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The Stratigraphy and Correlation of Jurassic Terrestrial Sections in the Southern Siberian Platform and the Role of Eustatic and Tectonic Factors in their Formation

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Abstract—A regional stratigraphic scale is proposed for Jurassic continental deposits of the southern Siberian Platform. This scheme includes six stratigraphic complexes that correspond to major erosion cycles. The decisive role in the formation of Lower–Middle Jurassic complexes (I–III) belonged to the eustatic factor, while formation of Callovian–Upper Jurassic complexes (IV–VI) was controlled by tectonics.

Keywords: Siberian Platform, Jurassic deposits, erosion cycles, eustasy, tectonics
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INTRODUCTION

Jurassic deposits are recorded in different areas of the Siberian Platform, where they fill several large troughs, syneclises, and depressions (Fig. 1). They are represented by terrigenous sections of three types. In the north (the Lena–Yenisei trough and the northern part of the Verkhoyansk trough), the entire section of Jurassic deposits is composed of marine sediments with representative paleontological assemblages, which allow their high-resolution stratigraphic subdivision and reliable dating. In the central part of the platform (Angara–Vilyui trough, Vilyui syneclise, the southern part of the Priverkhoyansk foreland basin), the Jurassic section includes both marine and terrestrial facies, which hampers their stratigraphic subdivision. In the southern areas of the platform, they are represented by the terrestrial sandy–clayey coaliferous sequences of the Kansk–Achinsk, Irkutsk, and South Yakutia basins. In this work, we consider the problem of their stratigraphic subdivision, dating, and the roles of the main factors that are responsible for their formation.

The regional stratigraphic scale that was developed on the historical–geological principles for the northern and central parts of the Siberian Platform (Panov and Chekhovskii, 2012) includes nine stratigraphic complexes, which are traceable through the entire region. The complexes are separated by unconformities and correspond to different stages in its geological development: from transgression to regression (Fig. 2). They represent large sedimentary cycles that reflect periods in the deposition of sediments in the epicontinental marine basin.

For the southern part of the Siberian Platform, a universal regional stratigraphic model of terrestrial sections is still unavailable. In total, up to 30–40 "formations" that are poorly correlated between each other have been defined by different researchers in the Jurassic sections of different basins. They were defined and correlated on the basis of lithological features and distribution of coal seams. Taking their significant facies variability into consideration, such an approach determines the high multiplicity of the defined stratigraphic units. These units are dated on the basis of paleobotanical data, which frequently provide ambiguous ages.

When developing the regional stratigraphic scale on historical–geological principles, we define stratigraphic complexes that reflect major erosion cycles in the development of the regional relief. Each complex rests upon underlying strata with a distinct erosional surface and its basal part is composed of coarse-detrital rocks (cross-bedded coarse-grained sandstone, with locally scattered pebbles and conglomerate intercalations), which reflect the initial stage of the erosion cycle proceeding in highly differentiated topographic settings. Higher in the section, coarse-detrital alluvial channel facies are gradually replaced by finer clayey–silty (with subordinate sandstones) lacustrine–boggy sediments, which mark the termination of the cycle, relief leveling, and swamping of the region. Precisely these sediments are characterized by the maximum concentration of coal seams and abundant remains of freshwater organisms. The complexes that correspond to erosion cycles also represent sedimentary cycles that reflect periodicity in sedimentation in terrestrial settings.

The regional stratigraphic scheme for the subdivision of Jurassic continental deposits in the southern Siberian Platform. The proposed regional stratigraphic scheme that was developed for subdivision of Jurassic terrestrial section in the southern Siberian

Platform (Panov and Baraboshkin, 2014) includes six regional stratigraphic complexes, which are traceable through the entire region. They are corresponding to common stages in its development (erosion cycles). In the Kansk and Irkutsk sedimentary basins, the Lower Jurassic, Aalenian, and Bajocian interval comprises the Pereyaslavskoe (I), Kamalin (II), and Ivanov (III) complexes. In the South Yakutia basin, they correspond to a the single Yukhta–Durai complex (I–III). The Callovian and Upper Jurassic sections are formed by the Kobakta (IV), Berkakit (V), and Neryungri (VI) complexes. In order to avoid the introduction of new names, the complexes are named after "formations" that were previously defined in these section and are most characteristic for the corresponding complex.

The Lower–Middle Jurassic complexes (I–III) are most complete in the southwestern Kansk–Achinsk and Irkutsk basins (Fig. 3). They are most readily recognizable in depressions of the Kansk–Achinsk basin, where their sections were described by (Aksarin, 1957; Minko, 1964; Grigor'ev, 1968; Tazikhin, 1972; and others). For the Rybinsk and Taseevo depressions, a local stratigraphic model that was developed on historical–geological principles is available (Aksarin and Kokunov, 1967). The last authors defined four formations; each corresponds to an individual depositional cycle that correlates with the four complexes that are defined in this work. We specified only the boundaries between the formations and their structure and, above all, traced them through all the depressions of the Kansk basin as regional stratigraphic complexes.

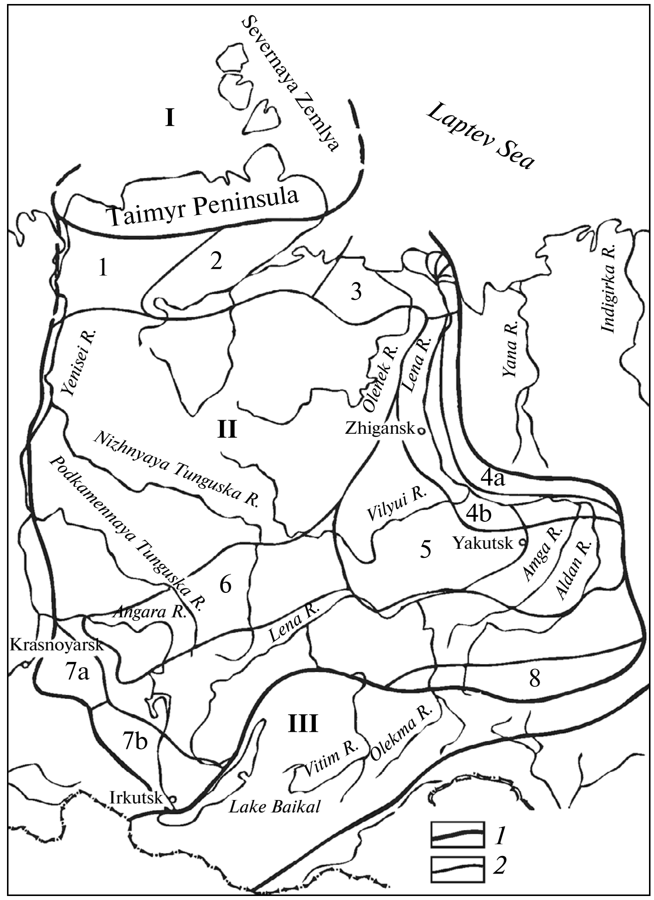

Fig. 1. The schematic locations of regions and Mesozoic troughs in East Siberia, after (*Stratigrafiya*..., 1972): (I) Paleozoic Taimyr–Severnaya Zemlya folded region, (II) Siberian Platform, (III) Paleozoic Baikal–Stanovoi folded region. Structures: (1–3) Lena–Yenisei trough: (1) Ust-Yenisei depression (included conditionally), (2) Khatanga depression, (3) Lena–Anabar depression; (4) zones of the Priverkhoyansk foreland basin: (a) inner, (b) outer; (5) Vilyui syneclise; (6) Angara–Vilyui intraplatform trough; (7) depressions of the Sayan piedmont trough: eastern part of the Kansk–Achinsk (a) and Irkutsk (b) coal basins; (8 South Yakutiya depressions of the Stanovoi foredeep: (*1*) boundaries of regions, (*2*) boundaries of structures.

Pereyaslavskoe Complex (Pliensbachian–lower Toarcian. In the Kansk basin, this complex unites the Pereyaslavskoe and Makarovo formations that were previously defined in different parts of the basin. The basal part of the complex is represented by conglomerates and gravelites that rest unconformably upon basement rocks. Higher in the section, they grade into coarse-grained poorly sorted sandstones. These rocks are mostly alluvial in origin. The upper part of the complex is composed of mudstones, siltstones, and sandstones with horizontal or wavy bedding and abundant (10–50) coal seams (Fig. 4).

The section is crowned by a peculiar green-colored member (15–70 m thick) of rhythmically alternating thin mudstones, siltstones, and fine-grained sandstones that are united into the autonomous Ilan Formation (Sakhanova, 1957; Il'ina and Shurygin, 2000). This member contains the remains of phyllopod species *Estheria heckeri* Tschern. and a peculiar palynological assemblage that is characteristic of Palynozone 6 that has been established in both continental and marine sections of Siberia (Il'ina, 1997): *Cyathidites* spp., Dipteridaceae, *Marattisporites scabratus*, *Klukisporites variegates*, *Classopolis*. This palynozone corresponds to the warming maximum in the early Toarcian. The Ilan Formation rests conformably on rocks of the Pereyaslavskoe and Makarovo formations and is overlain with a sharp erosional unconformity by the Kamalin Complex, which begins the next erosion cycle. Consequently, they form the uppermost part of the Pereyaslavskoe Complex. Their sediments were deposited in lacustrine–boggy settings that correspond to the maximum relief leveling sand climate warming, which was characteristic of the terminal stage of the erosion cycle.

The *section of the Irkutsk basin* is compiled using materials from (Deev, 1957; Gutova, 1963; Ermolaev and Teslenko, 1964; Tazikhin, 1972; Vinnichenko and Fainshtein, 1967; and others). In this section, the Pereyaslavskoe Complex includes rocks that were previously defined as the Zilara, Bezugol'naya (coal-free), and Lower Cheremkhovo productive "formations." As in the Kansk basin, the Pereyaslavskoe

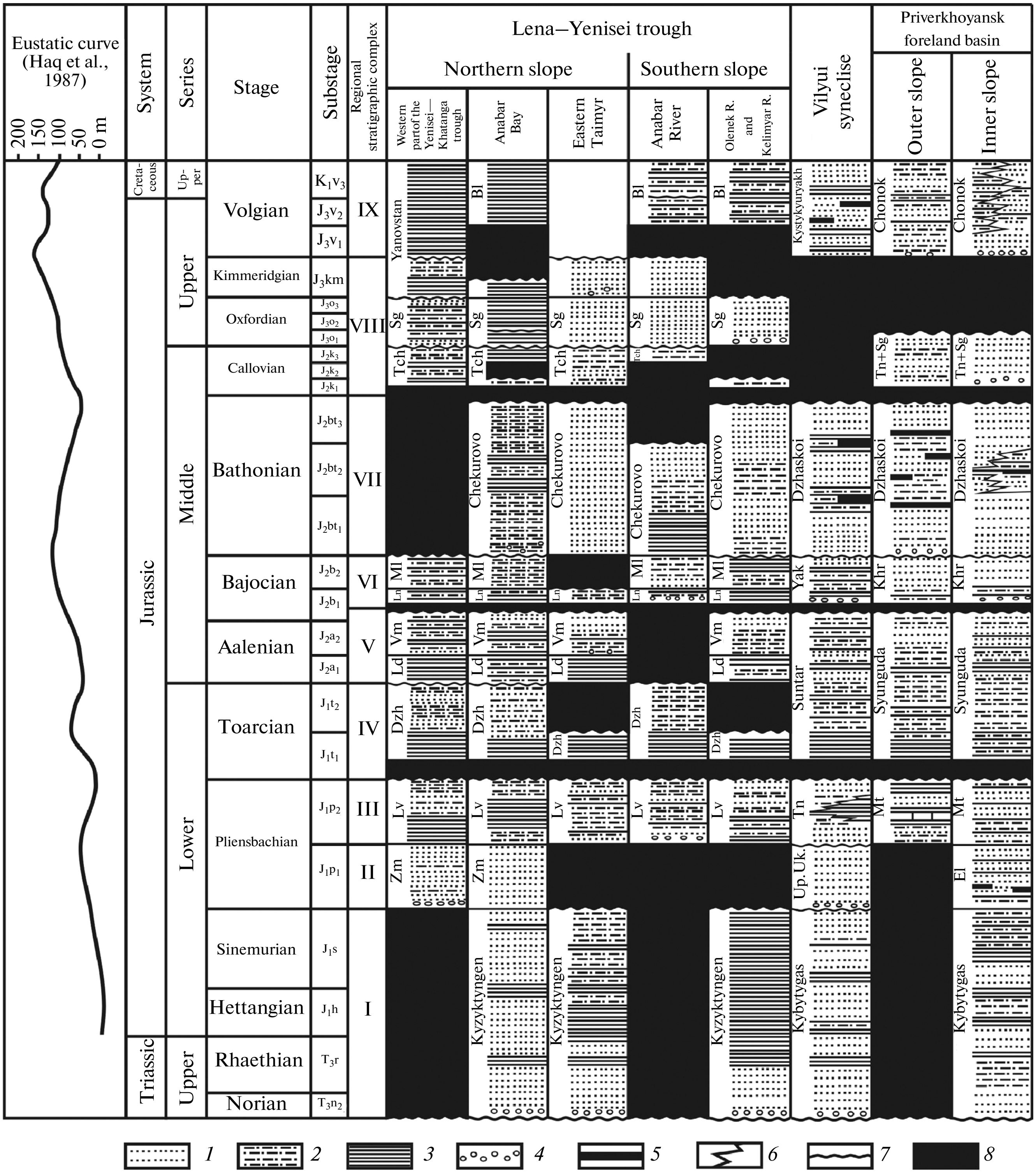

Fig. 2. The regional stratigraphy of Jurassic deposits in the northern, eastern, and central parts of the Siberian Platform, after (Panov and Chekhovskii, 2012).

Formations: (Bl) Bulkalakh, (Up.Uk) Upper Ukugut), (Vm) Vym, (Dzh) Dzhangod, (El) Elyudzha, (Zm) Zimnyaya, (Ld) Laida, (Lv) Leva, (Le) Leont'evo, (Ml) Malyshevo, (MTt) Motorchun, (Sg) Sigovo, (Th) Tochin, (Tn) Tyung, (Tn + Sg) Tochin and Sigovo, (Khr) Khorong, (Yak) Yakutsk.

(*1*) sandstone; (*2*) siltstone; (*3*) clay an mudstone; (*4*) conglomerate; (*5*) coal seams; (*6*) facies boundaries; (*7*) erosional surface; (*8*) hiatus.

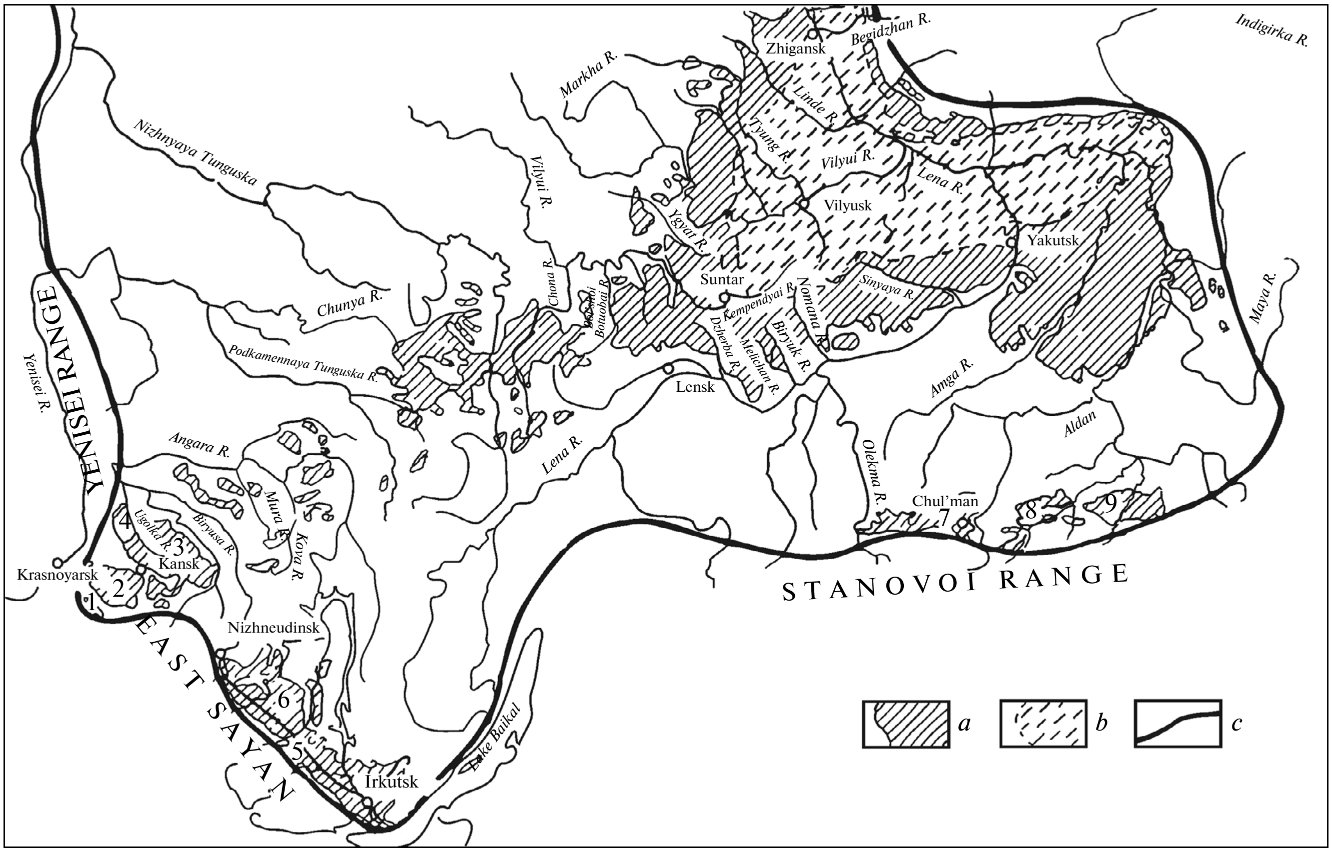

Fig. 3. The distribution of Jurassic rocks in the central, eastern, and southern parts of the Siberian Platform, after (*Stratigrafiya*..., 1972): (a) outcrops, (b) hidden under younger sediments, (c) boundaries of the platform.
Depressions of the Kansk–Achinsk coal basin: (1) Sayan–Partizanskaya, (2) Rybinskaya, (3) Abanskaya, (4) Usolkinskaya; zones of the Irkutsk coal basin: (5) inner, (6) outer; depressions of the South Yakutia coal basin: (7) Chul'man, (8) Gonam, (9) Tokin.

Complex rests with a sharp unconformity upon basement rocks that are composed of coarse- to medium-grained sandstones with large-scale unidirectional cross bedding underlain by conglomerates and gravelites in its basal (Zilara) part. The upper (lower Cheremkhovo) part of the section consists mostly of fine-grained sandstones with intercalations of mudstones, siltstones, and abundant (including thick) coal seams. In the southwestern, Baikal, zone the lower part of the Pereyaslavskoe Complex or its entire section is replaced by a single conglomerate sequence (Fig. 5).

The upper part of the Pereyaslavskoe Complex represents the main culmiferous formation of the Irkutsk basin. It contains the remains of insects, phyllopods (*Pseuoestheria* sp.), fish, and freshwater bivalves (*Ferganoconcha sibirica* Tschern., *F. subcentralis*, *F. curta* Tschern., *Sibireconcha* sp., *Najadites* sp.). As in the Ilan Formation of the Kansk basin, these sediments are lacustrine–boggy in origin and were deposited at the terminal stage of the erosion cycle characterized by maximum relief leveling.

Plant remains from the Pereyaslavskoe Complex characterize the Pliensbachian–Toarcian Aban floral assemblage (Kiritchkova and Travina, 1990; Kostina, 2004). The complex also contains two palynological assemblages: the lower, Pereyaslavskoe (Pliensbachian) and upper, Ilan (Toarcian). As was mentioned, the age of the Ilan palynological assemblage has now been determined; it is estimated as the early Toarcian (Il'ina and Shurygin, 2000). In the Irkutsk basin, plant remains from the lower and upper parts of the Pereyaslavskoe Complex are attributed to the Pliensbachian Zilara and Toarcian Cheremkhovo phytoassemblages, respectively (Kiritchkova and Travina, 2000; Kirichkova et al., 2005). Thus, the stratigraphic span of the Pereyaslavskoe Complex may be estimated to be the Pliensbachian–lower Toarcian.

Kamalin Complex (upper Toarcian–lower Aalenian). This complex is best recognizable in the *Kansk basin* (Fig. 4), where it overlies with a distinct erosional surface and conglomerate lenses at the bases of different formations of the Pereyaslavskoe Complex. The complex is subdivided in two parts. Its best distinguishable lower part is composed of thick sandstone members with conglomerate lenses, which are traceable in all the sections and serve as an excellent reference level for their correlation. They are mostly alluvial sediments of the channel facies. These rocks grade into the

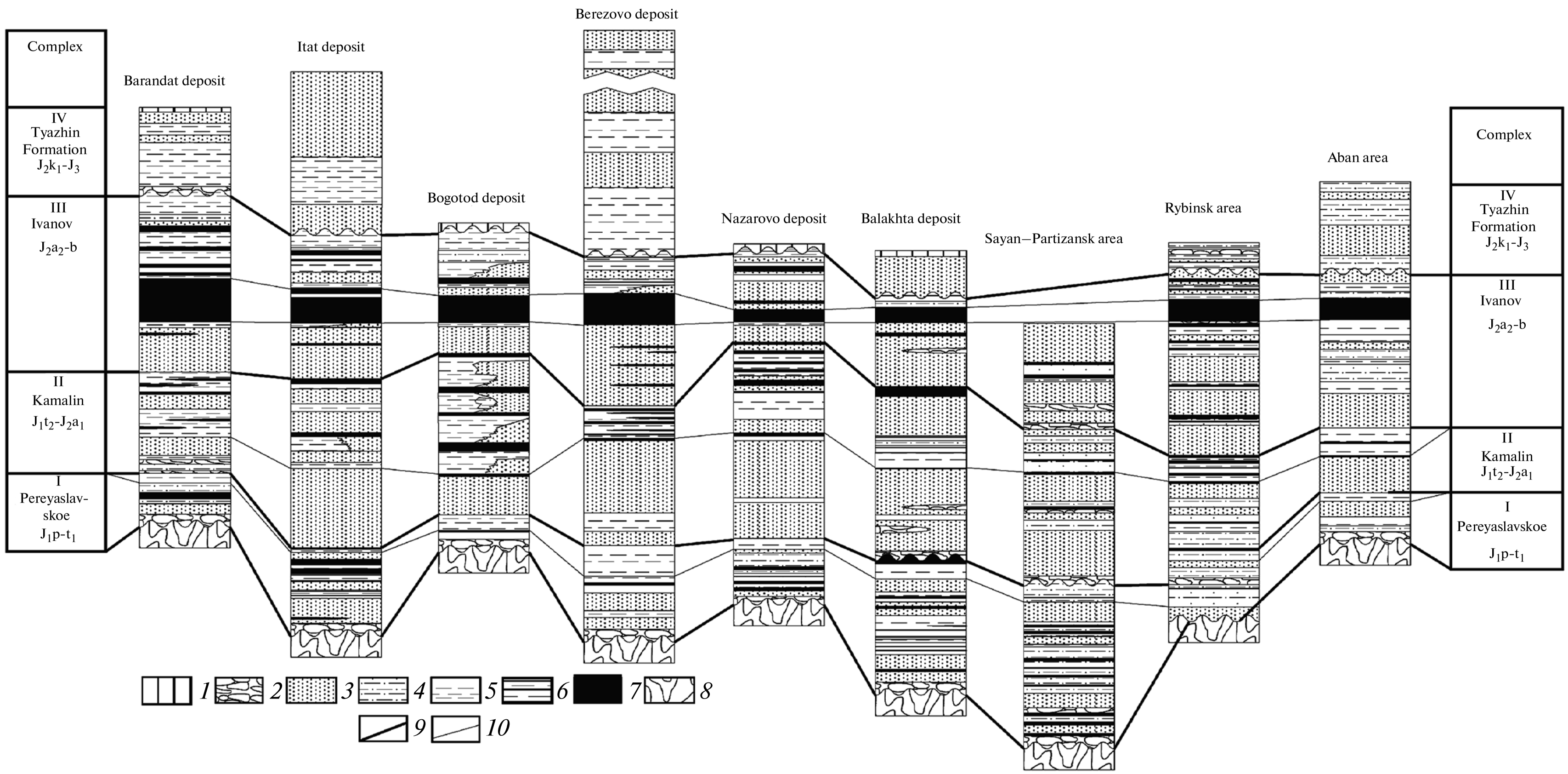

Fig. 4. The correlation of Jurassic sections in the Kansk–Achinsk coal basin, after (Grigor'ev, 1968 modified: (*1*) loam with rock fragments, (*2*) conglomerate and gravelite, (*3*) sandstone, (*4*) siltstone, (*5*) mudstone, (*6*) carbonaceous mudstone, (*7*) coal, (*8*) pre-Jurassic rocks, (*9*, 10) correlation lines: (*9*) complexes, (*10*) beds.

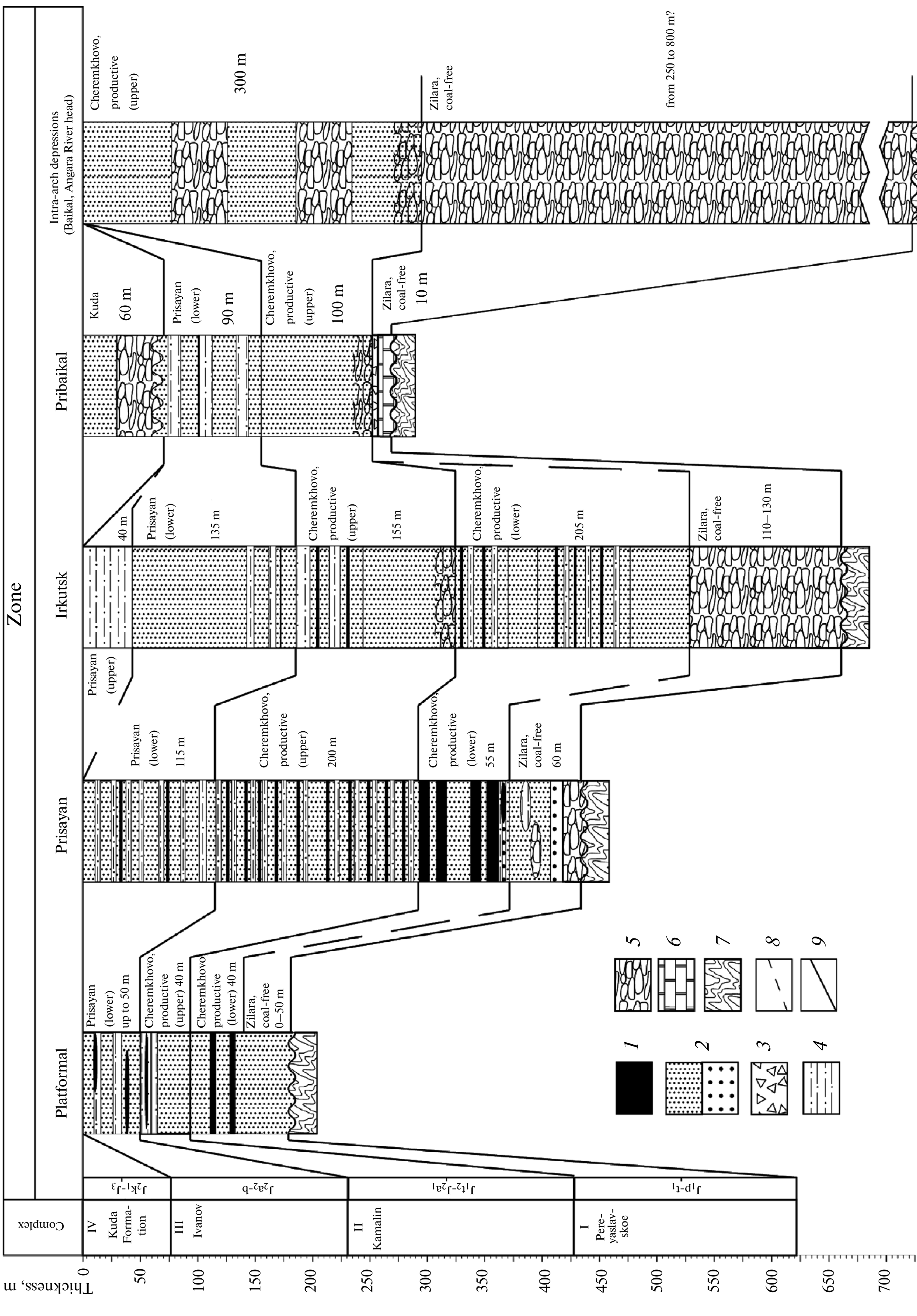

Fig. 5. The correlation of a section in the Irkutsk basin. (*1*) coal; (*2*) sandstone: (a) fine-grained, (b) medium-grained; (*3*) breccia; (*4*) siltstone; (*5*) conglomerate; (*6*) dolomite; (*7*) pre-Jurassic basement; (*8*, *9*) correlation lines: (*8*) beds, (*9*) complexes.

upper part represented by alternating sandstones and clayey–silty rocks with irregularly distributed coal seams characterized the variable thickness. These sediments are lacustrine–boggy in origin or represent floodplain alluvial facies.

In the *Irkutsk basin* (Fig. 5), the Kamalin Complex corresponds to the Upper Cheremkhovo "Formation." The lower boundary of the complex is locally not distinguishable as characterizing the beginning of the next erosion cycle. In the Prisayanskaya zone, the Kamalin Complex rests conformably on the Pereyaslavskoe Complex and rocks in the transitional interval are uniform, differing only by the absence of thick coal seams and coarser material in the former. Nevertheless, in most areas (Irkutsk depression, Platformal and Baikal zones, and others), the Kamalin Complex overlies different layers of the Pereyaslavskoe Complex with an erosional surface. Its basal part is represented by conglomerates that are replaced higher in the section by anisomerous sandstones, which grade into alternating sandstones and siltstones with thin coal seams. In some sections (for example, in the Irkutsk depression), the uppermost part of the complex is composed of clayey–silty rocks with abundant insect remains (*Mesoneta antique* Br., Redt., Gangle, *M. sibirica* Br., Redt., Gangle, *M. gracilis*, *Platyptera platypoda*, *Phramatoecites damesi* Opp., *Phr. jurassicus* Opp., *Pseudocassus zemcuznicovi* Mart., *Mesopanorpa hartungi* Br., Redt., Gangle, *M. angarensis* Mart.) and fish remains (*Palaeoniscinotus czekanowskii* Rohon, *P. irkutensis* Roghon, *Palyodon gracile* Bel., *Phlidophorus maari* Rohon, *Lepidotus sibiricus* Rohon, *Opsigonus gracilis* Rohon, *Baleiichtys gracilis* Rohon).

Like the upper part of the Kamalin Complex in the Kansk basin, this member is composed of lacustrine–boggy sediments, which were deposited at the stage of maximum relief leveling and flooding at the end of the Kamala erosion cycle. These sediments are overlain conformably or with erosional surface by coal-free sandy facies, which begin the next (Ivanov) erosion cycle.

In the Kansk basin, plant remains from the Kamalin Complex constitute the Rybinsk floral assemblage (Aalenian). It also contains the coeval Kamalin palynological assemblage (Kiritchkova and Travina, 1990; Kostina, 2004). In the Irkutsk basin, the Kamalin Complex is characterized by plant remains of the Aalenian Olkha floral assemblage, while its palynological assemblage indicates Middle Jurassic age (Gutova, 2000). This confirms the synchronism of sediments that are attributed to the Kamalin Complex in the basins under consideration here. Taking the fact into consideration that Aalenian plant remains were sampled from the upper (coaliferous) portion of the section and their correlation with marine sediments in the northern part of the platform (see below), we estimate the stratigraphic span of the Kamalin Complex as the upper Toarcian–lower Aalenian.

Ivanov Complex (upper Aalenian–Bajocian). In the *Kansk basin* the Ivanov Complex rest conformably, although with a distinct boundary, upon the Kamala Complex and is subdivided into two sequences.

The lower sequence is largely composed of inequigranular sandstones with subordinate siltstones and rare coal seams. In contrast, the upper sequence (the Borodino Formation in the Rybinsk and Aban depressions) is represented by alternating mudstones, siltstones, and sandstones with the dominant role of clayey–silty rocks and includes frequent thick coal seams, including the main one (90 m thick) that is recorded in all the sections as a reference unit (Fig. 4). This sequence yielded remains of the freshwater bivalves *Ferganoconcha sibirica* Tschern., *F. burejensis* Tschern., and *Acyrena* sp.

In the *Irkutsk basin* the Ivanov Complex comprises, in our opinion, the Prisayan Formation with lenses and intercalations of conglomerates at the base, which overly the erosional surface coaliferous sediments of the Upper Cheremkhovo Formation and are characterized by an even more distinct two-member structure. The lower Prisayan Sunformation is composed of inequigranular cross-bedded clayey sandstones with rare siltstone intercalations and coal laminae. The upper subformation consists exclusively of fine-grained rocks: siliceous siltstones with the remains of freshwater bivalves (*Ferganoconcha sibirica* Tschern., *F. anodontoides* Tschern., *F. subcentralis*, *F. curta* Tschern., *Tutuella* sp., *Arguniella* sp.), fishes (Palaeoniscinidae), insects (*Mesoleuctra gracilis* Br., *Platyperla platypoda* Br., *Mesopanopra hartungi* Br., *Mesoneta antique* Br.), and phylopods.

The upper part of the Ivanov Complex in both basins is undoubtedly represented by lacustrine–boggy sediments that characterize the terminal stage of the erosion cycle (III) with maximum relief leveling and regional flooding.

In the Kansk basin, the plant remains that were sampled from the upper part of the Ivanov Complex form the Bajocian floral assemblage. The same layers also contain the coeval palynological assemblage (Kiritchkova and Travina, 1990; Kostina, 2004). Plant remains that were found in synchronous rocks of the Irkutsk basin are referred to the Tapka floral assemblage (Kiritchkova and Travina, 2000).

Considering the absence of features that indicate a significant hiatus between the Ivanov Complex and underlying Aalenian strata and its correlation with marine complexes in the northeastern part of the platform (see below), the lower part of the complex is attributed to the upper Aalenian Substage. On the basis of palynological evidence from the upper part of the complex, we consider it to be the Bajocian in age assuming, similar to other researchers (Kostina, 2004; Kiritchkova et al., 2005), the absence of Bathonian sediments in both basins.

Yukhta–Durai Complex (Pliensbachian–Bajocian). In a dissimilar manner to the Kansk and Irkutsk basins, a single Jurassic regional stratigraphic scale developed on the historical–geological principles occurs for the *South Yakutia basin* (Tazikhin, 1972; Zhelinskii, 1980; *Yuzhno-Yakutskaya*..., 1981). The rhythmostratigraphic analysis made it possible to define five formations in the Jurassic section of this basin that correspond to first-order rhythms that reflect stages in its geological development (from the base upward): the Lower Jurassic Yukhta, Middle Jurassic Durai, and Upper Jurassic Kabakta, Berkakit, and Neryungri formations (Fig. 6).

The *Yukhta Formation*, which is defined at the base of the Jurassic section in all the depressions of the South Yakutia basin rests with a distinct unconformity upon Cambrian or older crystalline rocks of the Aldan shield. The base of the formation is marked by basal conglomerates and gravelites. Its largest part is composed of members of medium- and fine-grained sandstones that alternate with subordinate members of siltstones and rare mudstones. The sandstones that constitute up to 90% of the section are arkose–quartz in composition and exhibit large-scale cross bedding. They include only four lenticular coal seams greater than 1 m thick. These sediments are proluvial–alluvial and deltaic in origin.

Higher in the section the *Durai Formation* gradually replaces the Yukhta one, differing from the latter in the gradual disappearance of medium-grained sandstones and some decrease in the number of mudstone–siltstone members. In the upper half of the formation, clayey–silty rocks become dominant. The rocks are characterized by horizontal and wavy bedding and contain abundant coalified plant detritus, which form 29 coal seams, 5 of which are productive. The clayey–silty members are separated by subordinate members of fine-grained sandstones that are similar to their counterparts in the Yukhta Formation.

The upper layers of the Durai Formation yielded remains of freshwater bivalves: *Ferganoconcha curta* Tsch., *F. rotundata* Mart., *F. estheriformis* Tsch., *F. anadontoides* Tsch., *F. minor* Mart., *Pseudocardinia* cf. *jeniseica* var. *ungrensis* Mart., *Ps. duraica* Mart., *Sphaerium* cf. *sorneum* L.

The analysis of the structure of both formations and their interrelationships revealed that they form the single *Yukhta–Durai regional stratigraphic complex*, which corresponds to one erosion cycle. It began with the accumulation of proluvial–alluvial sediments in differentiated topographic setting and terminated with the deposition of coaliferous lacustrine–boggy sediments under conditions of relief leveling, flooding, and swamping.

Plant remains that were sampled from the Yukhta Formation form the Yukhta floral assemblage dated back to the Early Jurassic (Zhelinskii, 1980; Markovich, 1986) or Pleinsbachian–Toarcian (*Fitostratigrafiya*..., 1985). The diverse (over 50 species) flora of the Durai Formation is defined as the synonymous floral assemblage, which is characteristic of the entire Middle Jurassic Epoch. It contains many species in common with the Kamalin and Borodino complexes in the Kansk basin and with the Olkha and Tapka complexes in the Irkutsk basin, which are Aalenian and Bajocian in age. Lacustrine–boggy sediments with freshwater bivalves that constitute the upper part of the Durai Formation undoubtedly represent a stratigraphic analog of the Bajocian, which is a lithologically similar member in the uppermost part of the Ivanov Complex. On the basis of this fact, the stratigraphic range of the Yukhta–Durai Coma is accepted to be Pliensbachian–Bajocian. It corresponds to three stratigraphic complexes (I–III) in the Kansk and Irkutsk basins (Fig. 7).

Kabakta Complex (Callovian–Upper Jurassic). The sediments of complexes IV, V, and VI are distributed in the South Yakutia basin, where they are represented by three formations: Kabakta, Berkakit, and Neryungri. Each formation corresponds to an individual erosion cycle and is considered in this work as a regional stratigraphic complex.

The *Kabakta Formation in the South Yakutia basin* overlies with a distinct unconformity different strata of the Durai or immediately overlies the Yukhta (in the Usmun depression) formations (Fig. 6). Its lower boundary is lithologically very distinct: clayey–silty rocks and fine-grained sandstones of the uppermost Dutrai Formation are replaced by coarse-grained arkosic sandstones with abundant accessory minerals. The lower part of the Kabakta Formation is dominated by coarse-grained sandstones. They form members up to 20–40 m thick, which alternate with thin clayey–silty members. In the Chul'man depression, the fine-grained sediments enclose five coal seams (including productive): two of them are sustained and three are lenticular. In the Usmun depression, this part of the formation contains a single lenticular coal seam; in other depressions, coal seams are missing. All the sediments that constitute the formation belong to the alluvial type.

Upsection, the grain-size composition of sediments becomes finer with alternating clayey–silty members up to 10 m thick playing a dominant role in the uppermost part of the section. They are characterized by abundant coalified plant detritus and frequent coal seams, which are thinner than in underlying sediments, although well sustained. According to their origin, these sediments are lacustrine–boggy, which is typical of the terminal stage of the erosion cycle.

The Kabakta floral assemblage, which includes over 70 species, is close to the Durai one (particularly, in the lower part of the formation) differing from the latter in the presence of several forms that are typical only of the Upper Jurassic interval. This provided grounds for some researchers to attribute the Kabakta Formation to the Upper Jurassic (Zhelinskii; 1980; Markovich, 1986), most likely including the Callovian

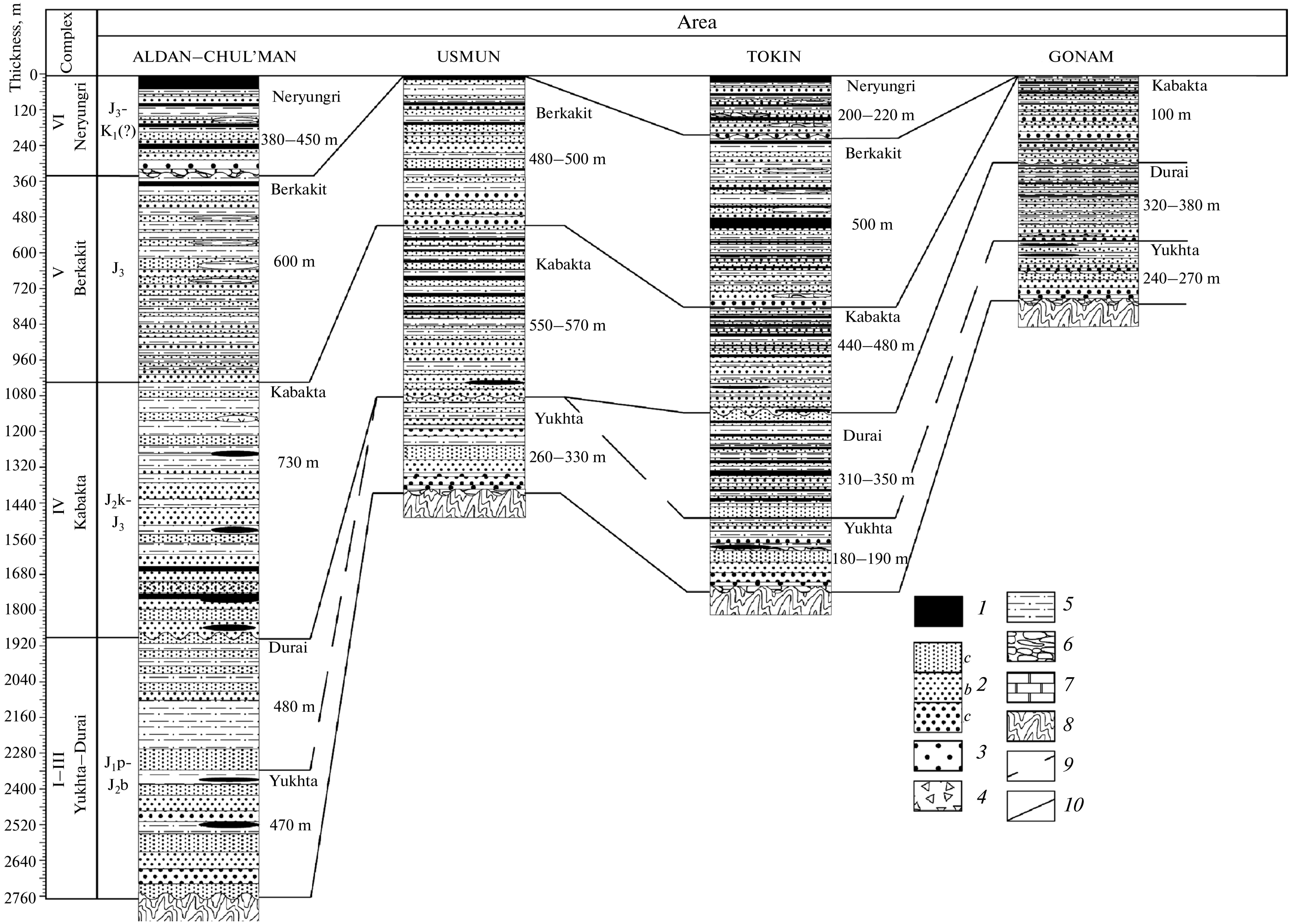

Fig. 6. The correlation of the sections in the South Yakutia basin. (*1*) coal; (*2*) sandstone: (a) fine-grained, (b) medium-grained, (c) coarse-grained; (*3*) gravelite; (*4*) breccia; (*5*) siltstone; (*6*) conglomerate; (*7*) dolomite; (*8*) pre-Jurassic basement; (*9*, *10*) correlation lines: (*9* beds, (*10*) complexes.

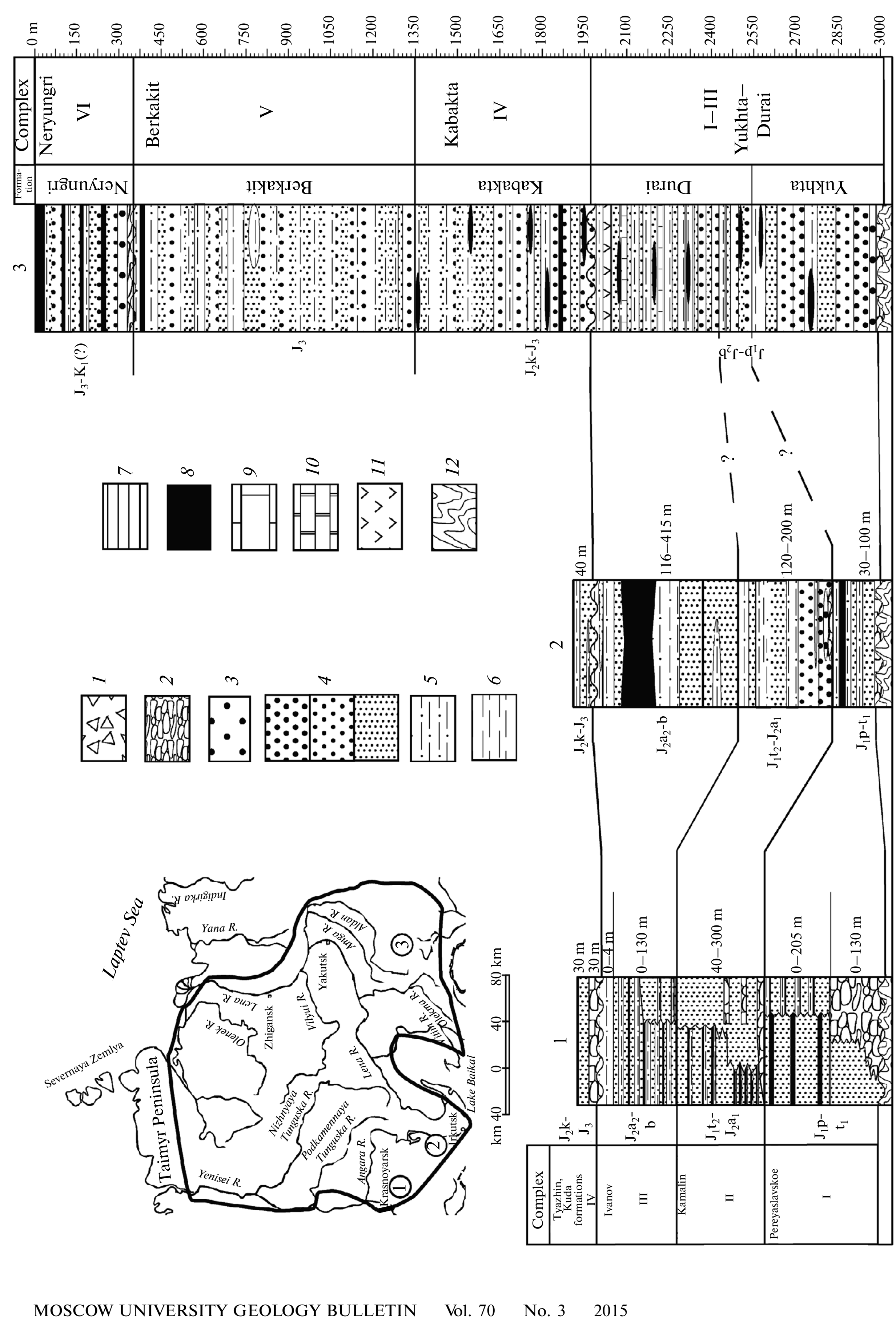

Fig. 7. The schematic location (inset) and correlation of Jurassic terrestrial sections in the southern Siberian Platform. (*1*) breccia; (*2*) conglomerate; (*3*) gravelite; (*4*) sandstone: from coarse- to fine-grained (from the top downward); (*5*) siltstone; (*6*) mudstone; (*7*) clay; (*8*) coal; (*9*) limestone; (*10*) dolomite; (*11*) volcanic tuff; (*12*) pre-Jurassic basement. Encircled numbers correspond to coal basins: (1) Irkutsk, (2) Kansk, (3) South Yakutia.

Stage, which belonged at that time as well to the Upper Jurassic Series in the geochronological scale. Indeed, in (*Fitostratigrafiya*..., 1985), the Kabakta phytostratigraphic assemblage is correlated with the Callovian–Oxfordian interval.

In the *Irkutsk basin* (Fig. 5), the Kabakta Complex is represented only by the locally developed *Kuda Formation*, which fills some depressions, where it rests with a sharp erosional surface upon different-age strata of the Ivanov Complex (Prisayan Formation). The formation is composed of inequigranular polymictic sandstones with a thick conglomerate sequence at the base. Judging from its structure and attitude, the formation begins the next erosion cycle; proceeding from its stratigraphic position, we consider this unit as a fragment of the lower Kabakta Complex (Fig. 7).

In the *Kansk basin*, a similar position is characteristic of the *Tyazhin Formation* (Fig. 4). In contrast with the Irkutsk basin, it is composed of fine-grained rocks that also rest unconformably upon different strata of the Ivanovo Complex, beginning a new cycle. It basal part usually consists of sandstones, which alternate or are replaced higher in the section by clayey–silty sediments. The absence of coal seams makes these rocks different from the coaliferous members of the Ivanov Complex.

The formation is characterized by remains of freshwater bivalve species *Limnocyrena wiljuica* Mart., *L.* cf. *ovatis* Ramm., *Lioplax* sp., *Volvata* cf. *helicoides* Nov., *Bairdestheria intermedia* Chi and ostracods (*Dervinula* sp., *Cypridea* sp.) indicating the Late Jurassic–Early Cretaceous age of host rocks (Tazikhin, 1972). The Tyazhin palynological assemblage is characterized by a high share of *Classopollis* Pflug. pollen (up to 28%, locally to 30–55%) accompanied by other Late Jurassic forms (Vdovin and Il'ina, 1967; Grigor'ev, 1968; Kostina, 2004), which together indicate the Callovian–Oxfordian age of this unit. In (*Fitostratigrafiya...,* 1985), the formation is correlated with the Callovian–Oxfordian interval.

Berkakit Complex (Upper Jurassic). In this work, the *Berkakit Formation*, which developed only in the *South Yakutia basin*, is considered to represent the regional stratigraphic complex (V).

The Berkakit Formation overlies the Kabakta Formation conformably, although with a distinct lithological boundary, and is represented by alternating medium- to fine-grained sandstones, siltstones, mudstones, and coal seams. The lower part of the formation is dominated by medium-grained sandstone varieties with a subordinate share of fine-grained and silty–clayey rocks. In the middle and upper parts of this unit, the dominant role belongs to fine-grained sandstones with clayey–silty members, whose number gradually increases upsection. As in the Kabakta Complex, sandstones are characterized by an arkosic composition and contain abundant coalified plant detritus, which is more characteristic of clayey–silty rocks. The Berkakit Formation includes up to 40 coal seams of variable thicknesses, as well as vertical and lateral distributions (Fig. 6).

The floral assemblage from the Berkakit Formation includes approximately 60 taxa of the typical Jurassic appearance. Most species are characteristic exclusively of Late Jurassic floras of the Siberia and Far East regions.

Neryungri Complex (Upper Jurassic–(?) basal Lower Cretaceous). The *Neryungri Formation*, which developed in the Chul'man and Tokin depressions of the *South Yakutia basin*, is considered to represent the next regional stratigraphic complex (VI) (Figs. 3, 6). The formation rests with the erosional surface upon sediments of the Berkakit Formation with a boundary that is marked by distinct lithological changes that are reflected in conglomerate and gravelites at the base, which undoubtedly indicate the onset of a new erosion cycle. The Neryungri Formation is formed by coarser material as compared with the underlying units. It is largely composed of alternating medium- and fine-grained sandstones with lenticular conglomerate and gravelite intercalations. Mudstones and siltstones constitute thin members at the bases and tops of coal seams. The formation encloses 10–12 coal seams with some of them being thickest in the basin; in total, coal seams constitute 8–9% of the section. Sandstones are characterized by the typical arkosic composition and contain a diverse assemblage of abundant accessory minerals.

The sediments of the Neryungri Formation are highly variable in composition with many intraformation hiatuses and represent alluvial (channel and floodplain) facies. The section is poorly differentiated: only its basal part includes a member of coarse-detrital rocks that reflect the onset of the cycle and the uppermost part contains the thickest coal seams, indicating relief leveling and swamping at the end of the cycle. The largest part of the section exhibits a uniform composition.

The floral assemblage from the Neryungri Formation consists of both the Late and Early Jurassic forms. They also include taxa that occur only in Upper Jurassic sediments of Siberia such as, for example, *Cladophlebis aldanensis* Vachr., which provided grounds for limiting the age of the host rocks as the Late Jurassic (Zhelinskii; 1980; Markovich, 1986). At the same time, remains of the fern species *Coniopteris hympharum* (Heer) Vachr., which is known, for example, in Yakutia only from Lower Cretaceous sediments, correlate the Neryungri Formation with the Volgian Stage, including its upper substage, which is now included in the Lower Cretaceous Series (Slastenov and Maksimov, 1981; *Fitostratigrafiya*..., 1985).

Correlation of stratigraphic complexes in continental and marine sections of the southern and northern Siberian Platform, respectively. The main factors that are responsible for their formation. As follows from the aforesaid, six stratigraphic sections defined in terrestrial sections of the southern Siberian Platform are distinctly divisible in two groups: Lower–Middle Jurassic (I–III) and Callovian–Upper Jurassic (IV–VI). It is reasonable to consider the above-mentioned problems separately for complexes of the first and second groups.

Lower–Middle Jurassic. As noted, the Lower–Middle Jurassic marine sections in the northern and eastern marginal parts of the Siberian Platform comprise seven regional stratigraphic complexes that correspond to stages in the geological development of these regions (Fig. 2). Each complex represents a sedimentary cycle of the regressive type and is undoubtedly of a eustatic nature. The onset of the cycle is determined by sea-level rise and transgression on continents. Sea-level fall results in shoaling of the marine basin, its regression, desiccation, and a sedimentation break at the terminal stage of the cycle.

The Lower–Middle Jurassic terrestrial sections of the southern Siberian Platform comprise three regional stratigraphic complexes (Fig. 7), which also corresponding to stages in geological development of this region. In contrast with the cycles in the northern and eastern areas of the Siberian Platform, these stages in its southern areas are represented by an erosion cycle in relief development. In the formation of these cycles, the decisive role could belong to the eustatic factor. A sea-level fall results in a lowered base level of erosion on continents, activation of erosional processes, and accumulation of coarse-detrital proluvial–alluvial sediments in dissected topographic settings, which is characteristic of the onset of the erosion cycle. A sea-level rise is accompanied by the elevation of the base level of erosion on continents, relief leveling, a rise of the groundwater level, and swamping, which is characteristic of the terminal phase of the erosion cycle.

To test these assumptions, we compared the upper parts of terrestrial complexes, which are composed of lacustrine–boggy sediments and correspond to relief leveling epochs at the end of the erosion cycle with the lower parts of marine complexes that correspond to sea-level rises and distribution of transgressions. If erosion cycles are of a eustatic nature, these sediments should be synchronous.

The particularly well-expressed member of the lacustrine–boggy sediments (the Ilan Formation) in the uppermost part of the Pereyaslavskoe Complex is readily correlated with sediments of the lower Toarcian Kiterbyut regional stage (I'ina and Shurygin, 2000) at the base of marine complex IV, which corresponds to the maximum distribution of undoubtedly eustatic transgression (Panov and Chekhovskii, 2012). It is not incidental that this member is missing from the section of the South Yakutia basin: the latter is located on the permanently elevated Aldan shield, where the early Toarcian sea-level rise is undistinguishable.

The less-expressed Aalenian lacustrine–boggy member in the uppermost part of the Kamala Complex is reliably correlated with sediments of the Laida Formation at the base of marine complex V (Fig. 2) deposited during the less significant transgression, which was determined by the lower sea-level rise. Like the previous unit, this member is unrecognizable in sections of the South Yakutia basin, where sediments were accumulated on the elevated Aldan shield in the Early–Middle Jurassic epochs only during the Yukhta–Durai erosion cycle.

The correlation of terrestrial complexes with their marine counterparts allows their age to be specified. For example, the Laida Formation is attributed to the lower Aalenian Substage and the age of the Kamala Complex is limited at the early Aalenian. It appears that the lower part of the of the Kamala Complex belongs to the upper Toarciian, which was marked by a sea-level fall, transgression, and accumulation of sediments that constitute the upper part of the marine complex (IV) and indicating progressive shoaling.

The Bajocian lacustrine–boggy member in the uppermost part of the Ivanov and Yukhta–Durai complexes particularly distinct in sections of all the basins is readily correlated with Bajocian marine sediments of complex VI (Fig. 2), which were deposited during the most extensive transgression of the undoubtedly eustatic nature. The sea-level rise, the maximum one for the Early–Middle Jurassic epochs was responsible for the widest expansion of the transgression in the northeastern areas, universal relief leveling, and swamping of the southern Siberian Platform, including even the Aldan shield. Inasmuch as the upper part of the Ivanov Complex is correlative with the Bajocian sediments of complex VI, its lower part should be dated back to the early Aalenian marked by the sea-level fall, regression, and accumulation of shallow-water sediments that constitute the upper part of marine complex V (Vym Formation).

In the southern Siberian Platform, Bathonian sediments are missing. The Bathonian Age was marked by a significant sea-level fall. The northeastern part of the platform was subjected to regression that culminated in the universal sedimentation break; in its southern part, the sedimentation break was accompanied by the substantial tectonic reorganization: overlying complexes exhibit unconformity at the base and occur in the different tectonic settings.

This correlation shows that the formation of Lower Jurassic–Middle Jurassic stratigraphic complexes in the southern Siberian Platform and their cyclic structure are determined by the eustatic oscillations, although we are dealing with terrestrial sediments. Three stratigraphic complexes that were defined in this region correspond to three erosion cycles. These are sedimentary cycles, whose formation was also determined by sea-level fluctuations like those in marine basins. The role of the tectonic factor in the formation of the Lower Jurassic–Middle Jurassic complexes is limited. This factor determines the abrupt replacement of all complexes by coarse-detrital deposits in the Baikal zone of the Irkutsk basin (Fig. 5) and the above-mentioned absence of lacustrine—boggy members in the two lower complexes on the elevated part of the Aldan shield.

It should be noted that despite that fact that the cycles both in marine and terrestrial sections are characterized by a eustatic nature, they are asynchronous, demonstrating a shift in time. For example, while the lower part of the Pereyaslavskoe Complex corresponds to complexes II and III in marine sections, its upper part (the Ilan Formation) is correlative with the Kiterbyut regional stage at the base of marine complex IV (Fig. 2). The lower and upper parts of the Kamalin Complex correspond to the upper part of marine complex IV and to the Laida Formation that forms the lower part of marine complex V, respectively. In these and other examples, the upper part of the terrestrial complex is correlative with the lower part of the marine unit and such relationships should be taken into consideration in interregional correlations.

Callovian and Upper Jurassic. Three stratigraphic complexes that are defined in Callovian and Upper Jurassic sections differ to a significant extent from their Lower—Middle Jurassic counterparts. They are separated from them by a hiatus (Bathonian Age), rest upon them with unconformity, and are observable only in depressions of the South Yakutia basin that are located along the northern margin of the Stanovoi zone of the Aldan shield, i.e., they were formed in different tectonic environments.

The Callovian and Upper Jurassic sections are thicker and characterized by a coarser composition as compared with older complexes. They also demonstrate coarse, although vague rhythmic patterns. Three formations that are defined in these sections, which are considered as representing regional stratigraphic complexes, may be correlated with major erosion cycles with some reservation. The formations are usually characterized by uniform lithology, which is represented by alternating (locally with the rhythms of several orders) rocks with a different grain-size composition: from gravelites to mudstones with coal seams. All of them are alluvial sediments that accumulated in dissected relief settings with high tectonic activity. Their basal parts are represented by members of coarse-grained sandstones and gravelites with lenses of conglomerates, which imply activation of tectonic movements and relief renewal at the beginning of the cycle. At the same time, lacustrine—boggy members, which could indicate relief leveling at the end of the cycle, are practically missing. Although these sections enclose many coal seams, they are randomly distributed through the entire section. All these features indicate that the eustatic factor played a distinctly subordinate role in their formation.

An important feature of Callovian and Upper Jurassic deposits is the arkosic composition of detrital material in sandstones and siltstones with abundant and diverse accessory components. Inasmuch as no such properties are noted for the Lower—Middle Jurassic sections, the appearance of a new provenance in the Callovian, which provided detrital material for Callovian—Upper Jurassic sections, should be assumed. Only the Stanovoi zone of the Aldan shield, which is composed of metamorphic rocks and granites, could serve as such a possible source.

The sediments that constitute the Callovian—Upper Jurassic Kabakta, Berkakit, and Neryungri stratigraphic complexes were deposited in the newly formed Stanovoi foredeep, whose formation along the northern margin of the Stanovoi zone was in progress since the Callovian. The last zone experienced an intense inversion precisely at that time in response to the closure of the Mongol—Okhotsk basin and subsidence of its Mesozoic fold complexes under the southern margin of the Aldan shield (pseudosubduction, after V.E. Khain). This trough, whose formation is similar to that of marginal troughs of fold belts, accumulated a thick (over 3000 m) sequence of detrital coaliferous sediments of an alluvial genesis. The western boundary of the trough is recorded in the Irkutsk basin, where the Kuda Formation is characterized by a similar coarse-detrital composition. In the northwesterly located Kansk basin, the Tyazhin Formation is composed of sandy—silty—clayey rocks of a lacustrine—boggy genesis. The latter likely belonged to the distal part of the spacious apron of detrital material, which was transported from the elevated Sttanovoi zone. The composition of sediments in the Stanovoi trough became gradually coarser, which is evident from the successive comparison of the Kabakta, Berkakit, and Neryungri formations. This feature emphasizes its similarity with typical marginal troughs as well.

The formation of the Callovian—Upper Jurassic complexes (IV—VI) was controlled exclusively by tectonic factors: intense emergence of the Stanovoi zone and, correspondingly, appearance of the Stanovoi foredeep. Their cyclic structure is determined by phases of intensified tectonic movements and acceleration of the Stanovoi zone emergence, which resulted in rejuvenation of the relief and enhanced transport of coarse—detrital material of the arkosic composition, with the eustatic factor playing a negligible role. The Bathonian—Upper Jurassic terrestrial coaliferous sections of the Verkhoyansk marginal trough and Vilyui syneclise were formed in similar conditions. Their cyclic patterns are explained by repeated phases of Mesozoic folding in the Verkhoyansk region.

CONCLUSIONS

The first single regional stratigraphic scale based on the historical—geological principles, which is proposed for Jurassic terrestrial sections of the southern Siberian Platform, includes six regional stratigraphic complexes that are traceable in all the basins and correspond to major *erosion cycles* in relief development.

The same as for complexes of marine deposits in the northeastern part of the platform, the decisive role in the formation of Lower–Middle Jurassic complexes (I–III) belonged to the *global eustatic factor*. The onset, duration, and termination of erosion cycles were determined by sea-level fluctuations. It is apparent that they could occur only during thalassocratic epochs, when sea-level fluctuations resulted in changes of the base level of erosion, transgressions and regressions of epicontinental seas, and other phenomena. Despite the controlling role of the global eustatic factor in their formation, stratigraphic complexes in terrestrial and marine sections are asynchronous, being shifted in time: the upper part of the terrestrial complex is synchronous with the lower part of the marine one.

The formation of Callovian–Upper Jurassic complexes (IV–VI) was controlled exclusively by *regional tectonic factors*. The succession of erosion cycles in them was determined by phases of intensified tectonic movements: emergence of the Stanovoi zone of the Aldan shield and subsidence of the Stanovoi foredeep with a negligible role of global sea-level fluctuations. Such complexes (for example in the Stanovoi trough and Verkhoyansk marginal trough) are also asynchronous, being determined by tectonic processes in both regions.

In the terrestrial stratigraphic complexes of a eustatic nature, coal seams are usually well sustained and occur among lacustrine–boggy members in the upper part of the complex; they were formed synchronously with transgression in the neighboring epicontinental marine basin. In stratigraphic complexes that were formed under tectonic activity during phases of its intensification, coal seams that occur among facies-variable proluvial–alluvial deposits may be very thick although they usually are thickness-variable and randomly distributed through the section. Similar observations were presented in (Tseisler, 2004).

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