New areas of work related to search of large deposits of hydrocarbons in DDD

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Based on the research of geological structure, gas content, and facies analysis of reservoir formations of Kobzivske gas condensate field a forecast was made for distribution of the lithologically screened traps to search for natural gas deposits in Lower Permian - Upper Carboniferous build-ups on the monoclinal slope s of Zhovtneva area and Hryhorivskyi depression. The recommendations for 3D seismic surveys are justified, and the forecasted gas resources of prospective targets are estimated.

Key words: Kobzivka gas field, Oktiabrska area, Hryhorivskyi depression, lhitologically screened traps, gas deposits, resources

Over the past 30 years only one large gas condensate field, Kobzivka, with initial reserves and prospective resources of gas reservoir estimated at over 40 billion m3 [1], was opened in the Dnieper-Donets basin due to exhaustion of the fund of large non-drilled anticlinal structures and a high level of initial development of oil and gas resources of the basic oil and gas-bearing complexes.

The field is unique in that it first clearly demonstrated the possible existence of lithologically screened deposits in sediments of Kartamysh strata of the Lower Permian-Upper Carboniferous in non-structural conditions. This allows defining a new direction of exploration, i.e. search for hydrocarbons in the Lower Permian – Upper Coal Complex in non-anticlinal traps in the depression areas.

Understanding the geological structure peculiarities and deposit accumulation conditions which contributed to the formation of gas deposits at Kobzivka GCM allows predicting the presence of gas deposits in similar geological conditions and identifying the new areas (territories) for exploration.

Kobzivka gas condensate field (GCF) is tectonically located in the Near-axispart of the Central Graben of the Dnieper-Donets depression (DDD) and is dedicated to roller-like raising between Oktiabrska and Kegychivsk elevations.

Kobzivka structure, judging by the reflecting horizons in the Paleozoic, is an asymmetrical pleated brahianticlinal fold of sublatitudinal stretch with the size of 18×8 km in the Lower Permian – Upper Coal Complex sediments (limestone Q_8 at the bottom of Mykytivka strata). The fold is characterized by plicative nature of the structural form, and the absence of ruptures s in sediments of the underlying Lower Permian – Upper Coal Complex.

The southern wing of Kobzivka structure is immersed into Grygorivka synclinal basin, the northern wing – into the South-Sosnivka basic; it opens towards Kegychivka anticline through a narrow saddle (the amplitude of the arch from the saddle level is around 80 m) in the east, and it borders with the northern wing of Oktiabrska structure in the west (Fig. 1).

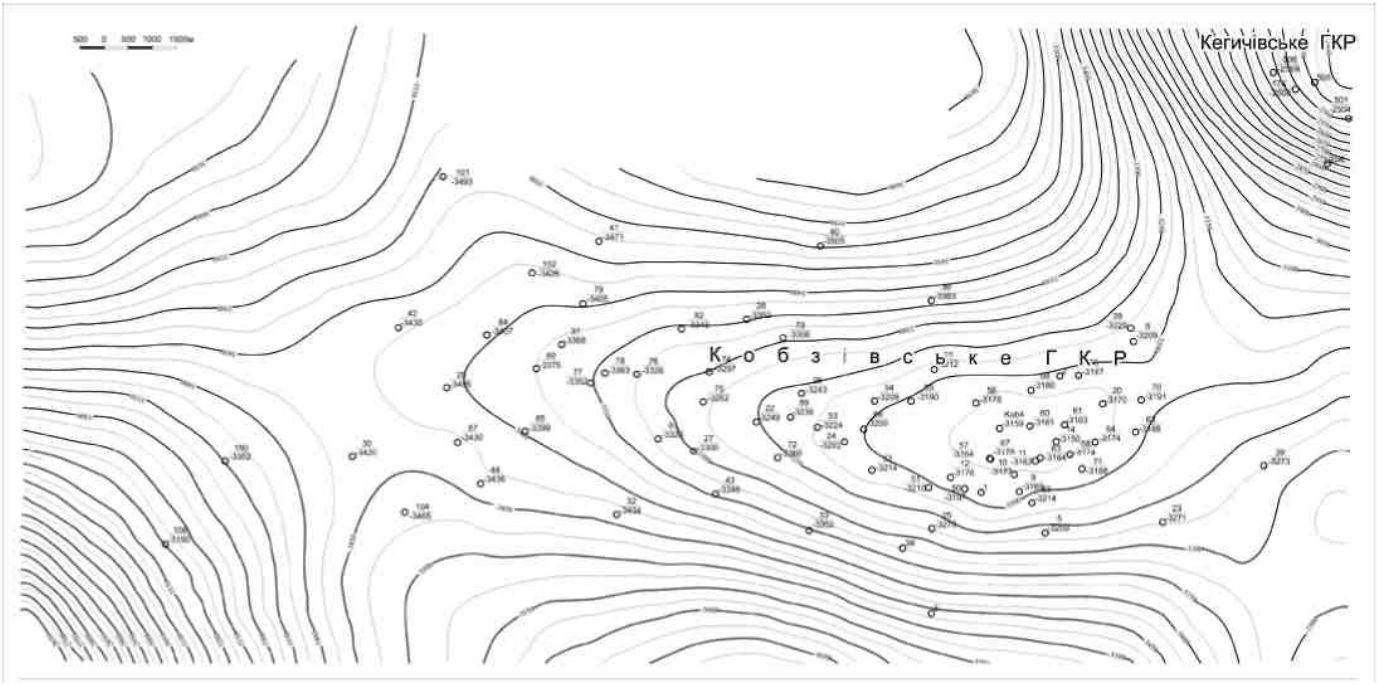

Fig. 1. Kobzivka GCM. Seismic structural map by the reflecting horizon of IV $_{G2}$

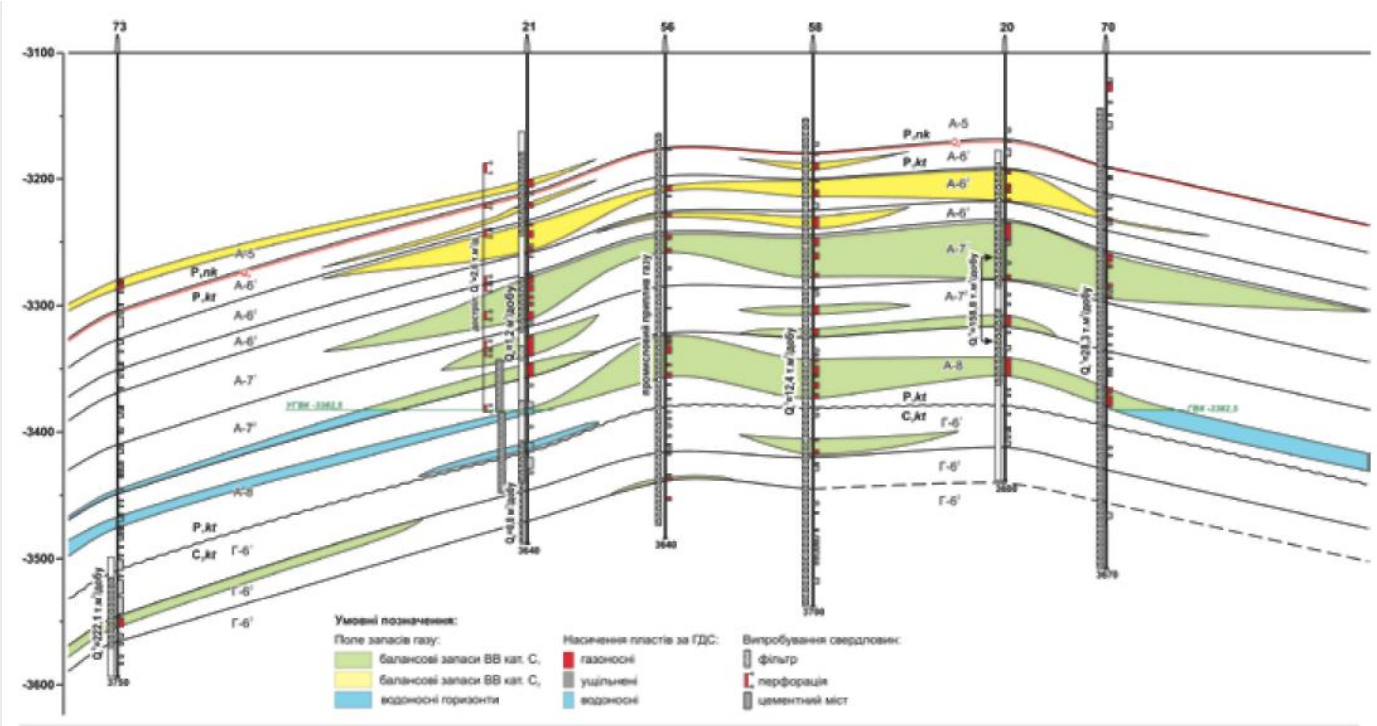

Fig. 2. Kobzivka GCM. Schematic geological section along the well line 73-21-56-58-20-70.

78 wells were drilled in Kobzivka field, which confirmed the commercial gas bearing of Kartamysh strata of the Lower Permian and Upper Carboniferous between which there is a stratigraphic inconsistency, i.e. Melykhiv erosion.

Upon calculation of the field commercial reserves in the gas-bearing thickness, the productive horizons were conventionally broken down into subhorizons, in the Lower Permian sediments A-5 (P1nk), A-6, A-7, A-8 (R_1^{kt}) and G-6 in the sediments of the Upper Carboniferous (C_3^{kt}). The stocks were counted for each subhorizon separately.

In fact, Kobzivka field combines two condensate deposits in fundamentally different types of traps.

The gas condensate deposit in sediments of Kartamysh strata of the Lower Permian is confined to the vault-like part of Kobzivka brahianticlinal fold (Fig. 2) and is analogous to the corresponding deposits or Permian parts of deposits of the Western Khrestyshche, Yefremivka, Melyhivka, Lannivka and all other fields of Mashivka-Shebelynka zone of large deposits of the south-eastern part of the PPD with massive stratal deposits in terrigenous sediments of Permian-Carbon well under the chemogenic cap.

The characteristic features of these deposits is the presence of a large number of low-capacity interlayers of gas-saturated sandstones and siltstones in the predominantly clay strata in the section, total or partial lithologic restriction of the reservoir development fields in the area and in the section, a conventionally single gas and water contact with the possible presence of lithologically limited interlayers with jammed waters.

The collectors in Kobzivka field are sandstones and siltstones. Sandstones are usually brown, mostly thin- and fine-grained, loamy. The fine-grained sandstone layers often contain the interlayers of sandy gravelites. Judging by the descriptions of species, conducted by UkrNDIgaz specialists, the polymictic and field spar-quartz differences are prevailing, and the olygomict sandstones are rarer. The sandstone cements are predominantly argillaceous, kaolinite-hydromicaceous, rarer carbonate-clay; their type is loop-like, incompletely porous, porous, basal porous [2, 3].

As a result of the study of reservoir properties of the reservoir rocks and facies analysis it was concluded that the rocks of Kartamysh strata of Kobzivka deposit are represented mainly by deposits of surface and underwater part of the delta formed during the movement of terrigenous material from the southern board zone of DDD. It also indicates the presence of deposits of discontinuous flows and alluvial deposits of the meandering rivers.

An absolute mark of the conventional gas and water contact of the gas condensate deposit in sediments P_1^{kt} is -3,382.5 m and the apical position of the foot of Mykytivka strata confirmed by drilling (limestone Q_8) is 3,150 m (well 14). Thus, the total floor level of the gas content is more than 240 meters.

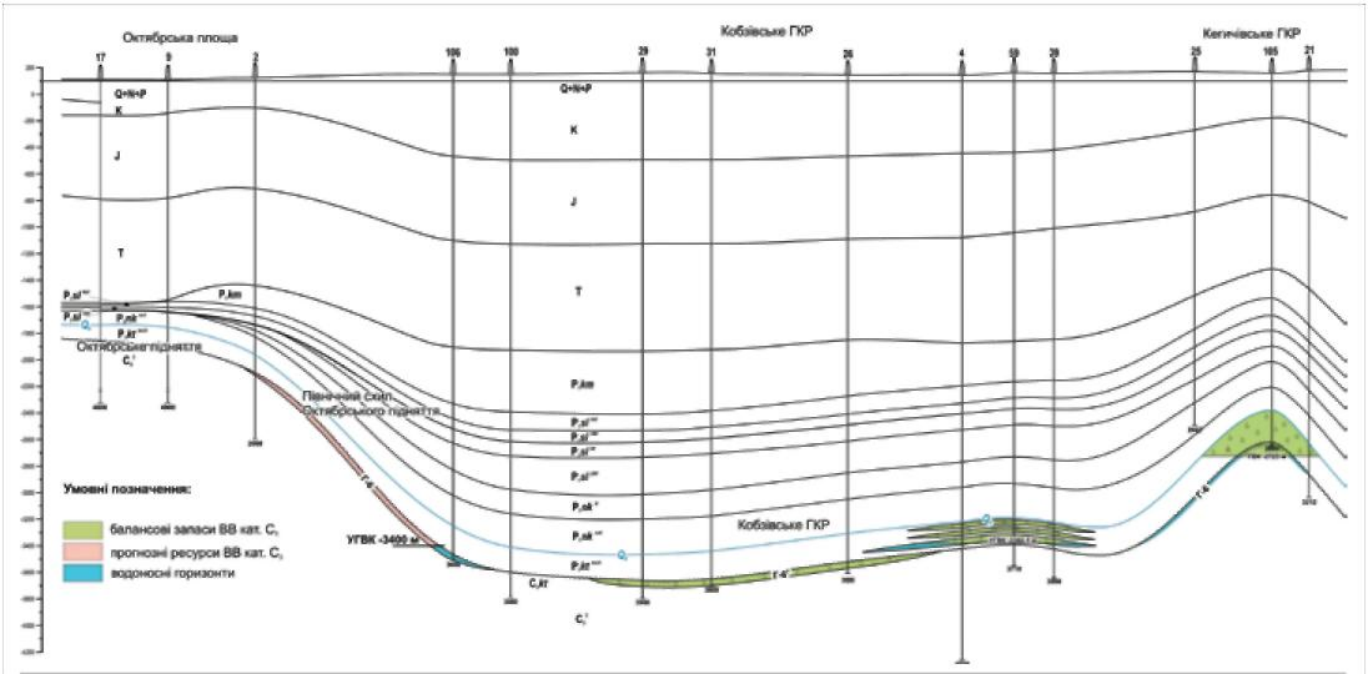

Fig. 3. Schematic geological section along the line II-I

The reservoir holds about a third of the initial gas reserves of C_1 category of Kobzivka field.

In the western part of Kobzivka GCM there was found the largest deposit reserve, i.e. deposit of horizon G-6, confined to the combined layered lithologically-screen trap of the fairly complex configuration. The reservoir occupies the western periclinal of Kobzivka elevation and extends through the saddle to the northern slopes of Oktiabrska elevation. The G-6 horizon deposit contains four layers, the most seasoned of which by area is G-62 subhorizon. Its collector holds 95% of the initial recoverable reserves of gas deposit C_3^{kt}. As regards the extension, the deposit is limited to lithologic screens in the arch-like part of the fold and in the west periclinal near the saddle between Kobzivka and Oktiabrska elevations (Fig. 3) and with conventional gas and water contact with an absolute mark of -3667 m at layers' immersion in the wing parts.

The location of such a large area of hydrocarbon deposit beyond the structural trap indicates the special conditions of sediment accumulation, generation and preservation of hydrocarbons.

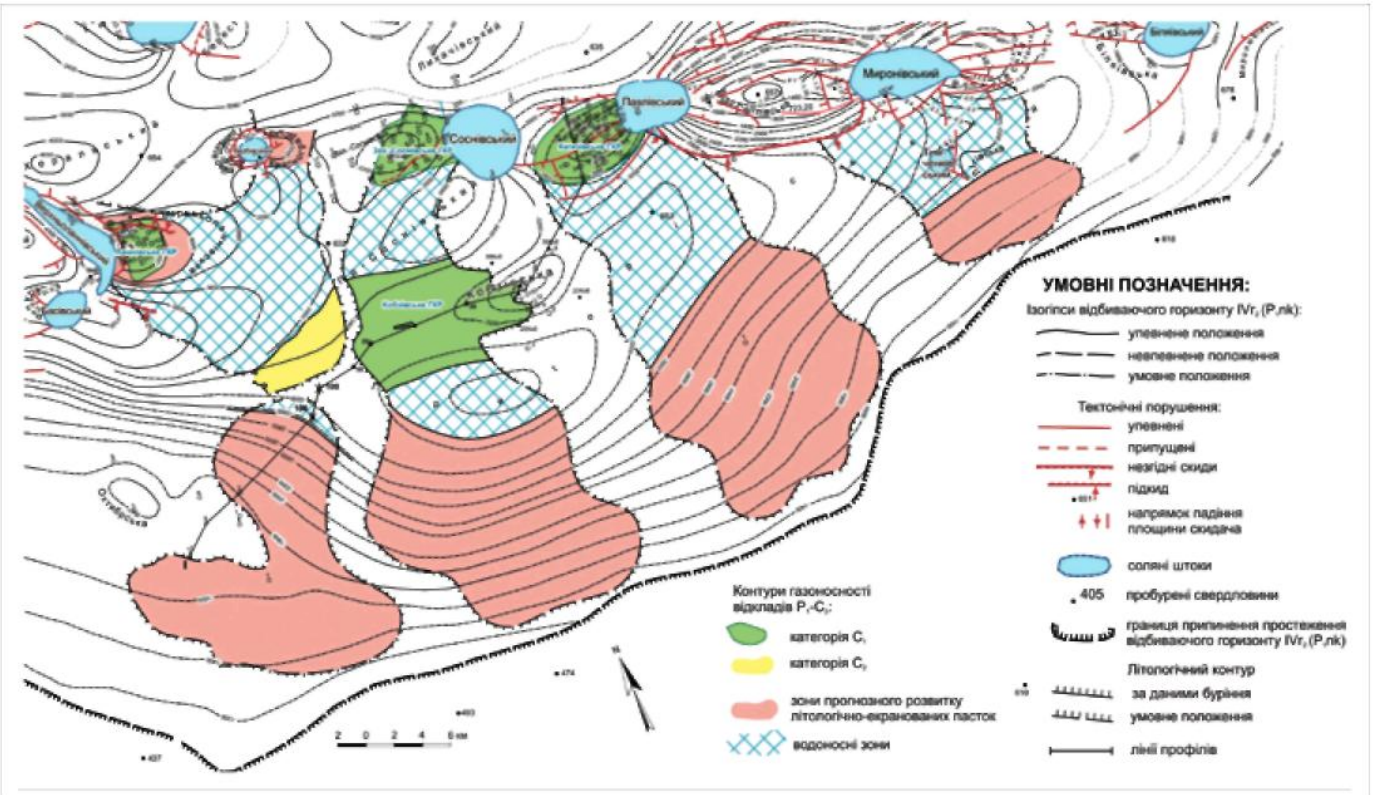

Fig. 4. The southeastern part of DDD. The structural map by reflecting horizon IV $_{r2}$(P_1nk)

The presence of the inconsistency within Kartamysh strata (Melykhiv erosion) leads to a significant change in its total capacity up to the complete erosion of the Upper Carboniferous part of the strata (C_3^{kt}), as evidenced by a number of wells outside the field, where the red deposits of Kartamysh strata of the Lower Permian are placed directly on the grey araucaritic strata of the Upper Carboniferous. Change of the sedimentation regimes (transgression-regression cycle) led to changes in spatial streams on the border between land and sea, and, accordingly, the position of sandstone bodies.

The coastal sea conditions were favorable for the formation of sand-alevritic alluvial, talus, deltaic sediments, which are the reservoirs containing the gas deposits. In the area of the Kobzivka structure location during the Kartamysh epoch there was the flow unloading zone directed from Oktiabrska horseback to Grygorivka deflection.

It is possible that during the correlation of sections of wells of the different fields the Permian and Carboniferous boundary within a fairly uniform cut of the Kartamysh strata is accepted by mistake and the sandstone of horizon H-

62 indexed in Kobzivka field is nothing but a basal sandstone of Permian sediments. This opinion is prompted by its consistency within the development field in view of the lithological limitations in general, better separation of grains than in the other layers, as well as the improved and sustained reservoir properties.

At the Lannivkam Western-Khrestyshche, Western-Sosnivka, and Kehychivka fields located in this zone the gas content within the anticlinal structures of sandstones are indexed differently, but are correlated satisfactorily with H-62 horizon of Kobzivka field.

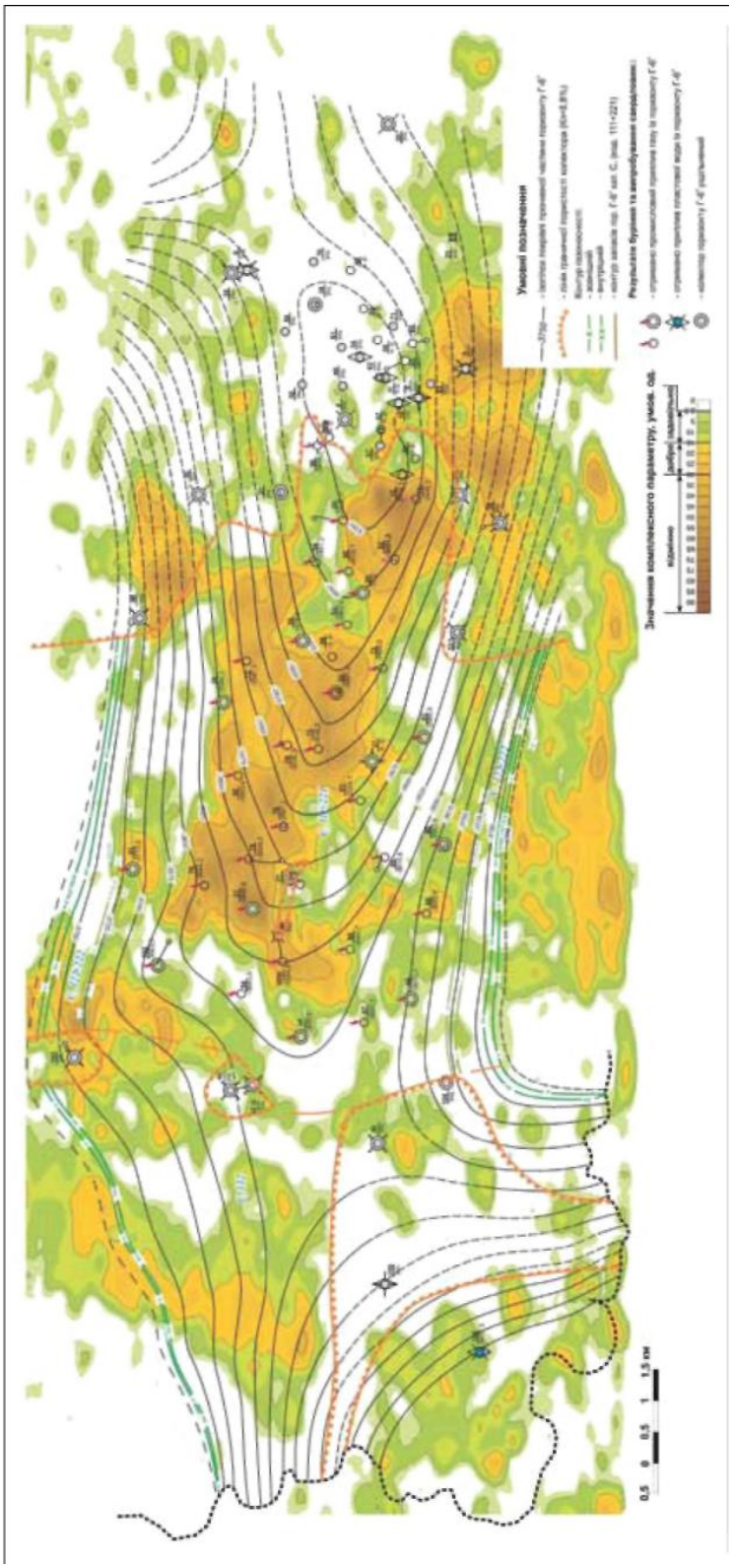

Fig. 5. Kobzivka GCM. The map of distribution of the complex parameter in the range of 28 to 42 msec over the reflecting horizon $V_{a,}$ (C_3, Kt)

However, the opening of Kobzivka deposit showed that the significant reserves of hydrocarbon deposits may not necessarily be confined to the anticlinal structures in this part of DDD. This fact opens up new perspectives and ways to search for hydrocarbon deposits.

Based on the peculiarities of the sediment accumulation at Kobzivka GCM, the genesis of reservoir rocks and taking into account the presence of the gas deposit far beyond the apical part of Kobzivka anticline, we can predict the distribution of gas reservoirs located next to the structural elements, especially in the western part of Kobzivka GCM on the northern slope of Oktiabrske elevation behind the saddle between them. GCS Ukraine justified and approved the gas reserves in the amount of 9.4 billion m^3 of category C2 (code 332) within this zone.

Most likely, this zone is separated from the main deposit of H-62 horizon with a lithological circuit at Kobzivka field, as evidenced by drilling of wells 100, 30, 42, 42-bis. The availability of the lithologically-screened traps in this area may be due to sedimentation of flows transferring the terrigenous material from the west.

Based on the analysis of the results of drilling of wells 100, 30, 106 at Kobzivka GCM, the data of stratigraphic partitioning and testing of wells at Oktiabrska area, there was found no $C_3^{И}$ deposit at Oktiabrska area and the availability of a collector in these sediments on the slope of Oktiabrska elevation (well 106, Kobzivka), indicating the possible existence of lithological-screened traps on the slope of Oktiabrska elevation [5].

The projected growth of collectors on the slope of the southern board monoclinal can be associated with the alluvial and diluvial deposits of surface and underwater part of the delta, sediments of riptide flows and alluvial sediments of meandering rivers formed during the movement of terrigenous material from the southern board zone of DDD. So, here were the necessary conditions for the formation of lithologically-limited and lithologically-screened traps for gas accumulation in alluvial and diluvial sandy-alevritic sediments.

On the slope of Grygorivka deflection there were identified three promising area to search for hydrocarbon deposits in lithologically-screened and lithologically-limited traps (Fig. 4):

1) on the southern slope of Grygorivka deflection opposite to Kobzivka GCM. The existence of deltaic sediments as an extension of the revealed delta within Kobzivka GCM in this zone is not excluded;

2) on the southern slope of Grygorivka deflection opposite Kegychivka GCM;

3) in the eastern part of Grygorivka deflection in the area of Tymchenkivka rod.

The development of reservoir rocks of the "stain" nature is supposed within the projected zones. Judging by the rise and extension of strata, the predicted traps should have a lithologic screening, as well as lithological screening or a gas and water contact on submerged strata. The configuration of traps within the allocated prospective zones can have any shape, depending on the plane development of reservoir rocks, so their prediction requires special seismic studies.

To predict the spatial development of reservoir rocks, i.e. traps for gas accumulation, it is recommended to conduct the seismic 3D works subject to construction of thin-layered models of reservoir rocks porosity and development within the promising areas. An example of the successful application of this technique is Kobzivka GCM, where UKRNAFTA-gazgeofizyka CJSC conducted 3D seismic works in 2006. The cards of porosity, sandiness, complex parameter etc., built according to the productive part of the cut in sections every 28 m (14 ms), were the basis for the selection of places to lay the new exploration wells. The results of drilling wells generally confirmed the forecast of reservoir rocks development. For example, the map of distribution of the complex parameter for 28-42 ms interval over Va1 reflecting horizon in the foot of C_3^{kt} sediments, corresponding to the interval of occurrence of the main productive horizon H-62, highlights the areas of reservoir distribution in the western periclinal of Kobzivka fold and the zones of deterioration of reservoir properties in the apical part of the structure, as well as in the saddle between Kobzivka and Oktabrska elevations (Fig. 5). The drilling results confirmed such distribution of reservoir rocks.

The successful use of 3D seismic work materials at Kobzivka GCM indicates that this technique is promising and needs to be used for the prediction of collector rocks distribution and contour determination of the predictive lithologic traps.

The area of the southern monoclinal slope of Grygorivka deflection has the significant projected reserves and resources of gas calculated by the density of gas reserves of category C1 on H-62 horizon in Kobzivka GCF as 295 million m^3 per 1 km^2 of area.

The gas resources in four projected areas on the southern monoclinal slope of Grygorivka deflection, based on their size and density of the adopted inventories, represent over 180 billion m^3 of gas. It is clear that the entire area of the allocated promising zones will not be gas bearing. This is only a zone within which it is possible to open separate hydrocarbon deposits.

List of References

1. **Benko V.M.** Kobzivka GCM - the main object of exploration works, gas production expansion and increase of resources of Ukrgazvydobuvannia SE / V.M. Benko, V.V. Dyachuk, M.I. Machuzhak [et al.] // Problems of Ukraine's gas industry development: Collection of scientific papers. - 2007. - Vol. XXXV. - P. 7-13.

2. **Lahutyn A.A.** Lithology and capacitative fitration properties of alevritic-sand rocks of Kartamysh strara of Kobzivka deposit based on the core studies / A.A. Lagutyn, S.F. Poverennyi, V.N. Buhtatyi, O.Y. Stepanov // Problems of Ukraine's gas industry development: Collection of scientific papers. - 2007. - Vol. XXXV. - P. 13-18.

3. **Kryvulia S.V.** Structure and facial features of lithologically-screened deposit of productive horizon H-62 of Kobzivka gas condensate field / S.V. Kryvulia, A.A. Lahutin, A.V. Zahorodnov [et al.] // Exploration and development of oil and gas fields. - 2012. – No. 3 (44). - P. 135-144.

4. Stratigraphy of USSR / T.Y. Lapchyk. - K.: Scientific opinion, 1970. - 246 p. - Vol. VI. - Part 1.

5. **Kryvulia S.V.** Lithologically-screened and structural-tectonic traps in P1-C3 deposits in the Central Graben and southern board zone of the southeastern PPD / S.V. Kryvulia, A.A. Lagutin, O.S. Minosyan [et al.] // Bulletin of Karazin National University of Kharkiv. - 2012. – No. 997. - P. 44-50.

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