and trial operation, and a comprehensive analysis of the distribution of oil reservoirs [13], it is believed that reservoirs are difficult to distribute at the field, and heterogeneity is intense. In general, they are intact multilayer lithologic-structural deposits with marginal and plantar water; the relationship between oil and water is complex.

In the horizon 11, the sections between oil, gas and water are complex, which allows to distinguish 11 systems of oil, gas and water. From the interpretation of the logging data

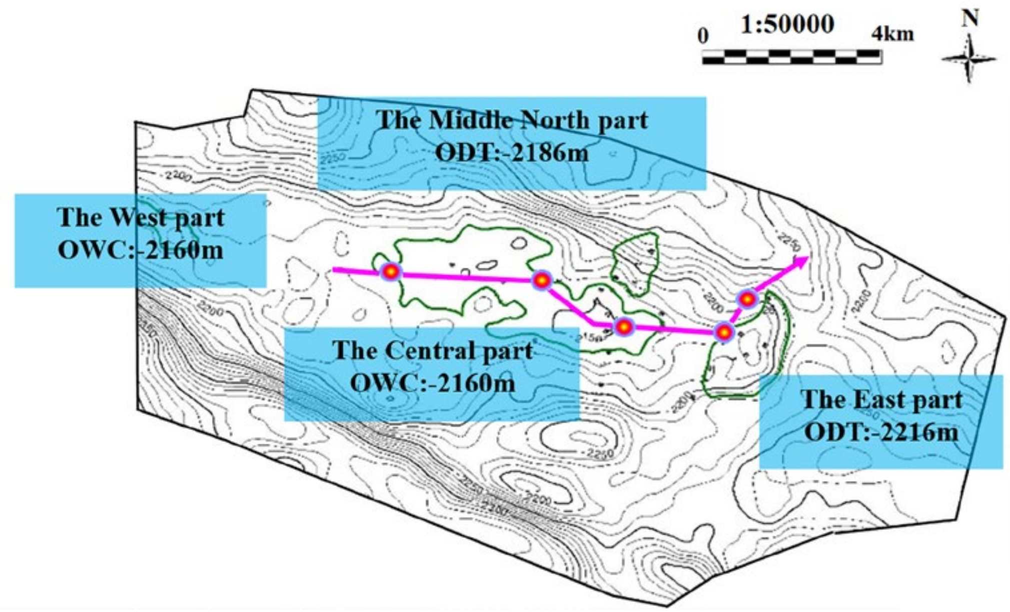

Figure 1 – **Structural map of sublayer B within the productive horizon 11**

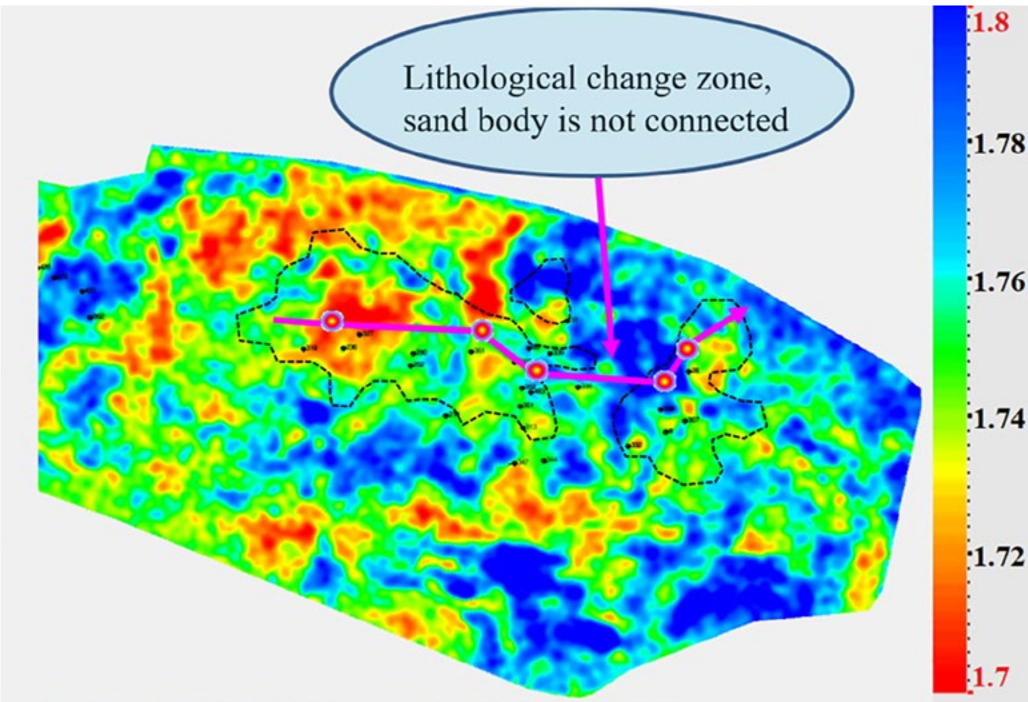

Figure 2 – **Vp / Vs attribute map by area along the productive horizon 11**

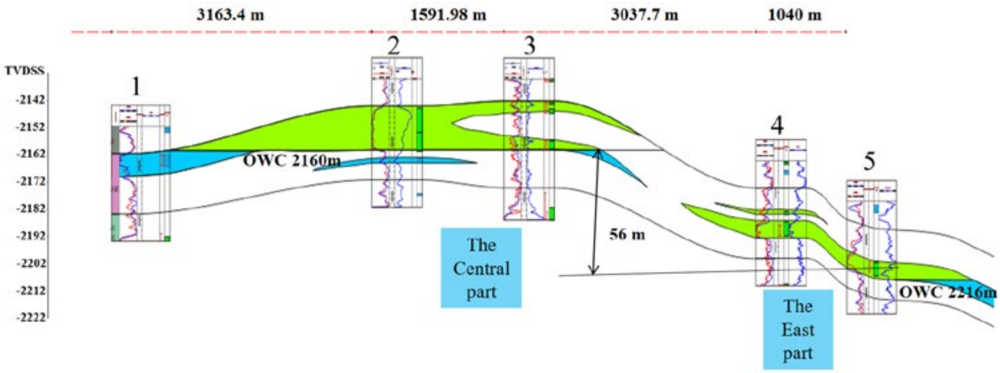

Figure 3 – **Section of deposits in the sublayer B of the productive horizon 11**

N/n	Type
1	Layered gas reservoir
2	Layered gas reservoir with oil rings
3	Layered gas reservoir with oil rings
4	Layered oil reservoir
5	Layered oil reservoir with gas caps
6	Layered oil reservoir with gas caps
7	Massive oil reservoir
8	Layered oil reservoir with gas caps
9	Layered oil reservoir with gas caps
10	Layered oil reservoir
11	Layered oil reservoir with gas

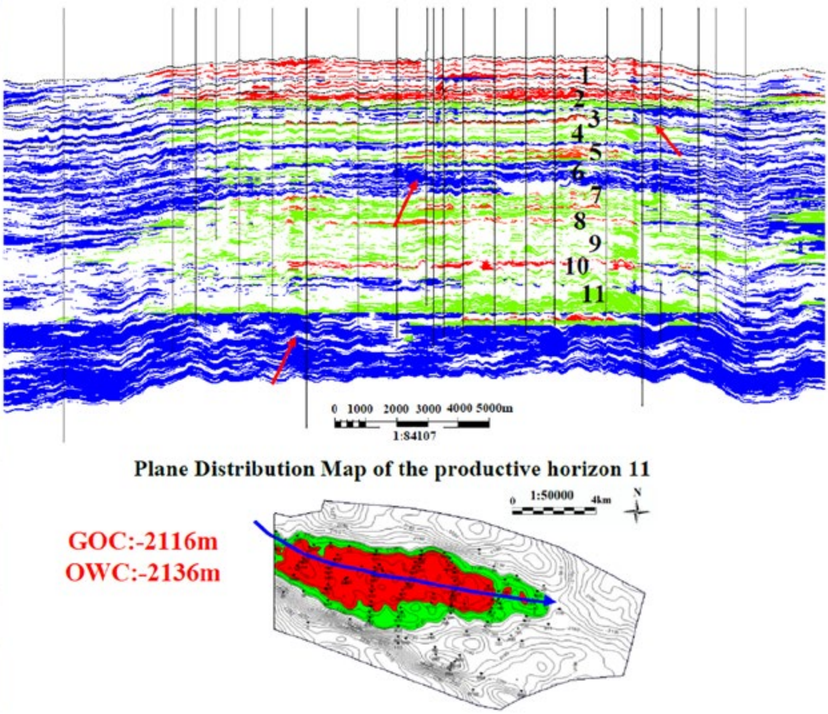

Figure 4 – **Section of the oil reservoirs along the certain direction**

and seismic data, it was noted that the A pack is an oil and gas bearing deposit, while the GOC is -2116.0 m, the WOC ranges from -2121.0 ~ -2136.0 m. Sublayers A is an oil-and-gas bearing reservoir, with a GOC of -2121.0 m and a GOC of -2132.0 ~ -2145.0. Pack A is a reservoir with a gas cap and circulating water. B1–3 pack is an oil and gas reservoir, which has a GOC of -2133.0 m, a WOC ranges from -2139.0 ~ -2162.0 m (in the western part) and 2136.0 ~ -2165.0 m (in the eastern part). The 4–5 pack is a reservoir; lithological and structural oil and gas reservoir, fluid sections in the field are complex. According to the study [14, 15], it was noted that lithological variability probably occurred in the central and eastern parts. In addition, a lithological change has also occurred in the northern part, resulting in the formation of oil and gas deposits with different oil and water systems, which, accordingly, leads to different oil and gas concentrations. Within the work area, it is divided into 4 zones, in turn -2158.0 ~ -2167.0 m (in the western part); -2186 m (in the central north part); -2154.0 ~ -2167.0 m (in the central part); 2216.0 m (in the eastern part).

CONCLUSIONS

The implementation of 3D seismic data by the method of quantitative interpretation is holistic and depends both on the quality of the input data and on the elastic properties of the rocks. Nevertheless, the quantitative involvement of deep trends in the interpretation of seismic data significantly enhances prediction validity and diminishes the uncertainty of the results of a comprehensive characterization of the reservoir.

1. Seismic Reservoir characterization data led to have detailed structural construction, the tectonic model of the research area.

2. A comprehensive study of seismic and geological data showed that the deposit is mainly of the delta type, and the reservoirs are sand bodies of river and branched-channel genesis, while the thickness of the sandstones varies sharply in area and the reservoir connectivity in lateral complex.

3. The main target horizons of the deposit are a structural type deposit, which determines the distribution of oil, water and gas. However, it is necessary to take into account the influence of the quality and type of reservoir on the prevalence of hydrocarbons and the flow rate of each individual well.

4. According to the the reservoir analysis, it is clear that the properties of oil within the deposits are characterized by regular variability with increasing depth.

5. The Oil field has the potential to expand the border; recommendations were made for the development of the field. The low-amplitude trap at the edge of the area appears to be the next potential area. It is necessary to drill new wells for the most rapid development of field reserves.

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