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IDENTIFICATION OF PALEOCHANNELS IN THE UPPER MOSCOVIAN SEDIMENTS IN THE CENTRAL PART OF THE NORTH BOARD OF DNIEPER-DONETS BASIN (ACCORDING TO SEISMIC PROSPECTING DATA)

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КАРТУВАННЯ ПАЛЕОРУСЕЛ В МОСКОВСЬКИХ ВІДКЛАДАХ ЦЕНТРАЛЬНОЇ ЧАСТИНИ ПІВНІЧНОГО БОРТУ ДНІПРОВСЬКО-ДОНЕЦЬКОЇ ЗАПАДИНИ (ЗА ДАНИМИ СЕЙСМОРОЗВІДКИ)

The results of seismic-facies researches in the central part of the North Board of Dnieper-Donets Basin allowed the mapping of amplitude anomalies on the sections of seismic cube and the description of the river channels in the Upper Moscovian sediments of Middle Carboniferous.
Keywords: Carboniferous, seismic-facies analysis, paleo-channels, DDB, hydrocarbons, horizon slices

В результаті застосування сейсмофаціального аналізу в центральній частині Північного борту ДДЗ, на погоризонтних зрізах сейсмічного кубу закартовано амплітудні аномалії, описані, як палеорусла у верхньомосковських відкладах середнього карбону.
Ключові слова: карбон, сейсмофаціальний аналіз, палеорусла, ДДЗ, вуглеводні, погоризонтні зрізи.

INTRODUCTION

Ukrainian geologists started the successful investigation of the problem of hydrocarbons research in non-anticline traps in the Dnieper-Donetsk Basin (DDB) in the middle of the 1980's years. The study of the Central Part of the North Board of Dnieper-Donets Basin was started at that time. The Paleozoic rocks and the rocks of Precambrian base appeared to be the oil-gas bearing.

The number of sedimentary-paleogeomorphological deposits (channels, bars etc.) in DDB is not considerable, but their industrial significance is obvious.

The exact mapping of lithological and combine traps, facial diagnostic of accumulative objects of different genesis requires the usage of geological researches (stratigraphic and lithological study), complex of logging and seismic data, that enables to trace the extension of the accumulative objects, to analyze their shapes and proportions. It is important to determine the paleogeomorphological model of sedimentation of the accumulative (alluvial) objects. It means the study of the tectonic structure of the area, the channel slope, the thickness of sediments, the water flow dimension, the climate conditions, and the analysis of the geologic processes in the alluvial conditions (Ригби и Хемблин, 1974). When the essential direct lithofacies information is absent or insufficient, the indirect lithology-facial characteristic is used. For example, the difference between marine and channel sandstones can be recognized by configuration of resistance curves on the logging diagrams. Without textural and structural descriptions of the rocks these features cannot be used as the universal facial indicator. However, they play very important role in facial reconstructions, when the drilling data is absent. The majority of lithological objects were discovered during the exploration of anticline structural deposits, and researchers did not pay sufficient attention to their study. In case of the absence of drilling data, they play significant part in facial reconstructions. As the seismic researches were focused on the exploration of anticline structural deposits, the majority of lithological objects were discovered during their investigation.

The process of geological interpretation of seismic images and attributes enables the analysis of the configuration, space location of accumulative objects, as well as making conclusions about their genesis and forecast of potential hydrocarbon traps location. Besides of that, the seismic section study allows exactly characteristics of paleogeomorphological and tectonic conditions of investigated area during the different periods of the geological history.

Such mapping of the different local accumulative objects, for example, channels, bars, sand tongues and other accumulative forms, in complex with study of facial differences of geological section, allows the transformation of geological section prognosis to facial prognosis (Лукин и др., 2012).

Modern stage of development of the seismic-stratigraphic researches enables the definite recognizing of different types of seismic images of prognostic hydrocarbon traps, especially lithological and structural-lithological. Lithological and structural-lithological traps in the shallow and lake-alluvial sediments have complicated contours on the maps and small thickness. They are located in thin-beds parts of the geological section, where the contrast of acoustic rigidity between collectors and shale is not large. Besides, low resolution of seismic prospecting restricts the possibilities of traditional interpretation methods to map the lithological traps zones, alluvial bodies of channel genesis. Screening of such deposits is realized in zones of argillithation at the edges of paleo-shelf and along the rising of the beds. It is important, that channel sandstones don't lose their reservoir properties for the depth of 3 km (Нежданов, 2000).

MATERIALS AND METHODS

The area of seismic researches is located on the flat monocline side in the Central Part of the North Board of Dnieper-Donets Basin. In the South-West part of the area two deep wells were drilled: 1-Kadnitska and 1-Voskresenivska. The mapping of expected sand bodies, related to alluvial accumulative objects, was based on the results of 3D seismic prospecting and logging data. It was found for the interval of the Upper Part of the Moscovian Layer of the Middle Carboniferous (suites C_3^1 - C_2^7; producing horizons M-1-3).

The conditions of sedimentation of the major part of the Upper Moscovian Layer in DDB were subcontinental. The sediments consist of the layers of sandstone, argillite, rarely – limestone and coal of the alluvial-delta and lagoon facies. The upper parts of Moscovian Layer are represented by sea sediments. The structure of the C_2^7 suite on the North Board of DDB is mainly consists of the sea sediments. In wells 1-Voskresenivska and 1-Kadnitska this suite is represented by the alternation of thin (4 meters) layers of sandstone, siltstone, argillite and clay. The layer of sandstone of 15 m thick occurs only in the lower part of the 1-Kadnitska well. The thickness of the producing horizon M-2-3 in the well 1-Voskresenivska is about 86 m; in the well 1-Kadnitska – 92 m.

The upper strata of the Upper Moscovian part of the suite C_3^1 (producing horizon M-1) basically consists of the continental and lagoon sediments, rarely – the shallow sea sediments. In the wells 1-Kadnitska and 1-Voskresenivska this suite is represented by alternation of thin layers of sandstone, siltstone, argillite, clay, probably - coal. In the well 1-Kadnitska in the central part of the suite section the 8 m sandstone deposit is detected. The thickness of the producing horizon M-1 is about 58 m in the well 1-Voskresenivska and 68 m – in the well 1-Kadnitska.

For seismic-facial analysis, the seismic cube slices along the seismic horizon were used. These slices characterize the amplitude variations along reflective horizon or within the small time interval (2 ms), that can be identified by the thin layer (up to 5 m). This approach indirectly increases resolution of seismic prospecting and allows the usage of changing of seismic records field as petrophysical variations that are reflected in changes of acoustic hardness and amplitude anomalies appearing. Logical analysis of the seismic cube slices along reflective horizons permits the mapping of amplitude anomalies, connected with the lithology changes. It gives the possibility to analyze and to trace their extension within the interval of geological interest.

RESULTS

On the Fig. 1(a) on the seismic cube horizon slice within the interval of producing horizon M-1 we can see the amplitude anomaly, that looks like a modern channel of the meandering river. On the section across the parts of this anomaly (Fig. 1 b), c)) we can see, that seismic background has the special features in the tagged places. These features can be related to the channel hollows in the underlaying rocks. The channel has very meandering configuration and wide loops of meanders. On the seismic cube horizon slices it is traced within the interval of 45 ms. The channel configuration within this interval is preserving, the amplitude values of seismic wavelet are changing. General channel length is about 15 km, the predicted flow direction is South-West – toward depression.

On the Fig. 2 on the seismic cube horizon slice within the interval of producing horizons M-2-3 the amplitude anomaly can be also observed, that looks like a modern river channel. It is traced approximately within the area of previous anomalous object. Seismic background on the tagged part of the section has typical features, that can be detected as the channel hollows in the underlaying rocks. This channel has less meanders than the previous one. On the seismic cube horizon slices it is traced in the interval of 60 ms. Channel configuration within this interval is preserving, the amplitude values of seismic wavelet and anomaly intensity are changing. General channel length is about 10 km, the predicted flow direction, as in previous prognostic channel is South-West – toward depression.

The real river channels are characterized by the hollows in the underlaying rocks across and along the flow. On the Fig. 3 the curvatures of the seismic axes after the flattening on top horizon of Moscovian sediments can be interpreted as the longitudinal (a) and cross-cut (b) hollows in the underlaying rocks.

In case of insufficient accumulation of the terrigenous sediments within the channel, outside

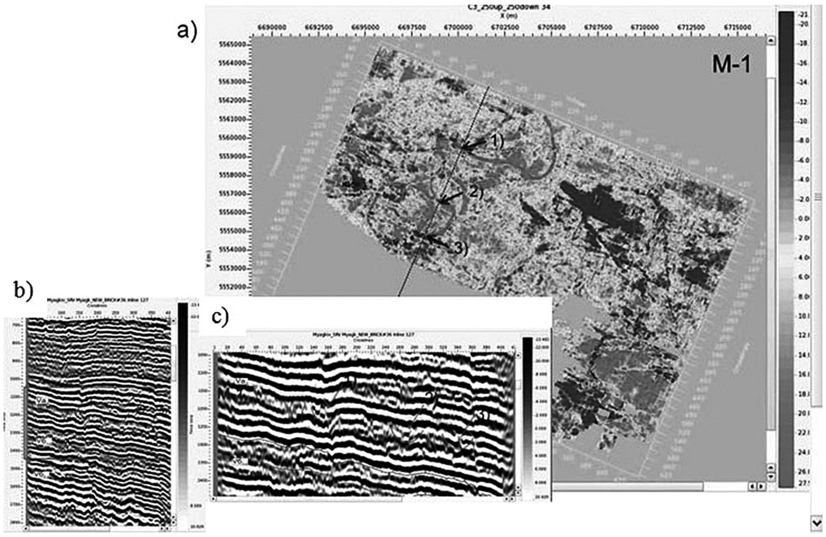

Fig. 1. Horizon M-1 amplitude anomaly imaging.
a – horizontal slice in the interval of productive horizon M-1, b – vertical section of the time migrated cube across anomalous areas, associated with paleochannels, c- expanded scale.

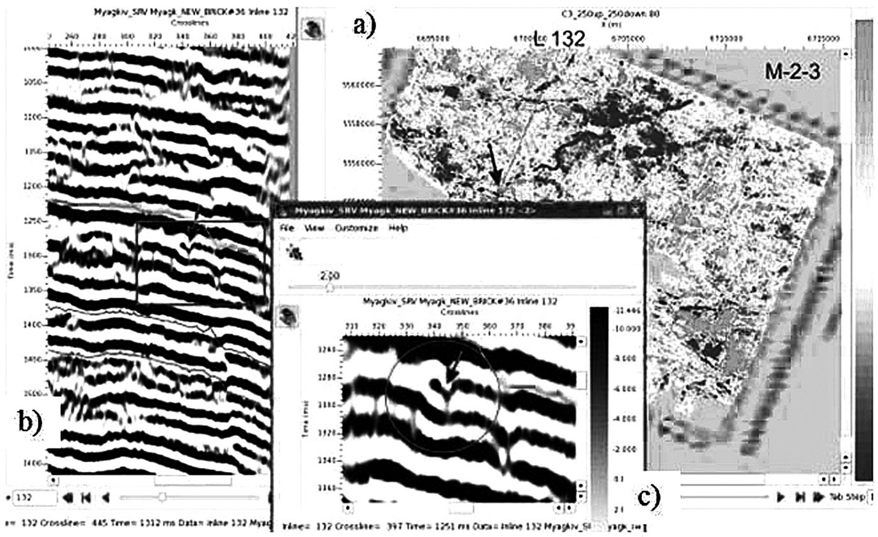

Fig. 2. Horizon M-2-3 amplitude anomaly imaging.
a – horizontal slice in the interval of productive horizon M-2-3, b – time migrated cube section across the anomalous area, c) expanded scale.

vertical parts of the hollows can be interpreted as a cover for uncompressed layers – predicted pools (Мартинюк та ін., 2013).

After comparison of all the contours of the prognostic paleo-flows on the combined map (Fig. 4), we supposed, that they characterize sequential levels (stages) of one river channel formed during the Late Moscovian age. The youngest predicted paleochannels (white lines on the Fig. 4) in the interval of producing horizon M-1 can be characterized as a meandering flow. The oldest predicted paleochannels (black lines on the Fig. 4) in the interval of producing horizon M-2-3 look like slightly meandering flows, joined in the South-West part of the area, probably on the gentle slope. This prognostic model, basically, agrees with the real structures of river channels of long-term forming on monocline slopes. In particular, the flows with wide meanders are forming and existing on the last stage of river system formation on the more plain relief, formed by extra sediments. According to such structure, prognostic river channel can be characterized by the next alluvial facies: alluvial sediments of meandering channels (channel of the horizon M-1) and alluvial covers, formed by coarse sediments of branched rivers (channels of the horizon M-2-3). Alluvial deposits of meandering channels include small amounts of hydrocarbon, concurrently the

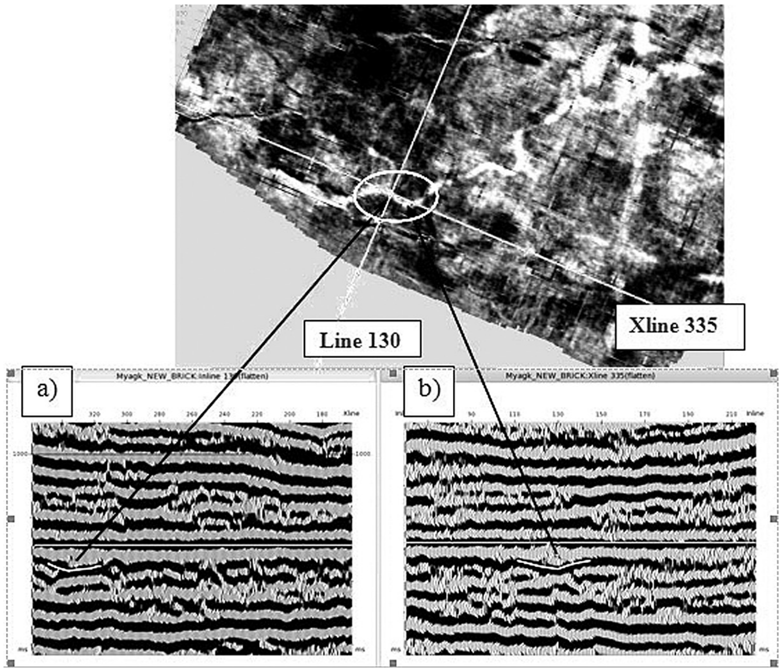

Fig. 3. Time migrated cube vertical sections.
a – longitudinal time section through prognostic paleochannel, b – cross cut through prognostic paleochannel.

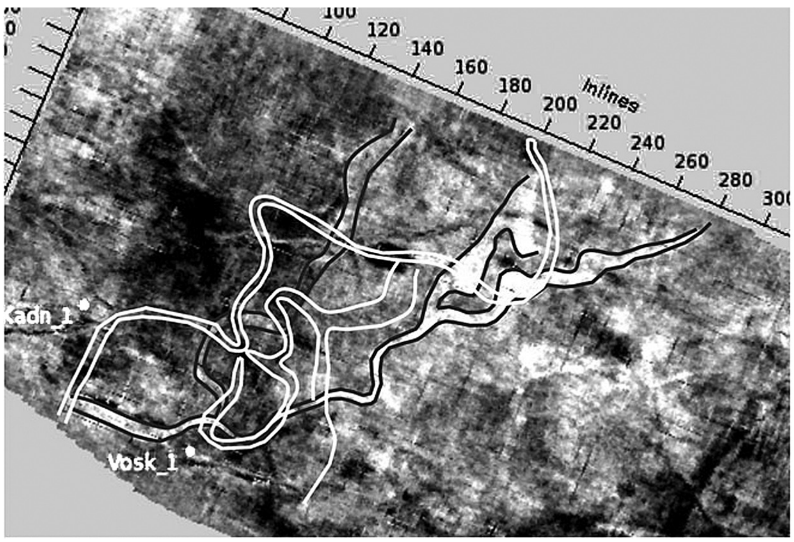

Fig. 4. Outlines of prognostic paleo-channels in sediments of productive horizon M-1 (white lines) and producing horizon M-2-3 (black lines).

alluvial deposits of branched rivers can consist of sandstone layers with high permeability (Мартинюк та ін., 2013).

Because of the absence of drilling information about the Later Moscovian sedimentation model on the area of the Central Part of the North Board of DDB, the results of seismic-facial analysis can be compared with the features of real river channels: one direction of the flow, hollows in the underlaying rocks and the sedimentation, meandering, branching, forming of the near-channels banks and valley sediments (Ригби и Хемблин, 1974).

CONCLUSIONS

The results of implemented seismic-facies researches made it possible to analyse the possibility of the prognosis of the extension of accumulative objects within the Central Part of the North Board of DDB on the base of seismic and logging data and connect it with the anomalous amplitude areas on horizon slices and vertical sections of the seismic cube. As the lithological, structural and textural rock descriptions are absent, the results of seismic-facial analysis allow the tracking of prognosis paleo-channels in the interval of the Upper Part of

Moscovian Layer of the Middle Carboniferous and hypothesize about it long-time forming within the joint river system. Prognostic objects are characterized on the seismic underground by meandering, longitudinal in single direction areas, by curvatures of the seismic axes on the vertical sections of the seismic cube, which can be described as the expected paleo-channels hollows in the underlaying rocks. Further additional researches will allow the detailed description of prognostic reservoir types: channel sandstone, near-channel banks, deposits, occurred in hollows, paleo-deltas, accumulative cones. As hydrocarbon reservoirs with effective clay covers are related to described alluvial objects, the applied approach can appear as a perspective for the facial researches on the monocline slopes of the board parts of DDB and for the prognosis and mapping of accumulative objects in Carboniferous sediments.

REFERENCES

Ivanyuta M.M., Fedishyn V.O., Denega B.I., Arsiriy Y.O., Lazaruk Y.G. (editors), 1998. Atlas of Oil and Gas Fields of Ukrainel. Lviv, *UNGA*, 1421 p. (In Ukrainian).

Bush D.A., 1977. Stratigraphic Traps in Sandstones. Exploration Techniques. Moscow, *Mir*, 215 p. (In Russian).

Ayzenverg D.E. (editor), 1988. Geology and Oil-Gas Content of the Dnieper-Donetz Depression. Stratigraphy. Kiev, *Naukova dumka*, 148 p. (In Ukrainian).

Martinyk L., Karpenko I., Okrepkiy O., 2013. The Perspective Seismo-lithofacies in the Carboniferous Sediments of the North Board in the Zone of Connection of Dnieper and Donets Sedimentary Basins for Non-traditional Hydrocarbon Deposits Exploration. Ukrainian Geologist, № 3, pp. 87-92. (In Ukrainian).

Muromtsev V.S., 1984.The Electromechanical Geology of Sand Bodies – Lithologic Oil and Gas Traps. Leningrad, *Nedra*, 260 p. (In Russian).

Nejdanov A.A., 2000. The Geological Interpretation of Seismic Exploration Data. Tyumen, *TyumGNGU*, 133 p. (In Russian).

Lukin A.E., Korjnev P.M., Naumenko A.D., Okrepkiy S.V., 2012. The Problem of Sand Bodies Facial Diagnostics and Methods for it Solution. Geological Journal, № 2, pp. 7-21. (In Ukrainian).

Rigby J. Keith, Hamblin Wm. Kenneth (editors), 1974. Ancient Sedimentary Environment Conditions and their Recognition. Moscow, *Mir*, 323 p. (In Russian).

Krawczynski Lukasz, 2004. Sequence stratigraphic interpretation integrated with 3-D seismic attribute analysis in an intracratonic setting: Toolachee formation, Cooper Basin, Australia; Master's Thesis. Queensland, *Queensland University of Technology, School of Natural Resource Sciences*, 186 p.

Атлас родовищ нафти і газу України / [М. М. Іванюта, В. О. Федишин, Б. І. Денега та ін.]. – Львів: УНГА, 1998. – 1421 с.

Буш Д. А. Стратиграфические ловушки в песчаниках. Методика исследований / Д. А. Буш. – Москва: Мир, 1977. - 215 с.

Геология и нефтегазоносность Днепровско-Донецкой впадины. Стратиграфия / [Д. Е.Айзенверг, О. И. Берченко, Н. Е. Бражникова и др.]. – Киев: Наукова думка, 1988. - 148 с.

Мартинюк Л. Перспективні сейсмолітофації в кам'яновугільних відкладах північного борту зони стикування Дніпровського та Донецького осадових басейнів при пошуках покладів нетрадиційних вуглеводнів / Л. Мартинюк, І. Карпенко, О. Окрепкий. // Геолог України. – 2013. – №3. – С. 87–92.

Муромцев В. С. Электрометрическая геология песчаных тел - литологических ловушек нефти и газа / В. С. Муромцев. – Ленинград: Недра, 1984. – 260 с.

Нежданов А. А. Геологическая интерпретация сейсморазведочных данных / А. А. Нежданов. – Тюмень: ТюмГНГУ, 2000. – 133 с.

Проблема фациальной диагностики песчаных тел и пути ее решения / А. Е.Лукин, П. М. Коржнев, А. Д. Науменко, С. В. Окрепкий. // Геологический журнал. – 2012. – №2. – С. 7–21.

Ригби Д. Условия древнего осадконакопления и их распознавание / Д. Ригби, У. Хемблин. – Москва: Мир, 1974. – 323 с.

Krawczynski L. Sequence stratigraphic interpretation integrated with 3-D seismic attribute analysis in an intracratonic setting : Toolachee formation, Cooper Basin, Australia: Master's Thesis / Krawczynski Lukasz – Queensland: Queensland University of Technology, School of Natural Resource Sciences, 2004. – 186 p.

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