The Vendian System of Siberia and a standard stratigraphic scale

V. V. KHOMENTOVSKY

Institute for Geology and Geophysics, U.S.S.R. Academy of Sciences, Siberian Branch, Novosibirsk, U.S.S.R.

(*Received* 1 April 1985; *revised version received* 14 November 1985; *accepted* 3 January 1986)

Abstract – In Siberia Vendian is equated with a Yudoma Complex or Yudomian. Yudomian deposits of the Siberian Platform and adjacent geosynclines differ greatly in facies and thickness. According to the composition and structure of Yudomian deposits, four facies provinces may be recognized on the platform. Local stratigraphic charts for each province are presented and their correlation and possibility to subdivide the Vendian System in Siberia into three horizons or stages are substantiated. The upper stage (Nemakit–Daldyn), on the basis of palaeontological evidence, is in its turn subdivided into two zones: *Anabarites trisulcatus* and *Purella antiqua.*

The most important Early Baikalian rearrangement is proved to take place around 800 ± 50 Ma. The pre-Vendian (Late Baikalian) movements, though less intensive, make the determination of the Yudomian lower boundary easier.

The specific character of Vendian biostratigraphy is discussed involving all groups of the organic remains, that causes the necessity of recognition, subdivision and correlation on the basis of the whole complex of data.

The boundary between the Vendian System and the Lower Cambrian Tommotian Stage (in type section) is proved to conform to the base of the Pestrozvet Formation, which divides the *A. sunnaginicus* and *P. antiqua* zones.

1. Introduction

In Siberia Vendian is equated with a regional stratigraphic unit, namely, the Yudoma complex or Yudomian. It is confirmed by the abundance of Ediacaran fauna, and a considerable rearrangement of the basement which took place some 660–670 Ma ago (Khomentovsky, 1974, 1976).

Though Yudomian is a junior synonym of Vendian one should use it in Siberia because of its peculiarity. Unlike the Vendian of the type locality, there is no tillite at the base of the Yudomian, and it is dominated by carbonate rocks. The Yudomian deposits contain microfossil and phytolite assemblages known in Europe from different stratigraphic levels.

2. Facies provinces

Yudomian deposits are very common in Siberia. In geosynclinal areas they form thick strata variable in composition. By contrast, the Siberian Platform is almost entirely covered by rather uniform, mainly dolomite Yudomian deposits whose thickness varies from 250 to 500 m. Only in axial zones of the Riphean aulacogen-like troughs, easily discernible along the southern and western margin of the Siberian Platform, does the thickness of the Yudomian markedly increase. Terrigenous rocks come to dominate the lower horizons, and locally extensive hiatuses are observed. All this enables four facies provinces for the Yudomian of the Siberian Platform to be recognized; they are the Yudoma–Anabar, Baikal–Patom, Yenisey–Prisayan and Interior provinces (Fig. 1). In the latter the Yudomian deposits were drilled in and therefore their correlation is mainly based on log sections.

2.a. Yudoma–Anabar province

The Yudoma–Anabar facies province is marked by rhythms, containing thin terrigenous basal units and dominated by dolomite. Two rhythms are developed in the east near the Sea of Okhotsk (Fig. 2, 3). The lower one as a rule wedges out on palaeouplifts (Khomentovsky, 1976, 1984*a*). To the north, two similar rhythms can be recognized (members of the Starorecheskaya Formation); however the upper rhythm of southern sections is divided in turn by an erosion surface and a basal unit into two parts (Fig. 4a, b). The upper part (Manykay Formation) is marked by the appearance of skeletal fossils (Khomentovsky *et al.* 1982). To the south, dolomite of the upper part of the second rhythm in places grades into limestone which yields the oldest skeletal fossils (Khomentovsky *et al.* 1972; Starnikov, Sukhorukov & Yakshin, 1983). This evidence enables three regional horizons within the Yudoma–Anabar facies province to be recognized. The two lower horizons (Yukanda and Sakhara) are recognized mainly on the basis of lithostratigraphical data while the third (Nemakit–Daldyn) horizon is substantiated by palaeontological data as well (Khomentovsky, 1984*a*). The Yudomian is disconformably overlain by true Cambrian variegated deposits. The erosion was caused by a transgression due to eustatic changes in the sea level. As a rule it

Geological Magazine, Vol. 123, no. 4, July 1986, pp. 333–474.

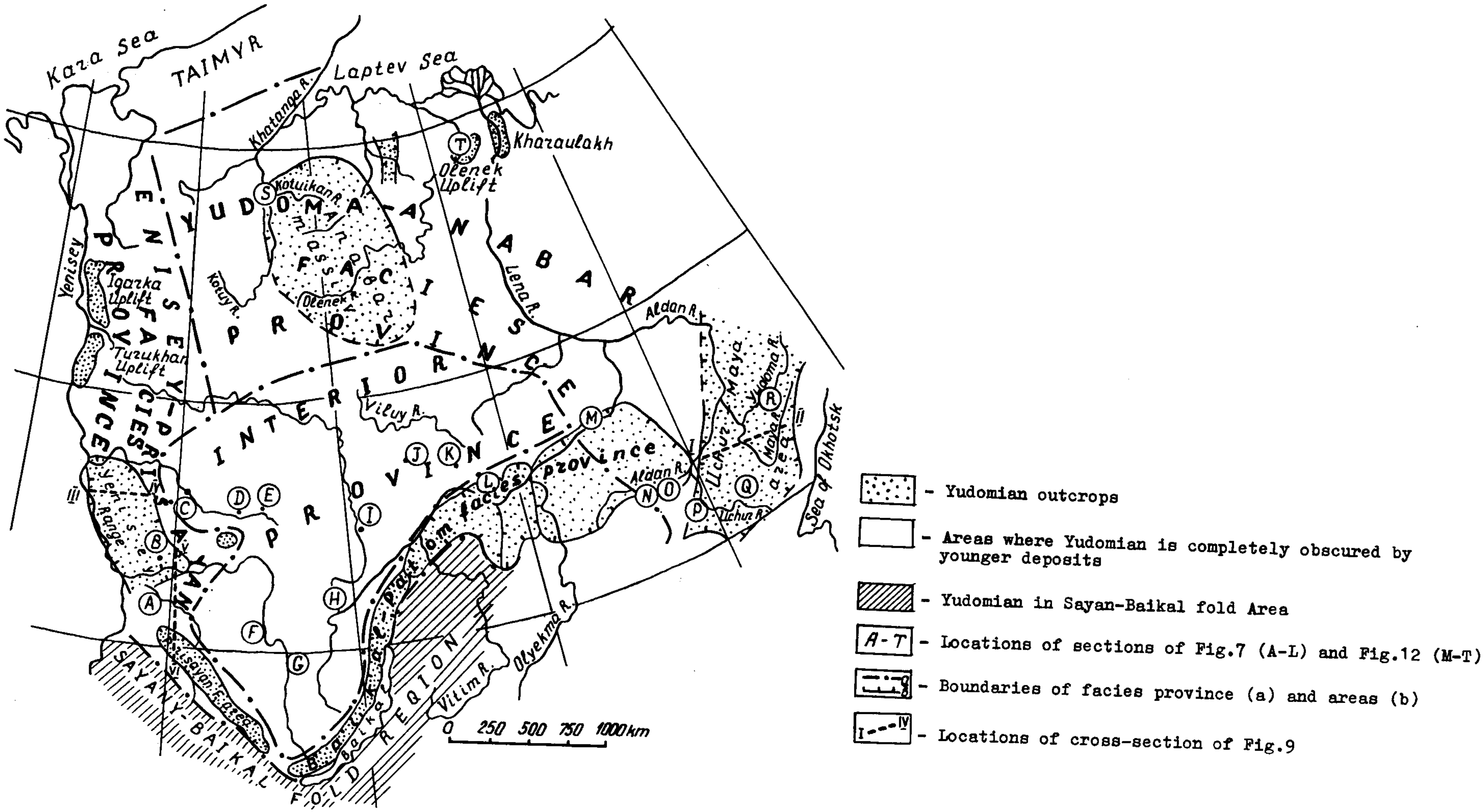


Figure 1. Distribution of Vendian deposits in Siberia.

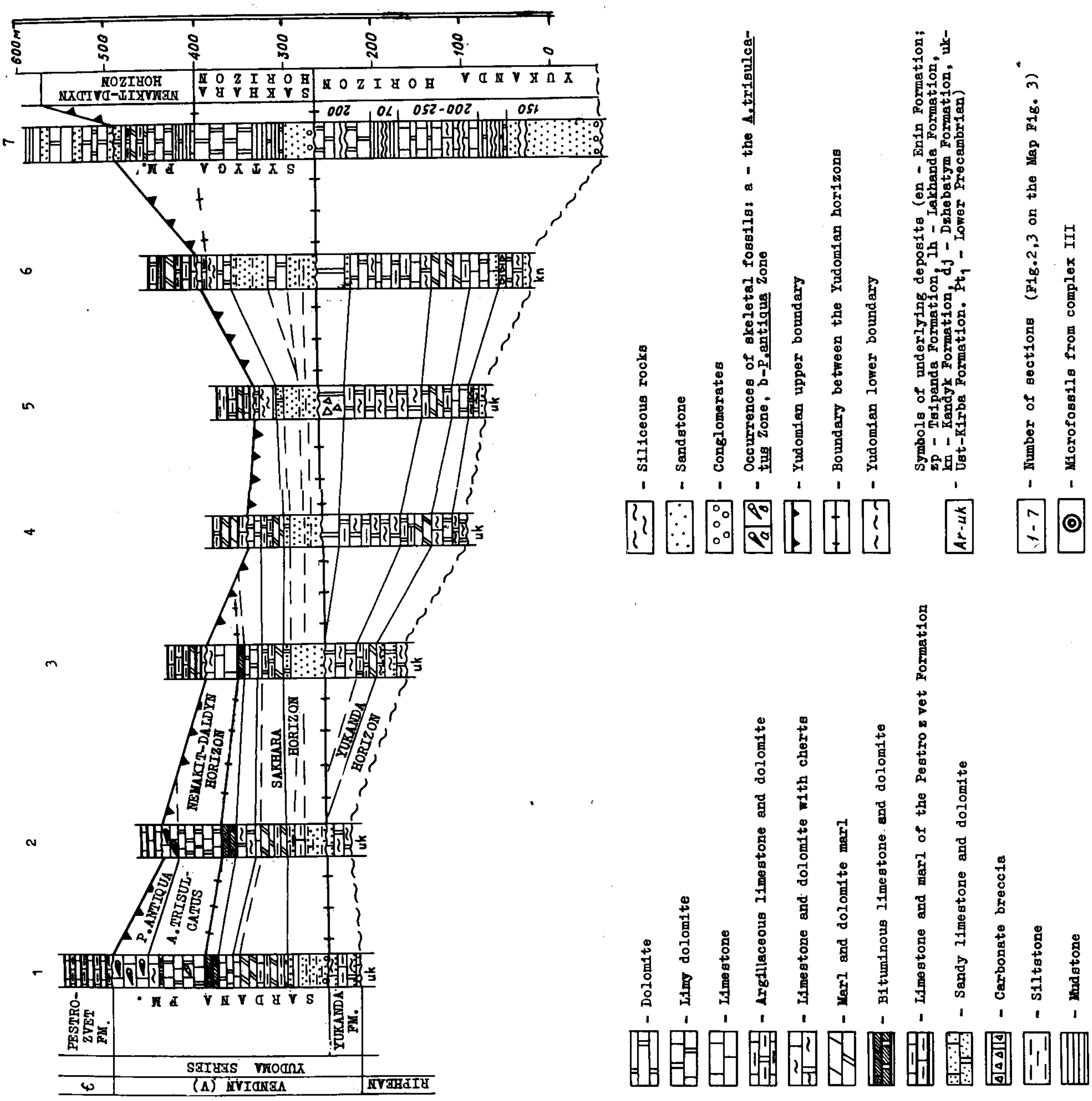


Figure. 2. Correlation of the Yudoma series sections in the Allakh-Yun' River basin.

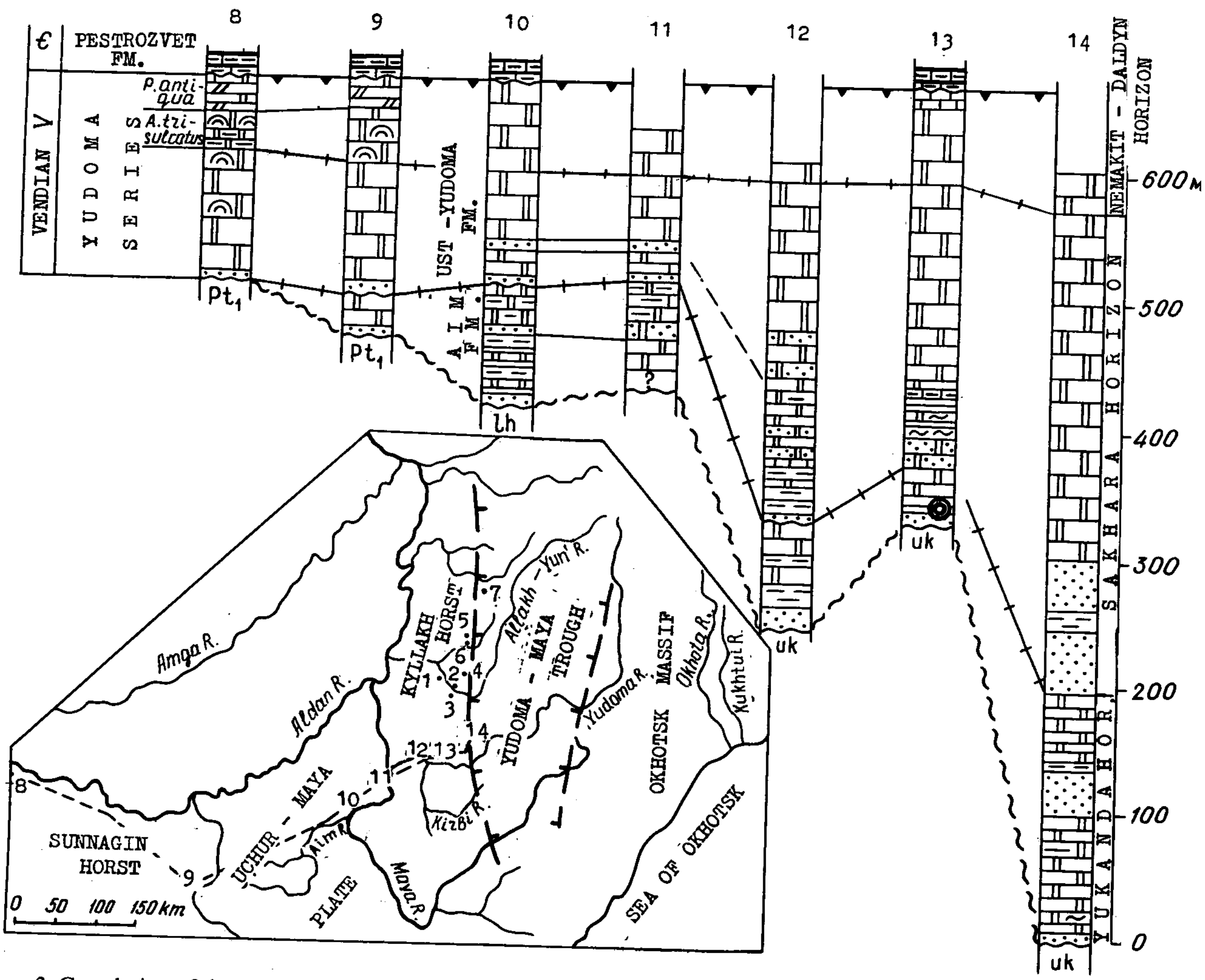


Figure 3. Correlation of the Yudoma series sections of southern Uchur–Maya area. For key see Figure 2. Map shows locations of sections from Figures 2 and 3.

is not deep, but on isolated palaeouplifts the depth sharply increase (Fig. 2).

2.b. Baikal–Patom province

The Baikal–Patom facies province also contains three rhythms, of which the lower one and often the middle one are dominated by terrigenous rocks (Fig. 5). The upper rhythm except for a thin basal unit is composed of carbonate rocks. Pogonofors, vendotaenids and the first calcareous algae were found there. These rhythms enable (in ascending order) the Lower and Upper Ushakovka and Irkutsk horizons to be recognized (Khomentovsky, 1984*a*).

2.c. Yenisey–Prisayan province

In the Yenisey–Prisayan facies province the Yudoman Complex is represented by a single rhythmic Ostrov horizon (Fig. 6), which structurally and palaeontologically (with *Cyclomedusa* ex gr. *davidi*, and Yudomian phytolites) resembles the upper sedimentary rhythm of the Yudoman Series. Therefore, in the type locality it may be equivalent to the Sakhara and Nemakit–Daldyn horizons (Khomentovsky, 1984*a*).

2.d. Interior province

In the Interior province of the Siberian Platform the Yudomian deposits show features in common with key sections of adjacent facies areas (Fig. 7). Three rhythmic horizons can be recognized there. In ascending order they are: the Bochugunor, Tira, and Danilov horizons (Khomentovsky, 1984*a*).

Therefore, the Vendian deposits of the Siberian Platform may be tentatively considered as having a tri-partite structure (Fig. 8).

3. Tectonic events

The termination of Siberian Platform formation is often attributed to Baikalian folding, resulting in separation of the Baikalian Riphean Complex from that of the Yudomian or Vendian. However in Siberia the most important tectonic events took place around 800–850 Ma, prior to the deposition of the Baikalian Complex (Fig. 9). These early Baikalian events account for granite intrusion, intense blocky movements, extensive non-deposition (in the north) or, in contrast, the regeneration of ancient palaeostructures in the southwest (Khomentovsky, 1976, 1984*b*). Erosion, local unconformities, intrusion of stocks, basic and alkaline sills as well as absence of Lower Yudomian horizons from the section are attributed to pre-Yudomian or Late Baikalian rearrangement. Most of these manifestations were caused by the Early Baikalian events and marked only by the base of the transgressive Yudomian succession. In general the pre-Yudomian rearrangement has resulted in disappearance of Riphean aulacogens and formation of the platform's Yudomian sedimentary cover (Khomentovsky, 1974).

Neither Early nor Late Baikalian movements have much in common with terminal Phanerozoic foldings.

In areas affected by the strong Early Baikalian and the weaker Late Baikalian folding it is difficult to distinguish between the Baikalian and Yudomian complexes. The problem has not been finally solved even for the western Siberian Platform and remains debatable as concerns its geosynclinal framework. The units earlier considered as Yudomian sometimes contain Baikalian deposits as well. The recognition of the equivalents of the Baikalian and Vendian complexes in other key sections of the world also poses a problem. Therefore, attempts were made to recognize a division including both complexes. Judging from isotopic dating, the Sinian System of China, and Windermere in the U.S.A. provide such an example. The recognition is complicated by the occurrence of tillites at the base of these divisions like the Vendian in the type section. If palaeontological criteria should be used for distinguishing standard stratigraphic units it would not be reasonable to consider the Sinian System as unit of a standard scale (Khomentovsky, 1984*a*).

4. Palaeontological divisions

The recognition of some Riphean phytems (Precambrian System) is based mainly on phytolites, but this is not the case for the Vendian system. The Yudomian of Siberia also was first recognized by means of Yudomian phytolites (Zhuravleva & Komar, 1962). However now it is quite obvious that many Yudomian microphytolites* even on the platform (Yenisey Range, Kharaulakh) appear in the Riphean. On the Russian Platform and in the Urals their Yudomian assemblage dominate the Riphean deposits (Khomentovsky, 1976). Therefore, apart from the Vendian it would be erroneous to place the oldest Kudash into the Yudomian (Keller & Kratz, 1979).

By contrast, in the East Sayan region the Yudomian and older Kalanchevian microphytolite assemblages are very common also in the Cambrian (Terleev, 1981), so that great care must be taken in using microphytolite assemblages for the recognition and correlation of the Vendian. A poor Yudomian stromatolite assemblage† has more stratigraphic value (Semikhatov, Komar & Serebryakov, 1970; Shenfil, 1975) but contains some older forms (diverse *Linella* and others).

Microfossil assemblage III (Volkova *et al.* 1980) occurs throughout the Yudomian succession on the Siberian Platform (Khomentovsky, Didenko & Pyatiletov, 1982; Fig. 10); it is very similar to that of the Lontova assemblage (Fig. 11) of Europe (Khomentovsky & Pyatiletov, 1978). Locally, at the level of the Ukanda horizon it is replaced by assemblage II similar to that of the Kotlin–Rovno successions of Europe (Figs 10,11). In some successions of the Interior province, assemblage III yields forms (*Baltisphaeridium*, *Leiovalia* and others) typical of the Lyukati horizon (Fig 11). In Europe the Lyukati and Lontova assemblages point to the true Cambrian. It leads some authors to consider Yudomian strata to be younger than Vendian. This would be impossible if the Cambrian lower boundary stratotype were proposed in much younger deposits in Siberia (Khomentovsky, 1984*a*).

In the Pribaikal area assemblage III appears in the upper Riphean Kachergat Formation, in the Prisayan area at Irkutsk it was found only in the Ryphean Olkha Formation; and in the Transbaikal area, in the Kholodnaya Formation of the same age. Therefore microfossils cannot be implicitly used for subdivision and distant correlation of the Vendian (Khomentovsky, 1984*a*).

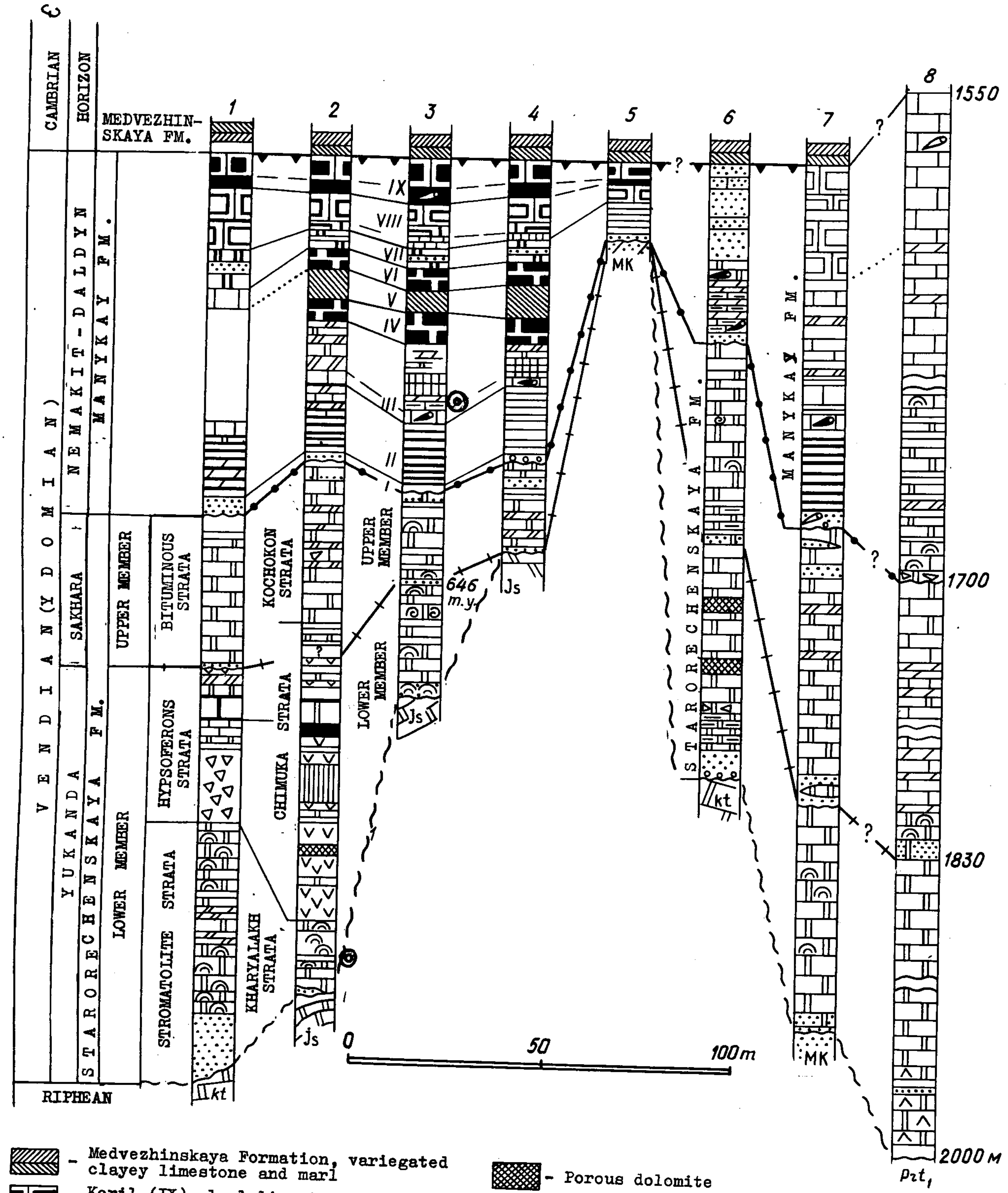
Five or six occurrences of the Ediacaran fauna‡ were reported from Siberia (Sokolov, 1972, 1975; Khomentovsky, 1976), mainly middle Yudomian. This fauna is indicative of the age and hence allows a detailed correlation with the type Vendian.

In so far as the recognition, subdivision and correlation of the Vendian is based mainly on metazoan evolution it contrasts with the Riphean

* Characteristic Yudomian microphytolites of the Siberian Platform are: *Vesicularites bothrydioformis* (Krasnop.), *Vermiculites tortuosus* Reitl., *Nubecularites abustus* Z. Zhur., *N. antis* Z. Zhur., *N. parvus* Z. Zhur., *Vesicularites lobatus* Reitl., *V. concretus* Z. Zhur., *V. reticulatus* Nar., *Vermiculites irregularis* (Reitl.), *O. corticosa* Nar., *Glebosites ninae* Korol., *Medularites ovatus* Nar. *M. lineolatus* Nar., diverse *Volvatella* and others.

† Interregional forms of the Yudomian stromatolite assemblage: *Boxonia grumulosa* Kom., B. allahjunica Kom. et Semikh., *Paniscollenia emergens* Kom., *Colleniella singularis* Kom.

‡ Ediacaran fauna from the Yudomian assemblage of Siberia: *Glaessnerina sibirica* (Sok.), the Olenek Uplift; *Pteridinium* sp., *Baicalina sessilis* Sok., Pribaikal area; *Cyclomedusa* ex gr. *davidi* Sprogg., the Yenisey Range; *Ovatoscutum* aff. *concentricum* Glaessner et Wade, V. Sayan; *Suvorovella aldanica* Val. et Masl., *Majaella verhoijanica* Vol. et Masl., Uchur–Maya area. In 1981 B. S. Sokolov and M. L. Fedonkin contributed greatly to the list of the Ediacaran fauna of the Olenek Uplift.



- Medvezhinskaya Formation, variegated clayey limestone and marl
- a – Koril (IX), algal limestone with a basal clayey limestone unit (a)
- a – Sub-Koril (VIII) algal limestone unit with laminated limestone at the base (a)
- Unit VII (dolomite and gritstone)
- Limestone units (IV and VI)
- Platy clayey dolomite unit V
- Limestone unit III with Anabarites at the base
- Porous dolomite
- Siltstone and mudstone
- Gypsum
- Breccia
- Stromatolite bioherms
- Microphytolites
- Microfossils of complex III

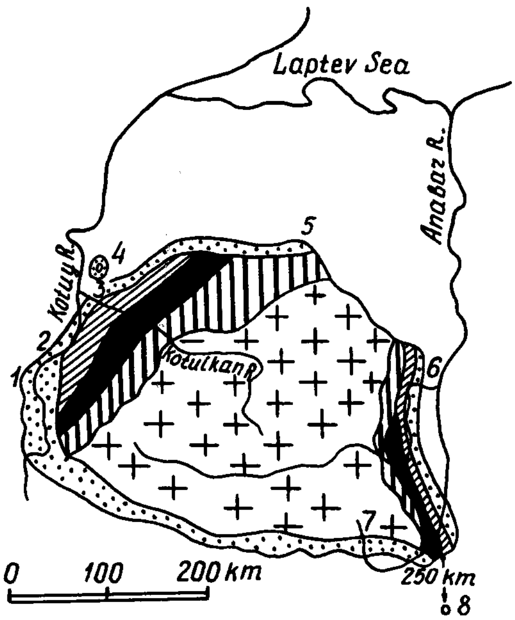
- Variegated siltstone unit II
- Massive dolomite and limestone
- Black platy dolomite
- Greenish-grey argillaceous dolomite and marl
- Limestone
- Marl
- Dolomite
- Dolomite marl
- Clayey limestone and dolomite
- Sandstone

- Skeletal fauna: a - A.trisulcatus b - P. antiqua Zone
- 1-8 - Numbers of sections, see locality map Fig.4b
- I-IX - Numbers of units of the Manykai Formation
- Lower boundary of Cambrian
- Lower boundary of Nemakit-Daldyn
- Lower boundary of Sakhara horizon
- Lower boundary of Vendian

Symbols of underlying deposits

- Kt-Mk - Kt - Kotuy Formation, us - Yusmastakh Formation, mk - Mukun Formation, Prt_1 - Lower Pre-Cambrian

Figure 4a. Correlation of the Yudomian sections of the Anabar Massif.



- Yudomian complex
- Riphean: Yusmastakh Formation
- Riphean: Kotuikan Formation
- Riphean: Mukun Formation
- Early Pre-Cambrian
- 1-8 - Localities of sections Fig.4a

Figure 4b. Distribution of the Precambrian deposits of the Anabar Massif.

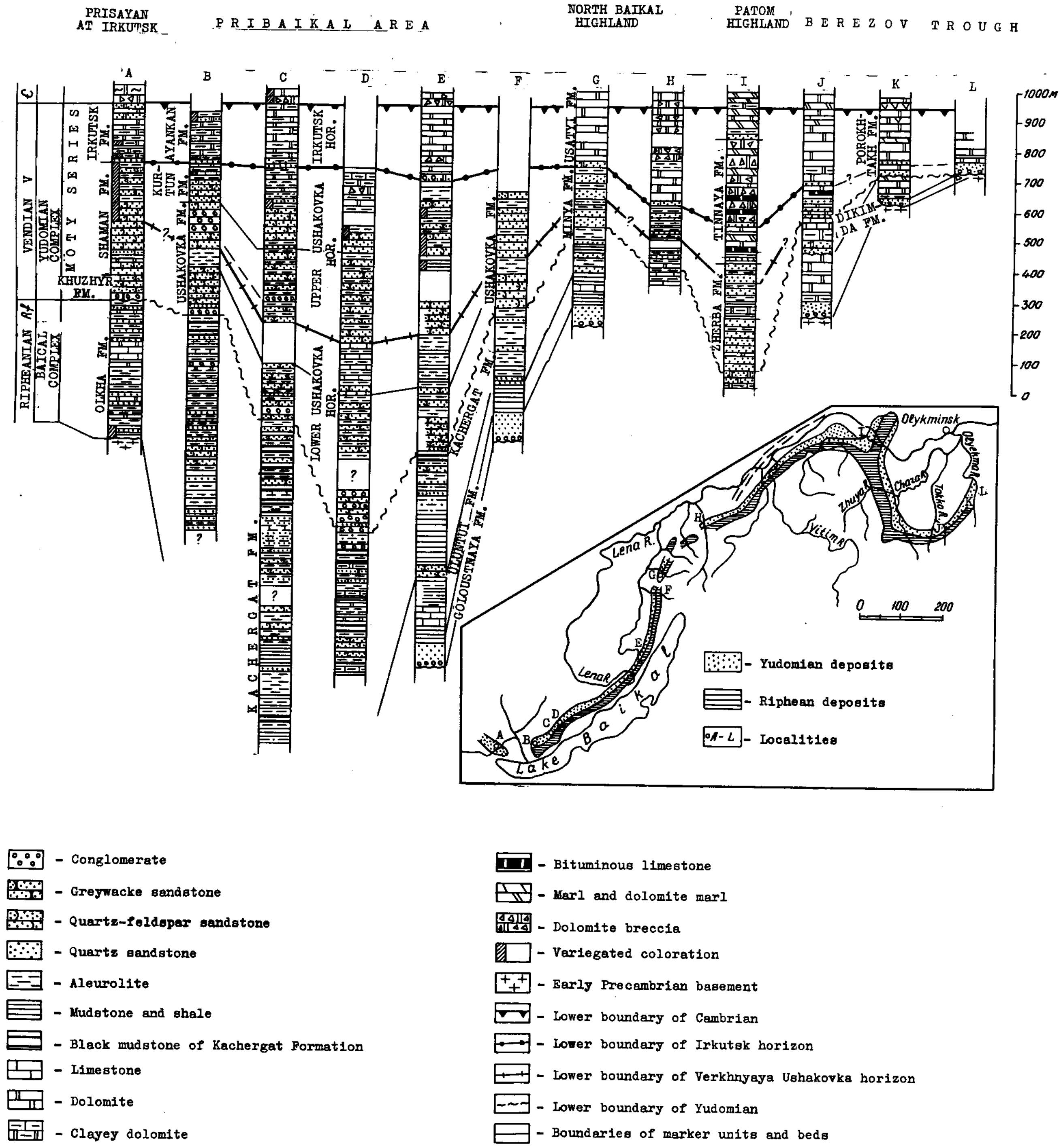


Figure 5. Correlation of Yudomian sections of the Baikal-Patom facies province.

phytems, and some consider it as the first Precambrian system of the Palaeozoic (Khomentovsky, 1974, 1976). On this basis it would be unreasonable to place the Vendian and Baikalian complexes into a single stratigraphic unit of a standard scale.

Medusoids and older microfossil and microphytolite assemblages survive in the Nemakit–Daldyn horizon. The ichnofauna changes at the base of the horizon and skeletal fossils appear in the oldest beds. The maximum thickness is 60–70 m and even 100 m when the pre-Pestrozvet erosion is allowed for. Two or three skeletal fossil associations of different age can be recognized within the Nemakit–Daldyn horizon (for distribution see Fig. 12) (Khomentovsky, 1976, 1984*a*). The oldest one is known as the *A. trisulcatus* Zone (Savitsky, 1975). Anabaritids are very common here. Apart from the zonal form they contain four–five species of the genus *Anabarites*, divers angustiocreids,

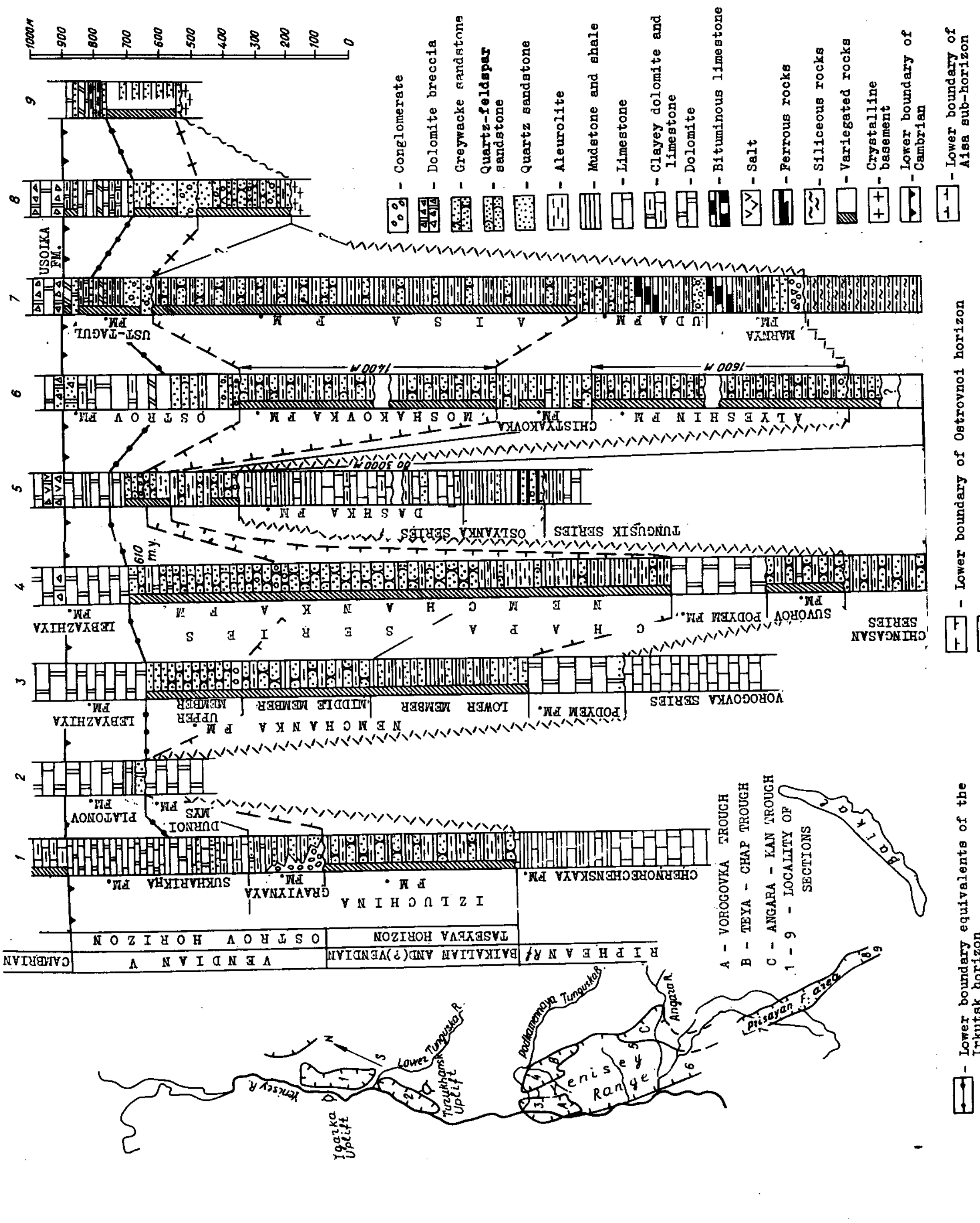


Figure 6. Correlation of Yudomian and Baikalian sections of Yenisey-Prisayan province.

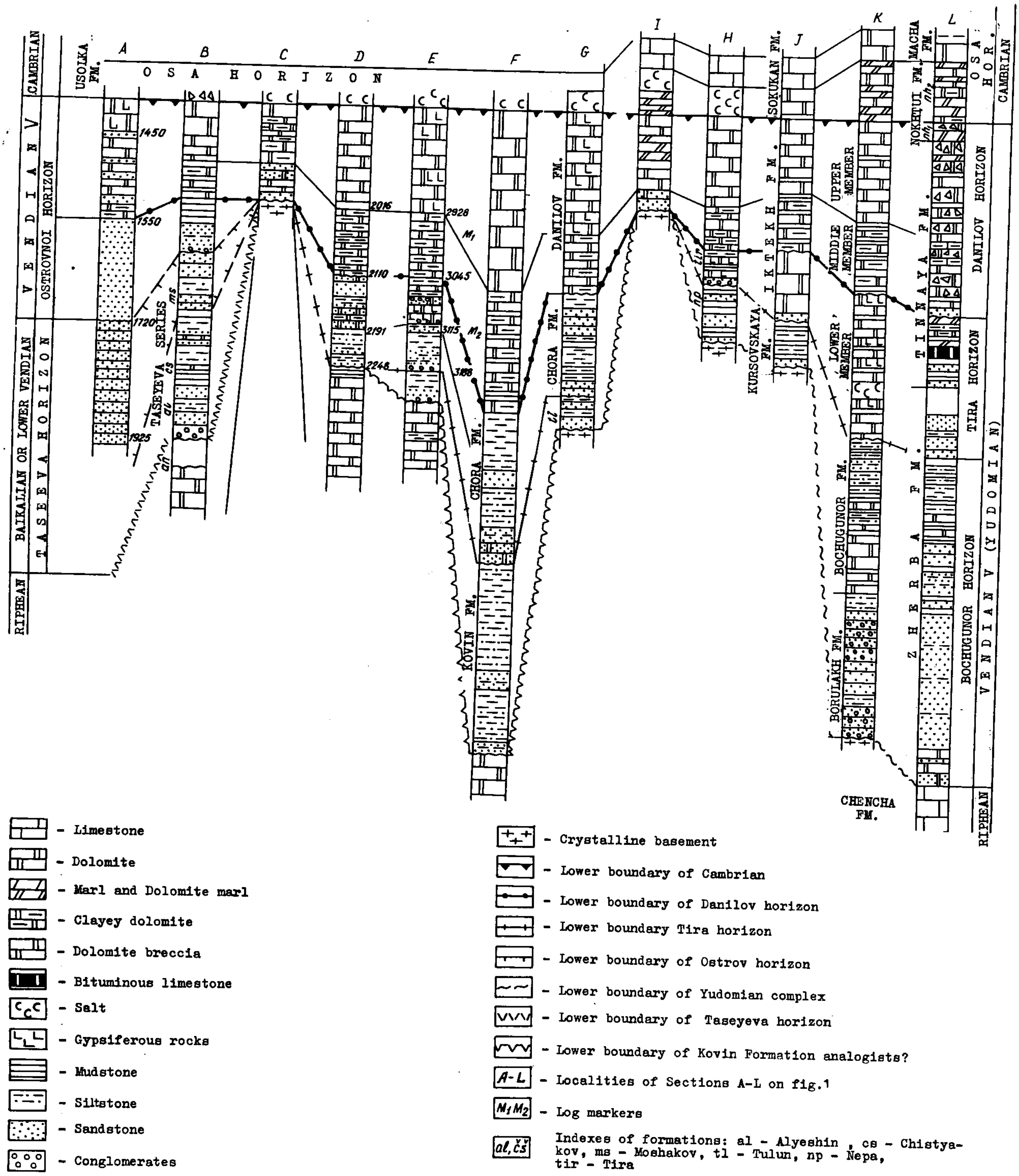


Figure 7. Correlation of Yudomian and Baikalian sections of the interior parts of the Siberian platform.

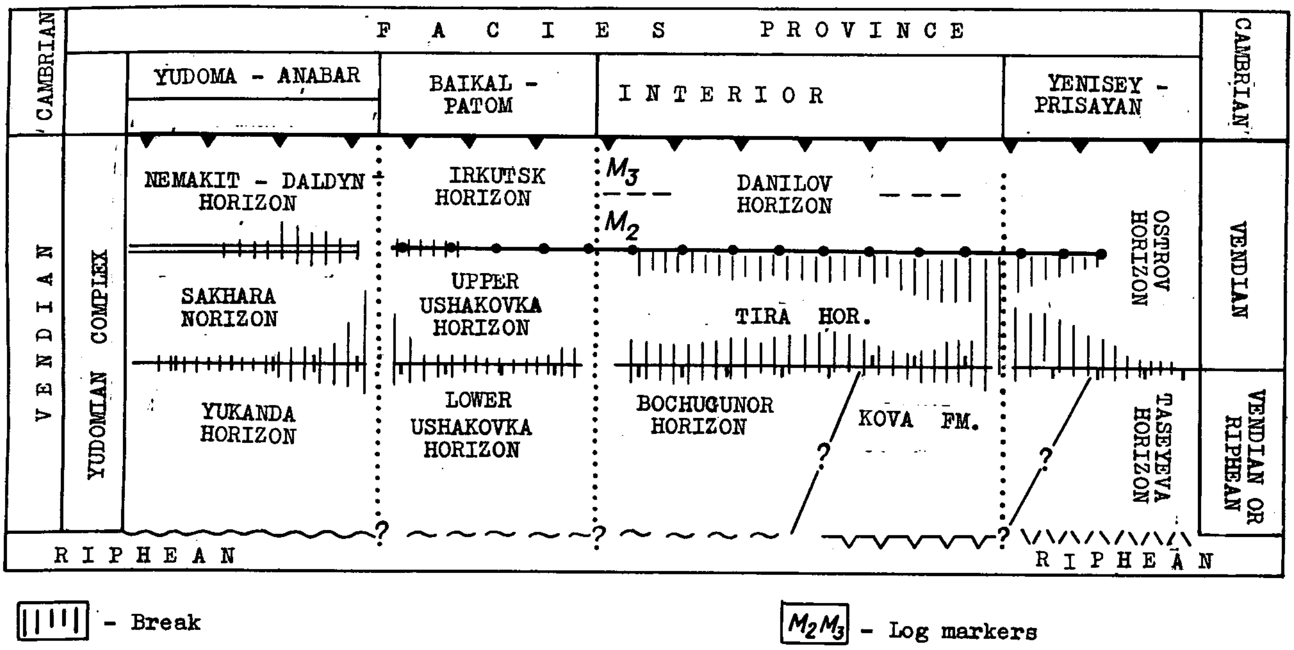


Figure 8. General correlation chart for the Yudomian of the Siberian platform.

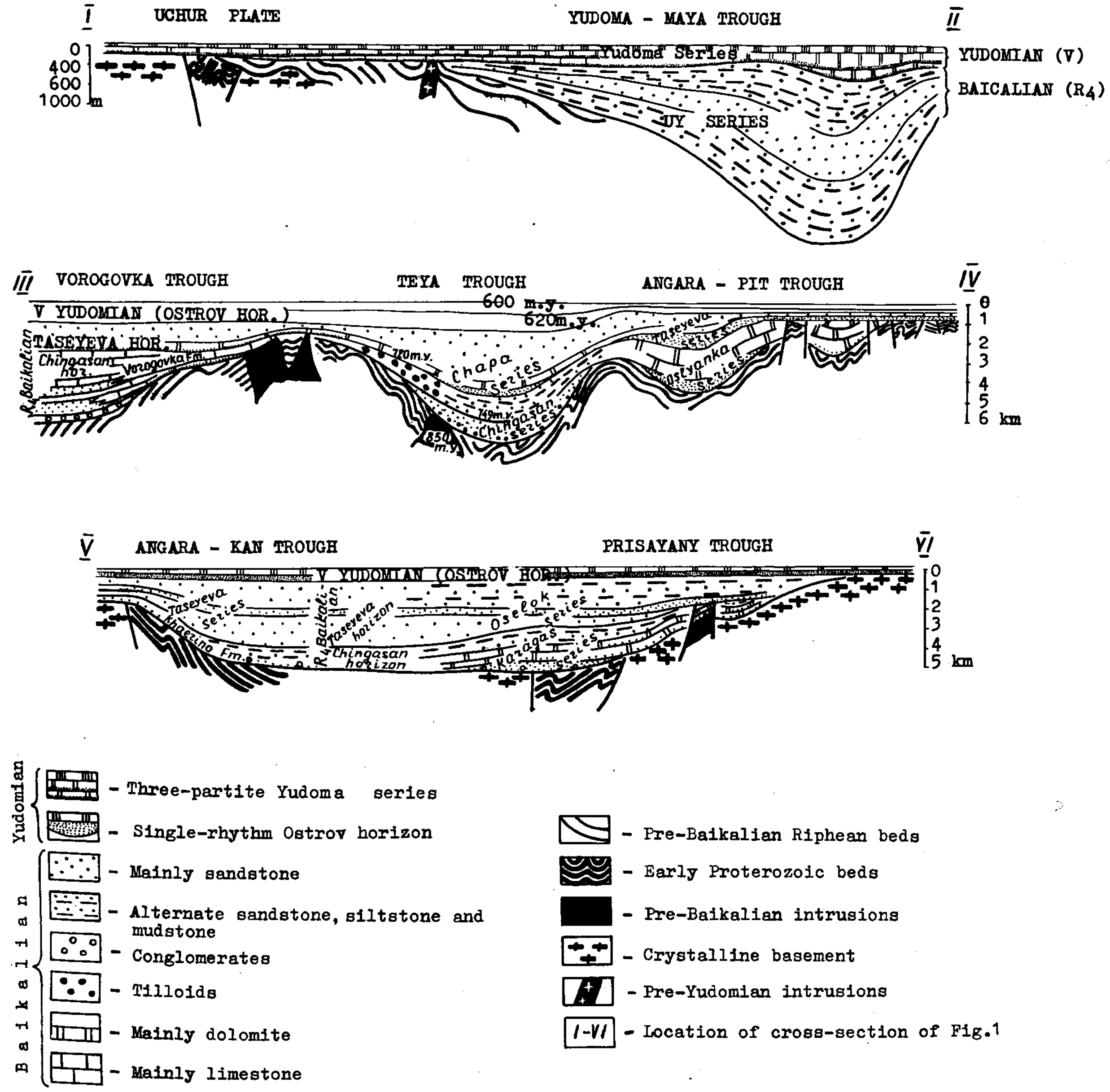


Figure 9. Cross-sections showing the relationship between Prebaikalian, Baikalian and Yudomian palaeostructures. Locations of sections shown on Figure 1.

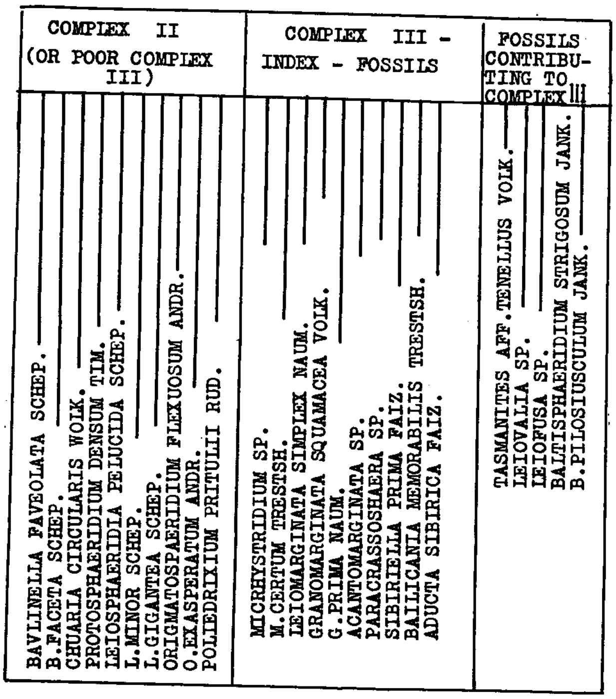


Figure 10. Vendian microfossil assemblages of Siberia.

first *Tiksitheca*, as well as first hyolithelmints (*Hyolithellus*, *Hyolithes* ex *Circothecidae*), problematics (*Cambritubulus decurvatus* Miss., *Protohertzina anabarica* Miss., Hertzina sp., *Chancelloria* sp.). The *A. trisulcatus* Zone yields rare *Sabellidites* and even *S. cambriensis* Jan. (Fig. 12).

We propose the name *Purella antiqua* (Ab.) for the upper zone (Khomentovsky *et al.* 1983) owing to the wide occurrence of this form. Apart from the sonal form, molluscs are represented by *Purella cristata* Miss., *Bemella* sp., *Igorella* sp., *Barskovia* sp., *Phyloxenella* sp., *Aldanella plana* Vost., *Latouchella korobkovi* (Vost.). *Hyolithes* become very diverse: *Spinulitheca* sp., *Turcutheca* sp., *Conotheca* sp., *Ladatheca annae* (Sys.); hyolithelmints: *Hyolithellus vladimirovae* Miss., *H. tenuis* Miss., *H. tschuscunensis* Val., *Fomitchella infundibuliformis* Miss., *Torellella* sp.; problematics: *Tiksitheca licis* Miss., *Markuellia prima* Val., *Sachites* sp., *Aldanolina magna* Pelm. (Fig. 12).

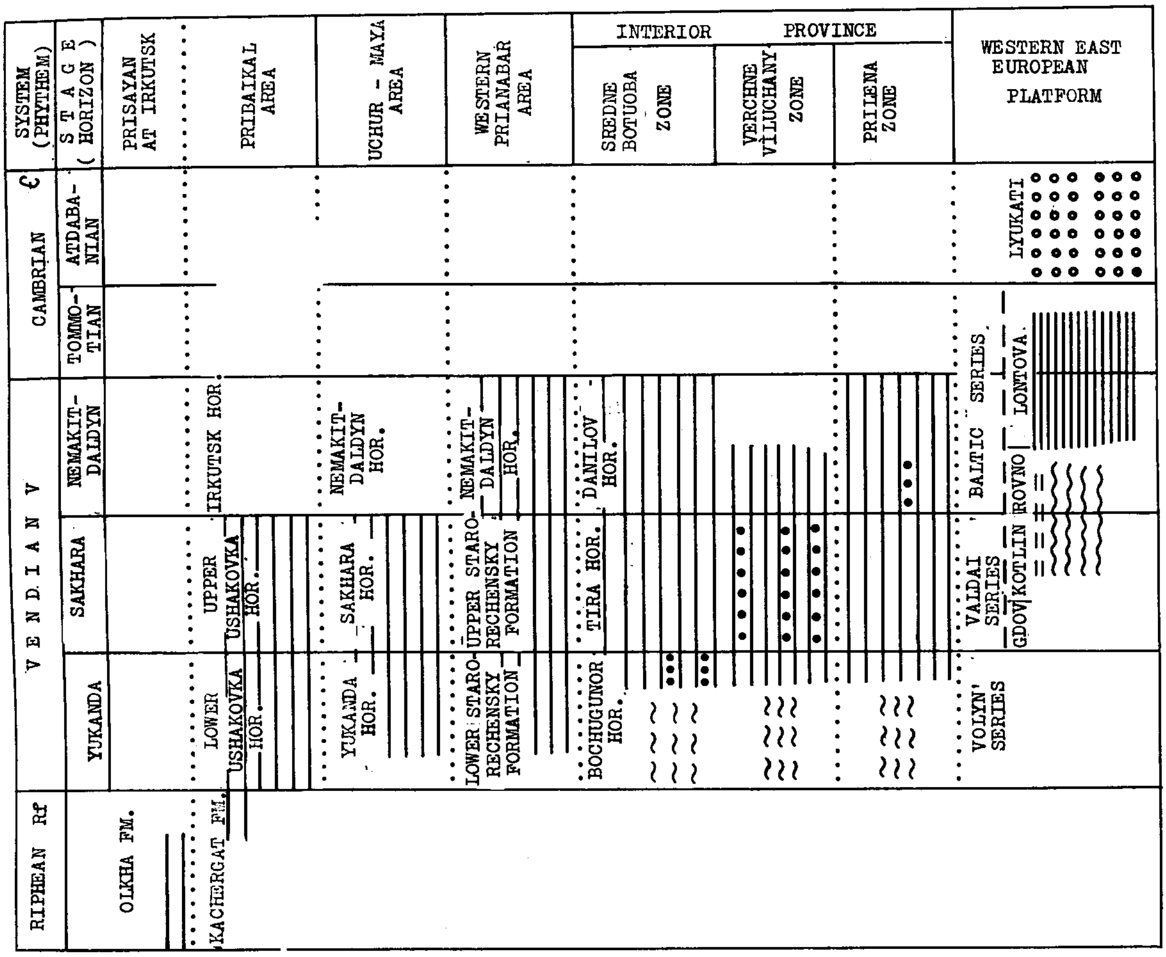
The abundance of diverse small forms made some authors place the *P. antiqua* Zone into the *A. sunnaginicus* Zone of the Tommotian Stage. However Figure 13 shows that even when based on small skeletal forms the boundary between the *P. antiqua* and *A. sunnaginicus* zones is much more distinct than, for example, the upper boundary of the latter.

The importance of this boundary in the evolution of skeletal fauna is supported by the mass appearance of archaeocyathids, tommorids, brachiopods (Rozanov *et al.* 1969) and probably the first trilobites (Fedorov, Egorova & Savitsky, 1979).

The Vendian–Cambrian boundary might be drawn at the base of the *A. sunnaginicus* Zone if we proceed from the principles accepted for the placement of the Silurian–Devonian boundary. Taking into account the rarity and endemicity of fossils of the *A. trisulcatus* Zone is unlikely that the boundary between the *A. trisulcatus* and *P. antiqua* zones can be universally traced (Khomentovsky, 1976, 1984*a*). The majority of the I.U.G.S. Precambrian–Cambrian Boundary Working Group considers that it is unreasonable to determine the base of the Cambrian System by means of the first occurrence of skeletal fossils (base of the *A. trisulcatus* Zone).

Hence I think that the base of the *A. sunnaginicus* Zone and that of the Tommotian Stage in their first definition is the best candidate for the lower boundary of the Cambrian (Khomentovsky, 1976; Khomentovsky *et al.* 1983; Avdeeva *et al.* 1983). In this case the Nemakit–Daldyn should be considered as a terminal stage of the Vendian system (Khomentovsky, 1974, 1976).

It is noteworthy that the boundary cannot be traced universally even at this stratigraphic level because all the zonal index fossils of the Nemakit–Daldyn and Tommotion stages occur in much younger beds. In this connection the *O. korobkovi–A. plana* Zone presents a severe problem because both index fossils have much wider age range than that in the type section of the eastern Prianabar area (Khomentovsky, 1984*a*). Therefore the fossil assemblage typical of zones of the Nemakit-Daldyn or lower Tommotian stages can be found stratigraphically higher, up to the Atdabanian Stage inclusive. Hence for the present the initial Cambrian boundary in Siberia may be based on both palaeontological and lithostratigraphical data.



— Rovno-Kotlin assemblage of Europe: Leiosphaeridia gigantea (Shep.), L.pelucida (Shep.), L.minor (Shep.), Origmatosphaeridium rubiginosum Andr. and oth.

— Assemblage II of Siberia: Leiosphaeridia gigantea (Schep.), L.pelucida (Schep.), L.minor (Shep.), Origmatosphaeridium rubiginosum (Andr.), Trachysphaeridium bavlensum (Schep.) and oth.

— Lontova assemblage of Europe: Leiomarginata simplex Naum., Granomarginata prima Naum., G.squamacea Volk., Tasmanites tenellus Volk., Micrhystridium tornatum Volk. and abundant Leiosphaeridia

— Assemblage III of Siberia: Leiomarginata simplex Naum., Granomarginata prima Naum., G. squamacea Volk., Tasmanites aff.tenellus Volk., Micrhystridium certum Trestsh., M.tornatum Volk., Aducta sibirica Fajz., Bailikania memorabilis Trestsh., B.faveolata Trestsh., Sibiriella prima Fajz. and abundant Leiosphaeridia

— Lyukati assemblages of Europe: Baltisphaeridium strigosum Jank., B.primarium Jank., B. cillosum Volk., B.cerinum Volk., B.pilosiusculum, Leiovalia sp. and oth.

— Enriched assemblage III of Siberia: Baltisphaeridium strigosum Volk., B.primarium Jank., B.cellosum Volk., B.cerinum Volk., B.pilosiusculum Jank., Leiovalia tenera Kirjan. and other forms of assemblage III

Figure 11. Distribution of microfossil assemblages in the upper Precambrian and early Cambrian of the USSR.

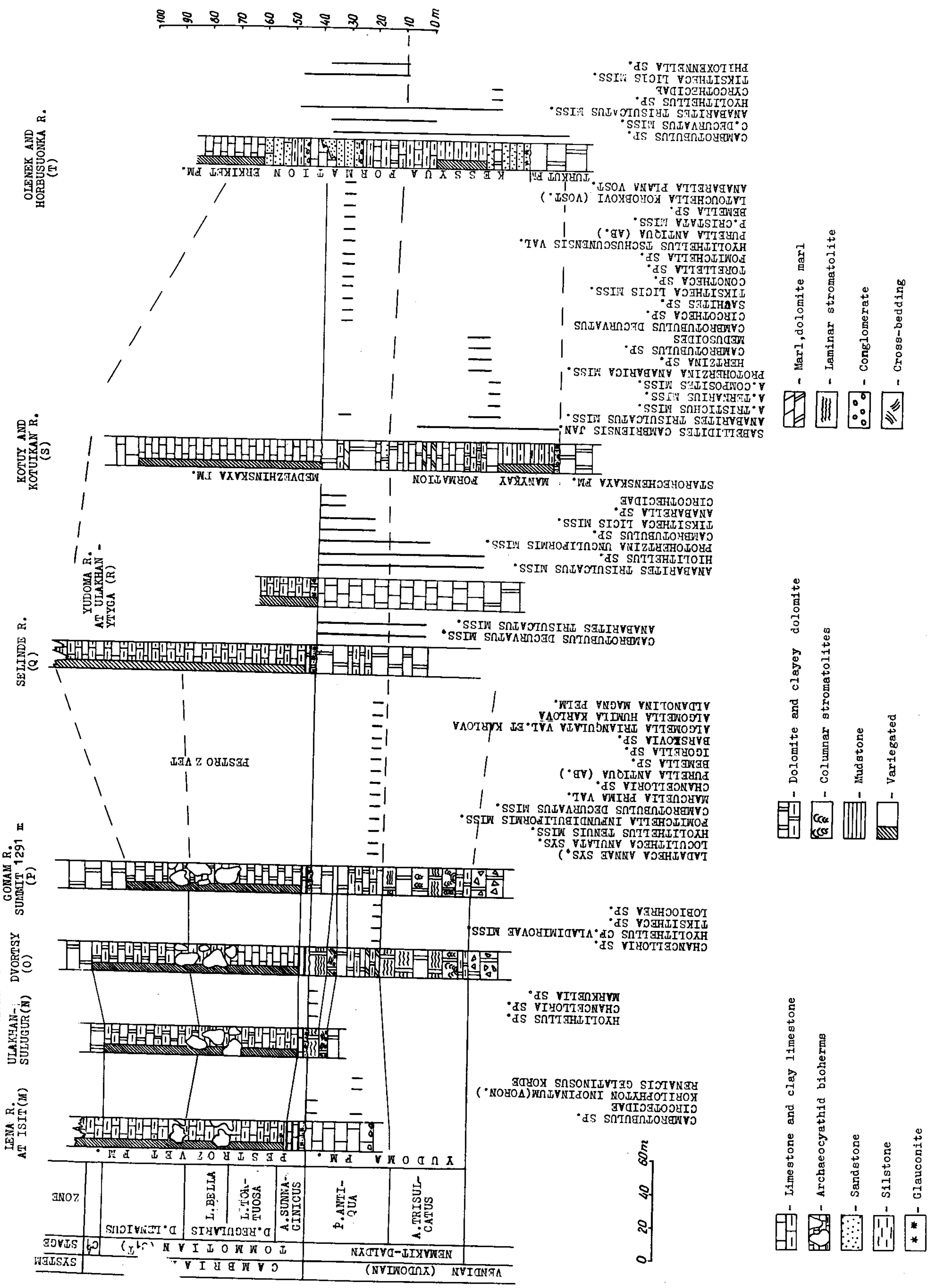


Figure 12. Distribution of first skeletal fossils in Vendian successions of Siberia.

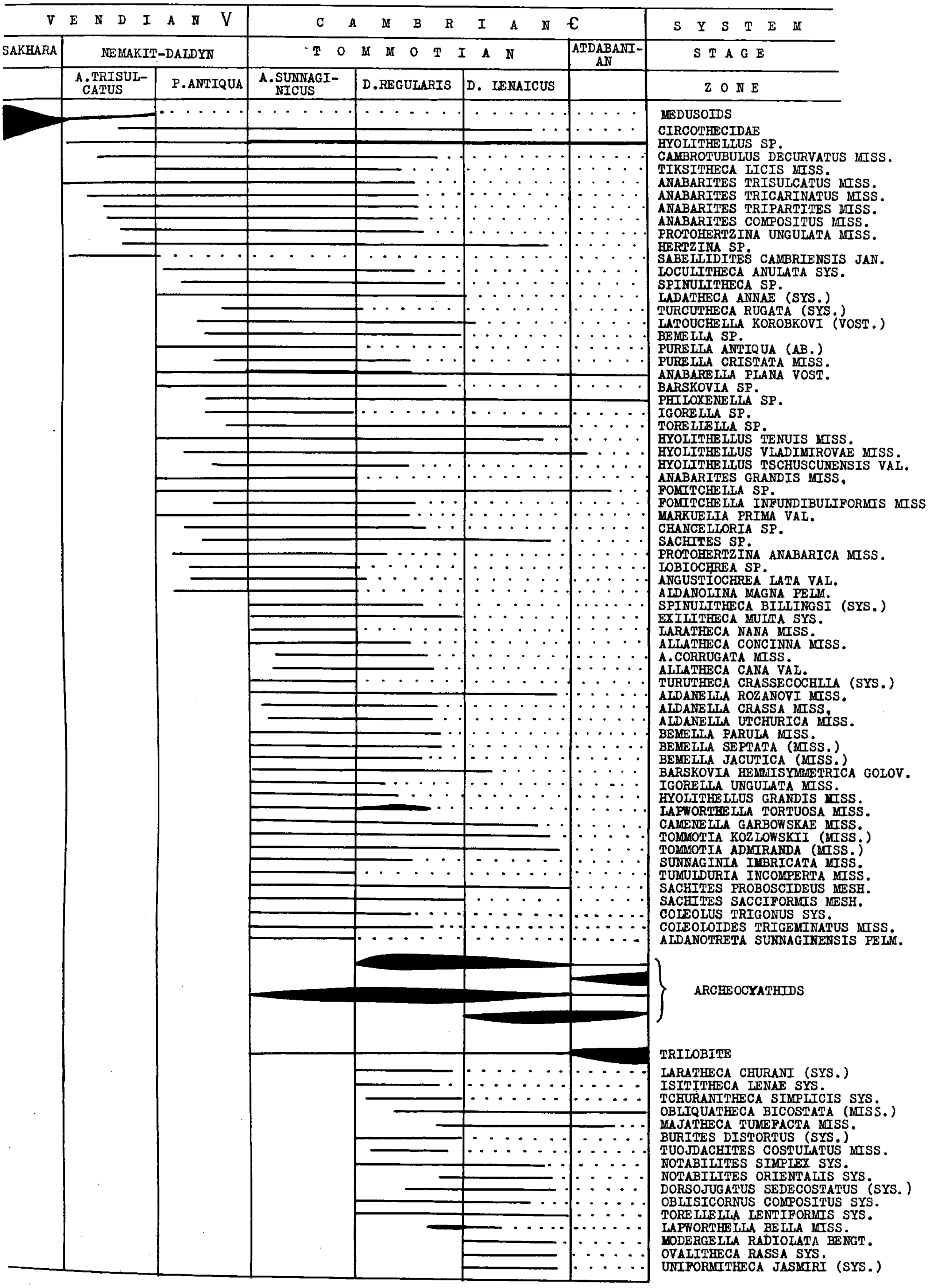


Figure 13. Oldest fossil assemblages of Siberia.

References

AVDEEVA, V. I., VALKOV, A. K., KARLOVA, G. A., MOSKVITIN, I. E., NUZHNOV, S. V., KHOMENTOVSKY, V. V. & YAKSHIN, M. S. 1983. On Cambrian lower boundary stratotype at Ulakhan-Sulugur outcrop of the Aldan River. In *Late Precambrian and Early Palaeozoic of Siberia. Vendian Deposits*, pp. 18–28. Izdanie Instituta geologii i geofisiki, Novosibirsk.

FEDOROV, A. B., EGOROVA, L. I. & SAVITSKY, V. E. 1979. First occurrence of oldest trilobites from the lower part of the Tommotian stratotype, Lower Cambrian (Aldan River). *Doklady Akademii Nauk SSSR*. **249** (5), 1188–90.

KELLER, B. M. & KRATZ, K. O. 1979. Standard stratigraphic scale for the Precambrian of the USSR and ways of its improvements. In *General Problems of the Precambrian Subdivision in the USSR*, pp. 127–46. Leningrad: Nauka.

KHOMENTOVSKY, V. V. 1974. Principles for the recognition of the Vendian as a Paleozoic system. In *Essays on Stratigraphy*, pp. 33–70. Moscow: Nauka.

KHOMENTOVSKY, V. V. 1976. *Vendian*. Trudy Instituta geologii i geofisiki Sibirskoe otdelenie AN SSSR, mem. 243, 271 pp.

KHOMENTOVSKY, V. V. 1984*a*. Vendian. In *Phanerozoic of Siberia*, **1**, pp. 5–35. Novosibirsk: Nauka.

KHOMENTOVSKY, V. V. 1984*b*. Baikalian complex and Baikalides. *Geologia i geofizika*, no. 8, pp. 33–40.

KHOMENTOVSKY, V. V. & PYATILETOV, V. G. 1978. On stratigraphic value of microfossils of the Siberian platform and its margin. In *New Evidence on Late Precambrian Stratigraphy and Paleontology of the Siberian Platform* pp. 49–69. Novosibirsk.

KHOMENTOVSKY, V. V., DIDENKO A. N. & PYATILETOV, V. G. 1982. General conclusions on the Vendian stratigraphy of West Prianabar area. In *New Date on the Late Precambrian Stratigraphy of Siberia*, pp. 3–30 Novosibirsk.

KHOMENTOVSKY, V. V., SHENFIL, V. YU., YAKSHIN, M. S. & BUTAKOV, E. P. 1972. *Key sections of Upper Precambrian and Lower Cambrian Deposits of the Siberian Platform*. Moscow: Nauka, 356 pp. (Trudy Instituta geologii i geofiziki, mem. 141).

KHOMENTOVSKY, V. V., VALKOV, A. K., KARLOVA, G. A. & NUZHNOV, S. V. 1983. Key section of Precambrian–Cambrian deposits of the Gonam River. In *Late Precambrian and Lower Palaeozoic of Siberia. Vendian Deposits*, pp. 29–44. Novosibirsk.

ROZANOV, A. YU., MISSARCHEVSKY, V. V., VOLKOVA, N. A., VORONOVA, L. G., KRYLOV, I. N., KELLER, B. M., KOROLYUK, I. K., LENDZION, K., MICHNIAK, R., PYKHOVA, N. G. & SIDOROV, A. D. 1969. *The Tommotian Stage and the Cambrian Lower Boundary Problem*. Moscow: Nauka, pp. 380.

SAVITSKY, V. E. 1975. Problem of the Cambrian lower boundary on the Siberian platform and the Nemakit–Daldyn horizon. In *Equivalents of the Vendian Complex in Siberia*, pp. 43–61. Moscow: Nauka.

SHENFIL V. YU. 1975. Stromatolites from the Yudomian complex of Siberia. In *Equivalents of the Vendian Complex in Siberia*, pp. 123–31. Novosibirsk: Nauka.

SEMIKHATOV, M. A., KOMAR, BL. A. & SEREBRYAKOV, S. N. 1970. *Yudomian Complex of Type Locality*. Moscow: Nauka, 207 pp.

SOKOLOV, B. S. 1972. Vendian stage in the Earth history. In *Paleontology* (International Geological Congress, XXIVth Session. Reports of Soviet geologists). Moscow: Nauka, pp. 114–23.

SOKOLOV, B. S. 1975. On paleontological occurrences in the Preusolje deposits of the Irkutsk amphitheatre. In *Equivalents of the Vendian Complexes in Siberia*, pp. 112–17. Moscow: Nauka.

STARNIKOV, A. I., SUKHORUKOV, V. I. & YAKSHIN, M. S. 1983. Yudomian series of the northern Yudoma–Maya trough. In *Late Precambrian and Early Palaeözoic Stratigraphy of Central Siberia*, pp. 61–73. Isdatelstvo Instituta geologii i geofiziki, Novosimbirsk.

TERLEEV, A. A. 1981. Lower Cambrian microphytolites of the Mansk trough (East Sayan). *Geologia i geofizika*, no. 9, pp. 135–42.

Volkova, N. A., Kiriyanov, V. V., *et al.* 1980. Upper Precambrian microfossils of the Siberian platform. *Izvestiya Akademii Nauk SSSR, Seria geologicheskaya*, no. 1, pp. 23–9.

ZHURAVLEVA, Z. A. & KOMAR, V. A. 1962. On the Riphean (Sinian) stratigraphy of the Anabar Massif. *Doklady Akademii Nauk SSSR*, **144**, pp. 197–200.