Biofacies and age of Cambrian trilobite associations of the Diringde reef complex (northern Siberian Platform, Russia)

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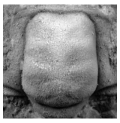

The Diringde reef complex (Kotuy River Basin, Southwest of the Anabar Region, northern Siberian Platform, Russia) has formed during the late mid-Cambrian–early Furongian at the shelf margin of the epicontinental marine basin. Two detached carbonate buildup complexes originated. The southern mid-Cambrian buildup complex is replaced laterally by shale-carbonate rocks of the open basin slope. The northern mid-Cambrian–Furongian buildup complex passes laterally into the inner shelf dolomites. The trilobite associations of the central parts of both buildup complexes consist of rare endemic polymerids, distributed mainly in interbeds between algal buildups. The trilobite associations in narrow facial transition zones (reef flanks) to surrounding stratified deposits differ in having more abundant polymerids, higher taxonomic diversity, and include also agnostoids. The trilobite associations are similar to the assemblage of the reef-dominated mid-Cambrian–Furongian Chukuka Formation that is widespread in the neighboring South Anabar Region. The associations from the reef flank of the southern buildup complex consist mainly of species distributed in Cambrian shallow-water deposits of the Saami, Sakha, Nganasany and Tavgi horizons in the Kulyumbe River reference section, northwestern Siberian Platform. The trilobite assemblages of deeper water deposits of the Eyra Formation that are found on the open marine side of the Diringde reef complex combine typical elements of mainly endemic, shallow-water associations of the southern buildups and the slope basin associations with various cosmopolitan pre-Furongian agnostoids enabling international correlations. • Key words: Cambrian, trilobite associations, Diringde reef complex, biofacies, Siberian Platform.

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The Diringde reef complex of the Cambrian age is located in the basin of the Kotuy River middle course within the Southwest of the Anabar Region (northern Siberian Platform, Russia, see Shishkin *et al*. 1978, Shishkin & Pegel 1978, Shishkin 1981, Astashkin *et al*. 1984). It is characterized by a complicated structure, abrupt sedimentary facies variations, lack of lithological markers and an irregular distribution of endemic fossils. The reef complex formed at the shelf margin of the epicontinental sea basin (Figs 1, 2). Together with the adjacent dolomites of the Kyndyn Formation, it represents the outer margin of the carbonate platform. Southward, the complex is replaced by the mid-Cambrian–Furongian rocks of the Eyra Formation deposited on the open-marine basin slope. The Eyra Formation was investigated by Savitsky (1959), who amassed an abundant palaeontological collection, which was studied by Lazarenko and subsequently by the author. The investigation of complicated structure and composition of the Diringde reef complex led to location of areas where replacement of carbonate buildups by stratified shale-carbonate rocks of the Eyra Formation was observed, offering an opportunity to estimate fairly precisely the age of the faunal assemblages of the buildups. The Diringde reef complex was formed during the late mid-Cambrian–early Furongian (see also Ivlev 1973, Shishkin *et al*. 1978).

Geological settings

The Diringde reef complex consists of two detached carbonate buildup complexes. The southern buildup complex is exposed along the Kotuy River *ca* 2–3 km upstream of the Diringde River mouth (see Figs 2, 3). The transitional zone (see above) reaches from the south side of this buildup complex to upper slope deposits of the Eyra Formation and is observed along the right tributary of the Kotuy River

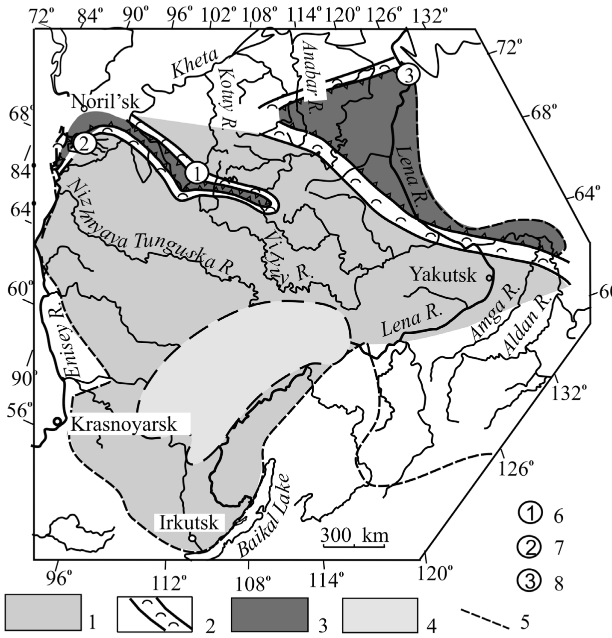


Figure 1. The palaeogeographical scheme of the Siberian Platform. Late Guzhangian–Paibian Stages (modified from Sukhov 1997, fig. 3E). 1 – inner shelf; 2 – open-marine shelf (outer margin of the carbonate platform); 3 – open-marine basin; 4 – dry land; 5 – boundary of the Siberian Platform; 6 – Diringde reef complex; 7 – Kulyumbe River section; 8 – Khos-Nelege River section.

ca 3 km upstream the mouth of the Diringde River. The overlying deposits are eroded. The relationship and contact with dolomites of the Kyndyn Formation laterally replacing the Diringde reef complex can be observed in the northern buildup complex in the Diringde River mouth.

The central parts (or cores) of each buildup complex are composed of algal limestone bioherms with detrital intercalations. Narrow zones of facies transition (strata of the reef flanks) exist at the contact of organic buildups and adjacent stratified floatstones/rudstones/grainstones to wackestones.

Distribution of trilobite associations

A number of trilobite associations were found in the organic buildups, the strata of the Diringde reef flanks and in the rocks of the Eyra Formation (Pegel 1982). The spacious depositional environments (outer margin of the carbonate platform, slope basin and the transitional zone) with corresponding trilobite biofacies (Fig. 2) provide a generalized image of the palaeobiogeographical distribution of trilobite associations.

The trilobite associations of the reef cores consist of polymerids, distributed mainly in interbeds and lenses of platy detrital limestone that fill the space between the algal buildups (Fig. 4). Trilobite associations of the inner parts of the bioherms are generally scarce, monotypic or consist of one to three species with few idividuals. Only occasionally, they can form accumulations. The cranidia of such trilobites are usually highly convex, hemispherical, with a massive glabella, narrow fixigenae and short palpebral lobes. Trilobite associations in the marginal parts of the cores are more abundant and diverse, with forms typical for the reef flank strata. They consist of mainly small or medium-sized cranidia, rare pygidia, librigenae, and thoracic segments which are evenly distributed and randomly oriented. The trilobites from the strata of the reef flank occur in limestone interbeds formed by organic detritus, oolitic platy limestones and calcareous sandstones. They differ from those of the core associations in a greater abundance, a higher

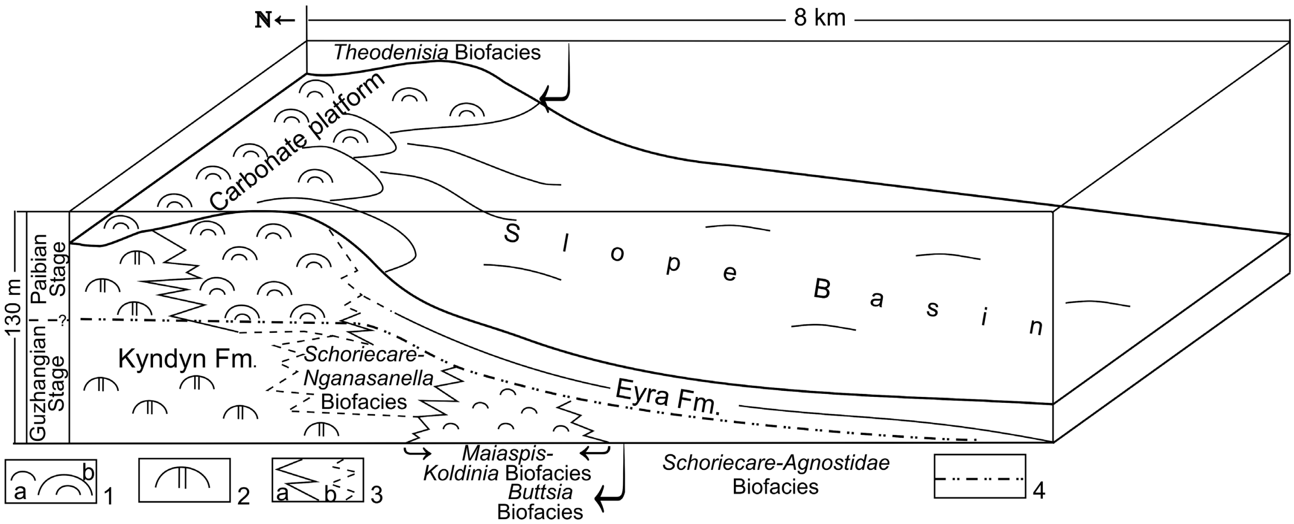


Figure 2. Trilobite biofacies in the Diringde reef complex (modified from Pegel 1989, fig. 1). 1 – algal buildups (a – southern buildup complex; b – northern buildup complex); 2 – dolomitised organic buildups; 3 – lithologic/facies boundaries (a – definite; b – supposed); 4 – supposed mid-Cambrian–Furongian boundary.

diversity, and include rare agnostoids. The trilobites from the strata of the reef flanks combine elements of the trilobite assemblages of the carbonate platform margin and the slope. Polymerids often have a flattened cranidium, different ratios of glabella and fixigenae, long and curved palpebral lobes, and a long frontal area. The abundance and diversity of the agnostoids increase towards the open marine slope. The absence of complete dorsal exoskeletons and abundant shelly accumulations provide evidence of transportation.

In the southern buildup complex the typical species of the trilobite associations of the reef core (including marginal parts) are *Maiaspis inflata* Chernysheva *in* Krys'kov *et al.,* 1960, *M. mirabilis* Chernysheva, 1956*, Buttsia contracta* Pegel *in* Pegel & Khramova, 1985, *Cyclognathina sibirica* Gogin, 1990, *Munija modesta* Khramova, 1980, *Seletella borea* Pegel, 1989 and Plethopeltidae (*Koldinia minor* Kobayashi, 1943, *Plethopeltoides elegans* Khramova, 1968 and *Koldiniella* sp.) forming the association typical for the *Maiaspis-Koldinia* Biofacies (see Figs 5A and 6A–I). Typical elements of the trilobite assemblages of the coeval deposits in the reef flanks are *Buttsia contracta* and *B. parvula* Khramova, 1977. They are accompanied by species of *Bonneterrina* Lochman, 1936, *Koldinia* Walcott & Resser, 1925, *Koldiniella* Sivov *in* Egorova *et al.*, 1955, *Plethopeltoides* Khramova, 1968, *Maiaspis* Chernysheva *in* Chernyscheva *et al*., 1956, *Olenekella* Khramova *in* Pegel & Khramova, 1985, *Onchonotellus* Lermontova, 1951, *Sacha* Rosova, 1964, *Schoriecare* Rosova, 1964, *Seletella* Ivshin, 1962, *Trinia* Poletaeva *in* Chernysheva *et al*., 1956, and other polymerids with rare individuals of agnostoids (*Buttsia* Biofacies, see Figs 5B and 8A–I). The overlying strata of the rear (north) side of the southern buildup complex include *Nganasanella interminata* Rosova, 1964, *N. tavgaensis* Rosova, 1963, *Catuniella lauta* Lazarenko*,* 1960, *Groenwallina decora* Rosova, 1964, *Pauciella prima* (Lazarenko, 1960), *Schoriecare compta* Pegel, 1989, *Ammagnostus simplexiformis* (Rosova, 1964), plus species of *Coosella* Lochman, 1936, *Modocia* Walcott, 1924, *Pesaiella* Rosova, 1964, *Nericella* Rosova, 1964, *Koldinia* Walcott & Resser, 1925, *Koldiniella* Sivov *in* Egorova *et al.*, 1955, *Plethopeltoides* Khramova, 1968, *Skryjagnostus* Šnajdr, 1957 and others (*Schoriecare-Nganasanella* Biofacies, see Figs 5C and 8J–T).

The trilobite associations from the base of the reef core in the northern buildup complex include *Didwudina* sp. and some species and genera that also occur in the southern buildup complex, such as: *Maiaspis* sp., *Munija modesta* Khramova, 1980, *Seletella borea* Pegel, 1989 and *Koldinia* sp. (*Maiaspis-Koldinia* Biofacies; Figs 5A and 6J–L). In supposedly related strata of the reef flanks, *Olimus compactus* E. Romanenko *in* Gogin & Pegel, 1997, *Prismenaspis* aff. *trisulcata* Ergaliev, 1980 and *Schoriecare compta* Pegel, 1989 occur (*Schoriecare-Nganasanella*

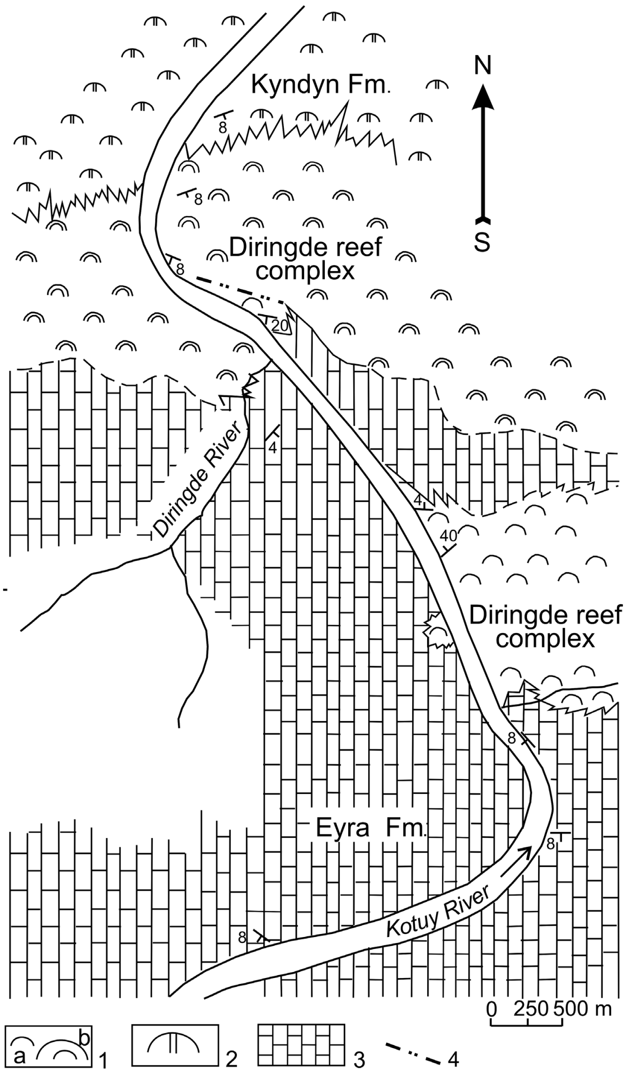


Figure 3. Schematic geological map of the Kotuy River area in the Diringde River mouth area (modified from Shishkin *et al*. 1978, fig. 1). 1 – algal buildups of the Diringde reef complex [a – southern (mid-Cambrian) buildup complex; b – northern (Furongian buildup complex)]; 2 – dolomitised organic buildups of the Kyndyn Formation; 3 – argillitic-carbonate stratified deposits of the Eyra Formation; 4 – supposed mid-Cambrian–Furongian boundary.

Biofacies; Figs 5C and 8U, V). The trilobite associations in the remainder overlying part of the northern buildup complex differ in their composition. New elements are several species of *Theodenisia* Clark, 1948 in association with *Albansia* Howell, 1937 and *Ritella* Khramova & Pegel *in* Pegel & Khramova, 1985 (*Theodenisia* Biofacies; Figs 5D, 6M–S, and 8W–Z). *Theodenisia* aff. *communis* (Rasetti, 1944), *Th. glabra* Pegel, 1989, *Th. dissortis* Pegel, 1989, *Munija gloriosa* Khramova, 1980 and *Ritella plena* Khramova & Pegel *in* Pegel & Khramova, 1985 are typical species of the middle part of the bioherm. *Albansia*? ex gr. *montanenis* Howell & Duncan, 1939, *Seletella subquadrata* Pegel, 1989, *Munija modesta* Khramova, 1980,

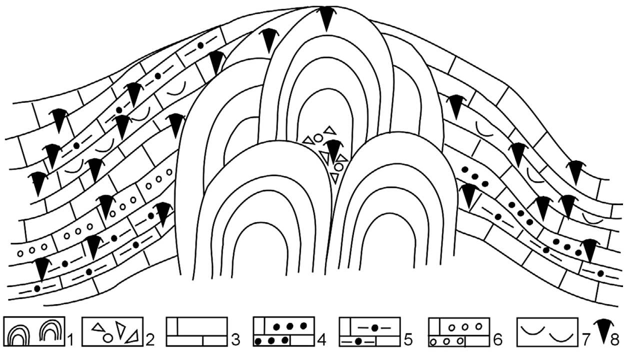


Figure 4. Trilobite distribution in algal buildups and reef flank strata. 1, 2 – algal buildups: 1 – algal bioherms, 2 – detrital intercalations; 3–7 – reef flank strata: 3 – limestone, 4 – calcareous sandstone, 5 – silty limestone, 6 – oolitic limestone, 7 – organic detritus; 8 – trilobites.

Ritella umbonata Khramova & Pegel *in* Pegel & Khramova, 1985 and *Theodenisia paulula* Khramova, 1977 dominate in trilobite assemblages of the marginal parts of the core and strata of the reef flanks near the frontal (southern) border of the buildup.

Age and correlation

The trilobite associations of the Diringde reef complex are endemic (particularly on the species level), which provides difficulties for the identification of their precise age. However, the Diringde reef complex is located at the boundary of two palaeoenvironments. The margin of the carbonate platform is composed of shallow-water deposits and has a

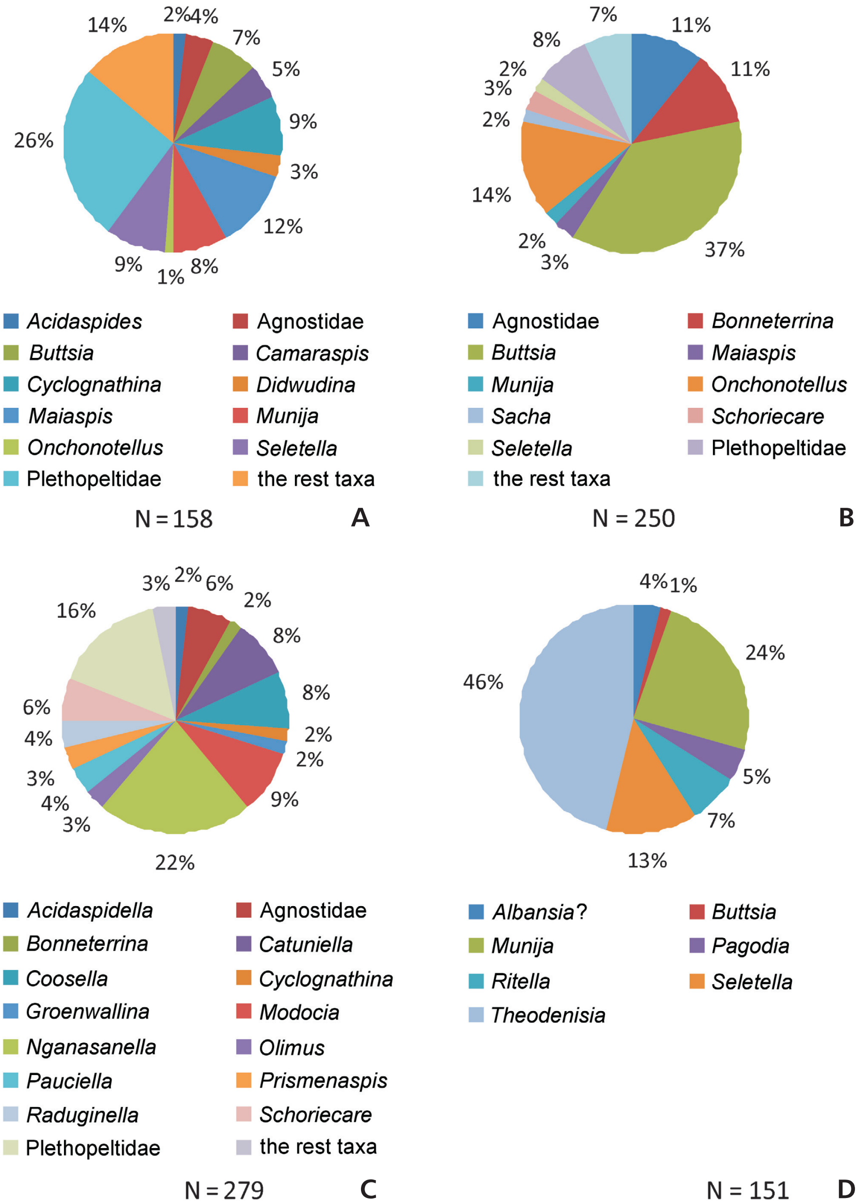


Figure 5. Relative abundances of taxa in the upper mid-Cambrian and Lower Furongian trilobite biofacies of the Diringde reef complex. N – the total number of individuals. • A – *Maiaspis-Koldinia* Biofacies in the mid-Cambrian reef core of the southern and northern buildup complexes. • B – *Buttsia* Biofacies in the mid-Cambrian reef flanks of the southern buildup complex. • C – *Schoriecare-Nganasanella* Biofacies in the mid-Cambrian reef flanks of the southern buildup complex. • D – *Theodenisia* Biofacies in the Lower Furongian reef core and reef flanks of the northern buildup complex.

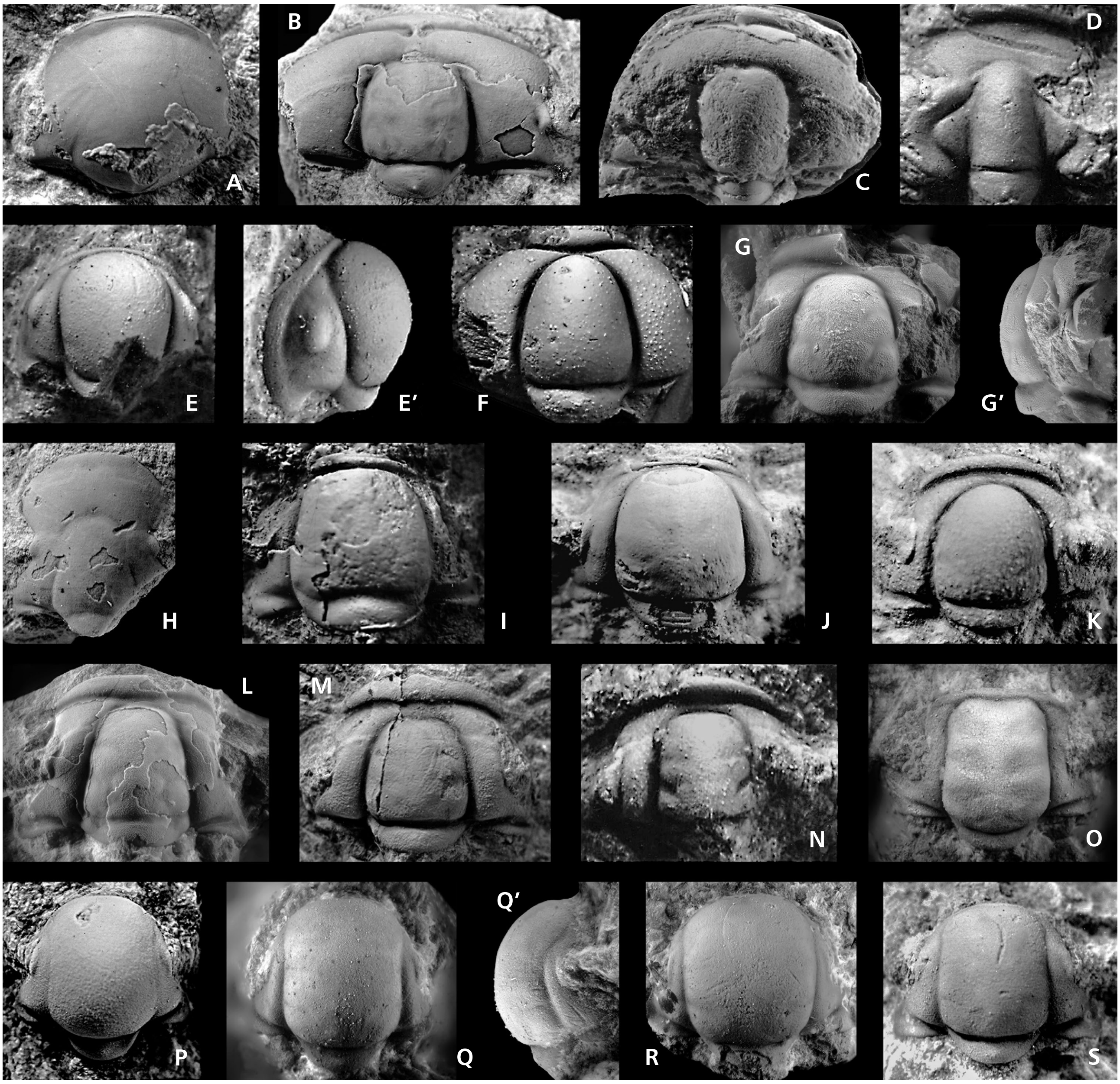


Figure 6. Trilobites of the organic buildups biofacies of the Diringde reef complex. Specimens are reposited at the Siberian Research Institute of Geology, Geophysics and Mineral Resources (SNIIGGiMS) and the Central Siberian Geological Museum (CSGM), Novosibirsk, Russia. • A–L – Mid-Cambrian *Maiaspis-Koldinia* Biofacies: A – *Koldinia minor* Kobayashi, 1943, cranidium, × 4.5, SNIIGGiMS, 366/47; B – *Maiaspis mirabilis* Chernysheva *in* Chernysheva *et al.*, 1956, cranidium, × 2, SNIIGGiMS, 366/84; C – *Maiaspis inflata* Chernysheva *in* Krys'kov *et al.*, 1960, cranidium, × 5, SNIIGGiMS, 366/224; D – *Schoriecare optata* (Chernysheva *in* Krys'kov *et al.*, 1960), cranidium, × 10 SNIIGGiMS, 366/111; E, E' – *Buttsia contracta* Pegel *in* Pegel & Khramova, 1985, cephalon, dorsal and lateral views, × 7, CSGM, collection 878; F – *Onchonotellus conusoides* Lazarenko, 1968, cranidium, × 6, CSGM, collection 909; G, G' – *Munija modesta* Khramova, 1980, cranidium, dorsal and lateral views, × 3, SNIIGGiMS, 366/221; H – *Plethopeltoides elegans* Khramova, 1968, cranidium, × 3, SNIIGGiMS, 366/80; I, J – *Seletella borea* Pegel, 1989, cranidia, CSGM, collection 909 (I – × 4.5; J – × 5); K – *Didwudina* sp., cranidium, × 7.5, SNIIGGiMS, 366/69; L – *Munija modesta* Khramova, 1980, cranidium, × 2.5, SNIIGGiMS, 366/72. • M–S – Furongian *Theodenisia* Biofacies: M – *Munija gloriosa* Khramova, 1980, cranidium, × 3, SNIIGGiMS, 366/74; N – *Ritella plena* Khramova & Pegel *in* Pegel and Khramova, 1985, cranidium, × 11, CSGM, collection 878; O – *Theodenisia dissortis* Pegel, 1989, cranidium, × 8, SNIIGGiMS, 366/145; P, Q, Q' – *Theodenisia glabra* Pegel, 1989, cranidia, × 6 (P – CSGM, collection 909; Q – dorsal and lateral views, SNIIGGiMS, 366/148); R – *Theodenisia* sp., cranidium, × 7, SNIIGGiMS, 366/147; S – *Theodenisia* aff. *communis* (Rasetti, 1944), cranidium, × 6.5, CSGM, collection 909.

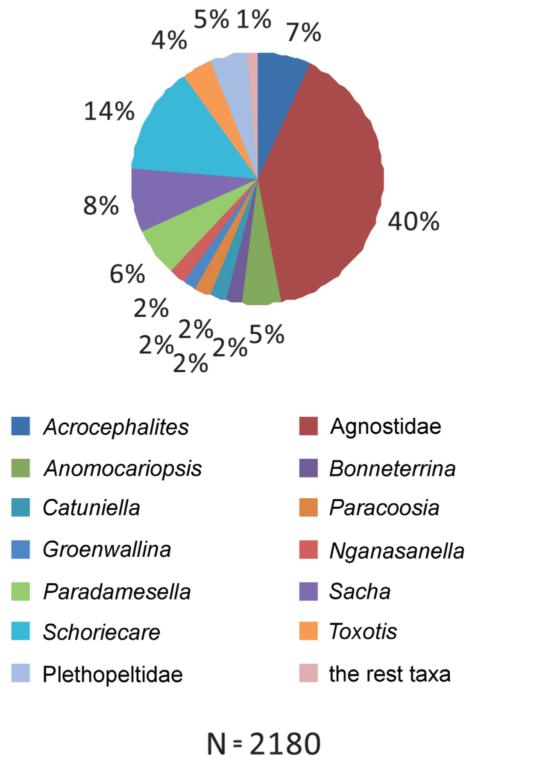


Figure 7. Relative abundances of taxa in collections from mid-Cambrian *Schoriecare-Agnostidae* Biofacies in open marine deposits of the Eyra Formation. N – the total number of individuals.

predominantly endemic fauna, whereas the open marine slope facies is characterized by faunal elements, which indicate far-reaching biogeographical relationships.

Structures similar to those of the Diringde reef complex are distributed on the southwestern slope of the Anabar antecline. These are characterized by a distinctive Chukuka faunal assemblage, the age of which has been discussed for a long time. Alternative interpretations favoured either a late mid-Cambrian–early Furongian age (Kaban'kov 1966; Kuteynikov *et al*. 1976; Khramova 1977, 1980) or an age corresponding with the younger half of the Furongian (Gogina *et al.* 1966).

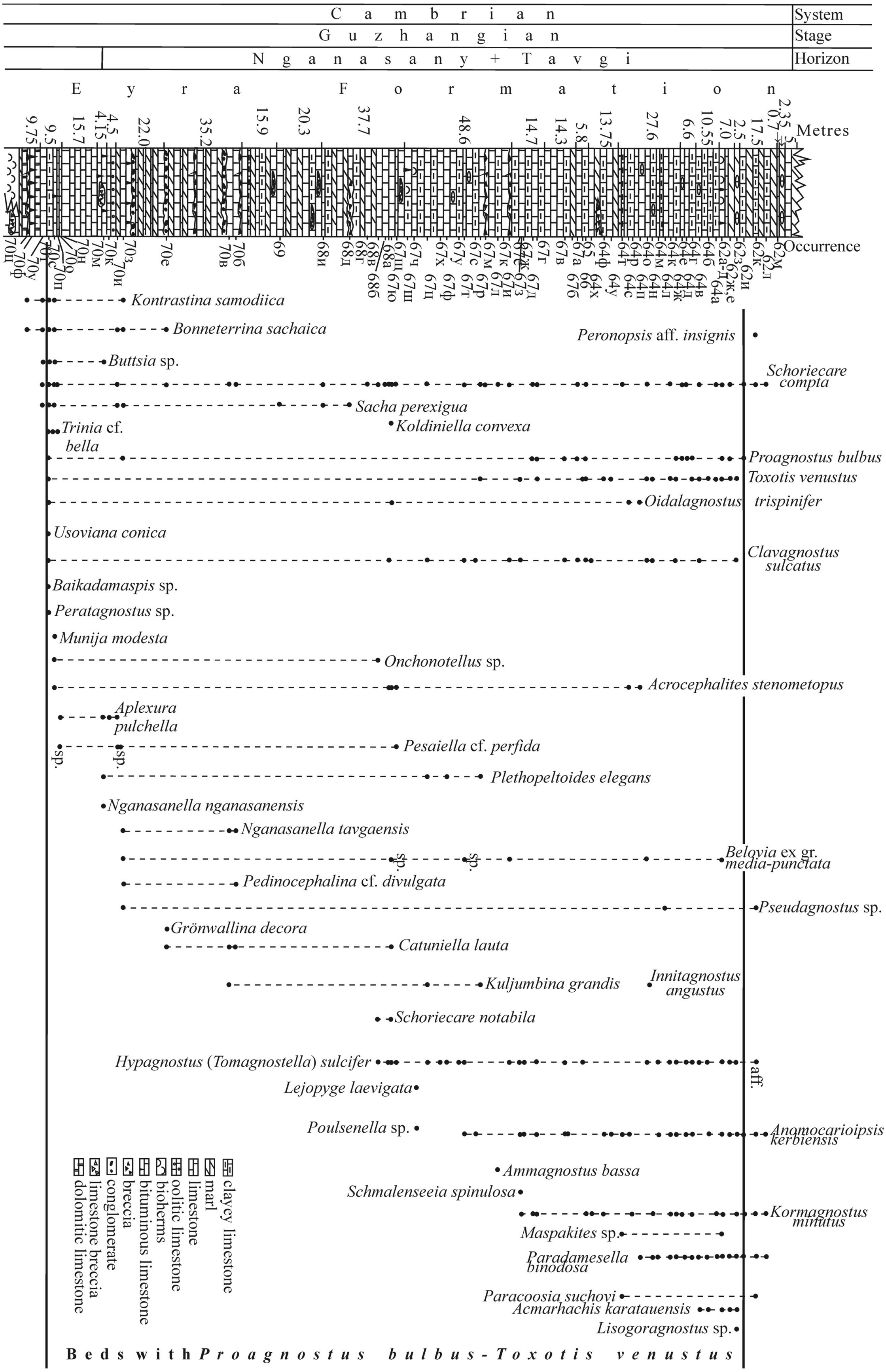
The trilobite associations of the cores and the nearest parts of the reef flank strata of the Diringde reef complex include *Maiaspis inflata*, *Plethopeltoides elegans*, *Munija modesta*, *Theodenisia paulula* and are similar to fauna assemblages of the reefal Chukuka Formation in the neighboring South Anabar region. This indicates the facies connection of the Chukuka faunal assemblage with the reef deposits described herein.

The associations from the strata in the reef flanks of the southern buildup complex mainly consist of species distributed in the Labazny and Orakta formations in the Kulyumbe River section of the northwestern Siberian Platform. Those associations of the Kulyumbe River area include *Ammagnostus simplexiformis* (Rosova, 1964), *Bonneterrina saamica* Rosova, 1964, *B. sachaica* Rosova, 1964, *Sacha perexigua* (Rosova 1964), *Belovia aliquantula* Rosova, 1964, *Acidaspidella limata* Rosova, 1963, *Acrocephalella granulosa* Rosova, 1963, *Nericella diffusa* Rosova, 1964, *Pauciella prima* (Lazarenko, 1960), *Groenwallina decora* Rosova, 1964, *Nganasanella nganasanensis* Rosova, 1963, *N. tavgaensis* Rosova, 1963, *Catuniella lauta* Lazarenko, 1960 as well as species of *Schoriecare* Rosova, 1964, *Pesaiella* Rosova, 1964, *Modocia* Walcott, 1924, and *Camaraspis* Ulrich & Resser *in* Ulrich, 1924. The Kulyumbe River section is typical for shallow-water deposits of the open-marine and inner shelves. The trilobites listed above are distributed in the Saami, Sakha, Nganasany and Tavgi horizons of this section (Rosova 1964). In the Russian stratigraphical scale (Anonymous 1983, Astashkin *et al.* 1991) deposits of the Saami and Sakha horizons are correlated with the upper part of the Mayan Regional Stage. The Nganasany and Tavgi horizons are assigned to the Ayusokkanian Regional Stage. This stage is correlated with the upper part of the global Guzhangian Stage. A.V. Rosova suggested that lower boundary of the Nganasany Horizon can be compared with the base of the *Glyptagnostus reticulatus* Zone (Rosova 1968, 1984, *etc.*) and thus the lower boundary of the Furongian.

The trilobite associations of the deeper water deposits of the Eyra Formation on the seaward side of the Diringde reef complex have typical elements of the predominantly endemic shallow-water shelf associations of the southern buildup complex (*Bonneterrina sachaica*, *Trinia* cf. *bella*, *Munija modesta*, *Groenwallina decora*, *Catuniella lauta*, *Plethopeltoides elegans*, *Schoriecare compta*, *Sacha*

Figure 8. Trilobites of the reef flank biofacies of the Diringde reef complex. Specimens are reposited at the Siberian Research Institute of Geology, Geophysics and Mineral Resources (SNIIGGiMS) and the Central Siberian Geological Museum (CSGM), Novosibirsk, Russia. • A–I – *Buttsia* Biofacies: A – *Buttsia contracta* Pegel *in* Pegel & Khramova, 1985, cranidium, × 5.5, CSGM, collection 909; B – *Buttsia parvula* Khramova, 1977, cranidium, × 10, SNIIGGiMS, 366/230; C – *Schoriecare* sp., cranidium, × 3.5, SNIIGGiMS, 366/27; D – *Maiaspis mirabilis* Chernysheva, 1956, cranidium, × 6, SNIIGGiMS, 366/85; E – *Plethopeltoides elegans* Khramova, 1968, cranidium, × 3.5, SNIIGGiMS, 366/168; F – *Koldinia infima* Lazarenko, 1968, cranidium, × 3, SNIIGGiMS, 366/46; G – *Seletella subquadrata* Pegel, 1989, cranidium, × 7.5, SNIIGGiMS, 366/152; H – *Olenekella alimbata* Khramova & Pegel *in* Pegel & Khramova, 1985, damaged cranidium, × 5.5, SNIIGGiMS, 366/94; I – *Bonneterrina saamica* Rosova, 1964, cranidium, × 4, SNIIGGiMS, 366/301. • J–V – *Schoriecare-Nganasanella* Biofacies: J – *Nganasanella tavgaensis* Rosova, 1963, cranidium, × 10, SNIIGGiMS, 366/61; K – *Nganasanella interminata* Rosova, 1964, cranidium, × 5, CSGM, collection 909; L – *Catuniella lauta* Lazarenko, 1960, cranidium, × 10.5, SNIIGGiMS, 366/116; M – *Schoriecare compta* Pegel, 1989, cranidium, × 4.5, CSGM, collection 909; N – *Groenwallina decora*

Rosova, 1964, cranidiun, × 4, SNIIGGiMS, 366/24; O – *Nericella diffusa* Rosova, 1964, cranidium, × 4, SNIIGGiMS, 366/118; P – *Pauciella prima* (Lazarenko, 1960), cranidium, × 10, SNIIGGiMS, 366/28; Q, Q’ – *Modocia* sp., cranidium, dorsal and lateral views, × 3, SNIIGGiMS, 366/31; R – *Pesaiella* sp., partial cranidium, × 2, SNIIGGiMS, 366/26; S, S’ – *Ammagnostus simplexiformis* (Rosova, 1964): S – cephalon, × 5.5, SNIIGGiMS, 366/36, S’ – pygidium, × 6.5, SNIIGGiMS, 366/35; T – *Skryjagnostus* sp., cephalon, × 4.5, SNIIGGiMS, 366/30; U – *Olimus compactus* E. Romanenko *in* Gogin & Pegel, 1997, partial cranidium, × 4.5, SNIIGGiMS, 366/76; V – *Prismenaspis* aff. *trisulcatus* Ergaliev, 1980, damaged cranidium, × 3, SNIIGGiMS, 366/64. • W–Z – *Theodenisia* Biofacies: W, X – *Albansia*? ex gr. *montanensis* Howell & Duncan, 1939, cranidia (W – × 13, SNIIGGiMS, 366/10; X – × 10, SNIIGGiMS, 366/79); Y – *Theodenisia paulula* Khramova, 1977, cranidium, × 10, SNIIGGiMS, 366/149; Z – *Ritella umbonata* Khramova & Pegel *in* Pegel & Khramova, 1985, cranidium, × 9.5, CSGM, collection 878.



C a m b r i a n
System
G u z h a n g i a n
Stage
N g a n a s a n y + T a v g i
Horizon
E y r a F o r m a t i o n
Metres
Occurrence
Kontrastina samodiica
Bonneterrina sachaica
Peronopsis aff. insignis
Buttsia sp.
Schoriecare compta
Sacha perexigua
Koldiniella convexa
Trinia cf. bella
Proagnostus bulbus
Toxotis venustus
Oidalagnostus trispinifer
Usoviana conica
Clavagnostus sulcatus
Baikadamaspis sp.
Peratagnostus sp.
Munija modesta
Onchonotellus sp.
Acrocephalites stenometopus
Aplexura pulchella
Pesaiella cf. perfida
Plethopeltoides elegans
Nganasanella nganasanensis
Nganasanella tavgaensis
Belovia ex gr. media-punctata
Pedinocephalina cf. divulgata
Pseudagnostus sp.
Grönwallina decora
Catuniella lauta
Kuljumbina grandis
Innitagnostus angustus
Schoriecare notabila
Hypagnostus (Tomagnostella) sulcifer
aff.
Lejopyge laevigata
Poulsenella sp.
Anomocarioipsis kerbiensis
Ammagnostus bassa
Schmalenseeia spinulosa
Kormagnostus minutus
Maspakites sp.
Paradamesella binodosa
Paracoosia suchovi
Acmarhachis karatauensis
Lisogoragnostus sp.
clayey limestone
marl
limestone
oolitic limestone
bioherms
bituminous limestone
breccia
conglomerate
limestone breccia
dolomitic limestone
Beds with Proagnostus bulbus - Toxotis venustus

perexigua, and others) and slope basin assemblages with various cosmopolitan agnostoids (Figs 7 and 9). These cosmopolitan agnostoids occur together with agnostoids of the Guzhangian Stage in the Ogon'or Formation along the Khos-Nelege River in the north-eastern part of the Siberian Platform and includes *Proagnostus bulbus* (Butts, 1926), *Oidalagnostus trispinifer* Westergård, 1946, *Clavagnostus sulcatus* Westergård, 1946, *Hypagnostus sulcifer* Wallerius, 1895, *Lejopyge laevigata* (Dalman, 1828), *Ammagnostus bassa* Öpik, 1967, and *Kormagnostus minutus* (Schrank, 1975), see Lazarenko *et al*. (2008) and Pegel (2010).

Available data confirm a late Guzhangian and pre-Furongian age of the Nganasany and Tavgi horizons of the northwestern Siberian Platform. Consequently, the trilobite associations of the southern buildup complex of the Diringde reef complex, which are linked with the mid-Cambrian deposits of the Eyra Formation, must have the same age.

Trilobite associations of the northern and southern buildup complexes differ strongly. The southern buildup associations comprise mainly Siberian species, whereas associations of the northern buildup predominantly contain species of genera, which are known from different regions of the earth. Among them are *Theodenisia* Clark, 1948, *Albansia* Howell, 1937 and *Buttsia* Wilson, 1951 that all occur mainly in the Furongian of North America, plus *Seletella* Ivshin, 1962, *Didwudina* Ivshin, 1962 and *Prismenaspis* Henderson, 1976 that are known from the Furongian of Kazakhstan. This trilobite assemblage clearly indicates a Furongian age of the northern buildup complex. The presence of some species that occur in the mid-Cambrian southern buildup complex (*Munija modesta*, *M. gloriosa*, *Seletella subquadrata*, *S. borea*) in the Furongian trilobite associations suggests that the northern buildups were formed at the beginning of the Furongian.

Conclusions

The trilobite associations of the cores and reef flank strata of the Diringde reef complex are both taxonomically diverse and endemic. Trilobite associations of the cores and the adjacent parts of the reef flank strata of the southern and northern buildups are similar to the mid-Cambrian–early Furongian Chukuka faunal assemblage of the Siberian Platform. The trilobite associations of the reef flank strata in the southern buildup complex include taxa which also occur in the trilobite assemblages of the Saami, Sakha, Nganasany and Tavgi horizons of the Kulyumbe River section, which typifies the Cambrian shallow-water shelf deposits of the Siberian Platform. The trilobite associations in the lower part of the Eyra Formation along the seaward side of the Diringde reef complex combine species of the shallow water type (present in the Saami, Sakha, Nganasany and Tavgi horizons of the Kulyumbe River reference section) and agnostoids of the slope facies known from the Guzhangian in the Khos-Nelege River section, which is typical for the Cambrian open-marine basin deposits of the Siberian Platform. The available data confirm the pre-Furongian age of the Nganasany and Tavgi horizons.

Figure 9. Stratigraphic distribution of trilobites in the lower Eyra Formation in the middle reach of the Kotuy River (by Savitsky, Lazarenko & Pegel; modified from Pegel 2010, fig. 3).

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