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THE LOWER AND UPPER BOUNDARIES OF THE LOWER CAMBRIAN ON THE SIBERIAN PLATFORM

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The Siberian Platform is well characterized paleontologically, sedimentologically, and geochemically. This makes it a suitable region for choosing stratotypes of the lower and upper boundaries of the Lower Cambrian. However, the correlation of these boundaries both within and outside the region is still disputable. The article considers one of the possible reasons for this disagreement, which rests upon the fact that the boundaries are drawn in most sections using organic fossils among bioherms and are correlated with boundaries in different facies sections.

Cambrian-Precambrian boundary, Lower-Middle Cambrian boundary, bioherms, Siberian Platform

INTRODUCTION

The Cambrian deposits on the Siberian Platform have been studied over many years, and the data obtained were summarized in the monograph "The Cambrian of Siberia" [1]. The basic results of this work were discussed before at the Third International Symposium on the Cambrian System, held in Novosibirsk in 1990. The symposium was devoted to determination of the lower and upper boundaries for the series adopted in the Soviet Union. Its participants discussed the Lower Cambrian stage scale, which was universally accepted. Nevertheless, a section on the Burin Peninsula (Newfoundland Island) was accepted as the global stratotype for the lower boundary of the Cambrian System. This boundary was defined by the first occurrence of *Trichophycus (Phycodes) pedum*. The Cambrian sections in Siberia are of top level; therefore, leading Cambrian specialists in Russia and abroad apply new stratigraphic methods first of all to the well-studied sections of the Siberian craton [2–5]. There is, however, much controversy about correlation of stratigraphic levels of different ranks, which tends to escalate rather than to decrease. Below, the boundaries between the Precambrian and Cambrian and between the lower and middle series of the Cambrian System will be discussed with due regard for the distribution of reef buildups within the indicated interval. The conclusions are based on our own and literature data.

PRECAMBRIAN–CAMBRIAN BOUNDARY

Most of leading Cambrian specialists in Russia believe that the global stratotype for the Precambrian–Cambrian boundary on the Burin Peninsula (Newfoundland Island) is a poor choice [5], and, consequently, the Siberian Platform is still the focus of attention as the major object in searching for the best version of the boundary [7]. Currently, there is no convincing scheme for correlation of Newfoundland sections with those of Siberia, but it is quite evident that the sections appropriate for such correlation are available on the Siberian Platform and can be selected. To do this, we should first solve the problem of correlation of coeval strata occurring in two different facies regions (Anabar-Sinyaya and Yudoma-Olenek) within the Siberian Platform and, depending on the result, choose the section for the stratotype (parastratotype) of the Cambrian lower boundary. In the search for the best section for this boundary, considerable disagreement must be overcome as to: 1) the boundary between the Nemakit-Daldyn and Tommotian Stages; 2) the presence or absence of a gap between these units; 3) the position of the Nemakit-Daldyn Stage in geochronological scale.

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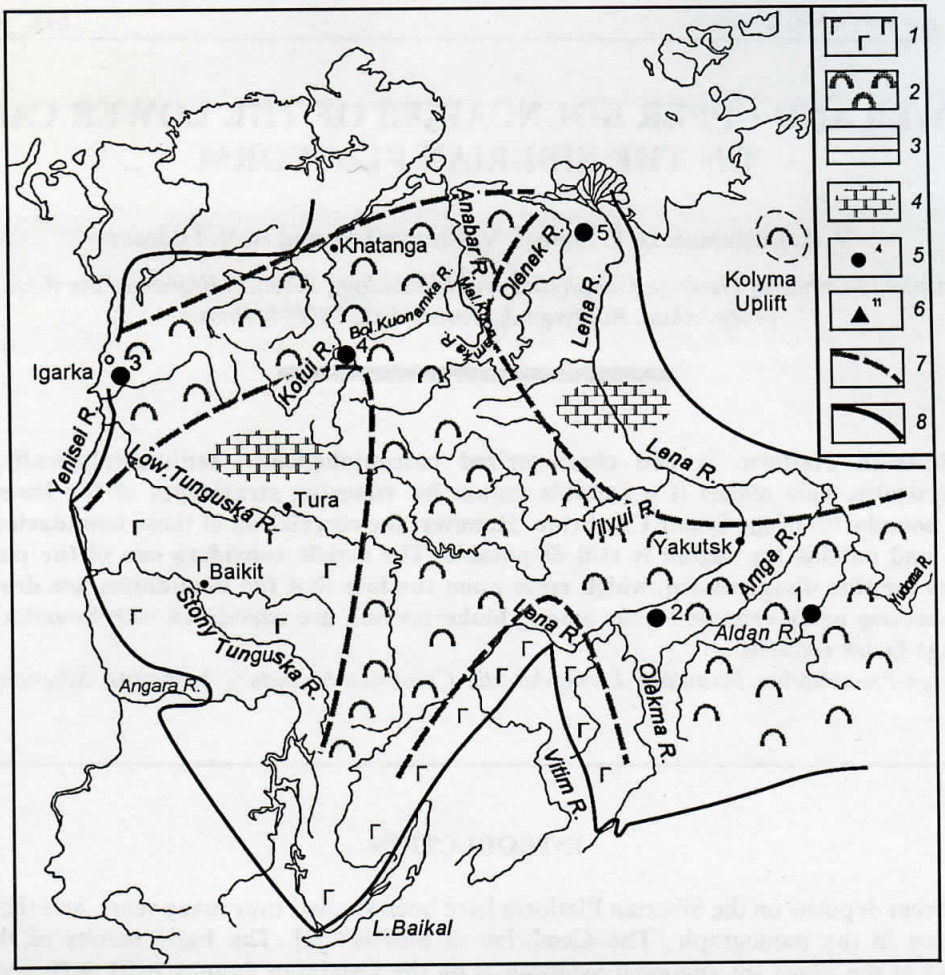

Fig. 1. Paleogeographic reconstruction of Late Vendian basin with reef structures on the Siberian Platform and localities of sections with the Precambrian–Cambrian boundary. *1* – evaporites; *2* – reef structures; *3* – deep-water rocks; *4* – dolomites; *5* – sections with Precambrian–Cambrian boundary; *6* – sections with Lower–Middle Cambrian boundary; *7* – outlines of the area of occurrence of reef structures; *8* – Siberian Platform boundary. Sections: 1 – Aldan River, Dvortsy exposure, 2 – Lena River, near Isit' Village, 3 – Sukharikha River, 4 – Kotui River, 5 – Olenek River.

Factual material. As reference sections, we selected sequences in two facies regions (FR): Anabar-Sinyaya (sections: 1 – Aldan River, Dvortsy exposure, 2 – Lena River, Isit' Village, 3 – Sukharikha River, 4 – Kotui River) and Yudoma-Olenek (5 – Olenek River section), which, owing to several international expeditions to the Siberian Platform, are well known among the specialists both in Russia and abroad (Figs. 1 and 2).

Aldan. Most Russian researchers define the Precambrian–Cambrian boundary in the Aldan sections 3–5 m lower than the roof of the Ust'-Yudoma Formation [1], where a representative complex of Tommotian (Sunnaginian) fossils occurs, and only Khomentovsky [8, 9] draws the boundary higher, between the Ust'-Yudoma and Variegated Formations. Shelly fossils are extremely scarce in the underlying Ust'-Yudoma Formation and are represented by *Hyolithellus* sp., *Chancelloria* sp., and *Lobiochrea*? sp. found 23.5 m apart from the roof of the formation. All researchers recognize a break in the roof of the Ust'-Yudoma Formation but interpret it in different ways. The leading experts on this problem share the opinion of most Russian researchers that this break is insignificant. They proceeded from the successive development of the Tommotian and Nemakit-Daldyn faunas [5], whereas A. Knoll et al. [10], based on the results of interpretations of carbon isotope data for the Aldan and Anabar sections, inferred that the pre-Variegated break in sedimentation was

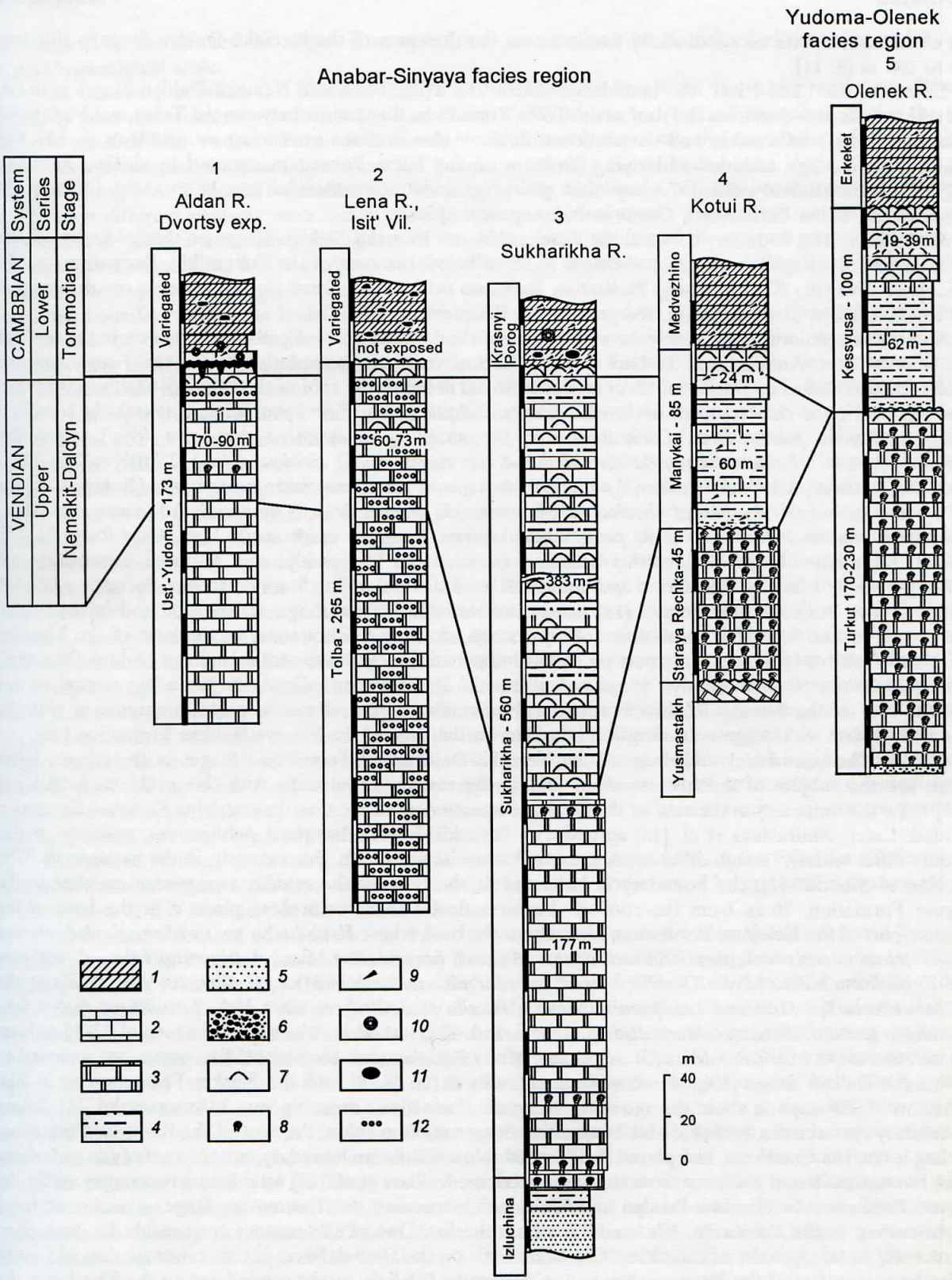

Fig. 2. Correlation of Precambrian–Cambrian deposits in reference sections of the Siberian Platform. *1* **– variegated limestones;** *2* **– limestones;** *3* **– dolomites;** *4* **– siltstones;** *5* **– sandstones;** *6* **– conglomerates;** *7* **– algal bioherms;** *8* **– stromatolites;** *9* **– SSF;** *10* **– archaeocyathids;** *11* **– archaeocyathid-algal bioherms;** *12* **– oncolites.**

quite extended. Experts on small-shelly fossils assess the thickness of the Nemakit-Daldyn Stage in this area at 70 to 100 m [8, 11].

Lena. On the Lena River, the boundary between the Tommotian and Nemakit-Daldyn Stages is drawn by all researchers at 5–6 m from the roof of the Tolba Formation, the contact between the Tolba and Variegated Formations being conformable and correlation with the Aldan sections presenting no problems [8, 13]. The Nemakit-Daldyn Stage includes underlying 70–82 m of the Tolba Formation exposed by drilling near Isit' Village [12]. This interval yielded *Coreospiridae* gen. et sp. indet., *Circothecidae* gen. et sp. indet. (12 m below the roof of the Tolba Formation), *Cambrotubulus* sp. and spicules.

Sukharikha. The boundary between the Tommotian and Nemakit-Daldyn Stages on the Sukharikha River is defined by a Sunnaginian complex of fossils 1–1.5 m below the roof of the Sukharikha Formation, and its contact with overlying Krasnyi Porog Formation shows no evidence of break [1, 13], whereas the thickness of the Nemakit-Daldyn Stage is 383 m, the greatest on the platform [14].

Kotui. The opinions differ widely on where to draw the Precambrian–Cambrian boundary in the sections of the northwestern Anabar area. In joint works of recent years, the boundary between the Tommotian and Nemakit-Daldyn Stages on the Kotui River is placed 16–20 m below the roof of the Nemakit-Daldyn (Manykai) Formation bearing a rich complex of fossils: *Purella antiqua* (Ab.), *P. cristata* Miss., *Latouchella korobkovi* (Vost.), *Anabarella plana* Vost., *Coonotheca* sp., *Circotheca* sp., *Ladatheca dorsocava* (Sys.), *Anabarites trisulcatus* Miss., *A. tripartitus* Miss., *Cambrotubulus decurvatus* Miss., *C. sibiricus* (Val.), *Tiksitheca licis* Miss., *Hiolithellus tchuscunensis* Val., *Halkieria projecta* Bokova, and *Siphogonuchites subremualis* (Bokova). At the base of the formation *Anabarites trisulcatus* Miss., *A.* cf. *grandis* Val., *Cambrotubulus decurvatus* Miss., *Protohertzina anabarica* Miss., *Hertzina penza* Didenko, and *Korilacus enigmaticus* Miss. were found [1, 15]. However, Khomentovsky [8] defines this boundary between the Medvezh'ya and Manykai Formations and includes the whole Manykai Formation and about 120 m of the underlying Staraya Rechka Formation into the Nemakit-Daldyn Stage. Missarzhevskii [11] names the Nemakit-Daldyn Stage as Manykai and includes both the Medvezh'ya and Manykai Formations into this stage, drawing the boundary at the base of the Manykai Formation. Vasil'eva [16], another expert on small-shelly fossils, includes the total Nemakit-Daldyn (Manykai) Formation into the Nemakit-Daldyn Stage and places the Precambrian–Cambrian boundary several meters below the roof of the Staraya Rechka Formation. Her version of correlation is quite in agreement with the opinion of experts who suggest drawing the boundary in the roof of the Staraya Rechka Formation [10].

Olenek. The boundaries and range of the Nemakit-Daldyn and Tommotian Stages in the Olenek River sections are the subject of much controversy among the researchers dealing with this problem. Savitskii et al. [17] draw the boundary in the roof of the Turkut Formation and note that the overlying Kessyuse Formation is eroded. Later, Zhuravleva et al. [18] agreed with Savitskii. In all subsequent publications, opinions on this boundary differ widely, though differences in factual material are subtle. For example, in the monograph "The Cambrian of Siberia" [1], the boundary is indicated at the base of the middle terrigenous member in the Kessyuse Formation, 70 m from the roof of the formation. Other researchers place it at the base of the carbonate part of the Kessyuse Formation, 38 m below the roof, where *Hyolithellus tenuis* Miss., *H. vladimirovae* Miss., *H. tchuscunensis* Val., *Anabarites trisulcatus* Miss., *A. hexasulcatus* Miss., *A. tripartitus* Miss., *A. ternarius* Miss., *Kugdatheca voluta* Miss., *Tiksitheca* sp., *Cambrotubulus decurvatus* Miss., *C. sibiricus* Val., *Archiasterella* sp., *Chancelloria* sp., *Halkieria sacciformis* (Mesh.), *Purella* sp., *Allatheca cana* Val., *Loculitheca rugata* Sys., *Crossbitheca arcuata* Miss., and *Markuelia* sp. were found. The rest 62 m, where at a distance of 12–15 m from the base *Anabarites trisulcatus* Miss., *A. tripartitus* Miss., *Protohertzina anabarica* Miss. occur, are assigned to the Nemakit-Daldyn Stage [19], whereas Khomentovsky et al. [8, 9] add the Turkut Formation to it. The conclusions of SSF-experts about the age of the Kessyuse Formation are ambiguous. Missarzhevskii [11] defines the boundary between the Manykai and Tommotian Stages at 60 m below the roof of the Kessyuse Formation, including it into the Cambrian, and places the Precambrian–Cambrian boundary into the roof of the underlying Turkut Formation. From evidence from the same sections, Val'kov et al. [20] established two stages within the Kessyuse Formation – Nemakit-Daldyn and Khayalakh, preceding the Tommotian Stage – and considered them to belong to the Cambrian. We could continue the list. One of the reasons responsible for such deep disagreement in stratigraphy of the oldest Cambrian beds on the Olenek River is that cabonate deposits occur only in the upper part of the Kessyuse Formation. However, the field works carried out on the Khorbosuonka River, a tributary of the Olenek River, in 2000 have revealed limestones with small algal structures occurring 0.5 m below the roof of the Turkut Formation (oral communication of Korovnikov).

Discussion of results. The review of the factual material suggests that the main point of disagreement among the researchers is determination of the boundary between the Nemakit-Daldyn and Tommotian Stages,

the range of break between the stages, if accepted, and the range of the Nemakit-Daldyn Stage and its place in geochronological scale.

The boundary between the Nemakit-Daldyn and Tommotian Stages on the Aldan and Lena Rivers is drawn by most researchers 5–6 m below the roof of the Ust'-Yudoma and Tolba Formations. As for the break in the uppermost Ust'-Yudoma Formation, namely, in the Dvortsy exposure, the correlation of sections in the Aldan area shows that the contact between the Sunnagin member (basal beds of the Variegated Formation) and underlying Ust'-Yudoma Formation may be progressive, with marks of local break, and even extremely sharp. Such different contacts were conditioned by numerous local events proceeding on the background of attenuation of positive movements giving rise to the Aldan-Lena uplift and of onset of general transgression. For this reason, depending on the environmental conditions in the sections of the Aldan River basin, a change in the *Nochoroicyathus sunnaginicus* Zone range is assumed, as well as a change in the position of the lower Cambrian boundary within the limits of Ust'-Yudoma Formation and its equivalents. Detailed correlation of the sections on the Aldan, Gonam, Selinde, and Dzhanda Rivers showed that the Vendian–Cambrian boundary runs at different levels from the roof of the Ust'-Yudoma Formation [21–23]. The boundary between the Nemakit-Daldyn and Tommotian Stages on the Sukharikha River is accepted, by analogy with the Aldan-Lena region, at 1.5 m below the roof of the Sukharikha Formation. In the three cases, the boundary is drawn at the base of biostrome strata bearing SSF complexes on each side of the boundary. The same principle was used for defining a synchronous boundary on the Kotui River; it was placed at the base of the organic Koril member between appropriate complexes of small-shelly fossils [1]. As follows from published data, there is a great variety of different opinions about the placement of the boundary between the Nemakit-Daldyn and Tommotian Stages in the Kotui River sections, despite the fact that all specialists use the same well-known complexes of small-shelly fauna existing in Lagerstätte environment, which was also favorable for biostrome formation. The potentialities for fossilization of coeval fauna among biostromes at different levels were not taken into account. On the Olenek River, a similar environment existed for a relatively short period – in late Vendian–early Tommotian time (see Fig. 2). In the early Nemakit-Daldyn Age, certain changes in the environment occurred in the East Anabar area as well, which is supported by cores from the wells drilled in the Ebelyakh region [24]. The Manykai Formation is represented in the core by a small amount of carbonate rocks containing complexes of small-shelly fossils common to this level. At the same time, the amount of terrigenous material markedly increases toward the top of the Manykai Formation, and its roof is made up of quartzy sandstone and gritstone intervened with marl. The sequences of the Ebelyakh region are intermediate between those of the West Anabar and Olenek regions. The replacement of carbonate sedimentation with terrigenous was apparently due to tectonic processes that occurred at that time in the eastern part of the platform, which, in turn, reflected oceanic events.

Analysis of versions of drawing the Precambrian–Cambrian boundary on the Siberian Platform shows that most researchers have the same opinion on the level of the boundary. The greatest disagreement exists in correlation of this boundary in the Olenek River sections.

The Russian scientists, as noted above, draw the boundary between the Nemakit-Daldyn and Tommotian Stages (between the Precambrian and Cambrian) based on analysis of SSF complexes. As to an international stratotype for the Precambrian–Cambrian boundary, the authors of "The Cambrian of Siberia" [1] proposed the Aldan reference sections, where small-shelly fauna found in the upper 23 m of the Yudoma Formation and basal 5–8 m of the Variegated Formation suggests five fauna complexes and permits drawing the boundary by the first appearance of the second fauna complex in the sections. The second SSF complex occurs in the upper 0.3–1.5 m of the Yudoma Formation and is characterized by the appearance of individuals typical of the Lower Cambrian Tommotian Stage. Small-shelly fauna of similar composition is known in the upper 5–6 m of the Tolba Formation on the Lena River (the exposure opposite Isit' Village), in the upper 0.5–1 m of the Sukharikha Formation on the Sukharikha River, 16–20 m below the roof of the Manykai Formation on the Kotui River, and at the base of the Kessyuse Formation on the Olenek River. This boundary agrees with the time of important changes in the development of organic world in the early Cambrian. Therefore, it is reasonable to include the Nemakit-Daldyn Stage into the Precambrian (Vendian) and to consider the Tommotian Stage the first stage of the Cambrian System. The Sukharikha River section, in addition to those of the Aldan River, can be proposed as one of the best sections where the position of the Vendian–Cambrian boundary between the Nemakit-Daldyn and Tommotian Stages is clearly defined. In addition to SSF characteristic of the Nemakit-Daldyn Stage, this section contains numerous imprints of problematic mollusks, which occur among alga-bacterial biostromes and show remote similarity to aulophycuses, plate-like archaecyathids, or calcareous sponges (Fig. 3). They co-occur with diverse pellets, whose origin is still unknown

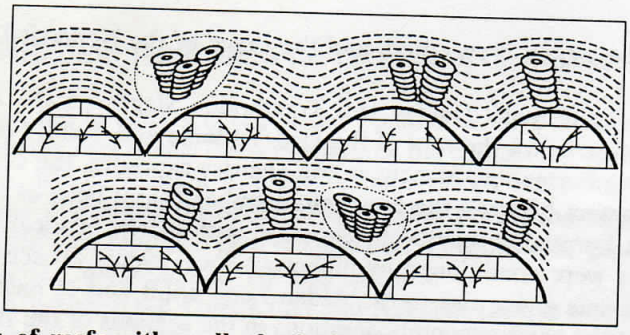

Fig. 3. Fragments of reefs with mollusks in interbiohermal terrigenous interbeds. The Sukharikha River section, Sukharikha Formation, Nemakit-Daldyn Stage, Upper Vendian.

[13]. It is possible that, as with calcareous algae, the shell appeared not in newly formed organisms but in their soft-body ancestors, which existed in the Vendian and had to adapt to new environments.

It should be taken into consideration that the Upper Vendian–Lower Cambrian carbonate sequences on the Siberian Platform are a nearly ideal model for the beginning of the transgressive cycle. The Vendian ended in sequences deposited under littoral conditions and containing, along with stromatolites, a poor complex of burrowing organisms (mainly Scolithos). Later, algal biostromes formed, which gave way to alga-archaeocyathid bioherms, and the latter, in turn, changed by deeper-water limestones bearing hyolithids and trilobites. Thus, the succession in change of environments, which corresponded to different phases of transgression, had an effect on the development and radiation of different groups of Early Cambrian biota. On the Siberian Platform, the stratigraphic evidence and data of facies analysis agree well with this model.

LOWER–MIDDLE CAMBRIAN BOUNDARY

The problem of the Lower–Middle Cambrian boundary on the Siberian Platform has received considerably less attention than that of the Lower Cambrian boundary both from Russian and foreign scientists. It is indicated in [1] that the stratotype for the Lower–Middle Cambrian boundary in Siberia was chosen in the sections of the middle course of the Lena River (Anabar-Sinyaya facies region) in homogeneous massive, in places, organic limestones of the Elanskoe Formation, where a change of trilobite complexes is clear. This level is less clearly defined by algae, hyolithids, and other groups of fauna. As seen from analysis of works on this problem, drawing of the Lower Middle Cambrian boundary leads to debates not only about the correlation between three facies regions but also about the boundary in the stratotype on the Lena River.

The selection of the best section for the stratotype of the Lower Cambrian upper boundary is being continued, and solution of this problem depends heavily on comprehensive study of all fossils.

Factual material. Detailed information on the reference sections for the Lower–Middle Cambrian boundary in three structure-facies regions of the Siberian Platform was published in "Biostratigraphy and fauna of the Lower–Middle Cambrian boundary deposits in Siberia" in 1983 [25]. Substantiation of this boundary is principally based on trilobite zones. In more recent works on reconstruction of the environment of carbonate sedimentation of that time data on litho- and biofacial analysis were published [26, 27].

As reference sections for the Lower–Middle Cambrian boundary, classical sections in the three structure-facies regions of the Siberian Platform were selected (Figs. 4 and 5): in the Turukhan-Irkut-Olekma facies region (section 6 in the upper course of the Lena River); in the Anabar-Sinyaya facies region (section 7 on the Amga River, a tributary of the Aldan River, section 8 in the middle course of the Lena River, Blanka Village, section 9 in the Daldyn-Alakit area, near the Udachnaya pipe, section 10 in the lower course of the Lena River, spurs of the Kharaulakh Ridge); and in the Yudoma-Olenek facies region (section 11 on the Nekekit River, a tributary of the Olenek River, section 12 on the Bol'shaya Kuonamka River, a tributary of the Anabar River, section 13 on the Yudoma River, a tributary of the Maya River).

Upper reaches of the Lena River. According to Ogienko's data [28], continuous sections of the Toyon and lowermost Amga Stages occur in the upper course of the Lena river, between Kirensk and Nokhtuisk Villages. The boundary between them runs within the Ichera Formation at 21.5 m from its base and is defined by the disappearance of trilobite genera *Namanoia*, *Bathynotus*, and *Aniagmella* and the appearance of *Deltocephalus*, *Itcheriella*, and *Chilometopus*. These sections are considered to be well correlatable with the sections in the

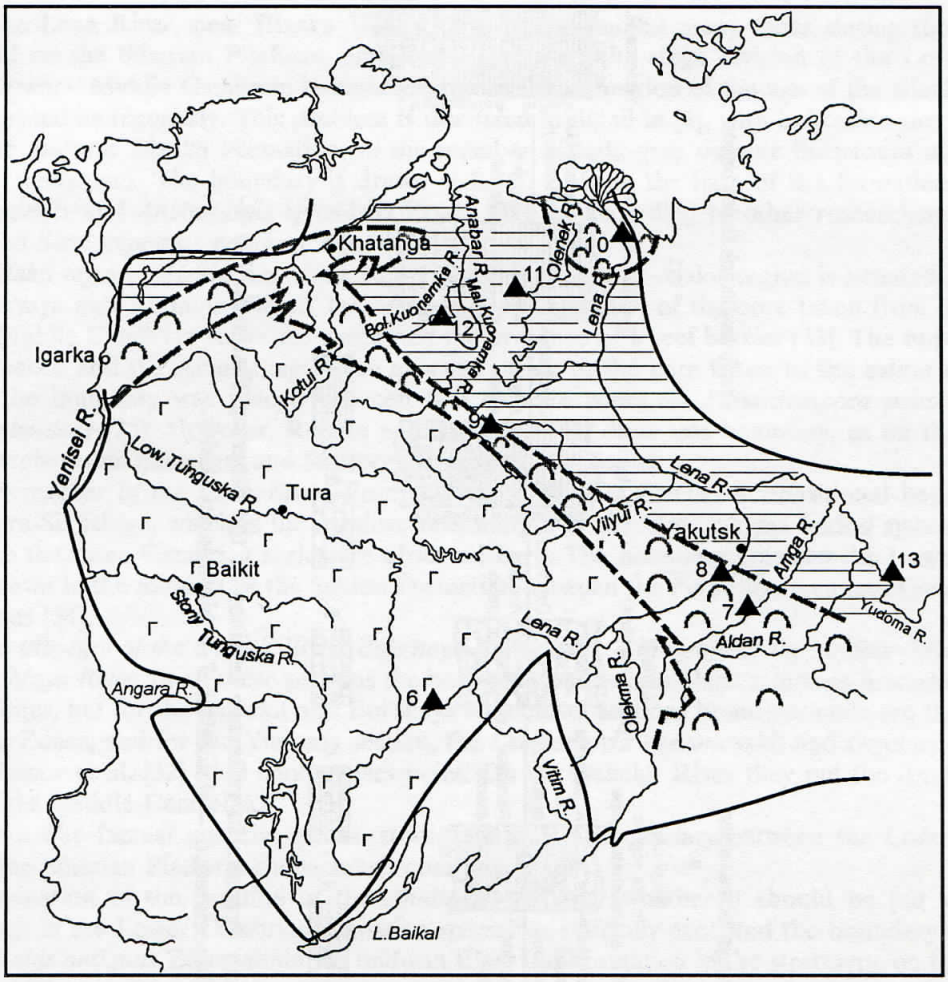

Fig. 4. Paleogeographical reconstruction of Early Cambrian basin with Sakha reef belt and localities of sections with Lower–Middle Cambrian boundary. Sections: 6 – Lena River, upper reaches, below the Ichera River mouth, 7 – Amga River, 8 – Lena River, middle reaches, near Elanka Village, 9 – borehole in the Udachnaya pipe area, 10 – lower reaches of the Lena River, 11 – Nekekit River, tributary of the Olenek River, 12 – Bol'shaya Kuonamka River, tributary of the Anabar River, 13 – Yudoma River, tributary of the Maya River. For symbols see Fig. 1.

areas adjacent to the West Baikal region and Baikal-Patom uplift. The Ichera Formation is made up of gray and dark-gray mottled-striated, often oncolitic, limestones.

Amga. The Amga Stage in the Amga Formation was established by Chernyshova [29] on the Amga River. She emphasized that "the lower boundary of the Amga Stage is drawn conventionally at the base of the Amga Formation with regard for lithologic and paleontologic features", since the contact with the underlying Khomustakh Formation is unexposed. In this connection, Savitskii [30] noted that "the upper part of the Khomustakh Formation, according to Chernyshova, and the Amga Formation cannot be lithologically distinguished from each other, since they form a single lithostratigraphic unit consisting of massive reef limestones". Chernyshova, with regard for this comment, draws the boundary at the base of beds with first *Shistocephalus antiquus*, which are typical representatives of the Middle Cambrian family *Paradoxididae*, 5 m above the base of the Amga Formation. The boundary in the Amga River section, described in "The Cambrian of Siberia" [1], was drawn in a similar way. Repina and Suvorova [31], when touching this problem, placed the base of the *Shistocephalus antiquus* Zone in the chart 70 m above the base of the Khomustakh Formation, whereas in the text they attribute it to the Amga Formation.

Middle reaches of the Lena River. The Lower–Middle Cambrian boundary stratotype is located on the

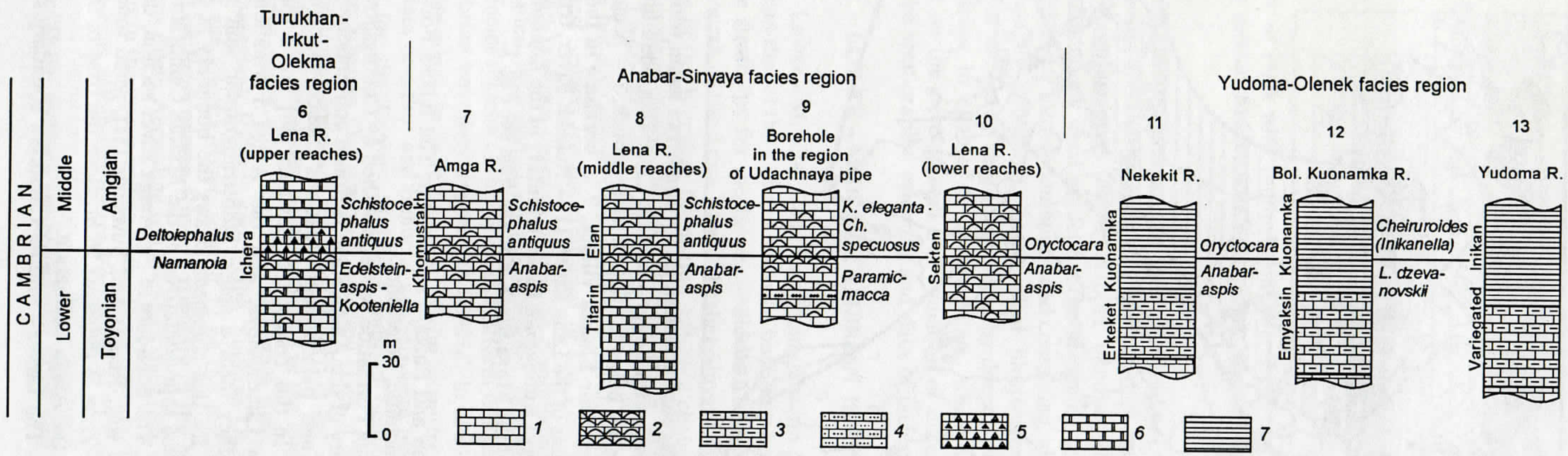

Fig. 5. Correlation of the Lower-Middle Cambrian deposits in reference sections of the Siberian Platform. *1–5* — limestones: *2* — algal, *3* — clayey, *4* — sandy, *5* — brecciated; *6* — dolomites, *7* — bituminous shales.

left bank of the Lena River, near Elanka Village, and was examined many times during the international excursions held on the Siberian Platform, aimed at clearing up the stage division of the Lower Cambrian. Drawing the Lower–Middle Cambrian boundary requires determination of the age of the Elanka Formation, which is interpreted ambiguously. This problem is discussed in detail in [1], with indication that the boundary runs within the uniform Elanka Formation, in the member of light-gray organic limestones alternating with dolomites and sandstones. The boundary is drawn at 22–27 m from the base of the formation, between the *Lermontovia grandis* and *Anabaraspis splendens* Zones [32] or, according to other researchers, between the *Anabaraspis* and *Shistocephalus antiquus* Zones [31].

Daldyn-Alakit region, BH-316 near Udachnyi Village. The Daldyn-Alakit region is situated at the joint of the Anabar-Sinyaya and Yudoma-Olenek facies regions. Examination of the core taken from the reefal part of the Lower-Middle Cambrian sequence confirmed the presence of a reef barrier [33]. The uppermost Lower Cambrian sequence and the Amga Stage were exposed owing to the core taken to the extent of 100% from BH-316, and the boundary was placed between two trilobite zones – *Paramicmacca petropavlovskii* and *Anabaraspis splendens* [25]. However, Repina and Suvorova [31] draw this boundary, as on the Lena River, between the *Anabaraspis splendens* and *Shistocephalus antiquus* Zones.

The lower reaches of the Lena River. From Lower to Middle Cambrian transitional beds are exposed within the Tuora-Sis Ridge, which is the northwestern margin of the Upper-Yana folded system. This region is unique, since the three Cambrian series are observed here. The boundary between the Lower and Middle Cambrian is drawn in the midpart of the Sekten Formation between the *Paramicmacca* and *Chondranomocare speciosum* Zones [34].

Nekekit, a tributary of the Olenek River; Bols'haya Kuonamka, a tributary of the Anabar River; Yudoma, a tributary of the Maya River. In all these sections the boundary is drawn in black schistose limestones containing abundant trilobites, but for the Nekekit and Bol'shaya Kuonamka sections boundary units are the *Anabaraspis* and *Oryctocara* Zones, and for the Yudoma section, the *Lermontovia dzevanovskii* and *Oryctocara* Zones [31]. However, Shabanov et al. [32] hold another viewpoint. On the Nekekit River they put the *Anabaraspis* Zone at the base of the Middle Cambrian.

Discussion. The factual material on the stratigraphy of the boundary between the Lower and Middle Cambrian on the Siberian Platform shows much controversy in:

1. Determination of the position of the *Anabaraspis* Zone (whether it should be put in the Middle Cambrian or left in the Lower Cambrian). Russian specialists officially accepted the boundary at the base of the *Schistocephalus antiquus* Zone within the uniform Elanskoe Formation in the stratotype on the Lena River, near Elanskoe Village.

2. Correlation of sections of three different structure-facies regions based on trilobite zonal scales only.

This controversy is due to the fact that all stratigraphic conclusions were based solely on study of trilobite complexes without regard for the features of sedimentation. As mentioned above, only a few publications have noted that trilobites were found among bioherms [30, 32, 35], though such structures were widespread on the Siberian Platform at the Lower–Middle Cambrian boundary and trilobite complexes possessed the features characteristic of the species adapted to such mode of existence. In some sections, e.g., in the middle reaches of Lena River, near Elanka Village, as well as in the lower reaches of Lena River, in the Khos-Nelege Creek section, combined trilobite taxa characteristic of the lower Middle Cambrian are found beginning with the Toyonian Stage. These are representatives of the families Oryctocephalidae, Agraulidae, Solenopleuridae, and Alokistokaridae. However, organic reefs were absent from the east of the Siberian Platform, and trilobites had to adapt to comparatively deep-water environment, which was responsible for the specificity of the complexes successively replacing each other. Condensed deposition has also introduced certain specific features. For example, in the middle reaches of the Olenek River, the Kuonamka Formation is merely 7 m thick; therefore, trilobite zones recognized here are several centimeters in thickness. Despite the fact that there are no visual marks of washout in the section, the *Bergeroniellus micmacciformis* Zone characteristic of the lower Bottomian Stage of the Anabar-Sinyaya facies region is omitted. The creation of similar stratigraphic scales based on brachiopods, hyolithids, and other fossils will provide an additional stratigraphic trilobite-based characteristics of the Middle Cambrian. The Lower–Middle Cambrian sediments were deposited in the middle of the transgressive cycle, and this period is considered the time of integration of basins and their deepening caused by a change of sea level. These events also had an effect on fauna changes [36]. It is well known that the greatest diversity of organisms producing archaeocyathid-algal bioherms on the Siberian Platform occurred during Atdabanian–Botomian time, but subsequent changes in the Late Botomian environment (deepening first of all) irreversibly lowered their populations. Calcareous algae succeeded in adapting to more severe conditions, whereas archaeocyathids entered a critical phase. For trilobites (with the exception of early

olenellids and redlichiids) the time of acme came. The processes that occurred at the Lower–Middle Cambrian boundary were recorded worldwide and are known as "Hawke Bay event" [37]. The Siberian sections are just those which can become a key for study of changes of environmental conditions owing to the fact that the boundary rocks formed under two different depositional conditions: in upper parts of the shelf, where reef buildups were widespread, and in deeper parts of the shelf, where black shales deposited. From the above it is quite obvious that study of the specific features of development of the Siberian Platform at the Lower–Middle Cambrian boundary is of great interest because this provides a key for better understanding of the subsequent events, which were responsible for the further development of the organic world on the Earth, while the Middle Cambrian epoch has received little study and lags behind that of both the Early and the Late Cambrian.

CONCLUSIONS

The Siberian Platform is the most promising region for drawing the Precambrian–Cambrian and Lower–Middle Cambrian boundaries. The stratotypes for these boundaries are within a stratotype region of the system itself, which is of major importance. The territory of the Siberian Platform and the adjacent areas are an ideal place for further study of the whole Cambrian System.

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