Subsalt Complex of Upper Jurassic Deposits as Long-Term Reserve for Development of Oil and Gas Complex of Chechen Republic

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***Abstract*—The general appearance and frequency of placement of folds in space are likely to influence the wave nature. Postsedimentation transformations of hard carbonate strata of the upper Cretaceous, caused by such stresses, have a clear periodic *character*. Formalized shape of the normalized indicators of secondary heterogeneity of the borehole sections in the region serves as an indicator of the position of the slit on various elements of a complex fold-fault dislocation. This is considered one of the forecast factors for traps and deposits.**

Keywords—wave stresses; folded deformation; secondary emptiness; periodicity; forecast

I. Introduction

A structural-tectonic appearance and oil-and-gas bearing of Terek-Sunzha of the folding zone today are described on the whole and in the numerous detailed aspects. The tectonic position of the folding zone is unchanging taken to the south side of the Terek-Caspian trough (to its western part). The folding zone, as a rule, consists of selection of some linear anticlinal zones divided by extensive synclines.

At a certain stage of intensive geologist-geophysics research, ideas cardinally changed about the structure of synclinal zones and their deep immersion sides. All these objects are intensively complicated by folds and breaks. Together with anticlinal zones, these deformations create the picture of the dense filling of all space on many structural and stratigraphic horizons. In the forefront, there are problems of regularity of placing of folds, their size rows, sequence of changing of deformations in space, their relative hypsometric position. Forming of ideas about all complexes of morphological, physicomechanical and many other descriptions approaches creation of models of their nature, origin and development.

II. Approaches to Formalization

The main criterion of presence of beds of hydrocarbons in a region is structural traps; they stipulate forming of secondary crack collectors in carbonate layers and in other lithologic differences. Variants of formalization of morphology of folds and folding, lithologic-physical, fluid dynamic indexes are revealed, which open new parts of structure and oil-and-gas bearing of the folding area.

The authors of the article as a result of treatment of the structure, spatial placing, oil-and-gas content of structures-traps marked the signs of organization of properties of objects as sets (ensembles, systems) of some size levels; consequently, objects are conditionally discrete on many descriptions [1,6,7].

Belonging of folds and folding zones to the general structural association determines high prognosis efficiency of analysis of distribution and intercommunications of morphological indexes of folds. In addition, fractal sense of association stipulated a priori base line of morphology of structural elements of the system - discreteness of distribution of values of morphological indexes. Empiric constructions confirm this position in a great deal.

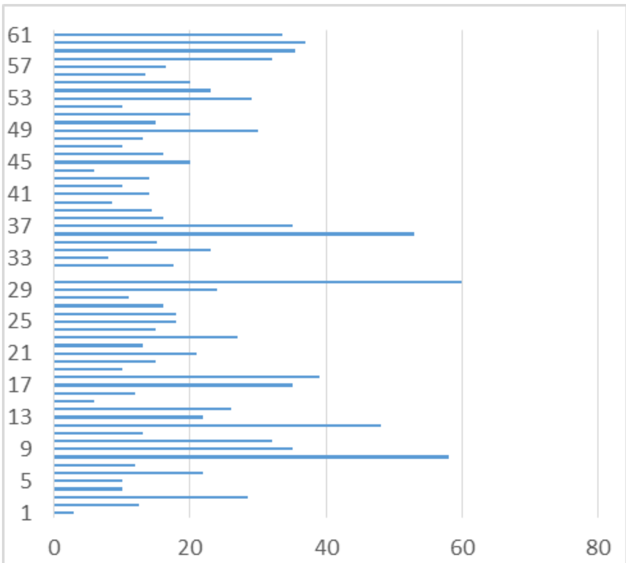

Fig. 1. Chart of ungrouped fold values of Upper Cretaceous of the Terek-Sunzhensk folded zone

The diagrams of frill values of length of folds and dependence of length and line of folds of overhead chalk (fig. 1) show that length of folds changes from 4-5 to 60 km (at a width from 1 to 5 km) and the step is reflected. The next middle size levels of length of folds (km) are set: 3, 10, 18, 24, 38, 52, 60. They must be examined among other indexes of the certain system of morphology of plicate deformations and taken into account during construction of structural maps from geological and geophysical data.

On the diagram there is dependence of length and linearity of folds of overhead chalk (fig. 2) for folds of up to 25-30 km with an increase in the linearity of structures; at greater length the linearity increases considerably less than approaching a certain critical size.

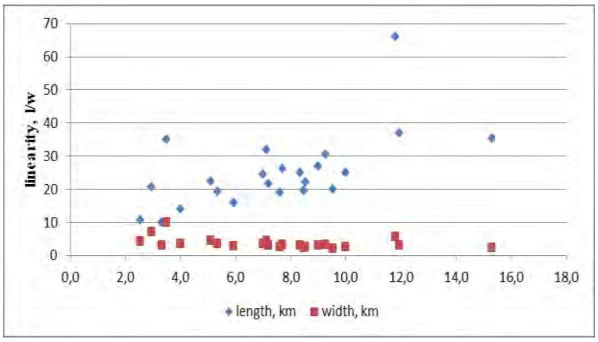

Fig. 2. Diagram of the length and linearity of the folds of the Upper Cretaceous of the Terek-Sunzhensky folded zone

Values of the vertical stages, the mirrors of folding (on the lines of transversal profiles), accommodated in the ranged row, distinctly form a group in discrete sets often near geometrical or arithmetic regressions. In one of profiles all set of values of the stages of hypsometry of vaults of nearby anticlinal bends are lined up in a sequence of 0; 300 (in some cases 400); 600; 900 (850) m. On other profile, the successive row of values of the stage looks like: 0 (0-100); 350-400; 500; 1300; 1800-1900; 2000-2100. Overall, on many transversal profiles the row of values of the stages is near to simple progression with the interval of values of 0-2400 m and by a step of 300 m.

Probabilistic connection of the vertical stage of mirror of folding (ΔH) and relative increase of distance (Δb) between nearby anticlinal bends (on transversal profiles) is near to parabolic (crowd conditions of connection - 0,87). By a form near to linear, this dependence becomes in space of natural logarithms (fig. 3); the size of ln (ΔH) is shown on horizontal and vertical lines of ln (Δb).

The points of the considerable moving away from the linear form of connection have the explanation. So, between Hayan-Court and Mineral folds there must be another anticlinal bend, independent fold to the west Goryacheostrochnensk (Hawk's) of raising. The position of this raising on the whole is observed on nearby profiles. The sizes of them are controlled by probabilistic connections between the basic morphological parameters of folds, *where B_1 is a width of track of fold (with that calculations begin); m is an amount of discrete groups; N_1, N_2, N_m - amount of folds of every group; k - a coefficient of correlation of B in a discrete row; P_1 - length of track of fold; t is a coefficient of correlation of P in a discrete row ; ΔH_1, ΔH_2, ΔH_m - values of the stages, the mirrors of folding, found from expression (2) on corresponding k*B.*

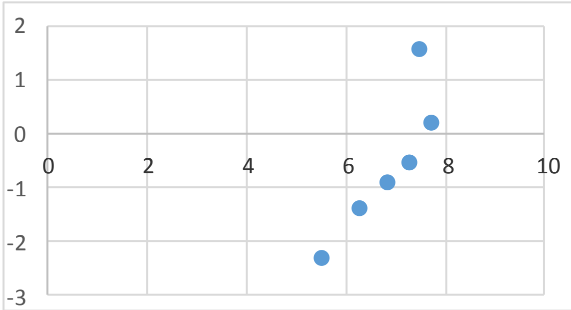

Fig. 3. Form of connection of ln (ΔH) and ln (Δb)

In the review of morphology of folds, two very informing index are involved: intensity sweet (attitude of height towards an area, m/km^2), linearity (coefficient of lengthening). The first is used in many works for analysis of the oil-and-gas bearing in both platform areas and folding zones. In Pre-Carpathians trough, Dnepr-Donetsk hollow, Pripyat trough the size of intensity forecasts anomalousness of strata pressure. Intensity is reflected in the tectonic compression of layers in the process of folding. The linearity has been already mentioned, it is related to length of folds. At the same time, connection is not traced with intensity; these two indexes reflect different parties of deformation of layers.

Information is presented in table 1 - separately on anticlinal zones and syncline.

The intensity of the folds of the Terek (Fig. 4) and Sunzha (Fig. 5) zones differs markedly; in the synclinal zone, the folds may have comparable intensity. Wrapping covered all zones.

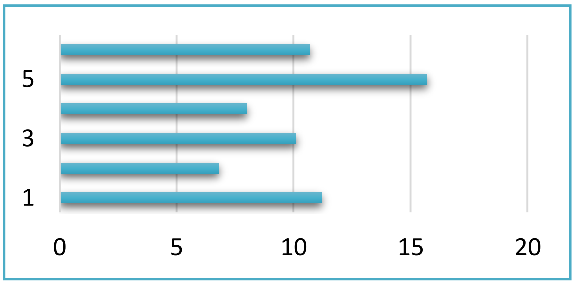

Fig. 4. The intensity of the folds of the Terek zone

There was a definite link between the hypsometry of the folds and intensity. There is a direction of increase in intensity with an increase in the absolute values of hypsometry. But it manifests itself at two levels - at relatively high and lower values of intensity.

TABLE I. THE MAIN MORPHOLOGICAL PARAMETERS OF FOLDS OF TEREK-CASPIAN TROUGH

Folds	**Intensity - height of area, m / km^2**	**Linearity - length of width, m / m**	**Degree of plicative complexity**
Folds of HC traps "tops" of the Priterechnaya anticlinal zone			
Right Bank	5.6	7.1	
Chervlennaya	11.78	3.5	
Folds of HC traps "tops" of the Terek anticlinal zone			
Akhlovskaya	11.2	7.2	
Malgobek-Gorskaya	6.8	11.8	
Eldarovskaya	10.1	9	
Goryacheistoch-nenskaya	15.7	10	Plicative form of medium complexity (superimposed closed and unclosed complications)
Khayan-Kortovskaya	8	16.3	Complex plicative form (small superimposed closed complications)
Bragunskaya	10.7	11.9	
Gudermes		8.3	
The folds of the hydrocarbon traps of the wings of the Terek anticlinal zone			
North Malgobek	2.5	5.1	
Forest	6.5	2.5	
Mesketinskaya	8.4	9.5	
Mineral	11.1	5.9	
North Mineral	6.6	8.3	Plicative form of medium complexity (superimposed closed and unclosed complications)
The folds of the hydrocarbon "tops" of the Sunzha anticlinal zone			
Zamankul	12	5.3	
Karabulak-Achalukskaya	14.9	7	
Sernovodskaya	7.2	8.5	
Starogroznenskaya	9.2	9.3	
October	16.2	7.7	Simple plicative form (superimposed unlocked complications)
Alkhanchurt		4.8	
The folds of the hydrocarbon traps of the wings of the Sunzha anticlinal zone			
Andreevskaya	11.1	7.6	
Folds - traps of hydrocarbon of Petropavlovsk syncline			
Hankala	9.5	8.5	
North Dzhalkinsky	2.5	3	
Folds - traps of hydrocarbons of the Montenegrin monocline			
Benoy	7,6	4	No complications found
Datyh	15,7	3,3	

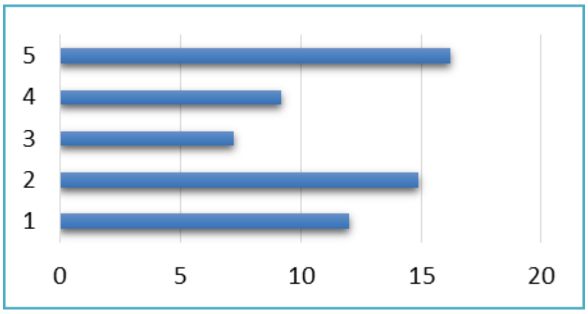

Fig. 5. The intensity of the folds of the Sunzhen zone

Some of the mentioned values and quantitative links between them need to supplement and expand the evidence base, study new relationships, build private and general models, new predictive conclusions. The data on studies of the structural features of hydrocarbon traps, fissure and fissure cavern reservoirs, contained in the publications, are used.

The systemic multi-level organization of location of objects has recently been noted in relation to the fractured zones of the productive carbonate massifs of the Timan-Pechora oil and gas provinces (OGP) and sandy layers of the West Siberian OGP [9]. The Layered-block discrete structure of fractured reservoirs, forming an organized integral system of 10 hierarchical levels, has been determined.

The discrete layered-block structure of reservoirs in the Mesozoic terrigenous rocks of the sedimentary cover in many fields of the West Siberian OGP is clearly fixed by manifestations of fracturing of productive complexes in the dynamics of hydrocarbon deposits development.

The patterns of structural localization and spatial zonality of highly permeable fracture zones within the fields, caused by the discharge of tectonic stresses in the process of formation of folded and disjunctive dislocations, are revealed. The cracks are associated with weakened ("dynamically stressed") zones of the formation, which are attached to flexures. The "structural and spatial zonality of fractured reservoirs on the basis of system analysis" is substantiated.

III. On current theoretical positions

In their works, Bogatsky V.V. [2], Petrova O. [4], Ustyantseva V.N. [8], (with important references) set forth possible mechanisms of natural processes leading to observable features of folded deformations and natural reservoirs. According to V.V. Bogatsky, "the spatial periodicity and discreteness of the distribution of geological objects and structures is a system property of the geoid.

The stability of the processes of regional structure formation, as the planetary quality of the Earth system, together with the periodicity and discreteness of the same regional structures, indicates that the main properties of the geological structures reflect the unity of the planetary creation mechanism that is wave. The structures of superimposed activation are formed as a result of the general process of what is happening in the mantle, which has a wave character (harmonics of the general earth standing wave)" [2].

At the same time V.N. Ustyantsev notes: "A wave is a disturbance genetically associated with physico-chemical deformations that propagates with a finite velocity in space and carries with it energy and matter" [8]. The source of energy of tectonic processes, according to [2, 3, 5] and many other authors, is internal geospheres. "Chemical energy in the form of deep flows rises along the permeable fault zones; this process is accompanied by the deformation of the tectonosphere" [8].

According to Bogatsky V.V. [2], "it is necessary to consider the reflected and autonomous activations as particular manifestations of the general superimposed activation process, the source of which is located in the upper mantle - the asthenosphere layer (crustal energy centers). The hypocenter can be located in any of the mantle spheres (mantle energy centers".

Earth's self-oscillating system generates stress waves, the length of which is determined by the structure of the system. The energy-carrying waves, entering the inhomogeneous medium, begin to reflect and refract at the interfaces between the media.

The undulating mode of deformations of the dense carbonate stratum of the Upper Cretaceous manifested itself in the complex distribution of the physico-mechanical properties of rocks along the section. There are signs of cyclical secondary (tectonic, lithogenetic) transformations, in particular, the relative secondary porosity (hollowness) of the carbonate sequence; There are examples of an increase in normalized secondary porosity of the lower part of the section, at the base of the thickness. Compared with the folded deformation scheme of a competent stratum, when the upper half is subjected to stretching and the initiation of large cracks, and the lower half is compressed [8], the actual picture is much more complicated. The study of the characteristics of indicators of secondary changes in the thickness will not only add information about the features of the structure of the reservoirs, but may also determine the position of the section (well) in one or another part of the folded deformation.

Several dimensional levels of morphological indices of discrete folded structures manifested themselves in the folded deformation space of the Upper Cretaceous sequence.

In accordance with the fact that folded deformations are a consequence of the manifestation of wave stresses, deformations of different sizes, most likely, could be conjugated, if not in time, then in space. This could significantly complicate the morphology of the trap structures and affect the indicators of the natural reservoirs of the Upper Cretaceous stratum and hydrocarbon deposits within them. The manifestation of such conjugation can be assumed in many known structures; the example of the North Mineral Deposit is indicative.

IV. Applied moments

The North Mineral uplift in the Cretaceous sediments is represented by a narrow anticline of sublatitudinal strike (Fig. 6, 7). The axis of the fold changes its direction, has an arched shape, facing the bulge to the south. The arch of the fold displaced formation water to the west.

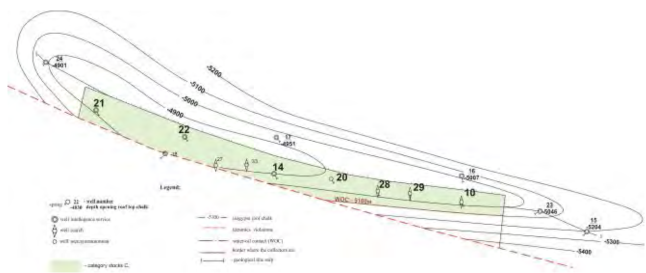

Fig. 6. North Mineral Deposit. Schematic structural map of the top Cretaceous sediments

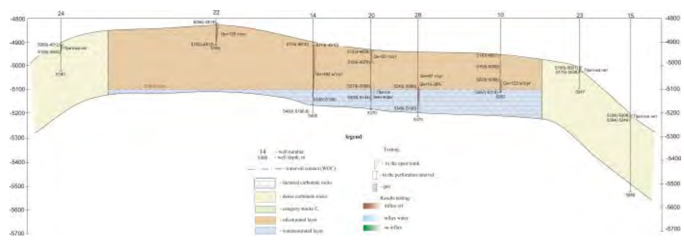

Fig. 7. North Mineral Deposit. Profile geological section

The western pericline of the structure is shorter and steeper, the eastern - shallow. Such structure of the fold may possibly be associated with a combination of deformations of two sizes: folds 25 km long (at iso-gypsum minus 5200 m, width 2,5 km) and deformations 10-12 km long. The width of the combined deformation is 4 km, the height is 450 m. The angles of incidence of the wings are: the north wing is 10-16 °, the south is 16-25 °. The southern wing and the near-water part of the structure are complicated by a longitudinal rupture separating it from the mineral structure.

The gap is predicted according to seismic data, can be traced in the Maikop sediments, the revealed thickness of which is increased by 400 m compared to other wells. It can be assumed that this gap can be traced in the Upper Cretaceous sediments.

Well number 20 (which has been operating since 1983) gives oil with significant pollution from the interval minus 4938-4978 m. A possible reason is the position of the well at the border of two different types of folded deformations noted above and a change in the structure of the natural reservoir of the reservoir. The oil deposit was formed on the main 25-kilometer trap. In the extended arch part of the fold in the carbonate stratum there are also good reservoir properties. The flow rates of wells №10, 14 are more than 490 tons of oil per day, they give almost pure oil. The superimposed deformation in the western part of the fold changed the picture. Well №20 was on the eastern pericline of the new complication. The void space decreased, the formation water partially penetrated into the reservoir.

V. Conclusion

The review and analysis involved indicators of the morphology and relative (spatial) position of anticline folds and some of their probabilistic relationships to build a multidimensional system of objects. The conclusion about the discrete form of the system indicators, the possibility of combining multi-level elements in space is important in this aspect. Relationships-dependencies of many indicators become linear and reliably extendable in the ln-sphere. The system of objects (in the form of a number of equations) includes indicators: linear and area dimensions of folds; the width of the trace of folds; the number of discrete groups of folds; the number of folds of each group; the length of the trace of the folds; ratios of indicators in discrete rows; the values of the hypsometry of the steps of the folding mirror, the intensity of the folds. The prediction of the spatial scheme of the hydrocarbon trap involves iterative procedures.

Fracture, secondary porosity, oil and gas content, the thickness of the Upper Cretaceous are due to folding stresses. The new, in this well-known phenomenon, consists in the frequency of enhancement of the impact, both along and across the base texture of the layered rocks. The intensity of secondary porosity (as the main parameter of reservoir rocks of hydrocarbon deposits) is associated not only with the magnitude of each phase of periodic stresses, but also with the imposition of phases. The transverse periodicity, the wave-like enhancement of fracture porosity along the section of the sequence may lead to the dismemberment of the deposit.

The zonal nature of the region's oil and gas potential is a direct consequence of the tectonic disturbance and permeability of the sedimentary sequence of the Terek-Caspian deflection. Hydrocarbons penetrate from the lower zones of the section and are distributed in the sedimentary column through traps and collectors. The hydrocarbon supply process is, for example, in the eastern part of the Terek-Sunzhensk region, which follows from a large and steady increase in the gas factor in the deposits.

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