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Validation of Some Elements of the New Model of the Nepa-Peleduy Arch Subsurface Structure of the Nepa-Botuoba antecline in the East of the Siberian Platform

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Abstract. The studies were carried out on the Nepa-Peleduy arch (NPA) of the Nepa-Botuoba antecline, the territory strategically important for the Russian Federation, where large and unique hydrocarbon deposits were discovered including those for the ESPO oil pipeline and the "Siberian Force" gas pipeline, which is under construction. The problem is in increasing the oil resource volume, as the hydrocarbon potential of the sedimentary mantle is largely exhausted. The evidence for the hypothesis by B.A. Sokolov, the Corresponding Member of the RAS, that the allochthonous crystal plate overlapping the aulacogen with Riphean deposits underlies in NPA, opens the possibility of increasing the hydrocarbon reserves in the "subfoundation" formations in the arch. Moreover, it can as clarify the controversial nature of the NPA deposits, which sedimentary mantle lacks deposits with a high content of organic carbon. We observe the Hilbert transform of the time section of the CDP method for the fragment of the "Batolith-1" geotraverse, passing through the Katanga Saddle, the NPA and the Cis-Patom foredeep, and geophysical materials and the data of the wells on it. Based on the original constructions on geological and geophysical data and modeling, related to the development of the abovementioned hypothesis arguments for confirming the existence of a crystalline plate opened by the wells at the base of the NPA and the reality of the development of the Lower Vendian and Riphean deposits beneath it were obtained. The inversion paleorift's western side position is outlined, the thickness of the plate and the oilfield characteristics of the deposits under it predicted are estimated, which can serve as a justification for the expediency of exploration of "subfoundation" deposits.

1. Introduction

The studies were carried out on the Nepa-Peleduy arch (NPA) of the Nepa-Botuoba antecline (NBA) at the south of the Siberian platform, the territory strategically important for the Russian Federation. two-thirds of the gas reserves and all the NBA oil reserves were discovered here and the large Verkhne-Chonskoye and Talakanskoye gas-oil and unique Chayandinskoye oil and gas fields were discovered, which are the basic for the ESPO oil pipeline and the "Siberian Force" gas pipeline, which is under construction. [7,12] (Fig. 1). The issue lies in increasing the oil resource volume further, as the hydrocarbon potential of the sedimentary mantle is well explored and the opportunities to discover new large deposits in it are scarce. It is advisable to include the investigation of the crystalline



basement and subfundamental formation to the research directions. There the formation of deposits is possible on non-traditional concepts of HC sources and the deposits formation mechanism [1,2,10,18]. The scientific contribution of such studies can be in the identification of the controversial nature of the NPS deposits lying near the basement in a sedimentary mantle with low organic carbon content and the absence of conditions for long-range hydrocarbon migration.

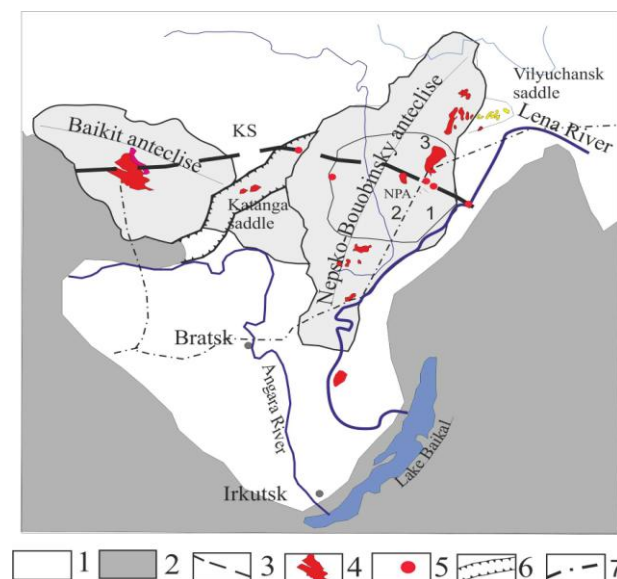


Figure 1. Nepa-Botuoba antecline and conjugated superorder structures with the geological load discussed. 1-Siberian platform; 2- platform folding frame; 3-"Batholith-1" -geotraverse; 4-oil and gas fields, including those mentioned in the text: 1-Talakanskoye, 2-Verkhnechonskoye, 3-Chayandinskoye; 5- wells on which the SDS sweeps are constructed; 6 - Irkineyevo-Chadobets aulacogen; 7 - the ESPO gas pipeline; БИКО-Baikal-Patom folded area, KC-Kureyskaya syncline; ННЦ -Nepa-Peleduy arch; БИКО-Baikal-Patom folded area.

In the 90-s of the last century B.A. Sokolov, a Corresponding Member of the RAS, proposed the hypothesis that the foundation of the arch opened by wells is an allochthonous plate pushed from the Cis-Patom foredeep in the pre-Vendian time to the southern part of the Irkineyevo-Katanga Riphean paleorift. Hydrogen generators are Riphean deposits under the allochthon, some of which migrate up the fissures, forming oil and gas deposits in the deposits of the sedimentary mantle represented by the terrigenous Vendian complex and carbonate rocks of the Vendian-Cambrian and Lower Paleozoic, in which there are no oil deposits. However, the considerable potential under the allochthon remains unclaimed [18].

B.A. Sokolov's hypothesis is confirmed with some differences by later investigations on the NPA deep structure features. The overlapping plate is the surface of the denuded allochthonous block of the granitic-gneiss layer of the earth's crust, a paleorift pulled from the Cis-Patom foredeep in its pre-inverting phase of development in the Late Riphean ?. Alongside with this, the genesis of the plate is closely related to the expected evolution of the paleorift [6]. The results obtained may be the indirect proofs of the hypothesis, and the model constructed is schematic for solving a range of detailed problems related to the hypothesis. A more objective model assumes a reliable confirmation of the existence of a crystalline plate opened by wells in the arch, estimation of its thickness, the nature of occurrence and the field characteristics of the deposits under the plate. The aim of the research is to substantiate the prerequisites for involving the prospecting of the "subfoundation" deposits in the base of the NPA and prospecting the hydrocarbon deposits in these in order to accelerate the growth of the raw material base in the east of the Russian Federation.

2. Research Methods

The geological structure of the NPA territory has been investigated on the eastern fragment of the "Batholith-1" geotraverse from the junction of the antecline with the Cis-Patom foredeep (the eastern side of the NBA) to the junction with the Katanga Saddle (western side of the NBA) [9] (see Fig. 1) Seismic sections of the CDP-method, profile gravimagnetic observations, deep wells data along the

profile were involved: stratigraphic breakdowns, correlation schemes, model constructions, well logging data.

2.1. Processing methods

Hilbert transforms of seismic sections; correlation stratigraphic analysis of well sections; the original method for constructing the cyclicity of well sections from GIS data using the RITM software [4,14]. The peculiarity of the software that builds spectral-depth sweeps (SDS) is that the cyclicity of sedimentation processes is investigated by continuous tracing the R metric parameter (correlation radius) in depth, calculated in several analysis windows of the log curve [4]. The logging curve is basic for the SDS construction for the terrigenous sulphate-carbonate section of the NPA. Comparison of the SDS with the lithological section and the results of numerical modeling give grounds to assert that they reflect changes in the gradient (coarse-grained) or disjunctivity (the number of layers per unit length) in the sedimentary mantle, as well as the direction of the sedimentation process forming a definite facies-lithological series of deposits [4,5]. The studies of the specific features of the cycloclimentogenesis of the Vendian-Cambrian deposits has been conducted using SDS on the Chayandinskoye, Talakanskoye and Verkhnevilyuchanskoye deposits explored by deep drilling, the results of which have been published [5].

3. Research results

The solution of the tasks posed depends to a large extent on the geological interpretation of the phenomenon observed at the time seismic section of the Hilbert transform of the "Batholith-1" geotraverse eastern fragment. The "subfoundation" reflections are observed below the marks of the opening of the crystalline rocks top in the Nepa-Peleduy arch (NPA) as well as other features that do not correspond to the traditional notions of the arch as an elevated part of the larger platform structure of consedimentation development with a consolidated foundation (Fig. 2).

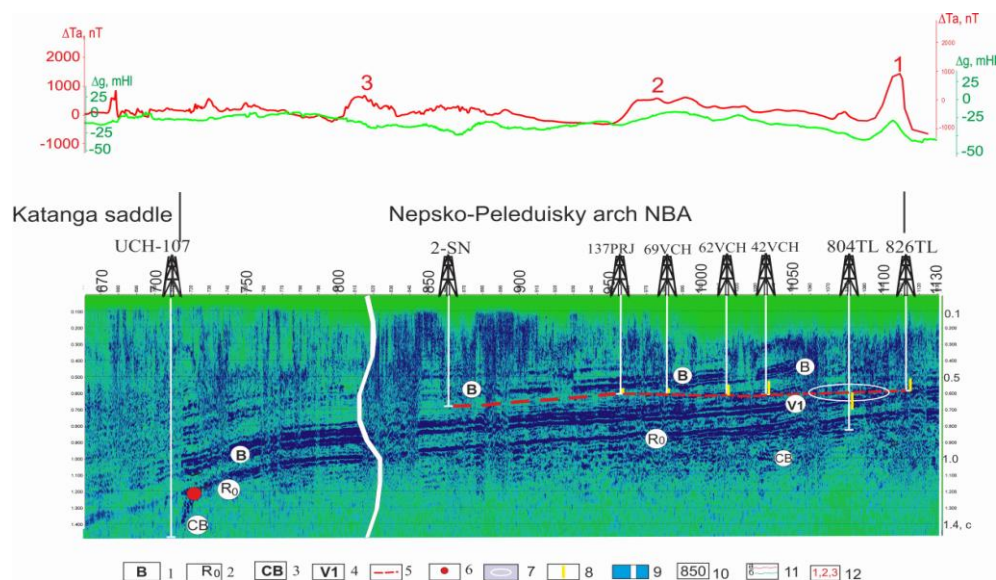


Figure 2. The section of instantaneous amplitudes (Hilbert transform) along the "Batholith-1" profile.

Seismic horizons: 1 - the boundary between the "Podosinsk" salts of the Usolsky suite and the carbonate theta suite; 2 - sole of the Vendian-Paleozoic complex (surface of regional erosion of Riphean rocks); 3 - foundation surface (AR-PR1); 4 - lower Vendian boundaries; 5 - T0 f.c line of opening of the surface of crystalline rocks by wells; 6 the point of bifurcation; 7) the proposed "erosion window" in the crystalline plate; 8) the thickness of the terrigenous Vendian in the well; 9) the proposed position of the western side of the inversion paleorift and the change in the type of the

section; 10 - pickets along the profile, in km; 11-profile observations of potential fields: a)- the ΔT magnetic field, b) the ΔG gravitational field; 12 the peaks of ΔT field, tied to the raised granulite-basite blocks of the paleorift system: 1 corresponds to the eastern edge of the aulacogen (see Fig. 2), 2 - intermediate block, 3- corresponds to the supposed western edge of the aulacogen.

1. Wells located on the NPA oil fields, open the crystalline rocks at close times of occurrence. In this case, the opening line is located almost horizontally and discordantly with the respect to the monoclinic rise of the reflecting horizons to the east from the well. 2-CH to the well. 826-TI.

2. Two distinct reflecting horizons under the T0.f.c opening line are present on the section, which are stratified as horizons "B" (sub-Osinsky salts of the Usolsky suite) and "R0" (the Vendian-Paleozoic complex bottom) on the depth seismic geological section of the geotraverse western fragment on the territory of the Katanga Saddle [13]. At the same time, the horizon "B" with the stratigraphic analogues of the sub-Osinsky salts in the Talakan area was discovered much higher, whereas the reflections of the Lower Vendian opened by the well №804 on this area, are correlated with the horizon "B".

3. In the proposed zone of junction of the Nepa-Botuoba anteklise western side (PK 810 km?) with the Katanga Saddle eastern side (PK 710 km) there is a significant immersion of the surface of crystalline rocks from a depth of 1500 m to a depth of 3500 m, which, with a consolidated foundation on the arch must be reflected, but not reflected in the gravitational field by the gravitational stage (Fig. 2).

To explain the features noted in the framework of the NPA deep geological structure model, repeatedly stemming from the B.A. Sokolov's hypothesis, geological arguments confirming this hypothesis are topical. Above all, they eliminate the doubts on the existence of the allochthonous plate (and hence the paleorift under it) and its parameters. One argument is based on revealing the surface of regional erosion between Riphean and Vendian deposits [3,8] and establishing its position in a section for the case of a consolidated foundation and an allochthonous plate. The well. No. 804 on the Talakan area provides such a possibility of construction. This well opened a geological section below the crystalline rocks top settled in neighboring wells, passed about 660 m along it and stopped, presumably, in the rocks of Riphean (R2?).

It is generally believed that the well fell into one of the graben-like structures of the basement, where the Riphean formations were preserved, since the Nepa-Botuoba anteklise in the Riphean time represented the largest denudation area [3,8]. An alternative point of view is that the well fell into the erosion "window" formed during the denudation of the allochthonous block to the state of the peneplanized crystal plate [6].

The importance of establishing the surface of regional erosion in well. No. 804 as a reference boundary between the riphean and the Vendian is that the definition of the age of some Vendian suites in the inland areas of the Siberian Platform is a far from being an ambiguous question [20]. With the use of "RITM" the spectral-depth sweeps (PDS) of the well №804 logging data have been built, which allowed to clarify existing concepts of the Vendian-Lower Cambrian-megacycle [11,16,17,19] and set the position of the regional erosion boundaries on a mark of 1560 m in reliance on the beginning of the megacycle (the closure of analysis windows), the presence of intervals of diffuse cyclicity at the base of the megacycle and deeper from its occurrence (Fig. 3).

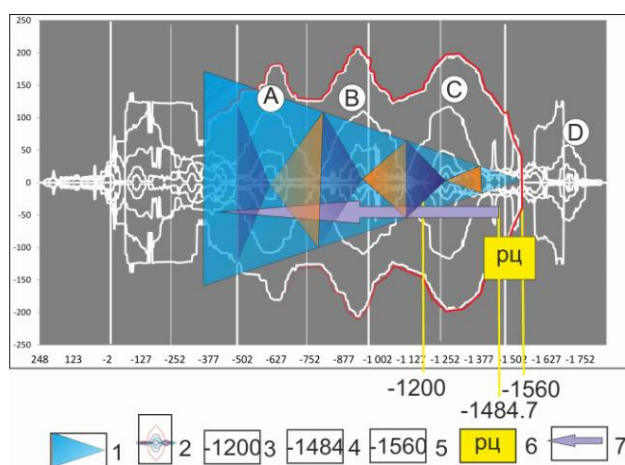


Figure 3. Spectral-depth sweep of acoustic logging of the well No. 804 on the Talakan area with the elements of interpretation (a); fragment of the geologic section of the well in the Vendian-Riphean interval (b).

1. Megaprocyclite of the Vendian-Lower Cambrian. 2. Synchronous growths of the GGR curves (reprocyclites), linked to potential oil and gas reserves: A - Tolbachan, B- Osinsky, C - Botuoba, D – Riphean. 3-5. Absolute marks of benchmarks: 3-the mean value of the crystalline rocks top along the wells adjacent to well No. 804; 4-Vendian-Cambrian boundaries according to drilling data; 5 - Megaprocyclite closures. 6. Blurred cyclicity. 7. Subsidence direction.

For the positions geometry of the mark of erosion at 1560 m and the marks of opening of the crystalline rocks top by the neighboring wells the models of sedimentation in the well. No. 804 were compared for cases of: graben in a consolidated foundation and an erosive "window" in a crystalline plate. The results of the simulation showed that the position of the regional erosion boundary between the Vendian and the Riphean below the crystalline rocks top can only take place in the case of an erosive "window" in the crystalline plate and can be the justification of its existence. The formation of the "window" occurred during the erosion of the granite-gneissic block to the state of the plate of critical thickness, when, undergoing the buckling process in individual sections under the influence of tangential forces, the plate breaks away from the autochthon, and subsequent erosion opens it. The calculated thickness of the plate in the area of the "window" was 330 m. The existence of the plate means the existence of the inversion paleorift system with the deposits of the Lower Vendian and the Riphean under it at the base of the NPA, from which the reflections on the time section are real (Fig.2)

The above-mentioned anomaly-free ΔG field in the interval of the depth difference of the crystalline rocks top (pickets 680-710 km) confirms that the wells in the NPA open not the consolidated foundation, but the top of the subparallel crystal plate of relatively small thickness. The very surface of the granulite-basite blocks of the paleorift system lies deep here. This is evidenced by the observed curve of the ΔT magnetic field, on which 3-peaks are singled out. We associate these with the rise of granulite-basite blocks. the first peak corresponds to the eastern edge of the paleorift system, the second to the intermediate block, and the third, presumably, corresponds to the western side (see Fig.2)

4. Conclusions

The study has proven the validity of scientific notions on the existence of a denuded allochthonous plate composed of rocks of the crystalline basement at the Nepa-Peleduy arch platform and the underlying "subfoundation" sediments of the Lower Vendian and Riphean, as well as reflections from these on the eastern fragment of the time section of the CDP-Method in Batholith-1 geotraverse. The thickness of the crystal plate has been estimated. Lower Vendian and Riphean deposits, which location is predicted under the plate, have been characterized positively in relation to the oilfield and geological features and to the development of potentially productive reservoirs in them. The positions of the western side of the inversion aulacogen and the end of the allochthonous plate covering it are found and proven. A change in the type of the geological section is possible further to the west is possible there. The results of the studies conducted can be used as an additional justification for target

drilling setting of the deep wells, opening of the "subfoundation" deposits and exploration of the oil and gas deposits predicted to be in them.

5. References

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