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EUSTATIC SIGNALS IN THE JURASSIC AND LOWER CRETACEOUS (NEOCOMIAN) DEPOSITS OF THE WEST-SIBERIAN SEDIMENTARY BASIN

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A transgressive-regressive (T-R) curve was constructed on the basis of a high-resolution chronostratigraphy for the entire Jurassic and lower part of the Neocomian of the West-Siberian sedimentary basin. This curve was compared with two other curves: a quantitative eustatic curve constructed earlier by Sahagian et al. from sedimentation and biostratigraphic evidence obtained on the Russian and Siberian Platforms for the interval from Middle Jurassic to Cretaceous and a curve derived by B. Haq et al. As a result, eustatic signals were extracted from local T-R events. Nineteen significant transgressive-regressive events were identified within Jurassic-Neocomian stratigraphic interval: 2 in the Early Jurassic, 3 in the Middle Jurassic, 4 in the Late Jurassic, and 10 in the Neocomian. Most T-R cycles correlate well with the eustatic curves. Fluctuations of sea level show an increase in frequency that is due to a decrease in regressive "shoulder" of the cycles in time. The evidence of significant T-R events in the West-Siberian Jurassic and Neocomian strata has been reported from both adjacent areas and other continents of the Northern Hemisphere. These include: Kiterbyut T-event (Early Toarcian), Vymskoe-Leont'evskoe T-R event (Bajocian), Middle Vasyugan R-event (Middle Oxfordian), Bazhenovo T-event (Late Kimmeridgian – Volgian), and 5 T-R events in the Valanginian. A "through" sequence-stratigraphic analysis was performed for the productive Jurassic and Neocomian strata of the West-Siberian sedimentary basin. These strata were divided into sequences of second and third ranks, which helped us to resolve some contradictions between the existing stratigraphic and depositional models.

Stratigraphy, Jurassic, Neocomian, eustasy, transgression, regression, West Siberia

INTRODUCTION

The concept of eustasy (global sea level change) in sedimentary geology is widely used at present to explain the mechanism of formation of unconformable planes in stratigraphic sections [1,2]. Interest in the eustasy particularly increased after the sequence-stratigraphic concept and eustatic curve for the Mesozoic–Cenozoic interval were published by Exxon's working group [3, 4]. However, opinions of experts about estimation of the role of eustasy in sedimentation differ essentially. Whereas some experts consider eustasy to be the main factor responsible for regional unconformities and believe that the Exxon eustatic curve may serve as a universal tool for global correlation [3], others completely deny the eustatic mechanism [5–8]. The main arguments against the eustatic nature of sedimenation are rather frequent cases of debate in correlation between well-documented successions, probably, under the effect of regional factors such as tectonics and rates of sedimentation. Nevertheless, numerous multidisciplinary studies have proved the eustatic nature of sea level fluctuations at least for the Neogene and Quaternary [9–11]. In these cases, the main mechanisms include glacioeustasy and orbital factors (Milankovitch cycles). In the Mesozoic, however, eustatic sea level changes are identified only in few short-term intervals [12, 13]. Thus, searching for eustatic signals within the Mesozoic stratigraphic interval and discovering them is one of the most urgent problems. By eustasy we mean a change of sea level caused by variation in equilibrium between the total extent of oceanic basins and overall body of oceanic water [14].

The giant West-Siberian basin of the Jurassic and Early Cretaceous time is one of those where eustatic fluctuations might have played an essential role in the Jurassic and Cretaceous sedimentation. Sedimentary sequences of this basin still have not been given an adequate study in the context of sequence-stratigraphic paradigm [15].

In order to identify eustatic signal in the curves of relative sea level change constructed for the West-Siberian Jurassic and Cretaceous, we used a quantitative eustatic curve for the Middle and Late Jurassic and Cretaceous, based on the sections of the Russian Platform and northern Central Siberia [12], and Lower–Middle Jurassic part of the eustatic curve constructed by Haq et al. (1988) on the basis of passive margins [3]. It should be noted that the quantitative eustatic curve devised by Sahagian et al. is based on a highly detailed (of zonal level) biostratigraphic subdivision of the sections. Tectonic stability in the central part of the Russian Platform during the Jurassic-Cretaceous sedimentation and its detailed chronostratigraphy provided a reliable base for eustatic-curve construction [12].

The West-Siberian basin is paleographically close to the Mesozoic epicontinental seas of the Russian and Siberian Platforms, and zonal correlation of the Jurassic and Neocomian sections of these regions is quite reliable. Therefore, it is an appropriate object to test possible application of the quantitative eustatic curve. We chose West Siberia also because a sequence-stratigraphic analysis has not been performed yet for the Mesozoic strata of the most part of the region and we have no unified sequence-stratigraphic basin scale. The latter is hard to justify, considering the vast expanse and economic importance of the basin. This is possibly due to unacceptability of new concepts for lack of sequence-stratigraphic literature in Russian or to the fact that the local oil companies generally focus their attention on the problems of geology of restricted petroleum field rather than on a large-scale (=regional and global) stratigraphic synthesis.

All things considered, we made an attempt to construct a curve of a relative sea level change in the West-Siberian basin with application of sequence-stratigraphic and other analyses and to compare it with the previously developed quantitative eustatic curve [12] and "Exxon" eustatic curve [3]. The final goal was to estimate the influence of eustasy as a factor which controlled the deposition of the Jurassic–Cretaceous strata in West Siberia, as well as to evaluate the potential utility of the eustatic curves in regional and interregional correlation and in reconstruction of the dynamics of sedimentation in the basin under investigation and to reveal the principles of the depositional history of the West-Siberian sedimentary cover.

MATERIALS AND METHODS

The object of study was the Jurassic and Neocomian sections of different areas in West Siberia. For the Lower, Middle, and Upper Jurassic series, the analysis was based on data from the southeastern part (Tomsk and Novosibirsk areas); for the Lower Cretaceous (Neocomian) series – from the Shirotnoe Priobie area (Surgut Arch) (Fig. 1). We used the published data and newly derived evidence on the detailed biostratigraphic datings of rocks, the results of litho- and biofacies analyses, and paleogeographic reconstructions of the Jurassic and Lower Cretaceous stages for the above-mentioned and adjacent areas [16–24]. We analyzed the regularities in lateral and vertical arrangements of strata on some regional sublatitudinal seismic profiles (RP-4, RP-9, and R-1) and logs for several tens of wells in the northern and southern parts of West Siberia. The most detailed log analysis was conducted in the Shirotnoe Priobie area (correlation profile for the Verkhne-Shapshinskaya and Asomkinskaya areas).

We used traditional methods in this study. The packet of parallel biostratigraphic scales [24] was used to determine the precise geological age of evidence of T-R and eustatic events and the facies analysis, to reconstruct the hydrological factors of environments and paleodepths. The seismostratigraphic analysis was useful for reconstructing the geometries and internal architecture of sequences and tracing their boundary surfaces; well logs were used for subdivision and correlation of beds and members, with their extent within the area tied up with seismic profiling and biostratigraphic data. In addition, we applied the latest calculation analysis of the dynamics of sea level variations (from formulas) [12, 14] for certain areas of stable blocks to construct a continuous standard curve of eustasy and sequence-stratigraphic studies to identify systems of tracts.

Sequences and systems tracts were recognized on the basis of analysis of the architecture and internal structure of clinoform units, depositional surfaces, and features of lithologic composition of rocks. For this purpose well-known methods [4, 11, 25, 26], were used in combination.

It is evident that the complex models devised for small local regions as well as the models based only

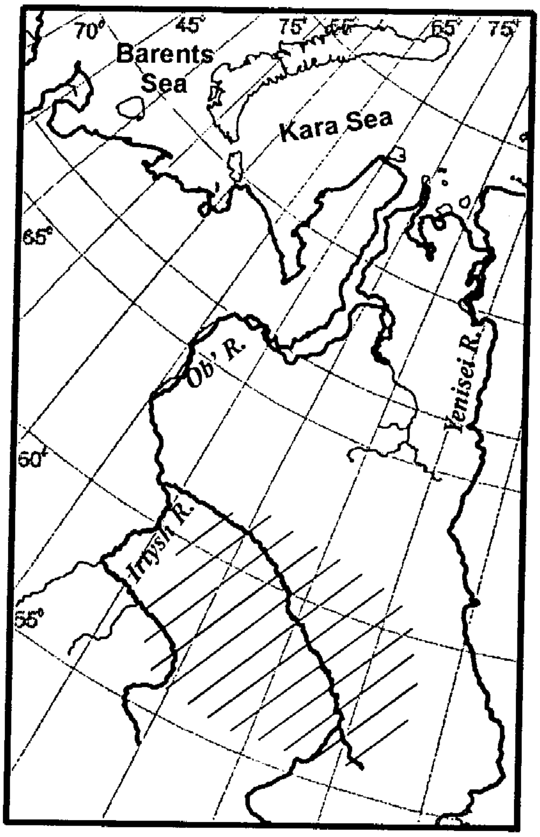

Fig. 1. Localities of the regions under study in West Siberia (hatched – Novosibirsk and Tomsk areas and Shirotnoe Priobie).

on one type of stratigraphic information can lead to contradictory results. The practical work has shown that the event stratigraphic models based on a complex analysis of the signs of both biotic and abiotic events are most efficient and provide high correlation potential. A regularly improving sequence-stratigraphic model should allow for not only stratigraphic pattern but the sedimentary history of the basin as well.

THE MAIN CHARACTERISTICS OF THE GEOLOGICAL STRUCTURE OF THE WEST-SIBERIAN MESOZOIC SEDIMENTARY COVER

The Mesozoic strata in West Siberia were deposited under the conditions of subsiding basin with a prolific supply of sediments and significant changes in sea level, resulting in alternation of horizons consisting predominantly of sands and shales. The nature of these alternations was interpreted differently by different authors. Kazarinov [27] was one of the first experts who made an attempt to explain the cyclic nature of the West-Siberian sedimentary cover in the context of transgression/regression. Later, this approach was further developed by Karagodin [28, 29] who identified 6 regocycles in the Jurassic and Neocomian, 7 mesocycles in the Upper Jurassic and Neocomian, and 24 zonal cyclites in the Neocomian.

Eustasy was often mentioned by many authors as one of the possible mechanisms of T-R cyclicity in the Jurassic-Cretaceous strata of West Siberia [18, 30–35]. An attempt to recognize eustatic signals in the Upper Cretaceous strata of northwestern West Siberia was made by Zakharov et al. [36]. Eustatic nature of shaly horizons was repeatedly supposed for the Lower and Middle Jurassic of West Siberia [37–39].

Sedimentation in the West-Siberian Jurassic and Early Cretaceous basin occurred in a wide range of environments: from alluvial, lacustrine and lacustrine-swampy coastal plains at places flooded in the Early and most part of the Middle Jurassic to an open sea basin in the Late Jurassic–Neocomian, where deep marine fans, turbidites, and condensed strata formed away from the shorelines. Variations in the rates of tectonic subsidence and irregular sediment supply made the structure of the Jurassic–Neocomian sequences of West

Siberia more complicate. Nevertheless, a succession of horizons is evident in the structure, which are dominated alternately by sands and clays.

According to the concept of sequence stratigraphy, depositional sequences consist of lowstand systems tracts (LST), transgressive systems tracts (TST), and highstand tracts (HST) [4]. Chiefly, TST and HST are present in shade horizons and LST, in sandy horizons, of the West-Siberian Jurassic-Neocomian strata. The former are characterized by a noticeable lateral uniformity over the large area of the West-Siberian Plain and represent condensed horizons, which formed during the transgression maximums and sea level high-stand [40]. In the Lower Jurassic these include: Levinsky, Kiterbyut, Laida, and Leont'evskoe Horizons; in the Upper Jurassic: Lower Vasyugan Subhorizon, shaly part of the Georgievka Horizon, and the bituminous Bazhenovo Horizon; in the Neocomian: Samotlor, Ur'evsk, Pokachi, Rodnik, Cheuskino, Sarmanovo, Pravdinsk, Pim, Bystry, and other members.

Lower and Middle Jurassic sandy horizons such as Zimnyaya, Sharapovo, Nadoyakh, Vymskoe, and Malyshevka, occurring between clayey datums, are also well traceable laterally in West Siberia. Upper Jurassic sandy beds merge together at times or conversely disintegrate because of clay seams wedging, or are laterally substituted by clay-silty strata (middle and upper parts of the Vasyugan Horizon and the lowermost Georgievka Horizon). Numerous Neocomian sand beds (of BS and AS groups) form a part of the clinoform series of lateral enclosure. They are generally considered to be either submarine and turbidites either shallow-sea or deltaic deposits in shelf.

Lower Jurassic datum shale horizons (Levinsky and Kiterbyut) consist largely of black and dark-gray mudstones and siltstones enriched in organic carbonified detritus. The transregional nature of the Kiterbyut Horizon is beyond doubt [18, 41]. The Lower Jurassic shale horizons, such as the Levinsky one in southern West Siberia, occasionally contain lenses and layers of coal. In marginal areas of West Siberia, especially in the east, there occur layers of fine sandstones of alluvial and lacustrine geneses. However, even in the southern margins of the plain (Shirotnoe Priobie, Nyurol'ka Depression, etc.) these horizons contain marine beds, which is supported by the findings of macro- and microfaunas and by geochemical evidence [23, 24, 30].

Middle Jurassic Laida and Leont'evskoe Horizons consist mostly of dark-gray, frequently coaly mudstones and siltstones with sandstone layers not persistent laterally. In southern West Siberia these horizons are of wider distribution than those of the Lower Jurassic and are enriched in coal layers to a greater extent (particularly the Leont'evskoe Horizon). In general, the Lower Jurassic comprises deposits filling depressions, whereas the Middle Jurassic represents strata of cover nature. Marine interbeds are present in both Lower and Middle Jurassic (most frequent in the Leont'evskoe Horizon). Lateral extension and frequency of occurrence throughout the section of marine interbeds in the Middle Jurassic clay horizons are greater in comparison to those of the Lower Jurassic, with these special features being enhanced up the section. Thus, marine sediments occur more frequently in the Laida and Leont'evskoe Horizons than in the Levinsky and Kiterbyut Horizons [24, 42]. Lateral extent of Lower Jurassic essentialy sandy horizons in southern West Siberia, such as Zimnyaya, Sharapovo, and Nadoyakh (U_{17}, U_{16}, and U_{15} beds, according to Tomsk geologists' classification), follows the same regularities as that of clayey ones. The area of distribution of sand beds, which form normally some part of depression infilling, increases in general up the section [23].

Sand horizons consist of fine to coarse sandstones generally of continental genesis with gritstone (in the lower horizons), siltstone, and, rarely, mudstone interbeds. The number of interbeds of fine-grained rocks increases in the upper horizons, where coaly siltstones are present. The Sharapovo and Nadoyakh Horizons contain interbeds (commonly of siltstones) with marine fauna. The number of these interbeds increases from south northward in the Nyurol'ka Depression and toward the Shirotnoe Priobie area. In the Nadoyakh Horizon these are greater in number compared to the Sharapovo Horizon. Middle Jurassic sand horizons (Vymskoe and Malyshevka) are present virtually throughout West Siberia except for the most elevated parts of positive structures (archs). These are represented by groups of sandstone beds, which are separated by silt-shale interbeds (beds U_{11-14} in the Vymskoe Horizon and U_{2-6} in the Malyshevka Horizon). In most cases these are inequigranular sandstones of continental genesis with bands of coaly siltstones and coal lenses. In southern West Siberia, coal bands of the Vymskoe Horizon show best lateral uniformity. Interbeds with marine fauna occur more frequently in the Malyshevka Horizon (especially in the upper part), where they are also known from the sections of the Nyurol'ka Depression. In contrast, the Vymskoe Horizon is characterized by the presence of fresh- and brackish-water bivalves, whereas interbeds with marine fauna are encountered in the sections farther north than those of the Malyshevka Horizon (Nadym, Urengoi, and other regions).

Clay horizons corresponding to the transgressive stage of evolution of the sedimentary basin (uppermost Middle Jurassic and Upper Jurassic) in Southern West Siberia are made up mostly of dark-gray mudstones with interbeds of siltstones and abundant marine fossils and pyrite. These mudstones are enriched in organic matter, whose quantity in the upper horizons may run occasionally to abnormaly high values. The Upper Jurassic Lower Vasyugan, Georgievka, and Bazhenovo Horizons are traced virtually throughout West Siberia, being excellent levels for correlation. In the southern and southeastern sections (Nyurol'ka and Ust'-Tym Depressions), among groups of sand beds $U_1^{3,4}$ and $U_1^{1,2}$ of marine genesis there occurs a very specific and laterally persistent carbonaceous-argillaceous member of continental genesis, which is replaced westward by marine sediments [43].

The Callovian–Upper Jurassic sand beds are concentrated in the Vasyugan Horizon and lower part of the Georgievka Horizon. Greenish-gray poorly sorted sandstones with glauconite and admixture of silt in the lower member of the Vasyugan Horizon (Pakhomov-U_2^0) and lower member of the Georgievka Horizon (Barabinsk-U_1^0) are typically transgressive-marine basal structures. These members are clearly traceable in the sections of the southern and central areas of West Siberia; westward and northward they are replaced by clay beds, where their temporal equivalents are easily recognized owing to the presence of abundant glauconite [19]. Stratigraphic range of the Pakhomov and Barabinsk sandstone units increases on the margins of West Siberia. Toward the central areas of the Nyurol'ka Depression, these units wedge out with clay partings. In the latter case they are frequently indexed as U_1^6 and U_1^5, although being coeval with U_2^0 deposits. The group of proper sand beds (U_1) in the Vasyugan Horizon is confined to its upper part. Sand beds of the group (U_1^3-U_1^1) frequently alternate with mud-silt layers and, in places (in the southeastern areas), coalesce to form a single rock unit.

In the central and northwestern parts of the Nyurol'ka Depression, the beds consist of poorly sorted gray marine sandstones with fossils. In southeastern West Siberia (area of the Naunak Formation), many of these beds are composed of continental sandstones. The thickness of intercoaly clayey unit that separates the U_1^{1-2} and U_1^{3-4} sandstones is maximum (over 30 meters) in the eastern areas of southern West Siberia. With its thickness reduced westward, this unit passes laterally into a coal bed and is replaced by marine deposits [43]. In general, sandstones of U_1 horizon are traceable along the southern margins of West Siberia. Sometimes they coalesce to form a single bed, and sometimes they differentiate into a series of beds, some of which (U_1^1, U_1^2) may be absent from the section.

The Neocomian section in the Shirotnoe Priobie area is of clinoform structure, which is clearly expressed on time seismic profiles and is currently accepted by most researchers [44, 45]. Complexity of the internal structure of this stratigraphic interval gives rise to numerous versions of its subdivision and genetic interpretation. Nevertheless, most researchers recognize two main sedimentary complexes: a clinoform complex, which formed as a result of lateral basin infilling, and a shelf complex, which formed owing to a vertical increase in sedimentation. Frequent regional transgressions in the Early Cretaceous, which occurred against the background of a general regressive trend, led to formation of clay horizons such as Pokachi, Sarmanovo, Pim, and other members.

Owing to their good lateral persistence, these are commonly used for detailed subdivision of a section into stratigraphic units (cyclites, etc.) as well as for regional correlation. Clay members are represented by fine mudstones with abundant organic matter and microfossils [20, 21]. Of the above-mentioned members, the Rodnik, Sarmanovo, and Pim ones are characterized by a greater lateral extent as compared with the rest. Sandstone beds of BS and AS groups, occurring between clay members, normally deposited as deep-sea fans or turbidites in the basin (clinoform) part and under the littoral-deltaic conditions of the shelf. They are characterized by lateral strong heterogeneity and, in many cases, by a complex structure.

DISCUSSION

A qualitative transgressive-regressive (T-R) curve was constructed for the Jurassic and Early Cretaceous (Neocomian) semisecular (half-stage) and momentary (zonal) time sections. Succession of the second- and third rank sequences was revealed for the entire Jurassic-Neocomian section. The main result is as follows: The shape of T-R curve reflects both the peculiarities of regional tectonic subduction and global eustatic events. Some intervals of the curve (e. g., Lower Jurassic and Neocomian) are of predictive value and, as such, may be used in combination with biostratigraphic scales for a detailed (zonal) panboreal correlation of sections.

A detailed correlation of Neocomian beds 2–3 m and thicker was useful for interpretation of the geometry of clinoform sedimentary bodies. Examination of coastal juxtapositions recognized on temporal sections made possible a preliminary quantitative estimation of the amplitudes of T-R events.

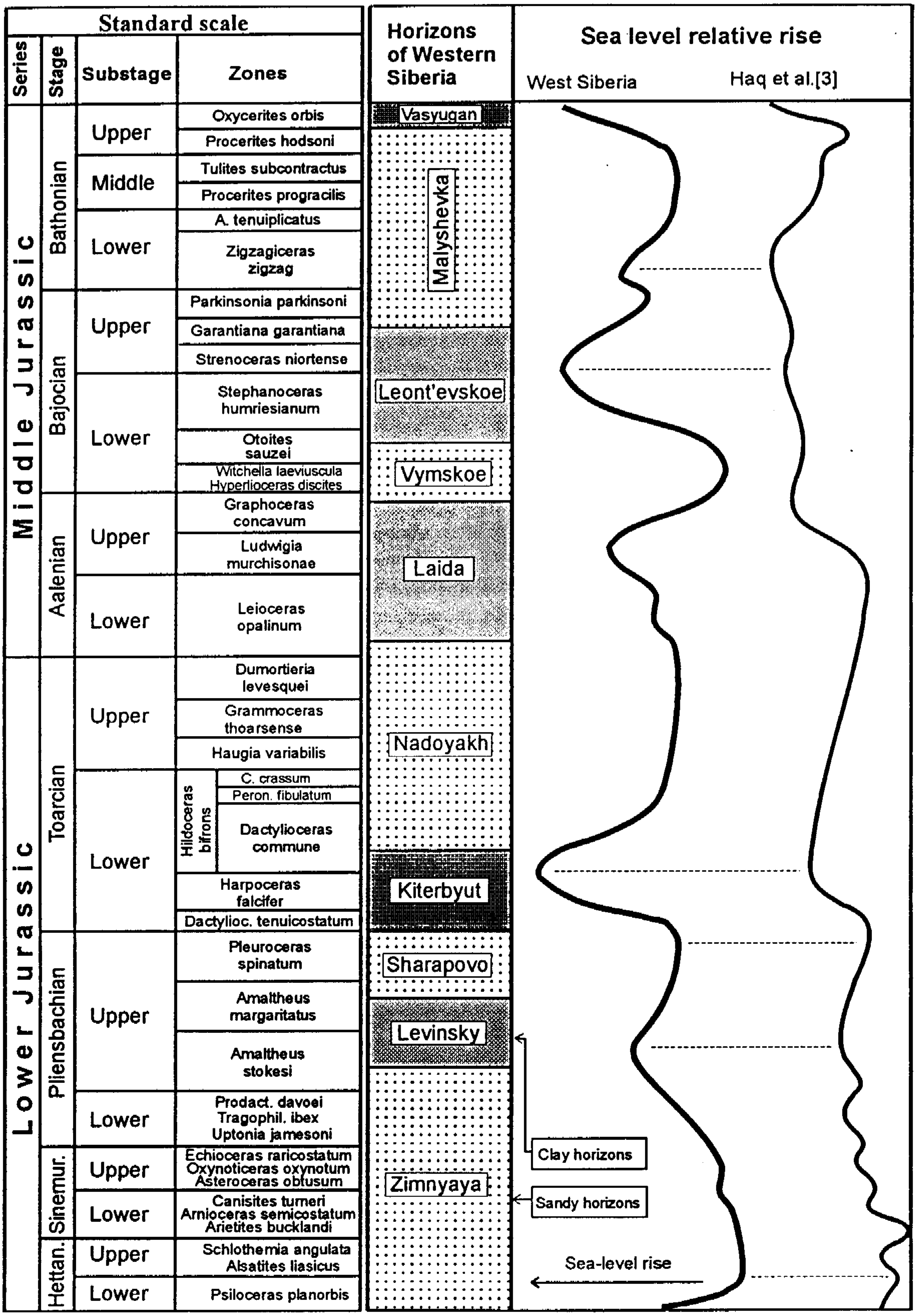

Fig. 2. Transgressive-regressive curve for the West-Siberian sedimentary basin at the Early – Middle Jurassic stage.

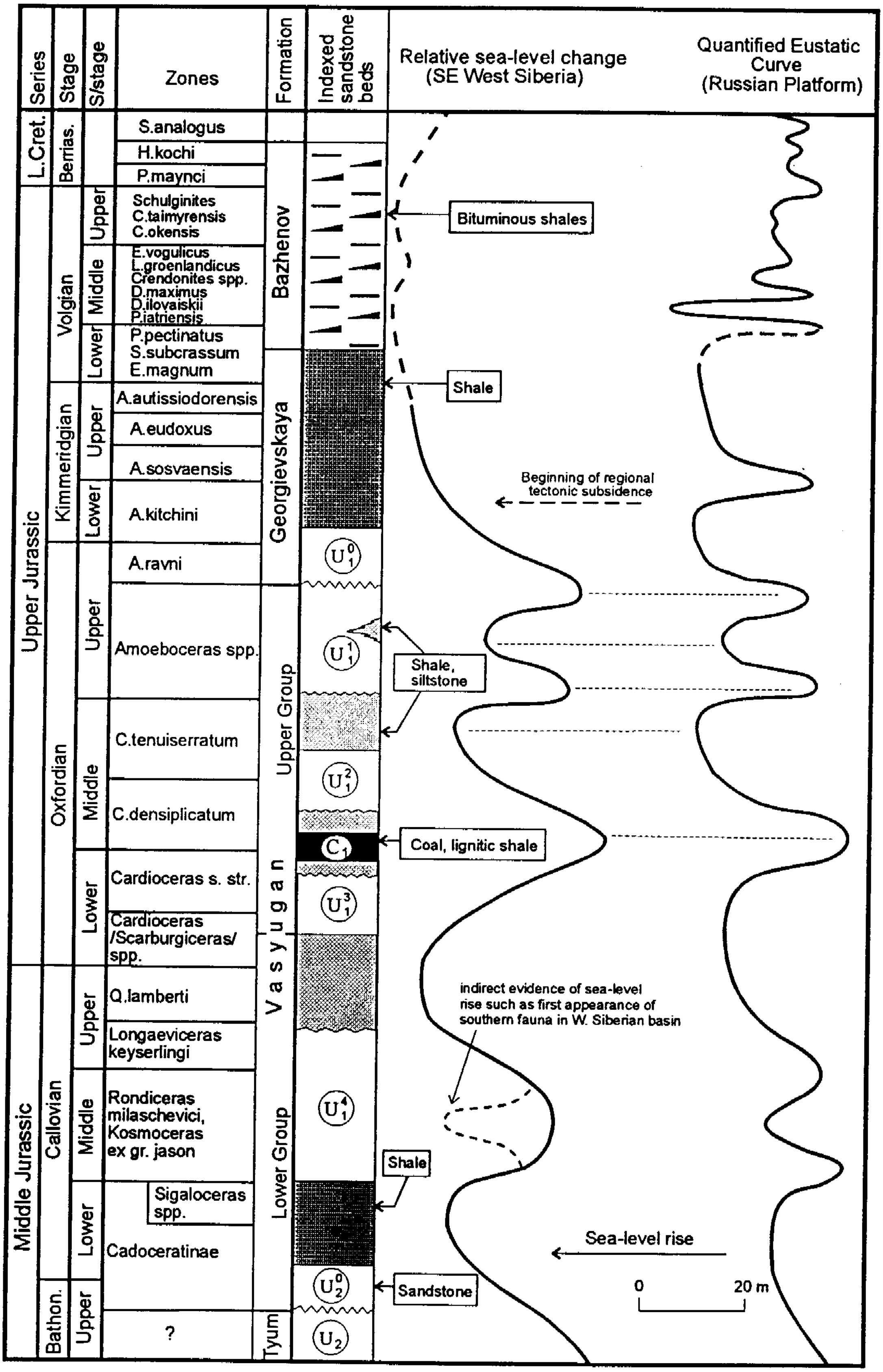

Fig. 3. Transgressive-regressive curve for the West-Siberian sedimentary basin at the Late Jurassic stage.

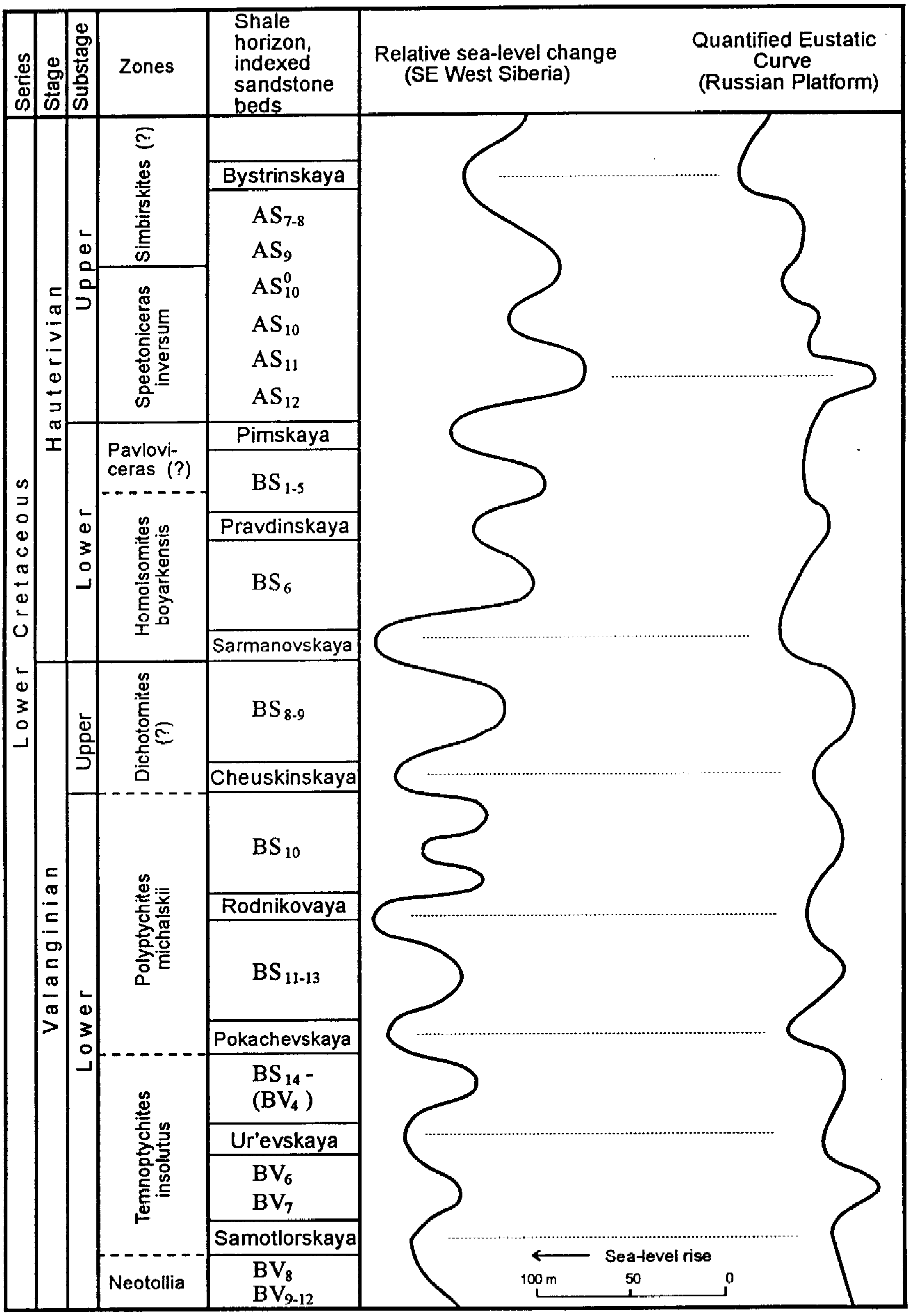

Fig. 4. Transgressive-regressive curve for the West-Siberian sedimentary basin at the Early Cretaceous (Neocomian) stage.

Description of T-R curves

Analysis of regular change of horizons of different compositions allowed recognition of 19 significant T-R cycles of different ranks in the Jurassic and Neocomian. There were identified 2 T-R cycles, possibly, of the second rank, in the Lower Jurassic , 3 T-R cycles also of the second rank (Fig. 2) in the Middle Jurassic (Fig. 2), 4 T-R cycles in the Late Jurassic (Fig. 3), and 10 T-R cycles of the third rank in the Neocomian (=boreal Berriasian, Valanginian, and Hauterivian) (Fig. 4). Thus, the frequency of T-R events increases with time. This conclusion is tentative, because the strata of Lower-Middle Jurassic age are studied poorly. Comparison of the shapes of the curves for different periods of time shows that T-R events are less regular in the Early and Middle Jurassic as compared with those in the Late Jurassic and Early Cretaceous. Two major Early Jurassic transgressive events, Levinsky and Kiterbyut, are almost similar in terms of time scale. However, the Kiterbyut T-event is more prolonged and much more pronounced in area. The signs of this event are well traceable over almost the entire territory of the West-Siberian Plate and recognizable on the north of East Siberia, whereas evidence of the Levinsky event is readily recognized only in the central and northern parts of the plate. The equivalents of the Kiterbyut T-event in the form of shales and, sometimes, black shales of Early Toarcian age are traceable beyond Siberia throughout the Northern Hemisphere: in Western Europe (southern Germany, France, North Sea) [46] and in North America (Canada and northern Alaska) [47]. Early and late Early Jurassic time has intervals of relatively regular change in basin level, although a regional transgressive trend is apparent from the very beginning of the period (Fig. 2).

Middle Jurassic interval of the curve shows a successive increase in amplitudes of transgressive events from the Laida (Aalenian), through Leont'evskoe (Bajocian), to early Vasyugan (Late Bathonian - Early Callovian). All the three Middle Jurassic transgressive episodes occurred against the background of gradually progressing regional transgression. There are reasons to believe that the penetration of some peri-Tethian ammonites (e. g., *Kosmoceras* genus) is associated with a short-term transgression that took place in the Middle Callovian.

In the Late Jurassic, signs of three T-R events were identified in the Vasyugan interval (Oxfordian) (Fig. 3). The most extensive and prolonged transgression occurred at the Callovian-Oxfordian boundary. In West Siberia it occupies an area of more than 2 mln km^2. The Lower-Middle Oxfordian boundary is characterized by a significant regression, the result of which is recorded by intercoal series at the base of the Middle Oxfordian. However, the largest transgression occurred at the end of the Jurassic, Volgian, when the sea occupied an area of more than 3 mln km^2. In the Shirotnoe Priobie area, a condensed horizon, as evidence of TST/HST, occurs at the base of the Middle Volgian Substage. Signs of this Kimmeridgian-Volgian transgression were recognized as highly bituminous black-shale strata over a large territory in the Northern Hemisphere: the Laptev Sea coast [48, 18], Kara and Barents Sea shelves [49–51], Franz Josef Land and Spitsbergen [52], northern Scandinavia [53], North Sea, Southern England [54, 55], and northern Greenland (Peary Land) [56].

Evidence of T-R events in the Neocomian comes from alternating shale members and sandstone beds (Fig. 4). The most frequent fluctuations (2 or 3 fluctuations during a zonal moment) are noted in the Early Valanginian. In the Late Valanginian and Hauterivian the rates of fluctuations of the third rank decrease to one per zone.

Correlation of the West-Siberian T-R curve with the eustatic curve

Comparison of the West-Siberian T-R curve with the world-ocean eustatic curve by temporal levels provides a certain correlation of the curves, and, thus, the conclusion can be drawn about the nature of T-R curve in the Jurassic and Early Cretaceous of West Siberia. For the Late Jurassic and Early Cretaceous we used the curve constructed by data for the Russian and Siberian Platforms [12]. The curve suggested by Haq, Vail, and Hardenbol [3] was used as a standard eustatic curve for the Early and Middle Jurassic. Figure 2 shows a good correlation between the curves. Match of the curves is noted for the earliest Jurassic, for the Levinsky and Kiterbyut T-R events. However, a weaker correlation was noted for the Leont'evskoe T-event. A eustatic rise in the Early Callovian correlates very well with the Middle Jurassic Early Vasyugan T-event and the rise in sea level at the Callovian-Oxfordian boundary, with late Early Vasyugan extensive transgression in West Siberia, which was replaced by no less impressive regression at the Early-Middle Oxfordian boundary. Thus, a full match of T-R events with the eustatic curve based on the data for the Russian Platform exists for the Oxfordian [12, 57] (Fig. 3). There is no apparent correspondence only in the Kimmeridgian and Volgian, which is a consequence of the regional tectonic subsidence of the West-Siberian Plate that occurred in the latest Jurassic and earliest Cretaceous.

A good match of the trend of the curves is evident in the Neocomian (Fig. 4). For example, in West Siberia, five of six Valanginian cycles match with those identified in the northern Siberian Platform [12]. Their time coincidence is supported by ammonite-based zone correlation. According to the data of M. Mikki (pers. comm.), nearly the same number of cycles (9) is established within the same stratigraphic interval (Valanginian-Hauterivian) as a result of T-R interpretation of Lower Neocomian sandy-argillaceous sequences in northern Alaska. Thus, the Valanginian interval of the curve, like certain stratigraphic intervals in the Jurassic after subsequent testing can be recommended as supplementary methods of detailed interregional correlation at least within the Arctic area.

Nature of the T-R curve of the West-Siberian sedimentary basin

The numerous matches of the patterns of T-R curve and the eustatic curve are not accidental. These are indicative of the same nature of the described events. Inasmuch as the curves were plotted on the basis of data for passive margins (Northern Atlantic Ocean) and stable cratons (Russian and Siberian Platforms), they are well representative of the eustatic effect. Consequently, the intervals of the Jurassic and Early Cretaceous T-R curve for West Siberia which match or clearly correlate with the eustatic curve of the world ocean also reflect the influence of global eustatic processes. Thus, it may be assumed that sedimentation in the West-Siberian basin during the Jurassic (except Kimmeridgian and Volgian) and Neocomian was largely controlled by fluctuations of world-ocean level, i. e., by eustasy. However, not all T-R episodes can be associated with the eustasy. The most expressive discordance between the curves in the Late Jurassic may be attributed to regional tectonic subsidence. Even this episode of subsidence of the West-Siberian Plate was followed by a rise of water at least within the limits of the Northern Atlantic ocean, since the Kimmeridgian and Volgian black shales are widespread in a westward direction: the plates of the Kara and Barents Seas, North Sea and adjacent areas, Franz Josef Land, Spitsbergen, Northern Greenland (Peary Land), as well as east of West Siberia to the Laptev Sea coast [18]. Normally these deposits are carboniferous on the described territory. Curiously, a higher content of carbon is found in the Middle Tithonian strata of Mendosa and Neuken oil basins in Argentina [58]. In other cases, for example, in the Kiterbyut and Leont'evskoe episodes, regional subsidence concurred with a eustatic rise, which amplified a transgressive effect (Fig. 2).

CONCLUSIONS

The main result of this study is represented by a T-R curve which was first constructed on a high-resolution chronostratigraphy base for the entire Jurassic and lower part of the Neocomian of the West-Siberian sedimentary basin. Comparative analysis of this curve and the quantitative eustatic curve which was plotted previously on the basis of data obtained for the Russian Platform and some sections of northern Central Siberia allowed recognition of the West-Siberian T-R events where eustasy played a significant role. The Jurassic-Neocomian interval has provided 19 notable T-R events: 2 – in the Early Jurassic, 3 – in the Middle Jurassic, 4 – in the Late Jurassic, and 10 – in the Neocomian. An apparent increase in frequency of sea level fluctuations in time is related to some extent to the reduced time of the regressive "shoulder" of the cycles. Many T-R cycles well correlate with eustatic curves. Signs of notable T-R events in the Jurassic and Neocomian strata of West Siberia are quite often traceable beyond the region, both in adjacent regions and on other continents of the Northern Hemisphere. These include: Kiterbyut T event (Early Toarcian), Vymskoe-Leont'evskoe T-R event (Bajocian), Middle Vasyugan R event (Middle Oxfordian), Bazhenovo T event (Late Kimmeridgian – Volgian), and 5 T-R events in the Valanginian. An attempt was made to perform a preliminary sequence-stratigraphic analysis of the Jurassic and Neocomian petroleum-bearing strata in the West-Siberian sedimentary basin. The strata were divided into system tracts of second and third ranks, which permitted some discrepancies between present stratigraphic and sedimentary models to be overcome.

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