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Satbayev University

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ИЗВЕСТИЯ

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SOME FEATURES OF STRUCTURAL INTERPRETATION OF CDP 3D SEISMIC DATA UNDER CONDITIONS OF THE BEZYMYANNOYE FIELD

Abstract. The Bezymyannoye field is located in the eastern part of the Caspian depression, in the southwestern flank of a salt dome located on Zharkamys uplift. Prospects of oil and gas potential in this area are associated with the salt deposits of the Kenkiyak stage. The area under study can be considered one of the most perspective regions of Kazakhstan in increasing oil and gas production.

Modern CDP seismic techniques provide solutions to structural and tectonic problems with high degree accuracy and reliability. However, the complexity of the geological structure and depth of surveying increases the inaccuracy of kinematic interpretation of seismic data up to a complete loss of data in target intervals, as evidenced by repeated facts of significant discrepancy between deep drilling data and seismic structures.

The article highlights the most optimal choice and implementation of processing graphs based on reprocessing of 3D seismic data from a seismically and geologically complex area. Particular attention is paid to the structural interpretation, thus allowing clarifying the geological structure of Mesozoic rocks, Paleozoic productive and salt-bearing sediments in the area. The article recommended correlating productive horizons for further use in building a geological model. An additional study of the Upper-Permian structure is recommended for explorational drilling purposes.

Key words: eastern near-edge zone of the Caspian Basin, Mesozoic and Upper Paleozoic sediments, 3D seismic survey, structural interpretation, stratification and correlation of reflecting horizons.

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БЕЗЫМЯННОЕ КЕНОРНЫНЫҢ 3D ЖТНӘ СЕЙСМИКАЛЫҚ ДЕРЕКТЕРІН ҚҰРЫЛЫМДЫҚ ТҮСІНДІРУДІҢ КЕЙБІР ЕРЕКШЕЛІКТЕРІ

Аннотация. Тектоникалық тұрғыдан Безымянное кен орны Каспий ойпатының шығыс шеткі бөлігінде орналасқан. Мұнай-газ перспективасы Кеңқияқ қадамының тұз үсті кен орындарымен байланысты, олар бірқатар мұнай және газ кен орындарымен, соның ішінде Безымянное кен орнымен (Жарқамыс көтерілімінің тұз күмбезінің оңтүстік-батыс қанаты) байланысты. Зерттеу аймағын мұнай мен газ өндіруді ұлғайту тұрғысынан ең перспективалы деп санауға болады.

Дәстүрлі құрылымдық-тектоникалық мәселелерді шешу МОГТ сейсмикалық барлаудың заманауи әдістері мен технологияларымен қамтамасыз етіледі. Бұл қарапайым геология жағдайында әділ, бірақ ортаның құрылысы күрделі және зерттеулердің тереңдігі үлкейген сайын сейсмикалық деректердің кинематикалық интерпретациясының қателіктері ұлғайып, өнімді интервалдар туралы ақпараттың толық жоғалуына ықпал етуі ықтимал. Оны терең бұрғылау деректері мен сейсмикалық құрылымдық құрылыстар арасындағы елеулі сәйкессіздіктің бірнеше рет анықталған фактілері дәлелдейді.

Мақалада Безымянное кен орнының мезозой-палеозой шөгінділерінің геологиялық құрылымын анықтау және нақтылау мақсатында күрделі сейсмогеологиялық жағдайларымен аймақ үшін 3D сейсмикалық мәліметтерді қайта өңдеу мысалында ең оңтайлы өңдеу ретін таңдау және енгізу көрсетілген. Нәтижесінде мезозой тау жыныстарының, палеозойдың өнімді және тұзды кен орындарының геологиялық құрылымын нақтылаған құрылымдық интерпретация кезеңіне ерекше көңіл бөлінеді. Кен орнының геологиялық моделін құру үшін пайдалануға болатын өнімді горизонттардың корреляциясы бойынша ұсыныстар берілген. Барлау ұңғымасын ықтимал бұрғылау үшін жоғарғы пермь құрылымын қосымша зерттеу бойынша ұсыныстар берілген.

Түйін сөздер: Каспий маңы ойпатының шығыс борт маңы аймағы, мезозой және жоғарғы палеозой шөгінділері, 3D сейсмикалық барлау, шағылысатын горизонттарды стратификациялау және корреляциялау, құрылымдық интерпретациялау.

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НЕКОТОРЫЕ ОСОБЕННОСТИ СТРУКТУРНОЙ ИНТЕРПРЕТАЦИИ СЕЙСМИЧЕСКИХ ДАННЫХ МОГТ 3D В УСЛОВИЯХ МЕСТОРОЖДЕНИЯ БЕЗЫМЯННОЕ

Аннотация. В тектоническом отношении месторождение Безымянное расположено в восточной прибортовой части Прикаспийской впадины. Перспективы нефтегазоносности связываются с надсолевыми отложениями Кенкиякской ступени, к которым приурочен ряд нефтегазовых месторождений, в том числе и месторождение Безымянное (юго-западное крыло соляного купола Жаркамысского поднятия). Район исследования можно рассматривать как наиболее перспективный в наращивании объемов добычи нефти и газа.

Традиционно решение структурно-тектонических задач обеспечивает современные методики и технологии сейсморазведки МОГТ, что справедливо при относительно простой геологии. По мере усложнения строения среды и глубинности исследований погрешности кинематической интерпретации сейсмических данных увеличиваются вплоть до полной потери информации о целевых интервалах, о чем свидетельствуют неоднократно установленные факты существенного расхождения между данными глубинного бурения и сейсмическими структурными построениями.

В статье показан выбор и реализация наиболее оптимального графа обработки на примере переобработки трехмерных сейсмических данных для района со сложными сейсмогеологическими условиями с целью уточнения геологического строения мезозойско-палеозойских отложений месторождения Безымянное, выявления и детализации строения новых структур в палеозойской части разреза. Особое внимание уделено этапу структурной интерпретации, по результатам которой уточнено геологическое строение мезозойских пород, палеозойских продуктивных и соленосных отложений. Даны рекомендации по корреляции продуктивных горизонтов, которые могут быть использованы для построения геологической модели месторождения. Даны рекомендации на доизучение верхнепермской структуры для возможного бурения поисково-разведочной скважины.

Ключевые слова: восточная прибортовая зона Прикаспийской впадины, отложения мезозоя и верхнего палеозоя, сейсморазведка 3D, структурная интерпретация, стратификация и корреляция отражающих горизонтов.

Introduction. The Bezymyannoye field is located in the eastern part of the Caspian Basin. The discovery of the Kenkiyak, Karatobe, Zhanazhol, Urikhtau, Karachaganak, Tortai and other oil fields in the subsalt complex led to the tendency to consider only subsalt deposits as promising for this area. However, during the last twenty years almost 15 oil and gas fields have been discovered, oil and gas content of which is mainly connected with the Mesozoic rock complex (Akhmetzhanov et al., 2020:2653; Kunin et al., 1978:29). The largest of the newly discovered fields is Kenbai, the productivity of which is associated with terrigenous sediments of the middle Triassic (1,050-1,386 m). Thus, along with the fact that the prospectivity of subsalt deposits in the study area has long been proven, the study of Mesozoic deposits suggests that the potential of suprasalt deposits is much higher than we might expect, and further discoveries may be associated with them.

According to geologists (Daukeev et al., 2002:247), the complexity of geological development of the region, confined to the junction zone of the East European platform and the Ural folded structures, as well as the salt-dome tectonics, created a variety of sedimentation settings and types of carbonate and terrigenous deposits, which conditioned uneven distribution (both vertical and lateral) of reservoir rocks. Consequently, there are different views on the structure and prospects of oil and gas bearing capacity in the subsalt complex and on the choice of exploration targets in suprasalt sediments. In this regard, the study of the deep structure of the territory, as well as the analysis of structural plan and lithological-facial zoning of suprasalt, Kungurian and subsalt complex rocks on the basis of seismic information in combination with drilling and other geological and geophysical methods, have prior significance.

The purpose of the studies was to clarify the geological structure of the Mesozoic-Paleozoic deposits of the Bezymyannoye field and to identify and specify new structures in the Paleozoic part of the section by selecting the most optimal procedures for structural interpretation of re-processed data.

A high-quality level of reprocessing and interpretation of seismic data can only be achieved if a number of conditions are met, in particular, high-quality of the source data and sufficient availability of prior geological and geophysical information on the study area (Kunin et al., 1978:29). Due to the complex structure of the Bezymyannoye field, the geological problems were solved by careful selection of an optimal processing graph, procedures and their parameters. The objective was achieved by solving the following tasks:

1. comparison and selection of the best procedures for processing seismic data in time (PSTM) and depth (PSDM) domains;

2. clarification of size of the oil deposit in the Kazan formation and determination of its contact line with salt, as well as clarification of the position of the Middle Jurassic eroded surface;

3. features of structural interpretation, in particular, stratification of reflecting horizons and their correlation, tracing of faults.

The Bezymyannoye oil field is located in the Baiganinsky district of Aktobe Region, Kazakhstan. The same-named uplift was first identified and studied back in 1912 by A.N. Zamyatin. It was not until 1927-1929 that A.P. Smirnov described it as a salt dome, then the structure was mapped by geological survey and confirmed during the 1940s-1950s. These advancements enabled L.Ya. Tushkanova identifying, during the 1:200,000-gravimetric survey, the 49 local minima of gravity, including the Bezymyannoye. In the 1960s, the first the RW and KMRW reconnaissance seismic surveys (Bogomolov) and then detailed area seismic surveys (V.P. Kan) were implemented to study the structure of the dome's steep slopes and the subsalt Paleozoic uplift. The surveys resulted in establishing the three-winged structure of the Bezymyannoye salt-dome structure. In 1976, structural maps were drawn for both the subsalt deposits and the Upper Permian "S" horizon. Here, an adjoining structure was revealed, 1.2x3.8 km within the closed isohypsis -1,200 m, extending in the submeridional direction.

In 1981, data about the adjoining structure changed upon results of the CDP seismic survey of the "S" horizon, when the structure was outlined at isohypsis -2,400 m and its dimensions were defined as 1.5x5.6 km, with an amplitude of over 300 m. In 1995, structural maps of 1:25 000 scale for the major reflectors III, V, VI, P1, P2, P3 and the Upper Permian D and S were built with help of 3D volumetric seismic survey. The data allowed to clarify the structure of the Upper Permian deposits and the salt surface configuration in the Bezymyannoye area, in support to modern calculation of reserves.

According to present-day views, the fold is confined to the southeastern flank of the Bezymyannoye uplift. The adjoining structure is of submeridional strike, northwest to east and southeast bounded by the slopes of the Kungurian-age salt massif (fig. 1A). Beneath the cornice of this massif in terrigenous sediments of the Kazanian stage of the Upper Permian, an oil accumulation was revealed, stratified, lithological and stratigraphic, screened by a steep salt slope. The OWC is set at -2,739 m (fig. 1B). The height of oil part of deposit reaches 57.4 m, effective oil saturation thickness varies from 17.5 to 39.9 m, and oil saturation coefficient is 0.67. Sandy reservoirs are porous, terrigenous with an open porosity of 17.8%. The reservoir is topped by claystone with a thickness of 15 to 50 m (Akhmetzhanov et al., 2020:2653; Bekzhanov et al., 2000:395; Kunin et al., 1978:29).

Exploratory drilling in the study area (1976) substantiated and then confirmed the presence of an oil horizon in the Upper Permian deposits (2702-2827 m). Note that the well was drilled to explore the subsalt deposits (-4996 m), but it confirmed the commercial oil-content of the Upper Permian deposits.

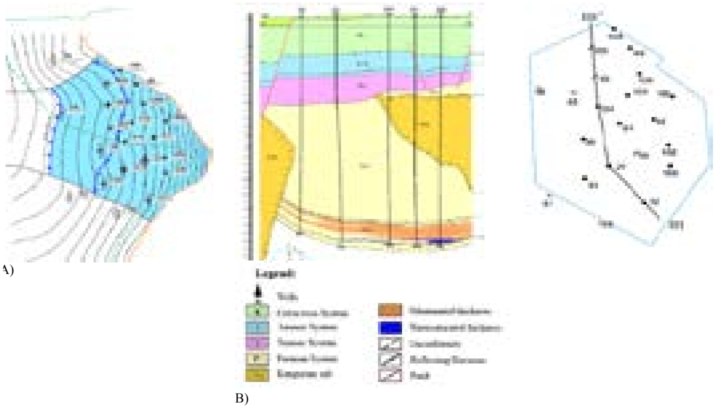


Figure 1. The Bezymyannoye oil field: A) Structural map of the reservoir roof (Upper Permian P_2kz); B) Geological section along III-III` (Ibragimov, 2018).

In total, 13 exploration wells were drilled for suprasalt deposits (Ibragimov, 2018; Istekova et al., 2014).

The Bezymyannoye deposit is confined to the southwestern flank of the Bezymyannoye salt dome located on the Zharkamys uplift. The salt dome is located in the zone of single salt massifs of submeridional strike, cutting through the overlying Upper Permian and Lower Triassic sand-clay deposits. According to researchers, the regional tilt of the subsalt bed, along with tectonic compression stresses through thrust-slip faults under the influence of the Mugodzhar island arc, which continued its formation until the Early Triassic, led to formation of salt ledges, expressed by salt thrust (squeezing) on the Upper Permian rocks (Bekzhanov et al., 2000:395; Daukeev et al., 2002:247). The salt-dome structure is divided by a narrow central graben into three wings: south-western, northern and eastern. The salt massif is located above the uplift on subsalt deposits, the roof of which lies at a depth of 3,900-4,300 m. The massif has an irregular shape, 6x5 km. The depth of the salt roof varies from -500 m to -2,400 m. The western and northern slopes of the massif are steep, with salt sheds of various shapes and sizes. The south-eastern slope is flatter (Fig. 1). Tectonic movements resulted in the Karatobe salt dome's tilt westward at an oblique angle of 110-115° to the horizontal. At the contact of the salt dome slope with rocks of the inter-dome trough, a contact oil trap was formed (with salt at the eastern contact) and lithologically constrained (from the north, west and south) in the Kazanian rocks of the upper Permian (Kunin et al., 1978:29).

Thus, the presented geological and tectonic information and past work records show a rather poor knowledge on the area and suggest to carry out modern seismic surveys for a more detailed data on the prospective structure. On the other hand, many processing and interpretation programs have appeared recently, allowing to obtain materials of high resolution and traceability (Brandes et al., 2019:370, Park et al, 2022). As a result of re-processing and re-interpretation of the existing data, for the first time, the 3D time and depth cubes of a total area of 46 sq.km of single multiplicity were obtained, guaranteeing new highly accurate information on deep geological structure of Mesozoic, productive Paleozoic and salt-bearing deposits. Recommendations on correlation of reflecting horizons to construct a geological model were obtained (Ibragimov, 2018).

Survey methodology. This article is based on results of the 2007 field seismic survey performed using the CDP 3D method. Parameters: INPUT/OUTPUT-IV seismic station, full multiplicity 54, RP spacing =40 m, SP spacing =40 m, number of active channels 108, bin size 20x20 m, 12 receiver clustering. The AHV-IV-362 vibrators were used as a source of elastic vibrations.

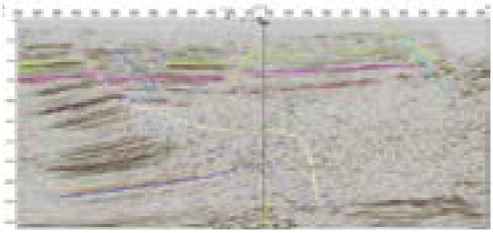
Structural interpretation of 3D CDP data was carried out using the GeoGraphix Discovery and DUG Insight interpretation packages. The interpretation work included structural interpretation, specification of the Upper Permian oil reservoir boundaries, identification of promising objects.

Once again, we note that the study site is characterised by complex surface and subsurface seismo-geological conditions. The former include, first, terrain variations in elevation and the complex structure of the upper part of the section. The deep conditions are characterized by intense dislocations. The latter include the determining influence of thrust-slip faults impacted by the Mugodzhar island arc, which continued to form until the Early Triassic, resulting in the phenomena of halokinesis and related deformations, expressed in salt thrusting (squeezing) on the Upper Permian rocks (Daukeev et al., 2002:247).

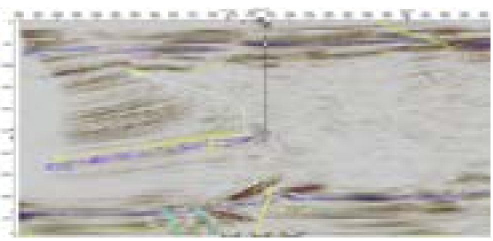
Processing of the 3D CDP field seismic data was conducted at the "Professional Geo Solutions Kazakhstan" using the PGS "Cube Manager User Integral", "HoloSeis" software. Although the 3D data of the Bezymyannoye field obtained in 2007 were characterized by errors of different nature, nevertheless the choice of the processing optimal graph has provided the selection and traceability of reflection horizons in the Paleogene, Cretaceous, Jurassic, Triassic and Paleozoic deposits; information on velocities and their spreading in the area was extracted to maximum from the initial CDP data; accuracy and resolution of kinematic and dynamic material features and etc was improved. Optimal parameters of the processing graph procedures were determined upon test results. The parameters were chosen in such a way as to achieve the highest possible temporal resolution of the wavefield and keep the signal to noise ratio high in the target interval (Isenov, 2021:68). Therefore, the influence of technical factors was minimized and seismic data of uniform quality obtained.

Research results. Let us focus on the study and analysis of the results of structural interpretation under conditions of the Bezymyannoye field, carried out after re-processing of the seismic data cube. Correlation of the upper structural layer was carried out in a semi-automatic mode with manual adjustment of horizons in places of correlation loss, weakening of seismic record dynamics and tectonic disturbances. Due to the complex geological setting of the salt-bearing and subsalt complex deposits, the correlation was implemented almost entirely in manual mode.

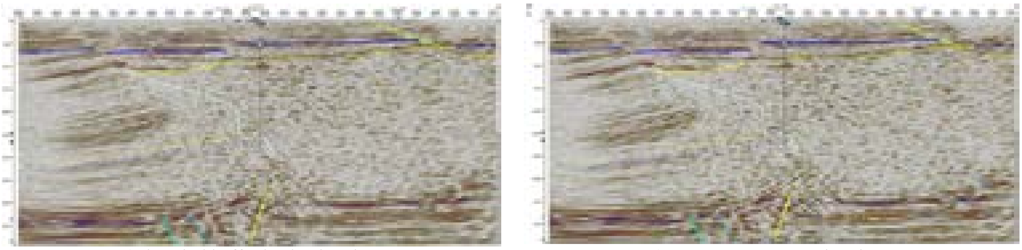
Techniques of tracing reference horizons is based on drilling materials, and the linking of seismic materials to GIS data was carried out with automatic selection of velocities in the section (Vogel et al., 1985:67; Wang et al., 2020:3177). Detailed linking of wells and the seismics in the time domain was carried out based on calculation of synthetic seismograms and their comparison with real traces of the pre-stack migration time cube (PSTM). Synthetic seismograms for stratigraphic referencing of reflections use a regular relationship between the section's lithological composition and their reflection characteristics. Acoustic logging data are paramount. Synthetic seismograms allowed determining how well an individual seismic reflection correlates with a stratigraphic marker layer. In absence of VSP data, positions of reference seismic reflections were used as starting points for selecting the positions of synthetic traces. Interpretation of the seismic data began with an analysis of temporal pre-stack migration (fig. 2A) followed by consideration of three variants of pre-stack depth migration (fig. 2B-2D).



A) temporal pre-stack migration



B) deep beam migration



C) the Kirchhoff's depth migration D) reverse temporary migration

Figure 2. Comparison of results for depth migration types to allocate the slope and salt cornice (Ibragimov, 2018)

These materials do not clearly trace the slope and salt cornice, which are the lateral screen for the Upper Permian oil accumulation. Therefore, two variants of the horizon (OG-VI-1) were interpreted to determine the geometry of the cornice: the first takes into account the minimum area of the oil deposit; the second, the maximum area. The figures show that the cornice does not have clear boundaries and the deposit area cannot be clearly delineated. Nevertheless, the 3D beam depth migration cube was chosen for final interpretation of the cubes' materials since the procedure showed the best recognition quality for the salt cornice and it clearly distinguished the boundary between the salt and the productive formation for most of the profiles (fig. 2C). The pattern of reflections from productive horizons by beam migration, linked to the logs, also defines their areal extent quite well compared to the other two depth cubes (fig. 2D, 2E). Noteworthy, the quality of seismic procedures depends directly on quality of the field materials, reliability of a mathematical processing model and the sufficiency of priority data. The salt ledge studied in figure 2 was undercut by drilling directly into the contact zone between the salt and the productive formation. The image clearly shows that, contrary to the notion that the junction of the terrigenous sequence with salt occurs through a system of faults, this junction according to the reprocessed data occurs smoothly as a salt envelopment of the terrigenous sequence, without visible faulting (Ibragimov, 2018).

The reprocessing of 3D seismic data enabled significant clarification not only of the size of the oil deposit in the Kazan suite and its contact line with salt, but also of the position of the eroded Middle Jurassic surface. Based on the results of synthetic trace calculation, section lithology and traceability information, selected were reflecting horizons and horizon correlation parameters.

1) The III reflecting horizon (the base of the Cretaceous and roof of the Middle Jurassic eroded surface), confined to the base of the Lower Cretaceous sediments, is characterized by rather unstable and dynamically poorly sustained reflections (fig.3). Often, transitions of this wave downwards, along the reflections (waves) cut by this surface of the Jurassic sediments, are observed. This reflected wave controls erosion-type unconformity boundaries near the boundary of the Jurassic roof and the base of the Neocomian terrigenous formations. In the figure, all reflecting horizons are labelled with VM letters. This means that the results are derived from depth migration.

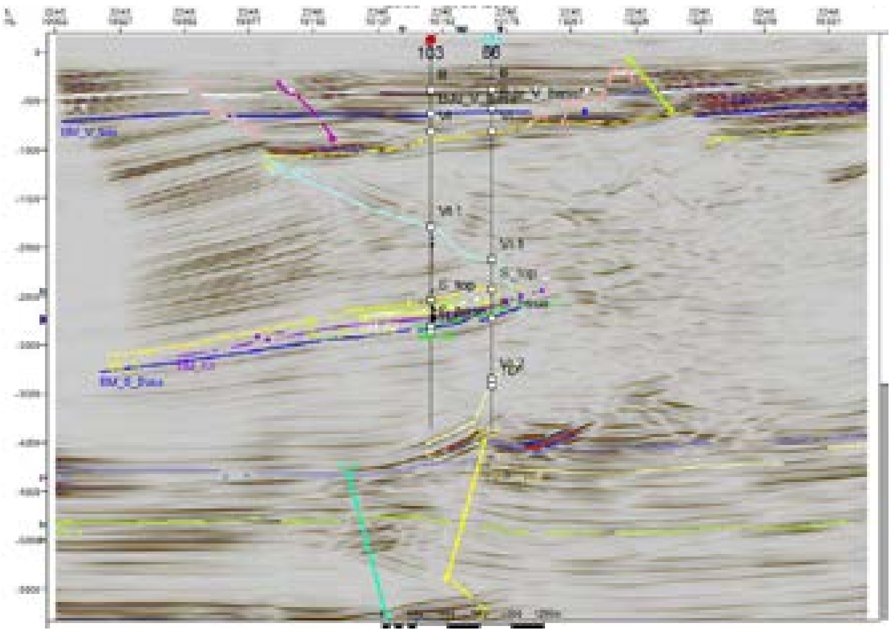
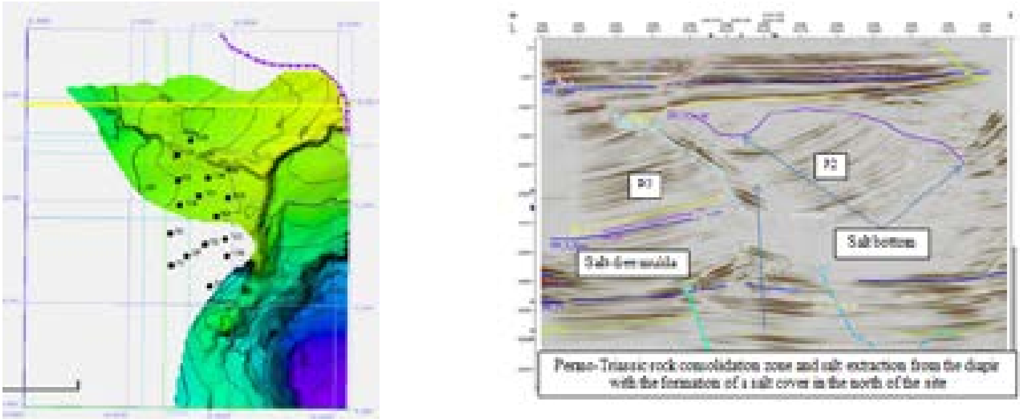


Figure 3. Case of seismic interpretation with indication of horizon names (Ibragimov, 2018)

The reflected wave III is indirectly recognized in the wavefield because of absence of a large acoustic stiffness gradient between the Cretaceous and Jurassic deposits. The same problem of locating the Cretaceous-Jurassic boundary at the Bezymyannoye structure is also observed from the logging data. The horizon surface was chosen among the positive reflections as the most consistent in the area in question.

2) The V_bas reflecting horizon corresponds stratigraphically to the basal sandstone roof at the base of the Lower Jurassic sediments. This reflecting horizon, within the territory in question, stands out as a one- or two-phase positive oscillation of varying degrees of dynamic expression. The horizon is correlated in PSDM (pre-stack depth migration) almost universally and stands out at 10-30 m above the angular unconformity with respect to the underlying rocks. In the wavefield, this reflection is recognised as the first reflecting horizon above the erosional surface between the relatively shallow Jurassic complex and the more steeply dipping reflections of the Triassic interval.

3) Reflecting horizon VI (salt roof) is prominent in the upper part of the salt dome. In the wavefield, this horizon is the divider between the layered suprasalt section of the Triassic and Upper Permian and the seismically mute salt sequence. The horizon is mapped only in the spreading zone of the salt dome and is absent in the western and northern parts of the survey area. The western part of the area is a salt-free trough. In the northern part, salt from the salt diapir was squeezed out and redeposited in a small area as a salt blanket. In the area of the salt squeezed-out from the dome, rocks of the two inter-salt troughs filled with Upper Permian rocks practically merge with each other. In this area, in the northwestern part of the section, only the remnants of a salt cornice and a salt diapir up to 100-200 m wide can be observed (fig. 4A, 4B).



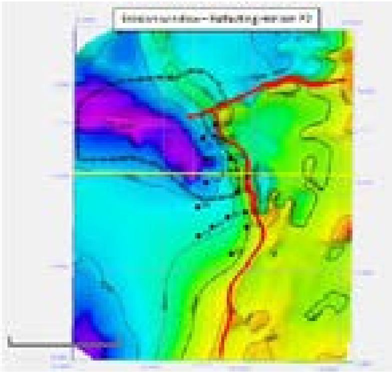
A) The VI RH structural map B) The Inline deep section

Figure 4. Example of seismic interpretation of a salt dome and the presence of salt cornices in the north of the site (Ibragimov, 2018)

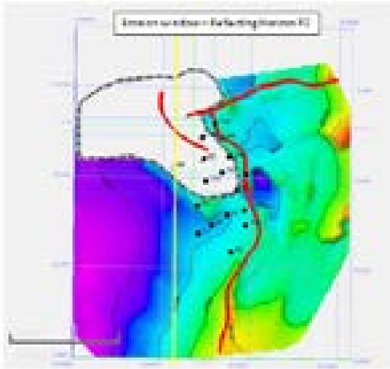
4) The reflecting horizon VI-1, the cornice and slope of salt, is divided into two non-contacting areas: BM_VI-1 (the main cornice and slope of salt that limits the Kazan deposit and extends from south to north, closer to the central part of the site) and BM_VI-1_NE (a similar cornice located in the north-east of the site). The cornice and salt slope were correlating as one reflecting horizon so that they formed a sloping area without a backward curve (an exposed slope as an overthrust) and so that the cornice or salt slope adjoined the salt roof from below upwards, the RH VI. The cornice was mapped as one gently descending horizon cutting the clay part of the upper Permian. By simplifying the representation of the cornice and ignoring its behavior in contact with the clay part of the upper Permian (P2tat), it became possible to outline the cornice and the salt diapir slope in one map instead of three (fig. 5A, 5B).

The subsalt reflecting horizons BM_P1 and BM_P2 are confined, respectively, to the Lower Permian terrigenous roof, and presumably to the roof of Middle Carboniferous carbonate-terrigenous deep-sea deposits. In the absence of data from the borehole, which penetrated the subsalt deposits, it is not possible to make a more specific stratigraphic reference of these horizons. In the study area, the RH P1 in the northwestern part of the site has an extensive area with an eroded surface (fig. 5). The horizon was elevated and eroded in this part of the area during pre-Kungurian time, as follows from the pattern on the temporal sections. The RH P2 at this location is exposed below the unconformity surface as an angular unconformity or erosionally sheared by the RH P1 horizon and is absent in both the erosion zone and in the northern part.

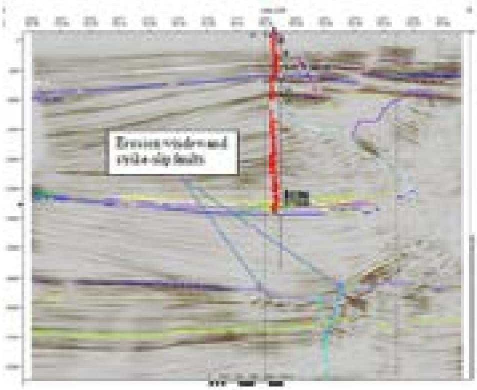
The erosional cut of RH P2 and P1 (in the form of a bowl) along with tectonic disturbances in the conditions of thrust and shear faults provide a good opportunity for oil migration from probably Upper-Middle Carboniferous oil-bearing deposits into suprasalt reservoir rocks and hydrocarbon traps. Thus, at the contact between Upper Permian suprasalt sediments and Paleozoic oil-bearing rocks under no-salt trough (or direct contact) conditions, the Bezymyannoye field oil deposit was probably formed (fig.5C).



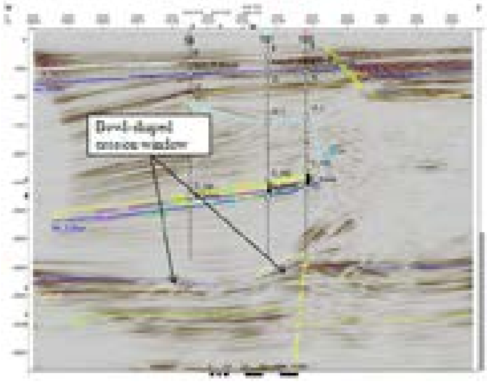
A) The RH P1 structural map and the erosion window



B) The RH P2 structural map and the erosion window



C) The crossline depth section and erosion cut image



D) The Inline depth section and bowl-shaped erosion cut image

Figure 5. Example of seismic interpretation of RH P1 and P2 with an erosion window into subsalt deposits at the level of RH P1 (Ibragimov, 2018)

About the same pre-Kungurian erosional scour bowl along with thrust tectonics has been identified in temporary sections to the north of the known Saigak oil field. The latter is thought to be the oil feed zone of the Saigak field as well as the depleted Shubarkuduk field from the subsalt complex (from Shell's seismic interpretation experience on the Temir block). A similar pattern with characteristic disturbance in the form of erosion of subsalt deposits in the fault zone is also observed near the Novobogaty field (Ibragimov, 2018).

For the mapping of productive horizons, reflections, roughly corresponding to the roof and sole of the productive formation as a whole, were selected from the logging data - RH BM_S (roof) and BM_S_base (sole) were identified. Four RH S1, S2, S3 and S4 were selected and correlated in the interval between these horizons and were roughly tied to the respective productive horizons, also identified by the logging data. This approach, or observation of reflectance propagation across the field area, has brought us closer to understanding of the position of the producing horizons within the oil-bearing area and in space. However, it should be noted that the productive horizon tops identified by the logging data do not always correspond exactly to the seismic boundaries (Kufasa et al., 2022:673; Kunin et al., 1982:222). This can be due to the fact that, in some cases, sand lenses and half-lenses often merge into single bodies in the productive section, and there are often no significant clay separations between them. In other cases, sandy bodies are laterally replaced by clayey bodies, and this changes the signal polarity, i.e., reservoir wedging (or clayification) of the section occurs. For this reason, the correlation of productive horizons was carried out automatically rather than manually. In the case of interrupted horizon reflection, it looks as a change in lithology along the same-age horizon or as a change in the physical parameters of the reservoirs (Umirova et al., 2020:21).

It is important to note that vertical seismic profiling data from several wells and, in the salt-cornice zone, from each well individually, are required to accurately relate the productive horizons to the seismic data. Only three wells data were used in these studies, so it was rather problematic to accurately link the reflections from the producing formations on time-lapse cross sections over the entire area.

Discussion. The sedimentation situation of the productive strata of the Upper Permian section of the Kazan suite is assumed to be as follows. The middle part of the Upper Kazan section is an oil-bearing sequence. According to the core description, it is composed of brown, dark brown, gray, fine- to medium-grained, polymictic, porous, oil-soaked siltstones and sandstones with interlayers of brown, fulvous argillite with rare thin gray micaceous and silty penetrations, in places with anhydrite nests and inclusions of white rock salt, finely crystalline and up to 2 mm in size (Ibragimov, 2018; Wang et al., 2020:3177).

The brown colour of the rocks, the presence of anhydrite nests and salt inclusions suggest that the rocks of the productive complex were accumulated under continental conditions with an arid climate. Occasionally, waters of reservoirs eroded the saline rock complexes. Climatic and topographic conditions at the time of sedimentation of the Kazan suite roughly corresponded to those presently observed in the region. The present sedimentation conditions are a rather arid climate with a sparse river network. Geographically, the region is, and was in Upper Permian time, in close proximity to the spurs of the Mugodzhars, which served as a source of sedimentary material and water as their transporting agent. Clastic rocks (gravelites, sandstones and clays) were brought down from the mountains by small rivers to form sand-rich channel deposits in the spring, and floodplain sediments were of a more clayey composition. Waters of small lakes, where clastic material was deposited, were salinized by contact with saline rocks in outcrops, and during hot dry summers this led to deposition of evaporites, which mixed with terrigenous rocks. Small lakes, abundant in the Caspian lowland, captured the main sedimentation of terrigenous rocks, and as a result were filled with sand and clay, and during summer heat period were enriched by evaporites intermixed with terrigenous material. Thus it can be concluded that the main sediments forming the productive sequence are fluvial (riverbed and floodplain) as well as lacustrine sediments from temporarily drying out reservoirs (Ibragimov, 2018; Zeng et al., 2022:215).

Conclusion. Thus, comparing the results of the two analyses, we can conclude that a high-quality kinematic processing of seismic materials is a prerequisite for further structural interpretations and the subsequent analysis of dynamic characteristics of the wave field. Incorrectly chosen parameters at some stages of the earlier processing (determination of static corrections and summing rates, filtration) may lead to distortion of reflecting horizons morphology in a complex geological structure and, eventually, to incorrect location of the designed borehole. The results indicate that, when locating production wells, it is advisable to determine its exact position not only from maps, but also from GMDS (ray migration) profiles. Use of optimal processing graph allowed performing the qualitative structural interpretations, to highlight tectonic disturbances, to specify the size of oil deposit in the Kazan strata and to determine its contact lines with salt, as well as to specify the position of eroded surface of Middle Jurassic.

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