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Structure and genesis of the Achimov olistostromic strata of Western Siberia

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Abstract. The question of the genesis of the anomalous Bazhen-Achimov zones remains to be one of the most controversial problems in Western Siberia. By now, about dozen hypotheses of the sedimentary environment of this specific formation have been proposed. However, none of these hypotheses is generally accepted. All hypotheses have been classified by genesis and their critical analysis is given in the article. The solution is closely related with experience of the geological exploration works, since the prospects of oil and gas are associated with these deposits. The article highlights the key features of the structure of the anomalous section's zones based on drilling and seismic data. The classification of the hypotheses is given and the features of sedimentation in the Bazhenov and Achimov times are highlighted. An accumulated data has allowed us to substantiate the olistostromous genesis of the anomalous section. Based on a set of data, including paleogeographic, sedimentological, paleotectonic reconstructions, a principal detailed model of the sedimentary environment of olistostromes is proposed for the first time. The proposed model seems to be the most logical, supported by the actual data known to date, is the most universal and fits into the paleogeographic situation and tectonic regime that prevailed in the Achimov time.

Keywords: zone of anomalous sections, Bazhenov deposits, Achimov clinoforms, olistostrom, olistolite, underwater landslide, sedimentary environment

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Introduction

One of the most controversial issues in modern geology of Western Siberia for more than 50 years has been the study of the structural features and formation of anomalous sections of the Achimov – Bazhenov deposits (ABD), or zones of anomalous sections (ZAS), which seems more correct. This issue is closely related to ideas about the regional geological structure and development, sedimentation conditions in the Late Jurassic and Early Cretaceous times. Discussions about the mechanism of formation of ZAS are still ongoing, as evidenced by new publications, which is also associated with practical interest in the search for hydrocarbon deposits in this peculiar complex of sediments. Let us note that not a single stratigraphic unit forming the section of Western Siberia is the subject of as many discussions and differences of opinion as the Bazhenov deposits and the ZAS.

Interest in them has also increased in connection with the development of "shale" deposits, closely linked with the practice of prospecting and exploration work. Understanding the genesis of the reserves significantly changes not only the principles of correlation of productive deposits, but also the idea of reserves and features of the search and exploration of deposits in these deposits. It can be stated with confidence that knowledge of the genesis of the ZAS is a kind of exploratory sign of the discovery of deposits in lithologically limited traps of Achimov age.

Zones of anomalous sections have now been discovered by drilling in more than 60 areas using hundreds of wells and studied using materials from numerous seismic surveys, including 3D. ZAS are confined to the lower Achimov horizon in a stratigraphically sliding range from the Berriasian in the east to the Lower Hauterivian in the west of the Neocomian clinoform complex. The deposits are underlain by the Bazhenov horizon in the volume of the upper Lower Volgian – Berriasian stages. ZAS are grouped into submeridional strips parallel to the strike lines of the Neocomian sedimentation basin and have a significant scale. The areas of individual anomalous zones exceed 1000 km^2. The greatest scope of ZAS reached in the south of Western Siberia (Fig. 1). They have a classic appearance in the Latitudinal Ob Region, where zones of anomalous sections were studied in detail in hundreds of wells, taking into account seismic data.

Describing the ZAS, the vast majority of researchers characterize it as the layering of sandstones and siltstones in the section of the siliceous-clayey strata of the Bazhenov deposits, where the thickness is increased to 70–210 m relative to the normal sections of the Bazhenov deposits (20–35 m). Thus, the deposits of the Bazhenov formation occur stratigraphically above their normal position and sometimes form several discontinuous layers in the section. Using seismic methods, the ZAS is detected by a sharp change in the wave field with a fundamentally different shape of the wavetrain, different from the record of normal sections of the Bazhenov deposits.

Many works are devoted to the structure and conditions for the formation of ZAS, see, for example, the bibliography in (Nezhdanov et al., 2017).

Due to the unique structure, specificity of composition, debatable genesis and oil and gas prospects, ZASs are

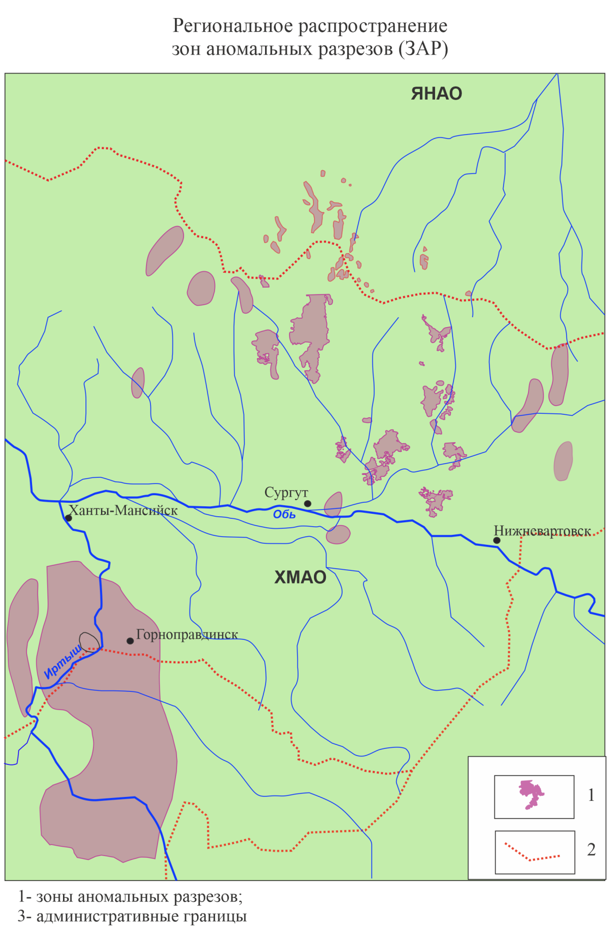

Fig. 1. Scheme of distribution of zones of anomalous sections using data (Nezhdanov, 2004), with refinements

used to substantiate various kinds of often mutually exclusive ideas and concepts of both regional geology and more global problems of the theoretical geology of the region. It can be stated that to date, almost all possible points of view on the nature of ZAS have been expressed. The conclusions of individual authors are often based on studying the structural features of these deposits in a separate area or section with an attempt to extend the "identified patterns" to the entire region. It is noteworthy that a particular theory, as a rule, is based on a certain type of information, depending on the professional interests of the researchers. This also determines approaches to the study of ZAS, when the entire set of manifestations of ZAS is ignored. While noting the importance of the conclusions made by the researchers, it is still necessary to emphasize that they are often based on incomplete knowledge about the patterns of the geological structure of the ZAS available today. As a result, various contradictory concepts are used in geological constructions (Fig. 2), or important components of the ZAS are not analyzed. To date, enough material has been accumulated that allows a more correct approach to the interpretation of the genesis of the ZAS, while the results of geological observations based on drilling data (especially core studies) and geophysical surveys of wells acquire special key significance, ignoring which is unacceptable (Fig. 3).

Thus, on structural maps, the top of the Bazhenov formation is shown along the top of the upper level of the Bazhenov olistoliths in the ZAS (in fact, as will be shown below, the ZAS is a zone of absence of bedrock Bazhenov deposits in the bedrock).

A detailed analysis of the evolution of views on the conditions of formation, the current level of knowledge and geological perception of facts allows us to reveal the essence of the phenomenon, assess the scale and significance of this rather unique complex of geological formations, which is reflected in many sections of the world.

Hypotheses for the ZAS formation

Hypotheses for the origin of the ZAS of Western Siberia can be conditionally divided into two groups with the predominant influence of certain causes: "tectonogenic" models and "sedimentogenic" models (Fig. 2). Supporters of the first are convinced that it is impossible to explain the formation of ZAS without the involvement of endogenous factors, and they associate the mechanism of formation of these objects with subvertical, sometimes horizontal zones of rock destruction or with mud volcanic activity.

Adherents of the second group explain the appearance of the ZAS by turbidite and other bottom movements of clastic material, accompanied by landslide phenomena in the Bazhenov suite of overlying Achimov deposits or,

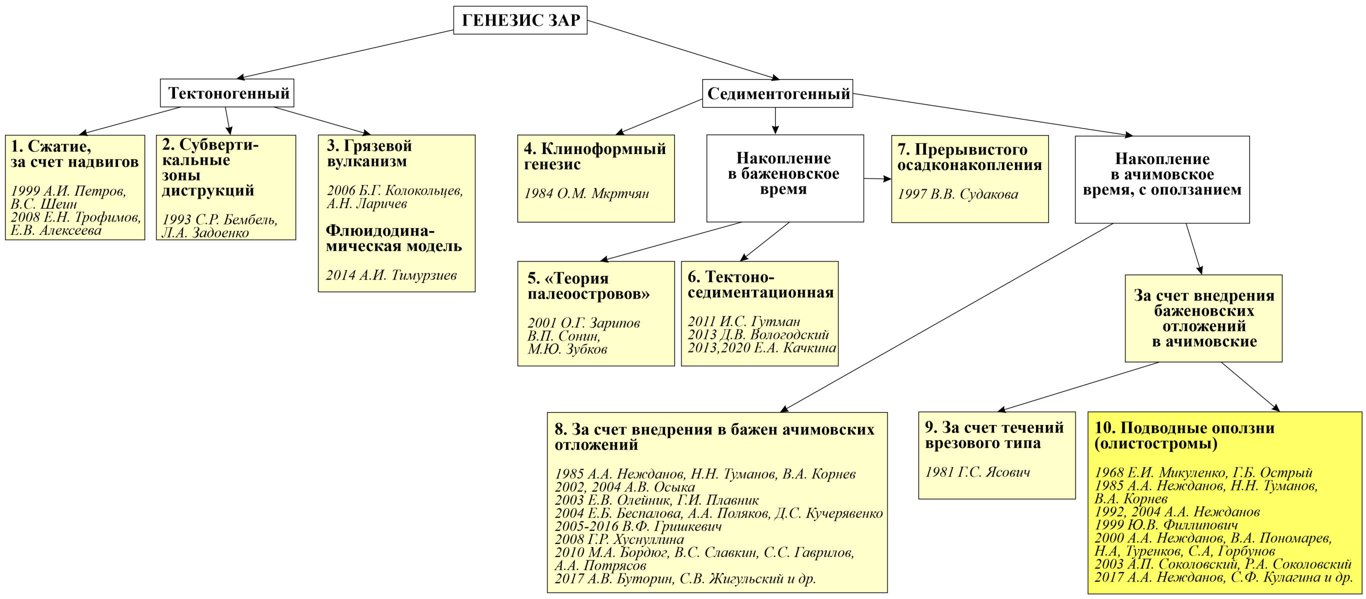

Fig. 2. Scheme of existing hypotheses of genesis of zones of anomalous sections (ZAR)

conversely, with the introduction of Bazhenov deposits in the form of inclusions in the Achimov deposits. Some authors admit the multivariance of ZAS types, explaining the genesis by different reasons (Filippovich, 1999).

All currently available hypotheses for the formation of this type of sections are analyzed below in a systematic way. It should be noted that the sedimentation group has a larger number of supporters, but is also distinguished by numerous variations and nuances in explaining its genesis.

Tectonogenic origin of ZAS

The formation model is highlighted in the works (Bembel, Zadoenko, 1993; Petrov, Shein, 1999; Trofimova et al., 2008; Kolokoltsev, Larichev, 2006).

Compression due to thrusts

Proponents of the first theory (Petrov, Shein, 1999) hypothetically believe that the anomalous in thickness sections of the Bazhenov formation are formed during horizontal displacements along thrusts and strike-slip faults, reaching 300–500 m due to crowding in the frontal parts and cracking in the rear parts of the faults. In the article (Trofimova et al., 2008), based on the study of the core, tectonic melange, neptunic rocks injections, etc., are noted, and also the characteristics of the frontal or frontal part of the tectonic cover are given, in which the allochthonous part is represented by deposits of the Bazhenov formation, the autochthonous part is represented by Lower Cretaceous deposits of the Achimov formation thickness.

Subvertical zones of destruction

In the article (Bembel, Zadoenko, 1993), based on the results of the analysis of seismic sections together with drilling and logging data, a "fundamentally new hypothesis is put forward about the mechanism of formation of anomalous sections, which is based on the formation of subvertical zones of rock destruction and subsequent hydrothermal metamorphism" (Bembel, Zadoenko, 1993, p. 118).

Mud volcanism

Another theory was put forward by V.G. Kolokoltsev and A.I. Larichev (Kolokoltsev, Larichev, 2006).

In their opinion, the formation of the ZAS is closely related to mud volcanism that occurred during the late Mesozoic tectonic-magmatic-metasomatic activation of the West Siberian Plate, from which it follows that "the areal distribution of oil fields in the Cretaceous layers is stably controlled by the zones of distribution of anomalous sections, which, according to our ideas, are derivatives of mud volcanic activity," and that "additional lithological witnesses to the ascending vector of the entry of psammitic-siltstone mixtites into the Bazhenov formation are the fragments of those rocks contained in them that lie hypsometrically and stratigraphically lower" (Kolokoltsev, Larichev, 2006, p. 280). However, we do not encounter any pronounced morphological volcanogenic formations in the section.

In 2014, another theory of a type of mud volcanism appeared (Timurziev, 2014). A.I. Timurziev, solely based on seismic survey data, proposed a new model for the formation of the ZAS, in which, in the figurative expression of the author, "the introduction of the roof of the Bazhenov formation into the Achimov formation in areas of the "anomalous Bazhenov" resembles the effect of a "torn off lid" (Timurziev, 2014, p. 29). The ideas were based on a fluid-dynamic model of the formation of an "anomalous Bazhenov" according to the mechanism of plastic injection and impregnation of fluid, which occurs in local areas of crustal extension, spatially and

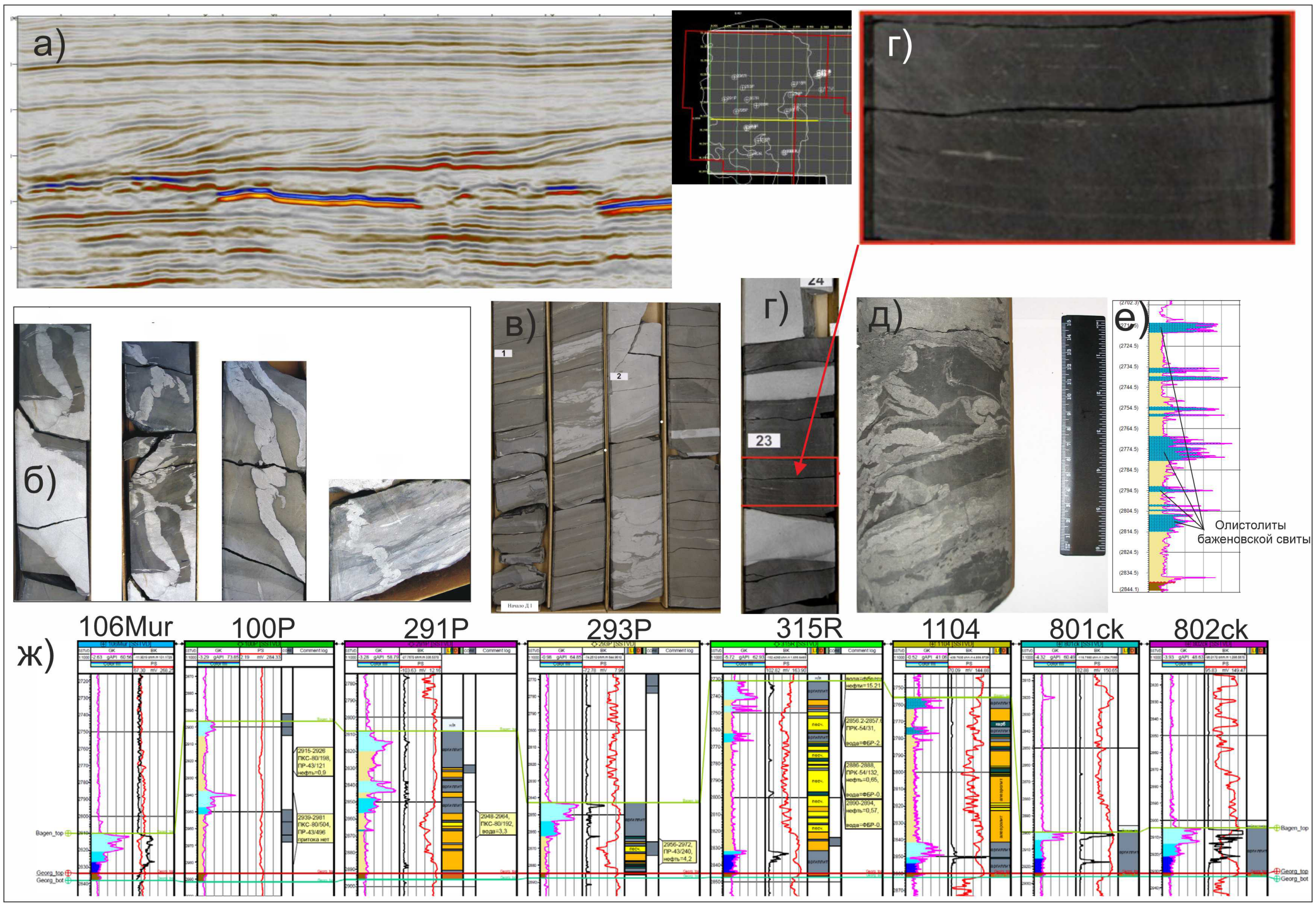

Fig. 3. Key features of the structure of zones of anomalous sections: a) temporary section, Verkhne-Konitlorskaya area; b) clastic dikes, well 107p, Yuzhno-Konitlorskaya area; c) alternation of landslide and normal-layered interlayers in ZAS, well 280, Imilorskaya area (interval 3043.5–3049.4); d) normal-layered texture in Bazhenov olistolites, well 316-3, Kechimovskaya area; e) sharp-angled fragments of Bazhenov sediments, well 307, Severo-Konitlorskaya area; f) multilevel development of olistolites in ZAR, well 196, Non-Yeganskaya area; g) correlation scheme of ZAR, Severo-Konitlorskaya area

genetically associated with horizontal basement shifts activated at the latest stage. At the same time, the author rightly pointed out the existence of faults that attenuate at the level of the base of the Achimov deposits.

Taking into account the scale of the observed phenomenon, it should be recognized that a purely tectonic hypothesis and mud volcanism do not explain all the local and regional features of the structure and distribution of the ZAS and often contradict the available geological and geophysical information.

Sedimentogenic genesis of ZAS

The largest group consists of supporters of the formation of the ZAS at the sedimentary stage, however, even here there is no unity of ideas not only about the structure, but also about the stratigraphic affiliation of the ZAS – what is their age – Bazhenov or Achimov. Among the followers of the sedimentation model there are supporters of the accumulation of this type of section in the Bazhenov time and adherents of formation in the Achimov time. The latter, in turn, are divided into supporters of the introduction of Bazhenov deposits into Achimov deposits and supporters of wedging of Bazhenov deposits by Achimov clinoforms. Both points of view fundamentally assume the predominance of submarine landslide processes.

For the first time in 1968 for the West Siberian region, K.I. Mikulenko and G.B. Ostry described deformations of submarine landslide origin in Jurassic and Cretaceous sediments and made assumptions about their possible nature associated with paleoseismicity (Mikulenko, Ostry, 1968). Note that by that time the ZAS in its modern form had not yet been opened; only numerous fluid textures and clastic dikes in the well core were used for analysis. It should also be noted that K.I. Mikulenko by that time had studied in detail numerous manifestations of ancient submarine landslides in the North Caucasus in Dagestan, where he conducted research on Paleogene deposits (Mikulenko, 1967). These authors also noted the spatial relationship of underwater landslides with the location of synsedimentary faults. For a long time, the only alternative to this model were turbidity currents and submarine currents, which delivered terrigenous material to the center of the sedimentation basin during the Bazhenov time.

Clinoform genesis

The clinoform model of the formation of the ZAS was proposed by O.M. Mkrtchyan (Mkrtchyan, 1985), according to which the Bazhenov deposits represent deep-sea facies of the clinoform sandy-clayey Achimov complex, being replaced in a westerly direction.

According to this model, multiple pinchouts of the Bazhenov lithofacies occur from east to west with the appearance of new ones at a slightly higher stratigraphic level, in close genetic connection with the migration of the Achimov clinoforms (Mkrtchyan et al., 1987). Further research, in particular fossil records, showed the inconsistency of this hypothesis.

Accumulation of ZAS in Bazhenov time

For a long time, it was customary to attribute the entire thickness of the "anomalous Bazhenov sections" to the Bazhenov deposits (hence the name of the considered sequence "ABD").

Paleo-island theory

In contrast to the theory of underwater landslide formation of the ZAS, there is a model of paleo-islands, which is discussed in detail in (Zaripov, Sonich, 2001). Based on the study of core samples from a number of areas in Western Siberia, the authors deny the connection between the sandy-siltstone interlayers of the Bazhenov formation and the Achimov deposits; they consider it more logical to adhere to the opinion that the sand layers are of the same age with the typical Bazhenov rocks that host them, allowing for the existence of marine pulsation currents in the form of grain flows. In this case, the main role, according to the authors of the theory, was played by local sources of debris, which were located within the waters of a vast basin in the form of island ledges of rocks of different ages. However, later paleontological finds of the Lower Cretaceous fauna in the ZAS, as well as seismic data, refuted this hypothesis.

M.Yu. Zubkov and Ya.A. Pormeister, according to seismic survey data, also adhere to the opinion that the sandy layers are of the same age with the typical Bazhenov rocks that host them, allowing for the existence of submarine pulsation currents in the Bazhenov paleosea (Zubkov, Pormeister, 2005). Thus, sandy-silt layers in the section of the Bazhenov formation are considered as a product of erosion of sandy layers of underlying stratigraphic horizons on elevated blocks of the sea bed. At the same time, for the western section of the Kalchinskoye field, a formation mechanism is also assumed, due to the intrusion of Achimov clinoforms into the unlithified bituminous deposits of the Bazhenov formation.

Discontinuous sedimentation theory

To complete the review of possible versions of genesis, we note the point of view of V.V. Sudakova based on seismic materials on the Savuyskaya area in the eastern part of Fedorovsky swell (Sudakova, 1997). It was suggested that here "there are several layers of bituminous-clayey, relatively deep-sea, lithological-facies type, separated in geological space, naturally migrating up the section and towards the axial zone of the paleobasin" (p. 15). It follows from the proposed model that the accumulation of relatively deep-sea sediments occurred periodically, but briefly, during the Late Jurassic-Early Cretaceous transgressive-regressive cycle.

Tectonic-sedimentation theory

In 2011 I.S. Gutman put forward a new point of view about the nature of the formation of anomalous cuts. He suggested the manifestation of synsedimentary faults in the Bazhenov time, in the area of which the ZASs were formed (Gutman, 2011). Based on the correlation of well sections for a number of fields in the Kogalym oil and gas region, the author assumes that the ZASs were formed as a result of the subsidence of individual blocks along synsedimentary subvertical faults. Considering the overlying Achimov deposits, I.S. Gutman comes to the conclusion that the formation of clinoform rock units occurred as a result of different-speed subsidence in the same time interval during wave-like vertical tectonic movements. The subsequent development of the idea was reflected in the works of his students, see, for example, (Vologodsky, 2013; Gutman et al., 2013; Kachkina, 2020, etc.).

However, it should be stated that the sedimentation of the Bazhenov formation took place in a calm environment characteristic of that time; moreover, it is incredible to assume an extremely sharp (jump-like) change of sections over a short distance (0.5 km) and the "uncluttered" psammitic component of the "normal" Bazhenov deposits present in adjacent to ZAS.

Accumulation of ZAS in Achimov's time

More widespread is the idea of a post-sedimentary (in relation to the Bazhenov deposits) Achimov time of formation of the ZAS, which is confirmed by new data from microfaunal and spore-pollen analysis obtained in 2005, confirming the Achimov age of the ZAS matrix. When carrying out spore-pollen studies and microfaunal analysis in the work (Braduchan et al., 2005), paleontological material was obtained for the first time, unambiguously proving that the gray deposits in the ZAS have a younger Valanginian age, in contrast to the Volgian bituminous mudstones of the Bazhenov formation. This circumstance refutes the hypothesis that ZAS belongs to Bazhenov formation, which is not taken into account by a number of authors. However, this version is also ambiguous.

Accumulation due to incision type flows

In 1981 G.S. Yasovich expressed the idea of turbidite and other bottom currents penetrating into the Middle Ob region along negative forms of bottom relief from the north and northeast: "These flows, along the path of their movement, in places cut channels in bituminous clays. The walls of the channels, judging by modern geomorphological analogues, were steep. This led to collapse, slumping of bituminous clays and the formation of neptunian dikes. Therefore, often the contacts of silty-sandy rocks with bituminous clays are uneven, sharp, flow textures are visible, etc." (Yasovich, 1981, p. 58). The currently known ZAS configuration also refutes this hypothesis (Fig. 1).

Formation of ZAS during intrusion of the Achimov deposits into the Bazhenov formaiton

The model for the ZAS of the in this understanding implies that the sandy-siltstone layers of the anomalous sections are the product of the activity of later (Achimov) landslides, which wedged out the unlithified deposits of the Bazhenov formation and introduced into it the brought clastic material of the Achimov formation. According to ideas (Nezhdanov et al., 1985), landslide masses, creating a load on the underlying Bazhenov formations, led to their rupture, collapse and splitting into separate layers, the gaps between which were filled with sandy-clayey material arriving in landslides. This publication was the first to reveal the mechanism of ZAS formation in this way.

The idea of penetration of terrigenous Achimov material into the section of unlithified Bazhenov deposits by flow deposits or wedging of already lithified deposits by flow deposits as a result of the "penetration" of Achimov clinoforms into Bazhenov deposits has become most widespread in the works (Osyka, 2004; Oleynik, Plavnik, 2003; Bespalova et al., 2004; Bordyug et al., 2010; Gatina, Garifullin, 2023, etc.). The idea was developed in more detail by V.F. Grishkevich, who believes that "the underwater landslides that gave rise to the anomalous sections of the Bazhenov formation occurred in Neocomian times on a sedimentary slope... The anomalous section of the Bazhenov formation is the result of the intrusion of a landslide mass of rocks of Valanginian or early Therivian age under bituminous mudstones, usually of Volgian age" (Grishkevich et al., 2017, p. 40). It is impossible to agree with the author's last conclusion. The authors of this hypothesis are not embarrassed (given the obvious complete lithification of the Bazhenov deposits by the beginning of the Achimov time, which is recorded from the core (Fig. 3, e)) by the physical complexity of the described mechanism. The proposed mechanism ("emergence" of up to hundreds of meters of Bazhenov deposits under the influence of Neocomian landslides) is unlikely, contradicts factual data and does not comply with the laws of physical and geological science. Penetration of younger sediments into the underlying layers is possible only during tectonic compression processes at later stages after lithification of sediments. The impossibility of this mechanism is evidenced by the scale of the ZAS, as well as the absence of geological analogues of such a formation previously described in the literature. Moreover, with the mechanism proposed by the authors, the Achimov deposits, which lie in the section between the olistoliths, would certainly have to be completely deformed. However, we also observe normally layered sandy-clayey formations in this part of the section (Fig. 3, c).

Formation of ZAS during the introduction of Bazhenov deposits into Achimov deposits

The most probable is the idea of the underwater landslide (olistostrome) nature of the ZAS, expressed by K.I. Mikulenko, G.B. Ostry (Mikulenko, Ostry, 1968), I.I. Nesterov, A.A. Nezhdanov, I.N. Ushatinsky (Nesterov et al., 1986), A.P. Sokolovsky, R.A. Sokolovsky (Sokolovsky, Sokolovsky, 2003). However, we note that the authors did not always describe in detail the structural features and conditions of formation of the sediment complex under consideration; they did not propose a model for the formation of the ZAS in the region, which gives rise to the variety of hypotheses discussed above.

The phenomena of gravitational movement of significant volumes of previously deposited sediments of olistostrome nature are known in many regions of the world; in their classical form, they are widespread in Dagestan, where they were first described in the Upper Cretaceous and Paleogene deposits by M.M. Moskvin and M.A. Semikhatov (Moskvin, Semikhatov, 1956). Later, we studied Paleogene olistostromes in the conditions of the submerged part of the Terek-Caspian trough (Sharafutdinov, 2003) on the basis of comprehensive field studies (Fig. 4), accumulated geophysical material and the results of drilling hundreds of wells that exposed the Miatlin olistostrome sequence.

As a result of the research, the spatiotemporal patterns of structure and conditions for the formation of the Miatlin olistostrome sequence in the North-Eastern Caucasus were established (Fig. 5).

Olistostromes of similar genesis are widely described in the literature and are very indicative in the sections of many regions of the world, without causing such contradictory judgments as in the conditions of Western Siberia. This circumstance was greatly facilitated by the lack of natural sections of the ZAS, when researchers are limited exclusively to closed territories. It should also be noted that the ZAS throughout the entire section was not fully characterized by core in any of the wells that exposed it.

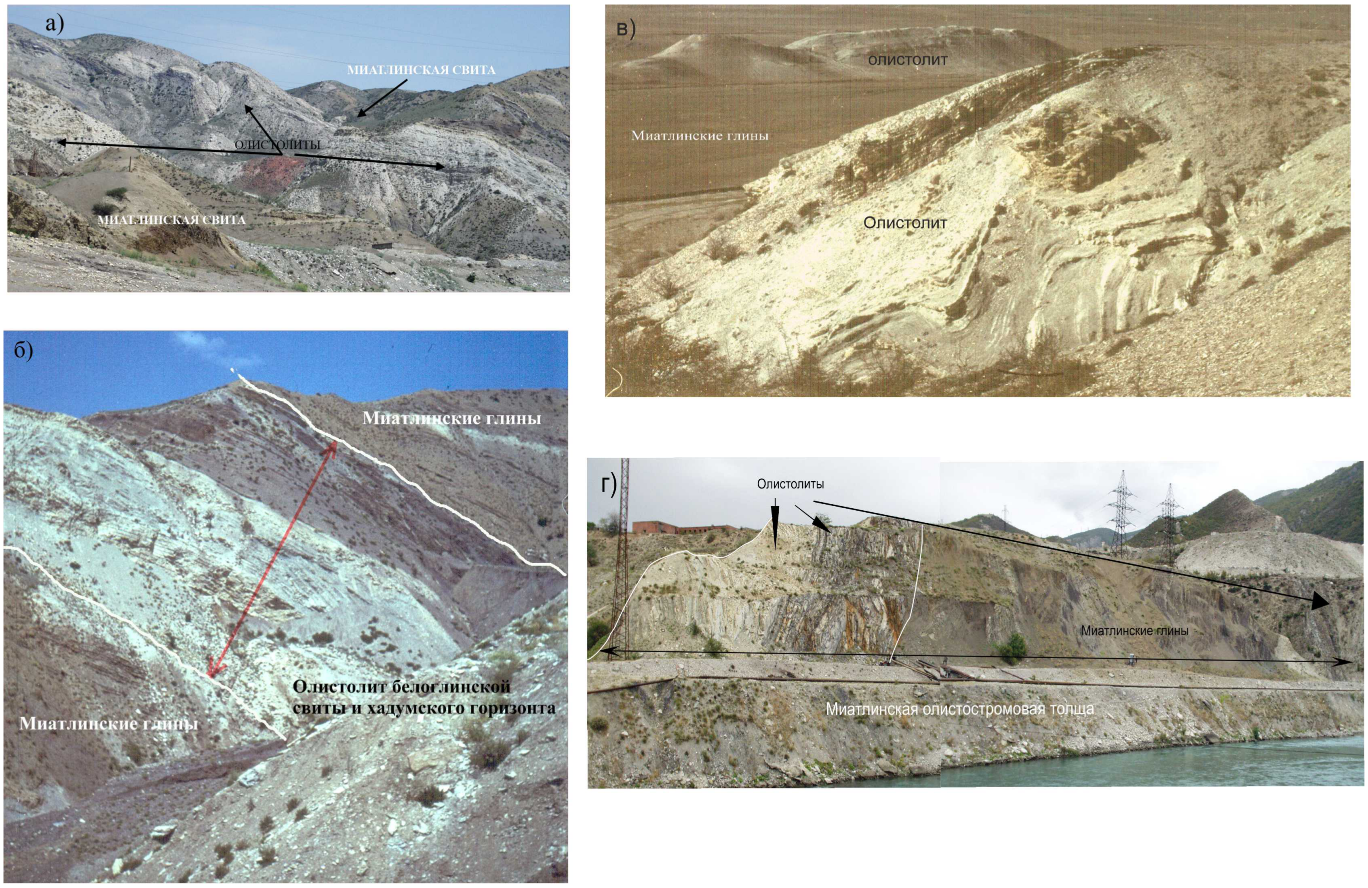

Fig. 4. Natural sections of the Miatlin olistostrome sequence of Piedmont Dagestan

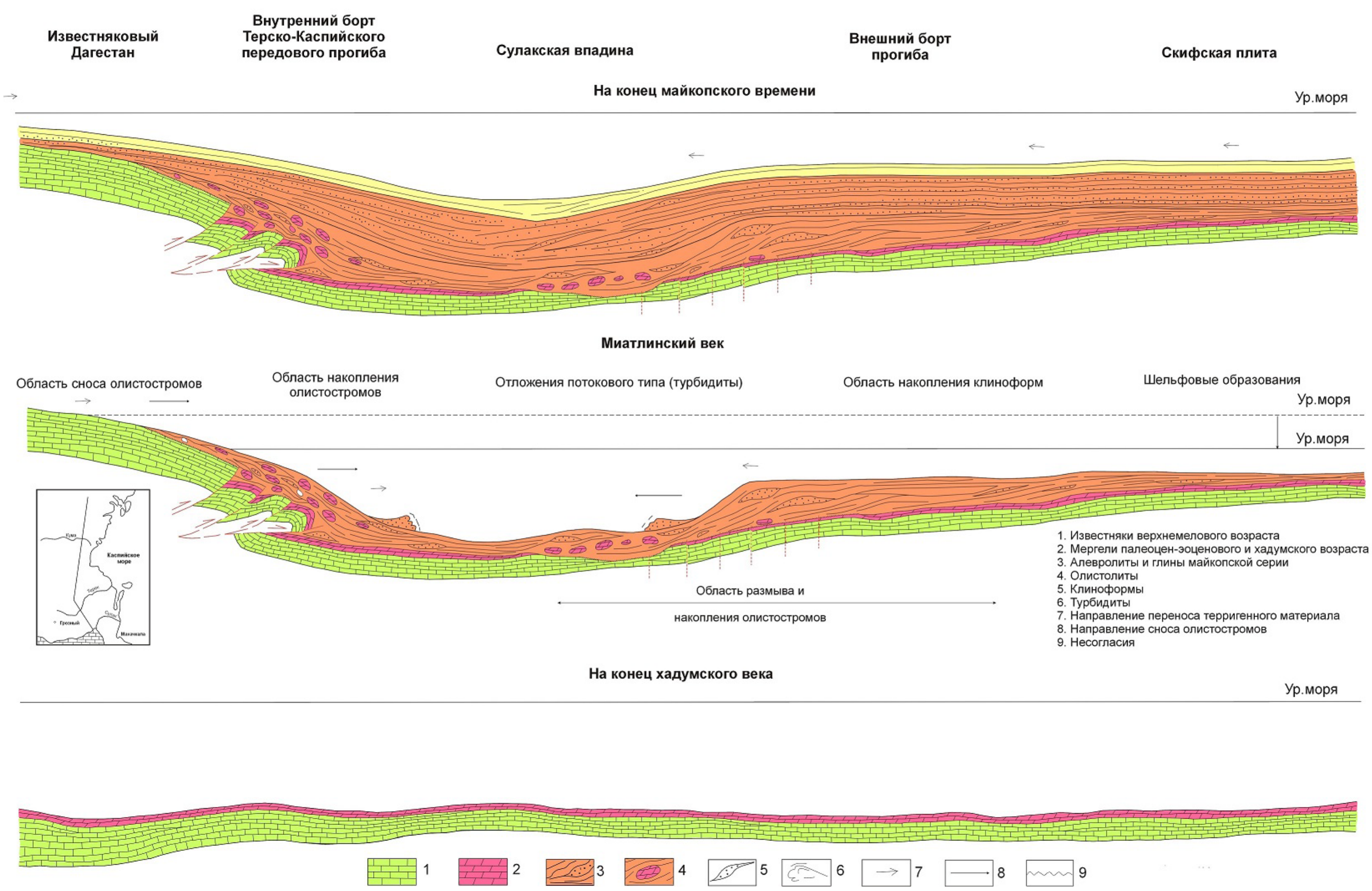

Fig. 5. Principal scheme of accumulation of Maikop sediments of the North-Eastern Caucasus

Materials and methods

The detail of the research carried out allowed us to re-examine controversial issues, reject those views that contradict the factual material, and develop consistent ideas. Thus, the most logical and acceptable for explaining many patterns of formation is the following point of view: consider the ZAS as an olistostrome strata, where the matrix is terrigenous Achimov deposits bearing traces of underwater landslide deformations, and Bazhenov deposits are olistoliths (intrusions) redeposited as a result separation and removal down the slope of the sedimentation basin of rock blocks. This is a classic idea of the sedimentary nature of olistostromes (translated from Greek as "layer – landslide").

The ZAS research methodology included the study of the structural and tectonic features of this territory, seismic-stratigraphic analysis (2D-, 3D-seismic exploration), well logging data and core analysis, as well as lithological-facies, sedimentological, paleogeographic and paleotectonic reconstructions in order to create a sedimentation model and justify the conditions formation of ZAS.

To substantiate the nature of the ZAS, a series of maps were constructed (ZAS thicknesses, thicknesses of olistoliths and thicknesses of ZAS sandstones), which were based on a detailed lithological subdivision of sections of 651 wells with the identification in the sections of inclusions of the Bazhenov formation and the terrigenous component of the Achimov deposits of the ZAS. As a result, qualitatively new data were obtained, which, by clarifying the internal structure, substantiate the genesis of the ZAS, which is included in the classification of olistostromes discussed below.

Identification of the genesis of olistostromes is associated with their structure and spatiotemporal patterns of placement. According to the fair remark of M.G. Leonov, "only understanding the totality of phenomena that lead to the formation of the olistostrome as a specific geological body allows us to correctly interpret the genesis of chaotic complexes" (Leonov, 1981, p. 51).

According to core data and geophysical studies of CDP and well logging, in the ZAS interval there is a wide development of landslide, fluid and cross-bedded textures, as well as olistoliths of various sizes (from a few centimeters to blocks 35 m in thickness), stratigraphic unconformities, clastic (neptunian) dikes, gliding planes, buried faults, etc., forming genetically related dislocations of olistostrome nature. Note that many dislocations have been previously described repeatedly by researchers, but not everyone appreciates their significance.

The variety of forms of olistostromes can be explained by the peculiarities of their formation, primarily the lithological-facial composition of the sliding rocks, the degree of their lithification, as well as exogenous and endogenous causes of sliding. All these factors often act together, involving in the sliding of strata of varying thickness, and lead to a variety of shapes. We consider the morphological classification to be the most appropriate for understanding the genesis, which includes those features of olistostromes that may indicate their origin and are easily diagnosed. Formations paragenetically associated with olistostromes are included in a special group. The body of the olistostrome consists of a ground mass (matrix), which, when formed in marine conditions, is characterized by underwater landslide deformations of unlithified sediment and olistoliths (inclusions). Olistoliths of various sizes are represented by thin-layered siliceous-clayey bituminous deposits of Bazhenov age.

Clayey non-bituminous rocks of the ZAS matrix are gray compacted clays, usually slightly silty with conchoidal and uneven chipping, the age of which is determined to be Achimov (Early Cretaceous). The sandstones and siltstones here are light gray, predominantly fine-grained with pelitic cement. Clays and sandstones are often subject to landslide deformations (Fig. 3, c), both in appearance and in mineralogical composition, according to studies, they are identical to the rocks of the Achimov strata and, in fact, are the same, which is confirmed by faunal data.

Submarine landslide deformations of the matrix, known as "intraformational disturbances", "pseudofolding", etc., are formed during the plastic flow of unconsolidated sediments; they are expressed by bending of layers and are well known from the core of Achimov deposits both in the ZAS and higher up the section. Based on morphology and degree of intensity, landslide deformations can be divided into folded and flow. Weakly lithified sediment with a relatively large degree of movement during the sliding process forms a characteristic texture, which is called flow. The movement of material as a result of its liquefaction can lead to the formation of gravity flows. The formation of landslides and flows can be caused by a common cause – seismicity, resulting in the formation of a group of redeposited sediments similar in morphology to turbidites, which indicates their origin is associated with active paleoseismicity. Landslide horizons in the section alternate with normally layered, undeformed deposits (Fig. 3, c).

The presence of olistoliths (inclusions of Bazhenov deposits) in the section indicates qualitatively different conditions for the genesis of olistostromes than simple sliding of unlithified sediment. Olistoliths are outliers that have gone through the stage of lithification and are redeposited into younger Achimov sediments. The sizes of inclusions vary from a few centimeters to olistoliths 35 m thick, which are identified based on well logging

(Fig. 3, d–g, 6) and seismic surveys (Fig. 3, a, 7). In anomalous sections, redeposited bituminous rocks, according to well logs and core materials, do not differ from similar rocks of normal Bazhenov sections, which is very significant. It is also noteworthy that the texture of the Bazhenov deposits in the core in the olistoliths is the same as in the bedrock: horizontally layered, without signs of resuspension and traces of convolute layering (Fig. 3, d), which indicates that by the time of the ZAS formation, the deposits of the formation were completely lithified and involved in sliding in the form of blocks. This circumstance refutes the statement of supporters of the hypothesis about the penetration of Achimov deposits into unlithified Bazhenov deposits, which would certainly be subject to intense deformation. From those shown in Fig. 3d of the cores clearly shows that the Bazhenov breccia with sharp-angled edges was formed as a result of redeposition of already compacted, lithified fragments of bituminous sediments over a distance of up to ten kilometers.

Let us make a number of comments based on factual data. Actually, the Achimov deposits, which lie between the olistoliths of the Bazhenov deposits in separate layers, often bear traces of landslide deformations, alternating with a normal-layered section. Note that such textural and structural features do not fit into the concept of the formation of the ZAS due to the introduction of Achimov deposits into Bazhenov deposits during their wedging. In the latter case, the entire Achimov strata would certainly be severely deformed and disintegrated, but we often observe normal interlayering of the section. Moreover, proponents of the "wedging" theory believe that it is the sandy pulp that, under its influence, is capable of "wedging" the Bazhenov deposits, however, sections are known where there are practically no sandy-silt varieties in the ZAS and the host stratum has a mainly clayey composition (Yuzhno-Vyintoiskaya area, Fig. 7, b).

According to the core data, in the matrix of the ZAS, in addition to landslide textures and olistoliths, there is a wide development of formations paragenetically associated with olistostromes: various rock fragments, clastic dikes, deposits of mud-stone flows, slip surfaces, lithification cleavage, enveloping textures, local unconformities, erosional incisions, etc.. Conglomerates and breccias are distinguished among the fragments, which differ in the degree of roundness. Very often, during the sliding of olistoliths, both on the body of the olistolith itself and on the surface along which it slides, traces of sliding are formed. Thus, when large olistoliths slide, stress arises on the underlying sediments and lithification cleavage is formed, which is determined by a system of parallel cracks. Another feature of the area of development of olistostromes is that, when moving, olistoliths and landslides produce bottom erosion (incisions), as if "plowing out" the underlying sediments. The considered structural features are characteristic of the *area of accumulation* of ZAS. The *ablation area* is characterized by stratiform fracturing, clastic dikes (Fig. 3, b), buried faults and erosional sections.

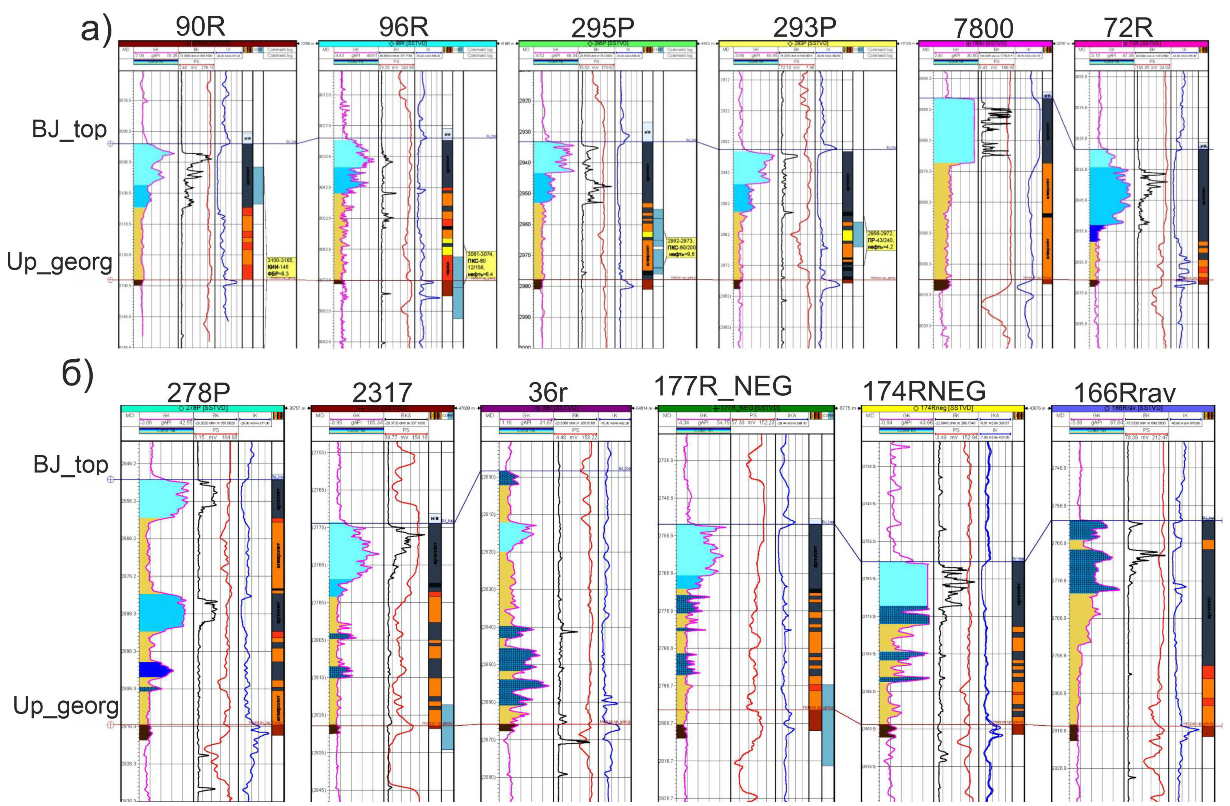

Fig. 6. Well correlation schemes: a) in the western part of the Shirotnoye Priobie (Severo-Konitlorskaya, Tevlinsko-Russkinskaya, Imilorskaya areas); b) in the eastern part (Kechimovskaya, Vyintoyskaya, Pokachevskaya, Potochnaya areas)

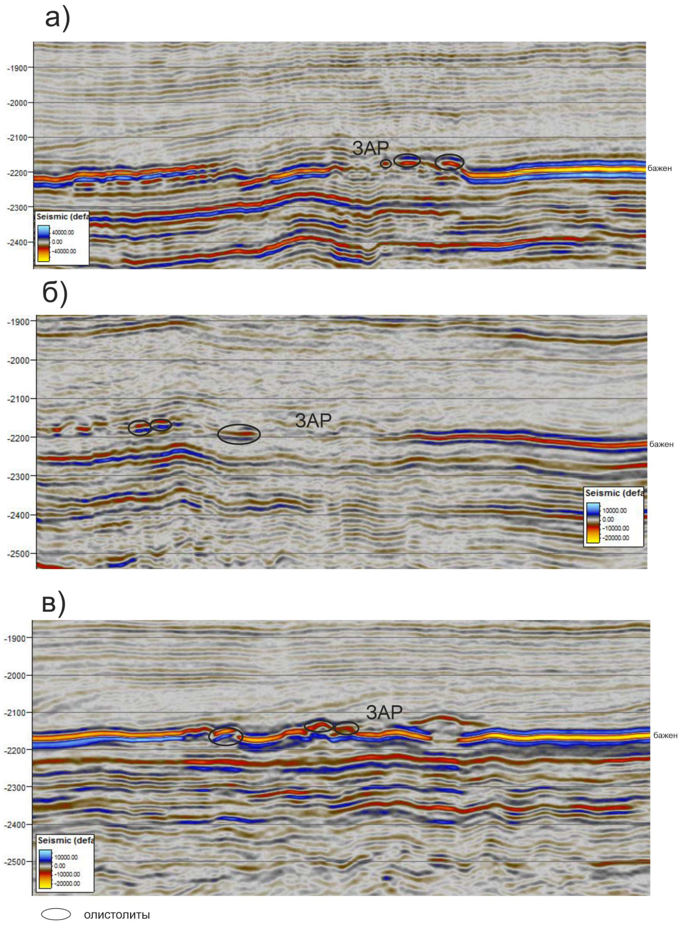

Fig. 7. Fragments of seismic sections illustrating zones of anomalous sections (ZAR): a) Imilorskaya area; b) Yuzhno-Vyintoyskaya area; c) Povkhovskaya area

Stratiform fracturing is a system of parallel cracks that violates the integrity of rocks and divides monolithic rocks into separate blocks, some of which are involved in sliding processes. During tectonic deformations, wider cracks are formed, which are filled with clastic material, forming clastic dikes, which are an indicator of paleoseismicity. Their association with sliding phenomena indicates that these horizons did not arise as a result of passive gravitational underwater sliding, but are associated with earthquakes (paleoseismicity), which is typical for the studied sections. Involved in sliding processes, slumped blocks form "scars" – erosional sections and stratigraphic unconformities, when typical Achimov deposits overlie the Georgievskaya formation or, less commonly, the eroded surface of the middle Bazhen (Fig. 3, g, wells 315, 801sk). Finally, in the area remote from the accumulation of olistostromes, turbidites and deposits of mud-rock flows appear.

Features of the spatial distribution of olistostromes are identified based on seismic survey and well logging materials, which were used in full for the Latitudinal Ob region.

The "landslide" model of the ZAS is quite confidently recognized on seismic time cross-sections. However, the complexity of the geological structure, strong lithological variability and unconsistency of the olistostrome strata (OSS) deposits for a long time made it difficult to study them using time sections and led to the emergence of various points of view on the formation, since the quality of seismic data in the early years did not correspond to the solution of these problems and gave very meager, and sometimes a false idea about the structure of "anomalous" sections. The analysis of modern seismic material, thanks to the widespread use of CDP 3D, is distinguished by a clear depiction of structural details, which makes it possible to study the internal structure of the seismic elements, identifying their olistostrome nature (Fig. 3, a, 7). On time seismic sections, ZAS are characterized by the absence of a stable shape of the wavetrain; they are recorded by abrupt, bumpy, chaotic in-phase axes with the absence of consistent areas and phases. In general, horizon "B", which was not dynamically maintained in the ZAS, can be traced fragmentarily along the section, where individual large olistoliths are visible. At a short distance, the correlation of layers is disrupted and the composition of the rocks changes abruptly, which is typical for olistostrome deposits. Sharp jumps in the thickness of the ZAS and contrasting acoustic properties in this part of the section often lead specialists to identify imaginary displacements of a discontinuous nature. The conceptual study of sections with close connection with drilling data has made it possible to largely reveal the features of the structure and formation of the ZAS, especially since the resolution of modern seismic exploration makes it possible to recognize the internal structure of these sections. However, the ZAS based on seismic survey data should be analyzed along deep sections and on a 1:1 scale in order to avoid a distorted idea of the formation of the studied deposits.

From Fig. 3, a, 7 it is clear that above the ZAS the clinoform structure of the Achimov deposits is clearly visible, but the "wedging" of the Achimov clinoforms of the ZAS is not visible, which is what supporters of the idea of wedging "Achimov fragments into Bazhen strata" adhere to. The latter can only indicate that even after the accumulation of ZAS with thicknesses of up to 100 m and more, the slope of the sedimentation basin was not compensated by sediments, and subsequently continued to accumulate the Achimov strata of clinoform structure. Severely uncompensated sedimentation distorts the picture of the structure of the ZAS on time sections, creating the illusion of a "torn off lid."

According to well logging data, large blocks of Bazhenov deposits are reliably identified, and small fragments are identified by core material (Fig. 3, e). In the ZAS, bedrock Bazhenov deposits are expected to be found near the western border of the ZAS, as, for example, in wells 102, 103, 103R, 104R of the

Severo-Kochevskaya area. Typically, the Georgievsk clays are overlain by Achimov deposits, in which one or several levels of olistoliths are distinguished. In the sections of the Bazhenov formation in the bedrock along the eastern borders of the ZAS, in a number of wells, sections are distinguished in which the reduction of the upper part of the Bazhenov formation is noted; these are zones of detachment and removal of olistoliths (Fig. 3, g). In the ZAS, several levels of olistoliths of the Bazhenov formation are often distinguished (Fig. 3, f, g, 6, b).

Normal sections of the Bazhenov formation are characterized by a certain facies variability within a particular study area, which affects the shape of well logging curves, especially gamma ray logging. In large olistoliths of the Bazhenov Formation in ZAS, the shape of the log curve is similar to the nearby (eastern) bedrock, which indicates their "local" origin. Thus, all identified ZASs are characterized by their own "paired" connections between the Bazhenov deposits in the bedrock and in the redeposited one – in the form of olistoliths.

Discussion and conclusions

Generalization of all material and construction of maps of ZAS thicknesses, total thicknesses of ZAS olistoliths and sandstones made it possible to identify a number of fundamental structural patterns within the Latitudinal Ob region, reflecting the key features of genesis.

In the study area, ZASs are represented by geological bodies up to 80 km long and from 2 to 34 km wide (Fig. 8). Based on a detailed downhole analysis and dissection of the ZAS, it was established that the creep involved mainly individual blocks of Bazhenov deposits up to 20 m thick; several stratified levels were formed in the section, reaching total thicknesses of up to 60 m (Kechimovskaya area). The distribution of olistoliths in the section, as well as their internal structure, indicate the synchronicity of these formations within the region under consideration and the peculiarities of their formation.

In the Latitudinal Ob region, seven large ZAS distribution areas have been identified: Konitlorskaya, Tevlinsko-Imilorskaya, Ravensko-Kechimovskaya, Vyintoiskaya, Povkhovskaya, Pokachev-Potochnaya and Vostochno-Perevalnaya. For each of the zones, a set of geological maps has been constructed, which can be used to predict the development of reservoir layers in the ZAS.

In general, according to the map of ZAS thicknesses within the studied region, the maximum thicknesses correspond to more western regions. Within the Imilor deposit, the ZAS reaches 135 m. In the central zones, the values do not exceed 100 m, and in more eastern regions, the average thickness rarely reaches about 70 m and in the extreme eastern regions does not exceed 45 m. Taking into account the nature of the thicknesses within each of the selected zones, we note that the maximum values occur in the central regions inside the ZAS. The indicated regularities are of practical importance for the correct interpretation of seismic survey data, in addition to forecasting the development of ZAS for drilling new wells.

The identified structural features confirm the underwater landslide nature of the ZAS and indicate their natural development on the Achimov paleoslope, when the thickness of the accumulating sediments of the ZAS increases towards the axial part of the sedimentation basin.

- ZAS form few landslide horizons (up to 5–7).
- The ZAS were formed by moving significant volumes of olistoliths in the sublatitudinal direction: from east to west – at a distance of up to ten kilometers, according to the analysis of the ZAS structure.
- The total thickness of the ZAS (fixed by the uppermost olistolith) decreases in the direction from west to east from more than 100 m to 20–30 m, as evidenced by correlation schemes constructed from the areas studied by drilling.
- Deposits of Bazhenov age discovered by wells are nothing more than outliers in the form of olistoliths (inclusions) of Bazhenov age in deposits of the Achimov formation.
- In fact, the areas of ZAS correspond to zones of absence of Bazhenov age deposits in their bedrock due to erosion and redeposition in the form of olistoliths, which is proven by the results of detailed correlation of sections, study of dynamic records, core material, etc.

Sedimentation pattern of the region in the Bazhenov time (Tithonian-Lower Berriasian)

The Bazhenov time in Western Siberia occurred at the final stage of the largest marine transgression in the geological history of Siberia. Already in the Kimmeridgian age, the sea almost completely flooded the West Siberian Plate. The Bazhenov Sea was the deepest one of all the Mesozoic and Paleogene epicontinental basins of Siberia. Zones with poor circulation of bottom waters, low sedimentation rates and quiet tectonics were predominated regimes. At this time, finely elutriated, horizontally layered or massive bituminous mudstones with foliated or thin platy sections were accumulated, which is associated with the passive hydrodynamics of the sedimentation basin. The Bazhenov horizon was formed not only during the maximum transgression, but also under conditions of tectonic quiescence and relief leveling.

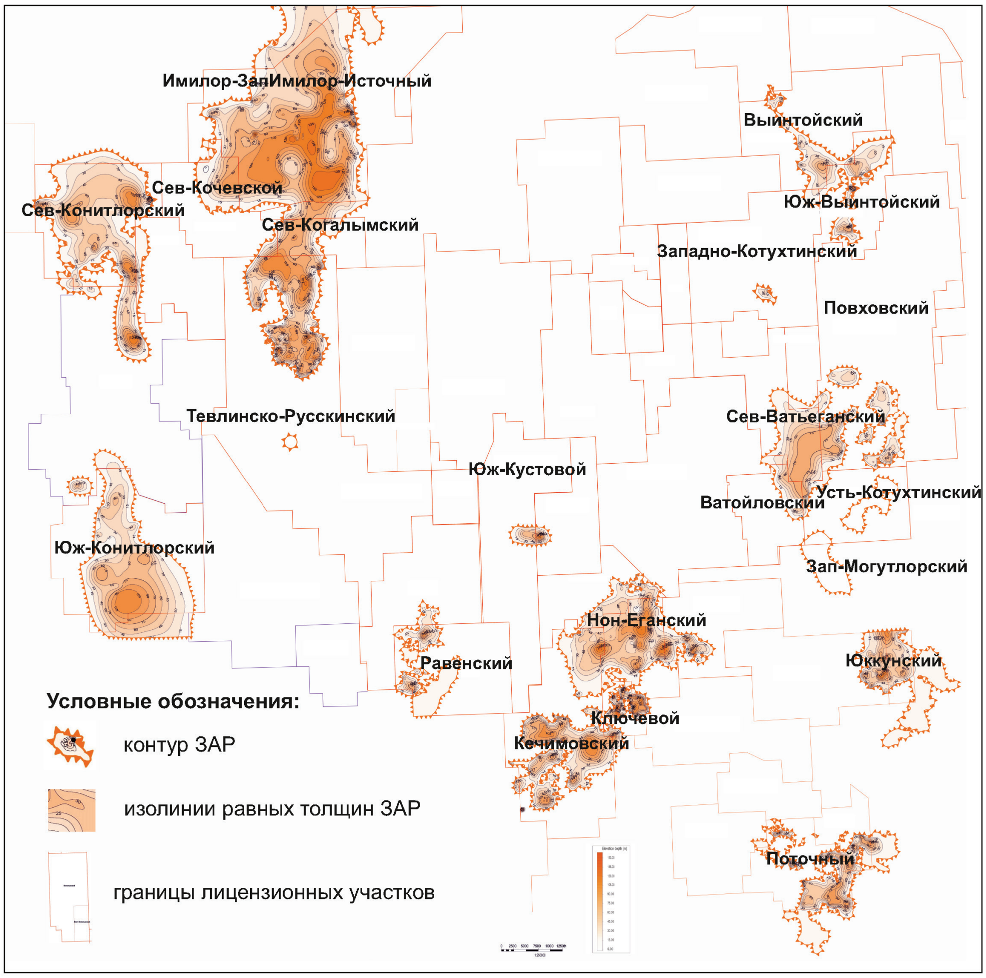

Fig. 8. Total thicknesses of ZAS of the Shirotnoye Priobye area

Sedimentation pattern of the region in the Achimov time

The stage of tectonic stabilization at the Bazhenov time was replaced by a period associated with the Late Mesozoic activation, the derivative of which at an early stage is the ZAS, which maximally manifested itself in the Early Cretaceous era. The peculiarities of sedimentation in the Neocomian time are due to the progradational growth of the slope in conditions of uncompensated subsidence of a wide (400–500 km) underwater plain, gently inclined to the west, which determined the basic elements of the structure of the clinoform Achimov complex and the ZAS. ZASs in space are subject to the same submeridional zoning as clinoforms, leaving no doubt about their genetic relation.

The time under consideration was accompanied by a pronounced manifestation of horizontal sedimentation, which is a constantly active and decisive factor in sedimentation, both during the formation of the ZAS and during the formation of the general clinoform complex of Neocomian deposits. Most researchers of the Achimov strata fairly believe that its formation was greatly influenced by sedimentary landslide processes. On the one hand, this opinion was based on general theoretical ideas about the conditions of sedimentation within the paleoslope, when the supply of clastic material outstripped the possibilities of its redistribution in the sea basin; on the other hand, this fact is indicated by the presence in the Achimov strata of rocks intensively dislocated by underwater landslide processes with an abundance of primarily unconsolidated clay inclusions in sandstones interbedded with normally layered formations. In our opinion, the most convincing evidence of the existence of underwater landslides in the Neocomian is ZAS. Since the processes occurred in the Achimov time and the Bazhenov deposits are in a redeposited state, it is worth abandoning the name "anomalous Bazhenov section" (ABS), since the latter is misleading about the time of their formation.

Genesis of ZAS

If the mechanism of sediment slumping is quite obvious, then questions of the genesis of olistoliths usually cause heated discussions. Dwelling on this issue, we note that for the possibility of redeposition of ancient rocks into younger sediments, a break in the sediments hosting the olistolith in the associated uplifted area is necessary. Due to the clinoform structure of the Achimov deposits, such geological prerequisites in the study area are obvious.

The causes of landslides can be divided into paleogeographic (gemorphology of the sedimentation basin), sedimentation (mainly determined by the rate of sedimentation), hydrodynamic (strong waves, especially during the passage of hurricanes, tsunami waves) and tectonic (paleoseismicity). Most often few factors act simultaneously, which determines the widespread occurrence of landslides and collapses on underwater slopes.

The completed paleotectonic and paleogeographic reconstructions with sedimentation analysis make it possible to reconstruct the conditions for the formation of the ZAS, both regional and local, using actual data.

We have made an attempt to specify the mechanism for the formation of ZAS. A basic regional diagram of the formation of olistoliths and olistostromes in general for the conditions of Western Siberia is shown in Fig. 9. It is obvious that at the time of olistolith failure, the Bazhenov deposits should be exposed in underwater conditions. Having come off, the olistoliths moved along the bottom slope and, having stopped, were overlapped by the deposited sediments, being buried in the form of inclusions that we observe. Multilevel development in the section of olistoliths reflects the pulsed multistage nature of the formation of olistostromes. The sliding of huge masses re-initiated resuspension and additional active processing of sedimentary material. It can be stated with confidence that these processes manifested themselves especially intensively during Achimov time. The accumulation of sediments overlying the Bazhenov deposits occurred under conditions of avalanche sedimentation.

The scale of the manifestation of ZAS (Fig. 1) cannot be explained only by ordinary sedimentation processes. ZAS were formed during sedimentary landslide phenomena caused by tectonic processes (including paleoseismicity). Confirmation of the manifestation of paleoseismicity in the study area are clastic dikes, as well as buried faults. Anomalous zones are located within both positive and negative structures, and their orientation is consistent with the strike of first-order tectonic elements.

Direct evidence of Achimov tectogenesis are numerous buried (consedimentary) faults that fade in Achimov deposits. During the accumulation of the clinoform complex, different areas of the bottom of the sedimentation basin experienced multidirectional vertical movements. The amplitude of the vertical component of displacements along faults at horizon level “B” is 15–25 m, less often 35–45 m. Signs of fault tectonics found in the core are confirmed by seismic data.

The bituminous shales of the Bazhenov formation, having a unique lithological composition and a tendency to schistosity, could easily slide from their base during seismic shocks and subvertical tectonic movements and, crushing into separate blocks, move under the influence of gravity down the slope of the sedimentation basin, subsequently becoming covered with sandy-clayey material from the Achimov deposits. As a result, slumping occurred and, as a consequence, the introduction of Bazhenov olistoliths into the Achimov deposits. A similar mechanism is shown step by step in Fig. 9. It must be recognized that, like the Bazhenov deposits, the Kuma bituminous shales of the North-Eastern Caucasus were also the main sliding horizon during the formation of the Miatlin olistostrome sequence of the Oligocene (Sharafutdinov, 2003).

The ruggedness of the relief was reflected in the formation of subsequent, younger layers, the sediments of which in some cases leveled the relief, filling the most submerged zones, in others they formed complex zones of sedimentation. The continuing subsidence of the territory against the backdrop of intensive input of terrigenous material allowed these bodies to be preserved and buried under later normal-layered sediments of the Achimov deposits. Repeating in time, dislocated ZASs alternate in the section with calmly lying Achimov deposits.

The Bazhenov sedimentation basin, undercompensated by sedimentation, predetermined the paleogeographical setting with relatively steep sides of the basin. Subsequent deposits of the Achimov strata are the result of periodic pulsating input of terrigenous masses into the sedimentation basin under conditions of its uncompensated subsidence and avalanche sedimentation with the formation of a thick clinoform complex of sediments. The zones of development of the olistostrome section correspond to the first impulses of filling the trough. According to the time of formation from east to west, ZASs are increasingly younger in age.

Thus, among the determining factors interrelated and “responsible” for the formation of ZAS, the following can be identified:

- favorable paleogeographic conditions – regional slope of a sedimentation basin with uncompensated sedimentation;
- sea level decline;
- features of the manifestation of avalanche sedimentation in the Achimov time with progradational growth of the slope, which determined the basic elements of the structure of the clinoform complex;
- tectonic Early Cretaceous activation;
- paleoseismicity – ZASs are mainly confined to zones of tectonic tension associated with fault tectonics and structure formation;
- pulsating manifestation of olistostrome formation factors;
- lithological factor of the Bazhenov olistoliths – the high content of finely dispersed organic matter gives rise to their leafiness and slight disintegration and shearing into blocks (olistoliths).

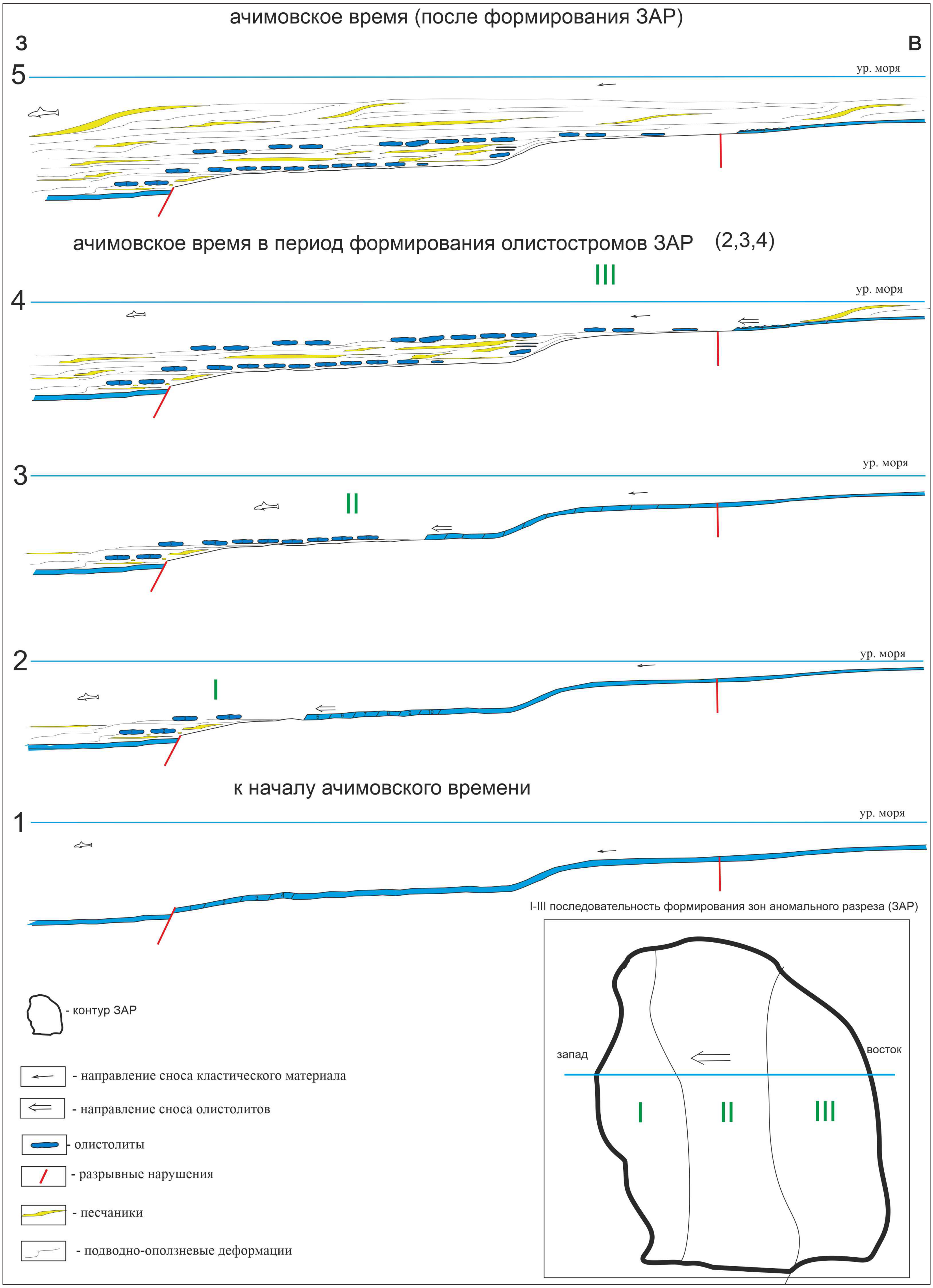

Fig. 9. Principal scheme of formation of ZAS

The correctness of the conclusions drawn is also confirmed by the fact that during modern earthquakes in underwater conditions, sediment slumps occur, manifestations similar in scale and conditions to the considered fossil ones.

Conclusion

The existing views on the genesis of ZAS are considered and their critical analysis is given. To date, about a dozen options have been proposed to explain the genesis of ZAS, but in most cases they turned out to be untenable when applied to explaining the phenomenon as a whole. Taking into account the data accumulated to date, none of the hypotheses considered is generally accepted. At the same time, the accumulated factual material allows us to significantly narrow the range of reasons for the genesis of ZAS.

Underestimation of the ZAS and/or incomplete analysis of the factual material leads to serious errors of a stratigraphic, structural and paleogeological nature, which negatively affect the practice of oil and gas exploration. As a result, to date there is no clear conceptual model of the strategy for searching for deposits in this unique complex of deposits. Accordingly, many of the reservoir models used cannot serve as an adequate basis for reservoir development.

Key structural features for understanding the genesis of ZAS have been established. Lithological-facial, structural and textural features of the structure of the ZAS have been determined, indicating their olistostromal nature. A classification of the identified ZAS morphologies was performed. The presence of olistoliths of the Bazhenov deposits at several levels indicates several phases of intensified formation of olistostromes.

The proposed model for the formation of olistostromes further substantiates the age of the ZAS, which allows us to speak with confidence about the Achimov, and not the Bazhenov, age of the deposits under consideration.

The reasons for the formation of ZAS have been established and their genesis has been substantiated. Based on the available data and structural features of the Achimov olistostrome strata, a mechanism for their formation is proposed due to underwater landslide (olistostrome) genesis against the background of consedimental tectonics.

It is fundamentally important to understand that the zones of the anomalous section represent a unique olistostrome facies of the Achimov time, when already lithified Bazhenov blocks (olistoliths) were intruded into the Achimov sediments as a result of underwater landslide processes.

The proposed model seems to be the most logical, supported by all currently known factual data, is the most universal, fits into the paleogeographical environment and tectonic regime that prevailed in Achimov's time. This model will allow us to take a fresh look at the structural features, evaluate reserves in the ZAS, and also give recommendations for carrying out prospecting and exploration work in the lithological traps of the ZAS.

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References

Bembel S.R., Tseplyaeva A.I. (2014). Geological structure and some features of formation anomalous cuts of the Bazhenov formation in Western Siberia. *Vestnik PNIPU. Geologiya. Neftegazovoe i gornoe delo = Bulletin of PNRPU. Geology. Oil & Gas Engineering & Mining*, (10), pp. 7–17. (In Russ.) http://dx.doi.org/10.15593/2224-9923/2014.10.1

Bembel S.R., Zadoenko L.A. (1993). The nature of anomalous sections of the Bazhenov formation on the Yuzhno-Vatyeganskaya Square (Upper Jurassic of Western Siberia). *Byulleten' MOIP. Otdelenie geologii,* 68(1), pp. 115–119. (In Russ.)

Bespalova E.B., Polyakova A.A., Kucheryavenko D.S. (2004). Features of the structure and formation conditions of the anomalous sections of the Bazhenov formation on the example of the Konitlorsky and Kurragansky fields of the West Siberian oil and gas basin. *Geologiya Nefti I Gaza = Russian Oil And Gas Geology*, (19), pp. 6–13. (In Russ.)

Bordyug M.A., Slavkin V.S., Gavrilov S.S. (2010). Features of the structure and formation of the anomalous section of the Bazhenov formation on the example of the Severo-Konitlorskoye field. *Geologiya Nefti I Gaza = Russian Oil And Gas Geology*, (1), pp. 32–40. (In Russ.)

Braduchan Yu.V., Glushko N.K., Komisarenko V.K., Shatova L.A., Grishkevich V.F., Kasatkin V.E., Predein S.A., Teploukhova I.A., Toropov E.S. (2005). On the age of deposits of anomalous sections of the Jurassic-Cretaceous boundary layers in the wells of the North-Konitlorsky field. *Vestnik nedropol'zovatelya Khanty-Mansiyskogo avtonomnogo okruga*, (16), pp. 24–26. (In Russ.)

Filippovich Yu.V. (1999). Types and mechanisms of the formation of anomalous sections of the Bazhenov horizon and Achimov strata. *Vestnik nedropol'zovatelya Khanty-Mansiyskogo avtonomnogo okruga*, (4), pp. 30–34. (In Russ.)

Gatina N.N., Garifullin I.I. (2023). The experience of constructing a detailed scheme of the oil content of the anomalous section zone of the Bazhenov-Achimov deposits on the basis of a seismogeological model. *Neftegazovaya geologiya. Teoriya i praktika = Petroleum Geology – Theoretical and Applied Studies*, 18(1), pp. 1–17. (In Russ.) http://www.ngtp.ru/rub/2023/12_2023.html

Grishkevich V.F., Kasatkin V.E., Lagutina S.V., Moskalenko N.Yu., Smolyakov G.A., Panina E.V., Laptei A.G., Toropov E.S., Starikov V.S., Khoroshev N.G., Blinkova A.V., Chernoskulova V.A. (2017). Some aspects of joint modeling of the Achimov strata and anomalous sections of the Bazhenov formation. *Geologiya, geofizika i razrabotka neftyanykh i gazovykh mestorozhdeniy = Geology, Geophysics and development of oil and gas fields*, (9), pp. 27–42. (In Russ.)

Gutman I.S. (2011). Correlation of the well sections of oil and gas complex facilities based on innovative technologies. Moscow: Gubkin Russian State University of Oil and Gas, 116 p. (In Russ.)

Gutman I.S., Kachkina E.A., Shalupina A.V., Semyanov A.A., Skachek K.G. (2013). Features of the geological structure of anomalous sections in the Upper Jurassic and Achimov deposits of the Kechimovsky deposit. *Neft'. Gaz. Novatsii*, 2(22), pp. 43–46. (In Russ.)

Kachkina E.A. (2020). Tectonic conditions for the formation of anomalous sections of the Bazhenov formation and the compensatory Achimov formation in the Latitudinal Ob deposits of Western Siberia. *Cand. geol-mineral. sci. diss*. Moscow: Sergo Ordzhonikidze Russian State University for Geological Prospecting. (In Russ.)

Kolokoltsev V.G., Larichev A.I. (2006). Late Mesozoic tectonic-magmatic-metasomatic activation of the West Siberian plate and its influence on the structure of the oil and gas basin. *Coll. papers: Actual problems of forecasting, prospecting, exploration and production of oil and gas in Russia and CIS countries. Geology, ecology, economics*. St. Petersburg, pp. 270–283. (In Russ.)

Leonov M.G. (1981). Olistostroms in the structure of folded regions. *Trudy Instituta*, (344). Moscow: Nauka, 177 p. (In Russ.)

Mikulenko K.I. (1967). Underwater landslide formations in Paleocene and Eocene deposits of Dagestan. *Izv. ANSSSR. Ser. geol*., (2), pp. 134–149. (In Russ.)

Mikulenko K.I., Acute G.B. (1968). Landslide formations in Mesozoic sediments of the West Siberian Lowland. *Litologiya i poleznye iskopaemye,* (5), pp. 111–118. (In Russ.)

Mkrtchyan O.M. (1985). About the structure of the Bazhenov formation of Western Siberia. *Doklady AN SSSR*, 280(3), pp. 700–704. (In Russ.)

Mkrtchyan O.M., Trusov L.A., Belkin I.M., Degtev V.A. (1987). Seismological analysis of oil and gas deposits of Western Siberia. Moscow: Nauka, 126 p. (In Russ.)

Moskvin M.M., Semikhatov M.A. (1956). Underwater landslide disturbances in Upper Cretaceous and Paleogene deposits of Dagestan. *Izv. AN USSR. Ser. geol.,* (10), pp. 67–84. (In Russ.)

Nezhdanov A.A., Kulagina S.F., Kornev V.A., Hafizov F.Z. (2017). Anomalous sections of the Bazhenov formation: a look half a century after discovery. *Izvestiya vuzov. Neft' i gaz = Oil and Gas Studies*, (6), pp. 34–42. (In Russ.) https://doi.org/10.31660/0445-0108-2017-6-34-42

Nezhdanov A.A., Tumanov N.N., Kornev V.A. (1985). Anomalous sections of the Bazhenov formation and their seismogeological characteristics. Seismic exploration for stratigraphy and lithology. Tyumen: ZapSibNIGNI, pp. 64–71. (In Russ.)

Nezhdanov A.A. (2004). Seismogeological analysis of oil and gas bearing deposits of Western Siberia for the purposes of prediction and mapping of non-anticlinal traps and deposits of HC. *Dr. geol. and mineral. sci. diss*. Tyumen, 297 p. (In Russ.)

Osyka A.V. (2004). Anomalous sections of the Bazhenov formation on Povkhovskaya Square are an object for searching for hydrocarbon deposits. *Vestnik nedropol'zovatelya Khanty-Mansiyskogo avtonomnogo okruga*, (14), pp. 40–42. (In Russ.)

Petrov A.I., Shein V.S. (1999). Geodynamic model of a reservoir with a siliceous-clay reservoir (on the example of the Bazhenov formation of the Salym oil field in Western Siberia). *Geologiya Nefti I Gaza = Russian Oil And Gas Geology*, (9). (In Russ.)

Sharafutdinov V.F. (2003). Geological structure and patterns of development of the Maikop deposits of the North-Eastern Caucasus in connection with oil and gas potential. *Abstract Dr. geol. and mineral. sci. diss.* Moscow: Lomonosov Moscow State University, 23 p. (In Russ.)

Sokolovsky A.P., Sokolovsky R.A. (2003). Anomalous types of sections of the Bazhenov and Tutleim formations in Western Siberia. *Vestnik nedropol'zovatelya Khanty-Mansiyskogo avtonomnogo okruga*, (11), pp. 64–69. (In Russ.)

Sudakova V.V. (1997). Anomalous sections of the Bazhenov formation on the example of the Fedorovsky oil and gas field. The model of their formation and oil content. *Izvestiya vuzov. Neft' i gaz = Oil and Gas Studies*, (6), p. 14. (In Russ.)

Timurziev A.I. (2014). The fluid-dynamic nature of the formation of the anomalous Bazhen in Western Siberia. *Burenie i neft*, (1), pp. 28–33. (In Russ.)

Trofimova E.N., Alekseeva E.V., Usmanov I.Sh., Kurylenkova G.A., Medvedeva E.A., Karlov A.M. (2008). Macro-study of the core. To the question of formation of anomalous sections of the Bazhenov formation and the clinoform structure of the Neocomian complex. *Ways to realize oil, gas and ore potential of KhMAO–Yugra: Proc. 11th Sci. and Pract. Conf*. Khanty-Mansiysk: IzdatNaukaServis, Vol. 1, pp. 240–259. (In Russ.)

Vologodsky D.V. (2013). Features of occurrence and formation of the Upper Jurassic and Lower Cretaceous deposits at zones of development of the anomalous sections on the example of the Tevlinsko-Ruskinsky oil field. *Abstract Cand. geol. and mineral. sci. diss*. Moscow, 26 p. (In Russ.)

Yasovich G.S. (1981). Oil potential of the anomalous sections development zones of the Bazhenov formation of the Middle Ob region. *Trudy ZapSibNIGNI*, (166), pp. 51–59. (In Russ.)

Zaripov O.G., Sonich V.P. (2001). A new type of section of the Bazhenov formation and prospects for increasing of recoverable reserves in the territory of Surgutneftegaz. *Ways to realize oil, gas and ore potential of KhMAO–Yugra: Proc. IV Sci. Conf*. Khanty-Mansiysk: IzdatNaukaServis, pp. 142–153. (In Russ.)

Zubkov M.Yu., Pormeister Ya.A. (2005). Clinoform structure of the Neocome and anomalous sections of the Bazhenov formation within the Kalchinsky deposit (according to seismic survey and tectonophysical modeling). *Ways to realize oil, gas and ore potential of KhMAO–Yugra: Proc. VIII Sci. Conf*. Khanty-Mansiysk: IzdatNaukaServis, pp. 305–318. (In Russ.)

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Строение и генезис ачимовской олистостромовой толщи Западной Сибири

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Вопрос генезиса зон аномального разреза баженовско-ачимовских отложений остается одним из самых дискуссионных проблем Западной Сибири. Решение этого вопроса тесно связано с геологоразведочными работами, поскольку с этим комплексом отложений связаны перспективы поисков залежей нефти и газа. К настоящему времени представлено около десятка гипотез условий формирования этого своеобразного комплекса отложений. Однако ни одна из предложенных гипотез не является общепринятой. В работе все гипотезы классифицированы по генезису и дан критический их анализ. Рассмотрены ключевые особенности строения зон аномального разреза по материалам бурения и сейсморазведочных работ. Приведена классификация олистостромов и описаны особенности осадконакопления в баженовское и ачимовское время. Накопленный к настоящему времени фактический материал позволил обосновать олистостромовую природу аномальных разрезов. По комплексу данных, включая палеогеографические, седиментологические, палеотектонические реконструкции, впервые предложена принципиальная детализированная модель условий образования олистостромов. Эта модель представляется весьма логичной, является наиболее универсальной и соответствует палеогеографической обстановке и тектоническому режиму, которые господствовали в ачимовское время.

Ключевые слова: зона аномальных разрезов, баженовские отложения, ачимовские клиноформы, олистостром, олистолит, подводный оползень, условия формирования

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