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ORDOVICIAN ERRATIC TRILOBITES (*ARTHROPODA, TRILOBITA*) FROM PLEISTOCENE DEPOSITS OF BELARUS (PRELIMINARY DATA)

Analysis of geographic distribution and determination of geological age of erratic pre-Quaternary sedimentary megaclasts (blocks, boulders and pebbles) enclosed in Quaternary deposits is especially important for localizing their possible sources and native areas. Except for some varieties of rocks that can be identified by their unique petrographic features, definite stratigraphic systematization of the majority of sedimentary megaclasts can be carried out only by means of paleontological study. However, petrographic features have been used solely in almost all previous publications dealing with sedimentary erratics from the territory of Belarus, so it is questionable whether the results can be considered reliable without paleontological confirmation.

Identification of trilobites (*Trilobita* Walch, 1771) is applied here for the purpose of ascertaining the geological age of Ordovician sedimentary blocks, boulders and pebbles redeposited in Pleistocene strata of Belarus. At this time, trilobites belonging to 15 genera and subgenera have been identified in the studied area. They represent the major part of the Ordovician carbonate bedrock succession typical for the East-European Platform. Strata of this succession are subjacent to various younger deposits in north- and southwestern parts of Belarus and in the Baltic States and crop out in northern Estonia and the St. Petersburg Region of Russia.

We propose that the studied Ordovician erratic material is not necessarily the result of long-distance transport, which is usually presumed according to the theory of Pleistocene continental glaciations, but might have been redeposited from nearby buried Ordovician bedrock sources as well. Taxonomic composition of the "Ordovician erratic trilobite complex" of Belarus denotes its similarity to the "erratic trilobite association" from northern Germany, northern Poland and Kaliningrad Region of Russia (formerly East Prussia). At the same time it also shows clear affinity to trilobite assemblages from Middle and Upper Ordovician bedrock outcrops in northern Estonia and the St. Petersburg Region (East Baltics), although it is not entirely typical for them. It is also notable that several of the collected trilobite specimens show morphological dissimilarity with typical trilobite material described in paleontological literature.

Key words: Trilobites; Ordovician; sources of pre-Quaternary sedimentary erratics; erratic trilobite association.
Fig. 28. Table 1. Ref.: 41 titles.

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АРДОВІКСКІЯ ТРЫЛАБІТЫ (*ARTHROPODA*, *TRILOBITA*), ПЕРААДКЛАДЗЕНЫЯ Ў ПЛЕЙСТАЦЭНАВЫХ УТВАРЭННЯХ БЕЛАРУСІ (ПАПЯРЭДНІЯ ЗВЕСТКІ)

Аналіз геаграфічнага пашырэння і вызначэнне геалагічнага ўзросту дачацвярцёвых мегакластаў (камлыгі, валуны, галькі) асадкавых горных парод, пераадкладзеных у чацвярцёвых утварэннях, мае асаблівае значэнне для ўстанаўлення іх верагодных крыніц і раёнаў паходжання. За выключэннем некаторых разнавіднасцяў парод, якія можна ідэнтыфікаваць па адметных петраграфічных асаблівасцях і якасцях, высновы аб стратыграфічнай прымеркаванасці большасці відаў асадкавых мегакластаў могуць грунтавацца толькі на выніках палеанталагічнага вывучэння заключаных у іх арганічных рэшткаў. Тым не менш, менавіта петраграфічныя асаблівасці выкарыстоўваюцца як асноўныя амаль ва ўсіх папярэдніх публікацыях, у якіх закранаюцца пытанні абласцей паходжання фрагментаў асадкавых парод, пераадкладзеных у плейстацэне на тэрыторыі Беларусі. Вынікі, атрыманыя без выкарыстання палеанталагічных доказаў, нельга лічыць надзейнымі.

У гэтай працы вызначэнне выкапнёвых рэшткаў трылабітаў (*Trilobita* Walch, 1771) упершыню ўжываецца з мэтай удакладнення геалагічнага ўзросту мегакластаў асадкавых парод, перазахаваных ва ўтварэннях плейстацэна Беларусі. На дадзены момант у межах даследаванага рэгіёну адзначаны трылабіты з 15 родаў і падродаў, якія характарызуюць большую частку стратыграфічнай паслядоўнасці карбанатнага ардовіка, развітага ў карэнным заляганні на Усходне-Еўрапейскай платформе. Стратыграфічныя падраздзяленні гэтай паслядоўнасці перакрываюцца разнастайнымі больш маладымі адкладамі на паўночным і паўднёвым захадзе Беларусі, а таксама на тэрыторыі Балтыйскіх краін, і выходзяць на паверхню ў паўночнай Эстоніі і Ленінградскай вобласці Расіі.

Паводле нашага меркавання, даследаваны пераадкладзены матэрыял не абавязкова з'яўляецца вынікам пераносу выключна на вялікія адлегласці, але можа быць перазахаваны таксама і з бліжэйшых карэнных адкладаў ардовіка, перакрытых маладзейшымі ўтварэннямі. Таксанамічны склад выяўленага комплексу ардовікскіх трылабітаў праяўляе падабенства да аналагічных комплексаў з валунных адкладаў паўночных Германіі, Польшчы і Калінінградскай вобласці. У той самы час ён дэманструе выразнае падабенства да трылабітавых асацыяцый з выхадаў сярэдняга і верхняга ардовіка ў паўночнай Эстоніі і Ленінградскай вобласці (Усходне-Балтыйскі рэгіён). Адметна таксама і тое, што некаторыя з сабраных узораў маюць шэраг марфалагічных адрозненняў ад тыповага матэрыялу, апісанага раней у палеанталагічнай літаратуры.

Ключавыя словы: трылабіты; ардовік; пераадкладзеныя дачацвярцёвыя пароды; крыніцы паходжання; асацыяцыі пераадкладзеных трылабітаў.

Мал. 28. Табл. 1. Бібліягр.: 41 назва.

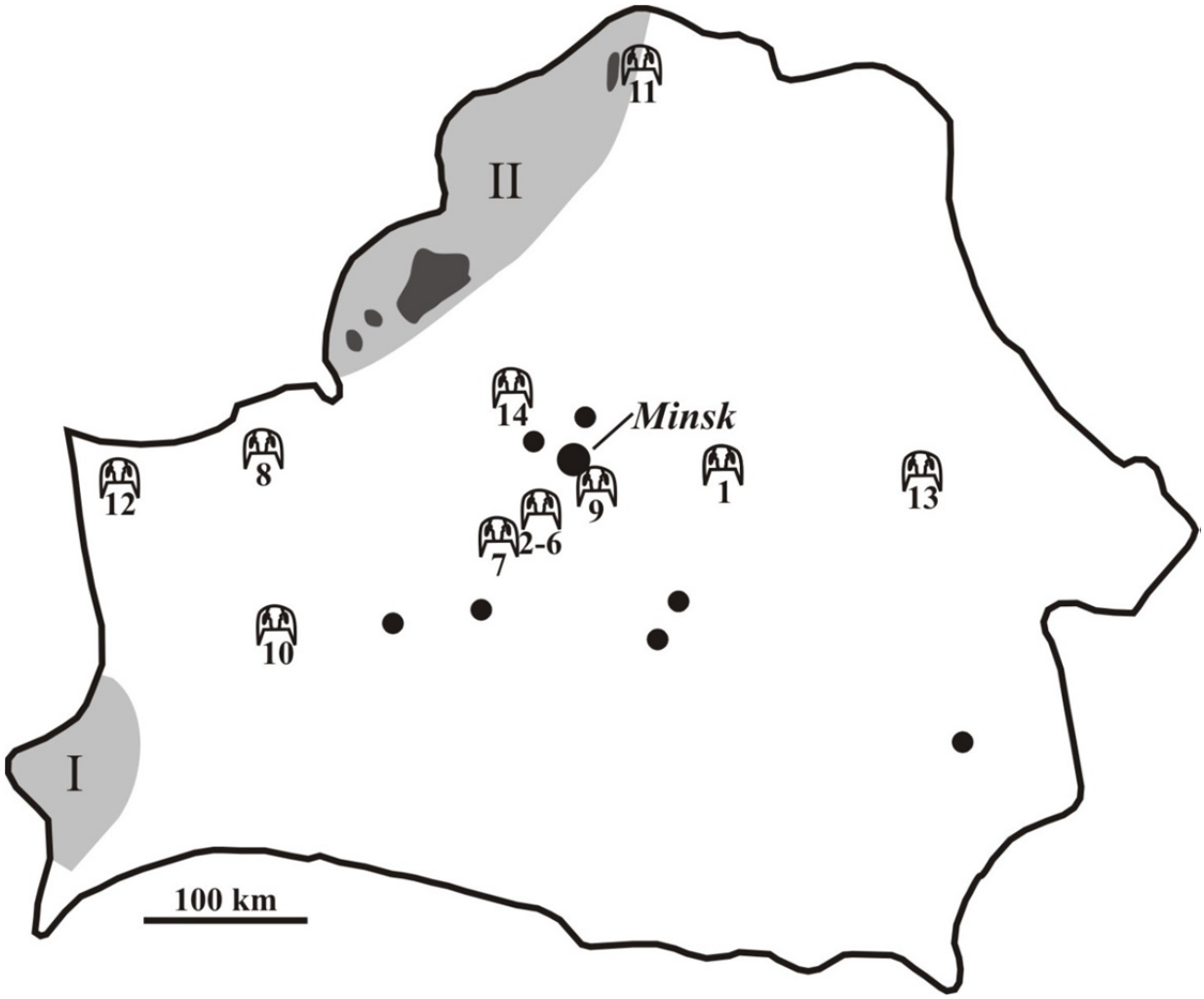
Introduction. In spite of their wide distribution in Paleozoic bedrock strata as well as in Paleozoic carbonate megaclasts enclosed in Pleistocene deposits, trilobites belong to the least studied fossil groups in Belarus. Taxonomic composition and stratigraphic distribution of trilobites have never been targets for a purposeful study. Certain restricted data on their occurrence are confined to quotations in several lists of fossil fauna. The first to mention trilobites in the studied area was A. P. Karpinsky in 1892 [1], who reported occurrence of *Megalaspis planilimbata* Angelin, 1851 and *Ampyx nasutus* Dalman, 1827, in the Middle Ordovician "Glauconite Limestone" (probably Volkhov Regional Stage) in a group of isolated Ordovician "erratic detached massifs" occurring near the village of Rawaničy (outskirts of the town of Bierazino in the Minsk Region). Later A. P. Karpinsky's finds were cited by Fr. Schmidt [2; 3] in his revision of East Baltic trilobites. Some specific names of trilobites were listed in a few subsequent publications in descriptions of paleontological characteristics of borehole cores recovered from buried Ordovician bedrock strata [4—6].

Recent field studies (2013—2016) as well as some data provided by private collectors suggest that erratic trilobites are widespread in Pleistocene sandy and clayey deposits, being particularly frequent on Belarusian Ridge and in the area to the north of it (Figure 1). The present paper considers preliminary results of investigation of the taxonomic composition and the geological age of redeposited Ordovician trilobites and suggests tentative conclusions about possible native areas of their enclosing sedimentary erratic megaclasts.

Geological Setting and Material. The studied material consisting of sedimentary megaclasts enclosing trilobites comes from flat- and cross-bedded sands, gravelly sands, gravels and sandy loams of the Middle Pleistocene Sož and probably the Upper Pleistocene Paazer'e Formations [7] enriched with pebbles and boulders. In terms of the Glacial Theory these deposits are interpreted as "morainic" and "fluvial-glacial", whereas an alternative Non-Glacial Hypothesis [8; 9] explains their origin by sedimentation in a cold-water sea under active flow dynamics, in combination with clastic material delivery by shore-fast ice and also with redeposition of residual material originating from Ordovician bedrock strata occurring nearby, including fractured and rounded rock fragments and debris produced in faults.

Identified Ordovician trilobites collected as Pleistocene erratics in the studied territory are listed below in the table 1 in stratigraphic order. Some more material represented by solitary parts could not have been identified with confidence and therefore have not been taken into consideration.

A vast majority of identified trilobite specimens are Upper Ordovician and fewer are Middle Ordovician, whereas Lower Ordovician trilobites have not been collected so far (Figures 2—28).



— areas of occurrence of buried Ordovician bedrock strata (**I** — South-Western and **II** — North-Western Structural-Facial Zones);

— areas where Ordovician bedrock strata are subjacent directly to Quaternary deposits;

— findings of Ordovician erratic megaclasts with unidentifiable fragments of trilobites;

— **1—14** — localities: **1** — "erratic detached massifs" near the village of Rawaničy (after A. P. Karpinskij [1]); sand and gravel pits: **2** — Ledniki-1, **3** — Zosina, **4** — Čarkasy, **5** — Biareža, **6** — Mazury, **8** — Yeramejewičy; **9** — Stajki, **11** — Puscielniki, **14** — Radaškawičy; **7** — Aliokhaŭka River near the village of Dzieščanka, **10** — outskirts of the town of Slonim; **12** — the town of Hrodna; **13** — outskirts of the town of Mahilioŭ

— раёны пашырэння адкладаў ардовіка, перакрытых пародамі іншага ўзросту (**I** — Паўднёва-Заходняя і **II** — Паўночна-Заходняя структурна-фацыяльныя зоны);

— плошчы, на якіх карэнныя пароды ардовіка перакрываюцца непасрэдна чацвярцёвымі адкладамі;

— знаходкі пераадкладзеных мегакластаў ардовіка з невызначанымі фрагментамі трылабітаў;

— **1—14** — месцазнаходжанні: **1** — «адорвені» каля н.п. Раванічы (паводле А.П. Карпінскага [1]); кар'еры: **2** — Леднікі-1, **3** — Зосіна, **4** — Чаркасы, **5** — Бярэжа, **6** — Мазуры, **8** — Ерамеевічы, **9** — Стайкі, **11** — Пустэльнікі, **14** — Радашковічы; **7** — бераг р. Алёхаўкі каля в. Дзешчанка; **10** — раён г. Слоніма; **12** — г. Гродна; **13** — раён г. Магілёва

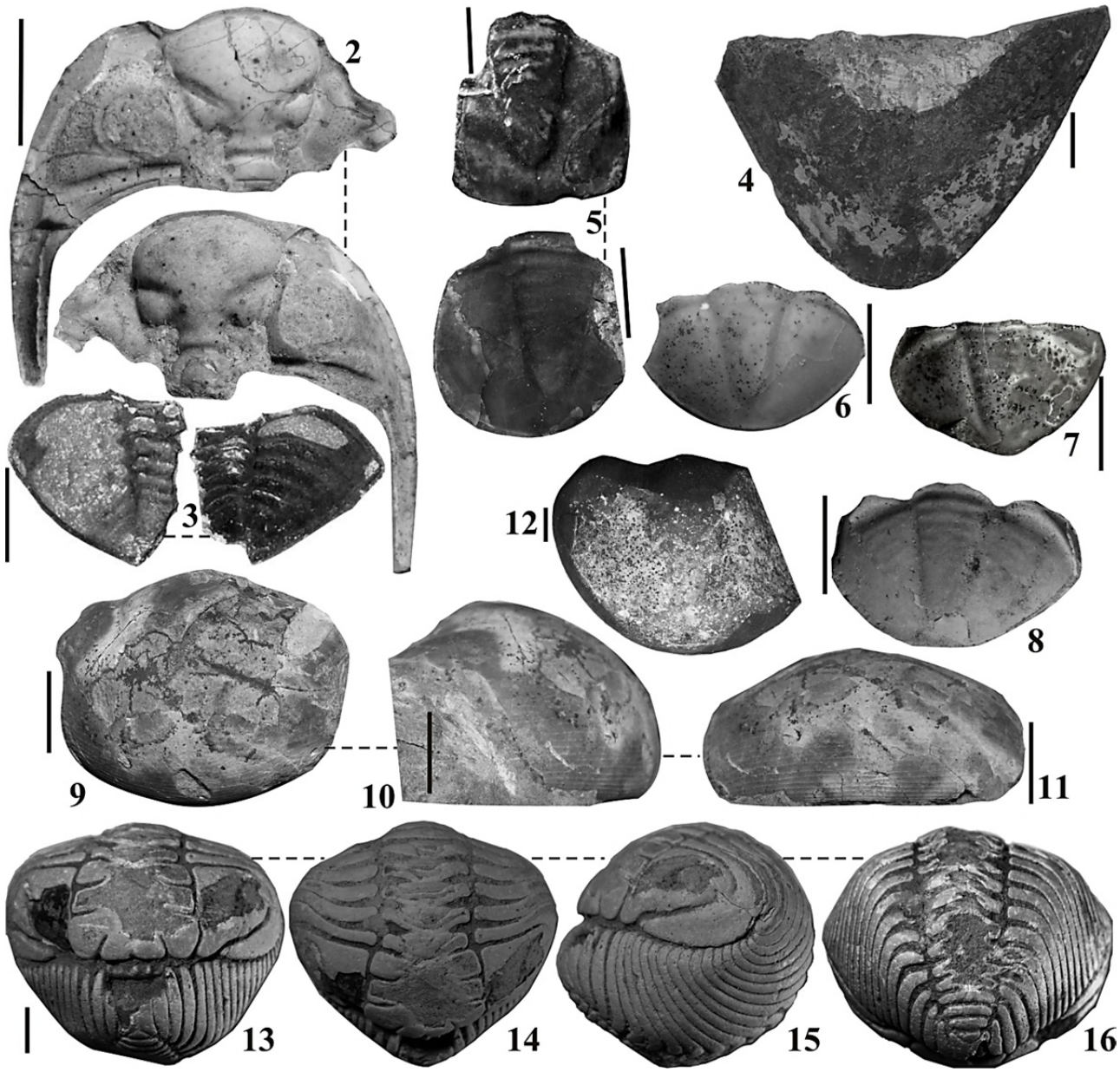
Figure 1. — Localities of Ordovician erratic trilobites in Belarus (as of 2016)

Малюнак 1. — Месцазнаходжанні пераадкладзеных трылабітаў ардовіка ў Беларусі (вядомыя на 2016 год)

T a b l e 1. — Taxon names and stratigraphic position of Ordovician trilobites from Pleistocene erratics of Belarus

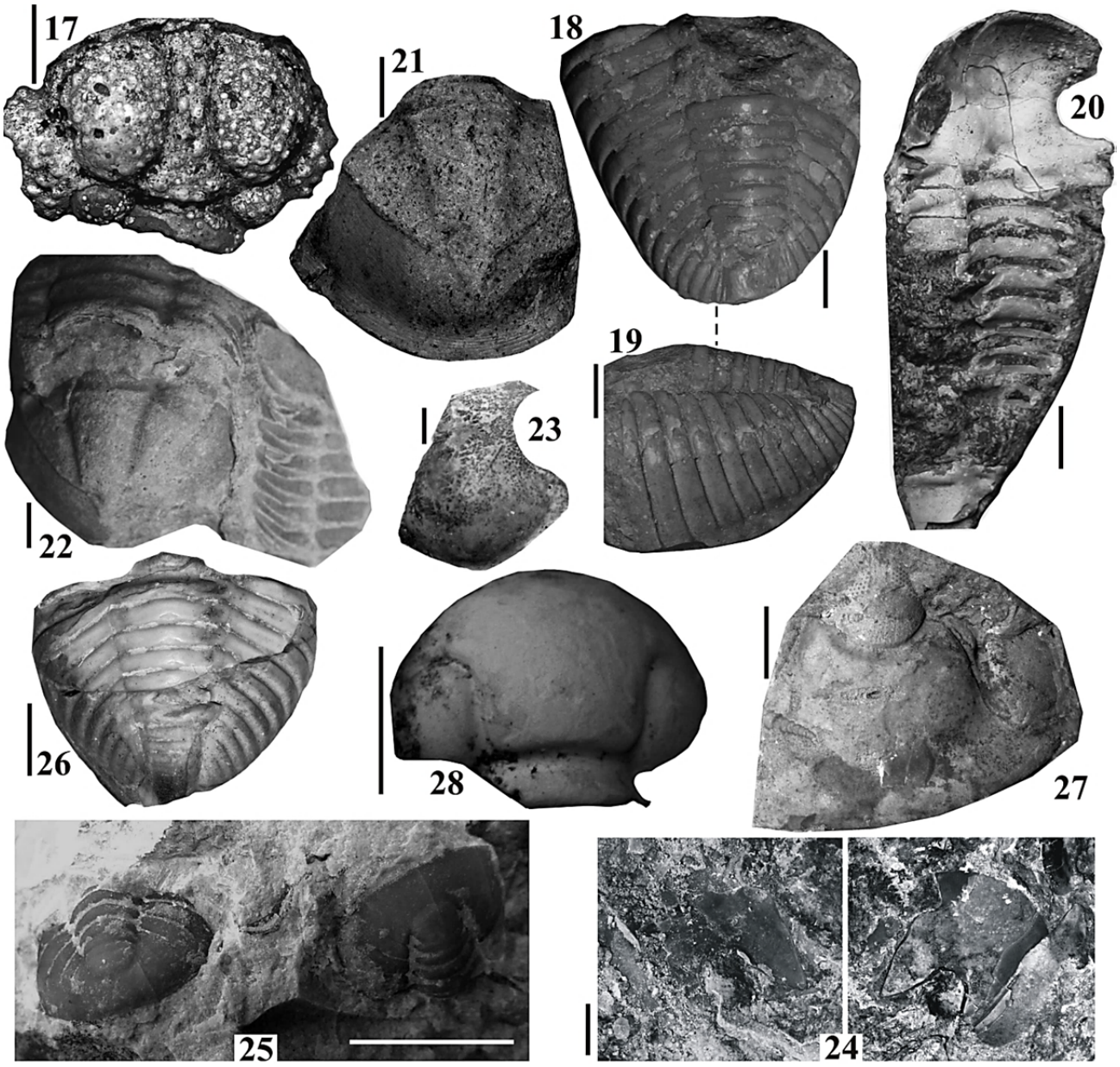
Т а б л і ц а 1. — Назвы таксонаў і стратыграфічнае распаўсюджванне трылабітаў з валуноў і галек ардовікскіх парод у адкладах плейстацэна Беларусі

Presumed stratigraphic position (Baltoscandian Regional Stages)	Taxon name	Locality
O_2, Dapingian, Volkhov Stage **(B_{II})** ("Glauconite Limestone")	*Megistaspis* (*Rhinoferus*) cf. *hyorrhina* (Leuchtenberg, 1843)	Sand pit of Liedniki-1 near Fanipal (Dziaržynsk District)
O_2, Darriwilian, Kunda Stage **(B_{III})**	*Pliomera fisheri fisheri* (Eichwald, 1825)	Outskirts of the town of Mahilioŭ
O_2, Darriwilian, Aseri—Uhaku Stages **(C_Ia—C_Ic)**	*Illaenus* ex. gr. *excellens* Holm, 1886	Sand pit of Liedniki-1 near Fanipal (Dziaržynsk District)
O_{2-3}, Darriwilian—Sandbian, Uhaku—Kukruse Stages **(C_Ia—C_{II})**	*Chasmops odini* (Eichwald, 1840)	Sand pit of Zosina near Fanipal (Dziaržynsk District)
	Asaphus (*Postasaphus*) *nieszkowskii nieszkowskii* (Schmidt, 1898)	
O_3, Sandbian, Kukruse Stage **(C_{II})**	*Chasmops* ex. gr. *odini* (Eichwald, 1840)	Sand pit of Liedniki-1 near Fanipal (Dziaržynsk District)
	Estoniops cf. *exilis* (Eichwald, 1840)	
	Asaphus (*Postasaphus*) *nieszkowskii nieszkowskii* (Schmidt, 1898)	
? O_3, Sandbian, Kukruse Stage **(C_{II})**	*Asaphus* (*Neoasaphus*) sp.	The city of Hrodna
O_3, Sandbian, Jõhvi Substage **(D_I)**	*Asaphus* (*Postasaphus*) *nieszkowskii jewensis* (Schmidt, 1898)	Aliokhaŭka River near the village of Dzieščanka (Uzdziensky District)
? O_3, Sandbian, Jõhvi Substage **(D_I)**	*Asaphus* sp.	Sand pit of Zosina near Fanipal (Dziaržynsk District)
O_3, Sandbian, Keila Stage **(D_{II})**	*Asaphus* (*Postasaphus*) *nieszkowskii kegelensis* (Schmidt, 1898)	The city of Hrodna; ballast quarry of Radaškavičy (Maladziečna District)
? O_3, Sandbian, Keila Stage **(D_{II})**	*Conolichas deflexa* (Angelin, 1854)	Sand pit of Čarkasy near Fanipal (Dzieržynsk District)
O_3, Sandbian, Haljala—Keila Stages **(C_{II}/D_I—D_{II})**	*Keilapyge laevigata* (Schmidt, 1881) *Chasmops* sp.	Sand pit near the village of Biareža near Fanipal (Dziaržynsk District)
? O_3, Katian, Oandu Stage **(D_{III})**	*Toxochasmops* sp.	Sand pit of Zosina near Fanipal (Dziaržynsk District)
O_3, Katian, Oandu—Rakvere Stages **(D_{III}—E)**	*Isotelus* (*Isotella*) *remigium* (Eichwald, 1858)	Ballast quarry of Radaškawičy (Maladziečna District); sand pit of Mazury near Fanipal (Dziaržynsk District)
? O_3, Katian, Oandu—Rakvere Stages **(D_{III}—E)**	*Stenopareia* ex. gr. *linnarssoni* Holm, 1886	Sand pit of Zosina near Fanipal (Dziaržynsk District)
	Chasmops sp.	
? O_3, Katian, Rakvere Stage **(E)**	*Toxochasmops* sp.	Sand pit of Stajki (Minsk District)
? O_3, Katian, Nabala—Vormsi Stages **(F_Ia—F_Ib)**	*Valdariops* sp.	Sand pit near abandoned village of Puscielniki, outskirts of Sarja (Verkhnyadzvinsk District); outskirts of the town of Slonim
? O_3 or S_1	*Sphaeroxochus* sp.	Sand pit near the village of Yeramejeviči (Lida District)



Figures 2—16. — **Middle and Upper Ordovician erratic Trilobites of Belarus. 2** — *Chasmops odini* (Eichwald), cephalon and its mould, **O_3C_Ia—C_{II}**, sand pit of Zosina; **3** — *Chasmops* ex. gr. *odini* (Eichwald), pygidium, **O_3C_{II}**, sand pit of Liedniki-1; **4** — *Megistaspis* (*Rhinoferus*) cf. *hyorrhina* (Leuchtenberg), pygidium, **O_2B_{II}**, sand pit of Liedniki-1; **5** — *Asaphus* sp., pygidium and its mould, **O_3D_I**, sand pit of Zosina; **6—7** — *Asaphus (Postasaphus*) *nieszkowskii nieszkowskii* (Schmidt): **6** — pygidium, **7** — pygidium (inner surface), **O_3C_{II}**, sand pit of Liedniki-1; **8** — *Asaphus* (*Postasaphus*) *nieszkowskii jewensis* (Schmidt), pygidium (mould), **O_3D_I**, Aliokhaŭka River near the village of Dzieščanka; **9—11** — *Illaenus* ex. gr. *excellens* Holm, head shield: **9** — upper view, **10** — side view, **11** — front view, **O_3C_Ia—C_Ic**, sand pit of Liedniki-1; **12** — *Stenopareia* ex. gr. *linnarssoni* Holm, pygidium, **O_3D_{III}—E**, sand pit of Liedniki-1. All scale bars are 5 mm; **13—16** — *Pliomera fisheri fisheri* (Eichwald), **B_{III}**, outskirts of the town of Mahilioŭ: **13** — front view, **14** — upper view, **15** — side view, **16** — back part of thorax and pygidium. All scale bars are 5 mm

Малюнкі 2—16. — **Пераадкладзеныя трылабіты Беларусі: сярэдні і верхні ардовік. 2** — *Chasmops odini* (Eichwald), цэфалон і яго ядро, **O_3C_Ia—C_{II}**, кар'ер Зосіна; **3** — *Chasmops* ex. gr. *odini* (Eichwald), пігідый, **O_3C_{II}**, кар'ер Леднікі-1; **4** — *Megistaspis* (*Rhinoferus*) cf. *hyorrhina* (Leuchtenberg), пігідый, **O_2B_{II}**, кар'ер Леднікі-1; **5** — *Asaphus* sp., пігідый і яго ядро, **O_3D_I**, кар'ер Зосіна; **6—7** — *Asaphus (Postasaphus*) *nieszkowskii nieszkowskii* (Schmidt): **6** — пігідый, **7** — пігідый (унутраная паверхня), **O_3C_{II}**, кар'ер Леднікі-1; **8** — *Asaphus* (*Postasaphus*) *nieszkowskii jewensis* (Schmidt), пігідый (ядро), **O_3D_I**, р. Алёхаўка, раён в. Дзешчанка**; 9—11** — *Illaenus* ex. gr. *excellens* Holm, галаўны шчыт: **9** — выгляд зверху, **10** — бакавы выгляд, **11** — выгляд спераду, **O_3C_Ia—C_Ic**, кар'ер Леднікі-1; **12** — *Stenopareia* ex. gr. *linnarssoni* Holm, пігідый, **O_3D_{III}—E**, кар'ер Леднікі-1; **13—16** — *Pliomera fisheri fisheri* (Eichwald), **B_{III}**, раён г. Магілёва: **13** — выгляд спераду, **14** — выгляд зверху, **15** — бакавы выгляд, **16** — задняя частка торакса і пігідый. Усе маштабныя палоскі роўныя 5 мм



Figures 17—28. — Upper Ordovician erratic Trilobites of Belarus. 17 — *Conolichas deflexa* (Angelin), cranidium, ?**O_3D_{II},** sand pit of Čarkasy; **18—19** — *Toxochasmops* sp., pygidium, ?**O_3(E),** sand pit of Stajki (**18** — upper view, **19** — side view); **20** — *Asaphus* (*Neoasaphus*) sp. (inner surface of cephalon and thorax), ?**O_3C_{II},** the town of Hrodna; **21—22** — *Asaphus* (*Postasaphus*) *nieszkowskii kegelensis* (Schmidt): **21** — pygidium, ?**O_3D_{II},** ballast quarry of Radaškavičy; **22** — pygidium with a reminder of thorax, ?**O_3D_{II}**, the town of Hrodna; **23—24** — *Isotelus (Isotella) remigium* (Eichwald): **23** — mould of glabella, **O_3D_{III}—E,** sand pit of Mazury, **24** — hypostome, **O_3D_{III}—E,** ballast quarry of Radaškavičy; **25** — *Keilapyge laevigata* (Schmidt), pygidia, **O_3D_I—D_{II},** sand pit near the village of Biareža; **26** — *Valdariops* sp., pygidium, ?**O_3F_Ia—F_Ib,** outskirts of the town of Slonim; **27** — *Valdariops* sp., ?**O_3F_Ia—F_Ib,** librigena, eye, sand pit near the village of Puscielniki; **28** — *Sphaeroxochus* sp., cranidium, **O_3** or **S_1**, sand pit near the village of Yeramejewičy. All scale bars are 5 mm

Малюнкі 17—28. — Пераадкладзеныя трылабіты Беларусі: верхні ардовік. 17 — *Conolichas deflexa* (Angelin), кранідый, ?**O_3D_{II},** кар'ер Чаркасы; **18—19** — *Toxochasmops* sp., пігідый, ?**O_3(E),** кар'ер Стайкі (**18** — выгляд зверху; **19** — бакавы выгляд); **20** — *Asaphus* (*Neoasaphus*) sp. (унутраная паверхня цэфалона і торакса), ?**O_3C_{II},** г. Гродна; **21—22** — *Asaphus* (*Postasaphus*) *nieszkowskii kegelensis* (Schmidt): **21** — пігідый, ?**O_3D_{II},** кар'ер Радашковічы, **22** — пігідый з рэшткамі торакса, ?**O_3D_{II}**, г. Гродна; **23—24** — *Isotelus (Isotella) remigium* (Eichwald): **23** — ядро глабелы, **O_3D_{III}—E,** кар'ер Мазуры, **24** — гіпастома, **O_3D_{III}—E,** кар'ер Радашковічы; **25** — *Keilapyge laevigata* (Schmidt), пігідыі, **O_3D_I—D_{II},** кар'ер каля в. Бярэжа; **26** — *Valdariops* sp., пігідый, ?**O_3F_Ia—F_Ib,** раён г. Слоніма; **27** — *Valdariops* sp., ?**O_3F_Ia—F_Ib,** рухомая шчака, вока, кар'ер каля в. Пустэльнікі; **28** — *Sphaeroxochus* sp., кранідый, **O_3** ці **S_1**, кар'ер каля в. Ерамеевічы. Усе маштабныя палоскі роўныя 5 мм

Presumably the oldest representative in the studied material is *Megistaspis* (*Rhinoferus*) cf. *hyorrhina* (Leuchtenberg) (Figure 4) from erratic boulders and pebbles of the "Glauconite Limestone" of the Volkhov Regional Stage **(B_{II}).** *Megistaspis (Rhinoferus) hyorrhina* (Leuchtenberg) is known in Ordovician bedrock outcrops of northern Estonia, St. Petersburg Region of Russia, Norway and Sweden [10—12]. It was also reported from erratic boulders in Sweden [13] as well as from "Ordovician detached erratic massifs" in Novgorod and Tver' Regions of Russia [14—17].

An almost complete loose enrolled specimen of *Pliomera fisheri fisheri* (Eichwald) (Figures 13—16) most probably represents erratics of the Kunda Regional Stage **(B_{II})** and is typical of the "Lower Oolite Limestone" of St. Petersburg Region and northern Estonia. Also the same subspecies was collected by A. V. Krylov from the "Orthoceratite Limestone" (Kunda Regional Stage) in "Ordovician detached massifs" of the Tver' Region of Russia. *Pliomera fisheri* (Eichwald) is uncommon in Ordovician bedrock strata outside of the above-listed East Baltic areas, although it was reported from erratic boulders in Western Europe (e.g. in "Münsterländer Kiessandzug", northwestern Westphalia, Germany) [18].

Erratic megaclasts of strong yellow-brown dolomitic limestone with *Illaenus* ex. gr. *excellens* Holm (Figures 9—11) are related by the authors to the stratigraphic interval of the Aseri to Uhaku Regional Stages **(C_Ia—C_Ic).** *Illaenus excellens* Holm is widespread in Aseri to Uhaku strata of Estonia and the St. Petersburg Region [19; 20] and was collected by A. V. Krylov (unpublished data) from "Ordovician detached erratic massifs" in Novgorod and Tver' Regions of Russia.

Buried bedrock deposits of the Volkhov to Aseri stratigraphic interval occur in southern and northwestern parts of Belarus, where they are subjacent to younger strata and are represented by the Prybuhskaya and Miadzelskaya Formations (Volkhov Regional Stage), Pivorskaya and Tviariačuskaya Formations (Kunda Regional Stage), and the Daŭbnioŭskaya and Miorskaya Formations (Aseri and possibly Lasnamägi Regional Stages) [7]. These strata extend northwardly and crop out in northern Estonia and St. Petersburg Region.

Pebbles of light grey detrital limestone with *Chasmops odini* (Eichwald) (Figure 2) and *Asaphus (Postasaphus) nieszkowskii nieszkowskii* (Schmidt), which are usual in Uhaku **(C_Ic)** and Kukruse **(C_{II})** Regional Stages, are here considered as being of uppermost Middle to lowermost Upper Ordovician age. The two above-mentioned trilobite species are widespread in Ordovician bedrock strata in Latvia, Estonia and St. Petersburg Region [20—27], whereas in erratic boulders they were reported from the Kaliningrad Region, northern Poland [28], northern Germany [29], as well as from "Ordovician detached erratic massifs" in Yaroslavl' Region of Russia [17].

Boulders of very dense light-brown and dark-grey limestone enclosing fragments of *Chasmops* ex. gr. *odini* (Eichwald) (Figure 3), *Estoniops* cf. *exilis* (Eichwald), *Asaphus (Postasaphus) nieszkowskii nieszkowskii* (Schmidt) together with reticulate Bryozoa, Gastropoda and Brachiopoda represent the Kukruse Regional Stage **(C_{II})**. Petrographically this limestone is almost identical to limestone samples collected by A. V. Krylov from outcrops of the Kukruse Regional Stage in St. Petersburg Region. A boulder of light-grey limestone enclosing several pygidia and other parts of *Asaphus (Postasaphus) nieszkowskii nieszkowskii* (Schmidt) (Figures 6—7) is probably also of Kukruse age.

Trilobite representatives similar or identical to the above listed were reported from buried and exposed Ordovician bedrock strata in Latvia, Estonia and St. Petersburg Region [20; 21; 23; 26; 27]; many of them are known from erratic boulders in the Kaliningrad Region, northern Poland, northern Germany, and Sweden [13; 28; 29], and were collected in "Ordovician detached erratic massifs" of Yaroslavl Region of Russia [17].

Uhaku and Kukruse Regional Stages in Belarus are represented by the Kraštajskaya and Kriaŭnoskaya Formations in the North-Western Structural-Facial Zone and by the Liasovičskaya Formation in the South-Western Structural-Facial Zone, where they are covered by younger deposits [7].

Buried Uhaku and Kukruse strata also occur in Lithuania and Latvia and are exposed in northern Estonia and St. Petersburg Region.

Erratic megaclasts of the Haljala Regional Stage (Jõhvi Substage, **D_I**) are represented in the studied material by a weathered limestone pebble enclosing microgastropods and a pygidium of *Asaphus (Postasaphus) nieszkowskii jewensis* (Schmidt) (Figure 8). This trilobite subspecies is known in Ordovician bedrock strata in northern Estonia [20; 22—25; 30] and in Pleistocene erratic boulders in northern Germany, northern Poland and Kaliningrad Region [28]. Pebbles of dense grey limestone with *Asaphus* sp. (Figure 5) probably should also be attributed to the Jõhvi Substage. These erratics are apparently identical to the so-called "Testudinaria-Limestone", which are widespread as Pleistocene erratics in northern Germany and in some other areas of Western Europe (J. Koppka, personal communication). Similar trilobites were earlier reported from Ordovician bedrock strata of northern Estonia and St. Petersburg Region [20; 23; 31], as well as in erratics of Kaliningrad Region and northern Poland [28].

The following trilobite species (subspecies) have been revealed in petrographically inhomogeneous erratic boulders and pebbles of the Keila Regional Stage **(D_{II})**:

– *Asaphus* (*Postasaphus*) *nieszkowskii kegelensis* (Schmidt) (Figures 21—22), enclosed in dense light-grey and yellowish limestone;

– *Conolichas deflexa* (Angelin) (Figure 17), enclosed in a weathered silicified white pebble of bioclastic conglomerate consisting of an agglomeration of Brachiopoda and Trepostomid bryozoans;

– *Keilapyge laevigata* (Schmidt) (Figure 25), enclosed in dense light-grey to greenish limestone;

– *Chasmops* sp., enclosed in an angular boulder of yellow-brown secondary dolostone.

The above-listed or similar trilobite representatives are known from exposures of the Keila Stage in northern Estonia and St. Petersburg Region [20—25; 31; 32; unpublished data by A. V. Krylov] and in Pleistocene erratics of northern Poland, northern Germany and Kaliningrad Region [28; 33]. *Conolichas deflexa* (Angelin) was reported also in erratics in Westphalia in northwestern Germany [18] and in the erratic "Macrourus limestone" in the Moravian-Silesian area in the Czech Republic [34].

Within the North-Western Structural-Facial Zone in Belarus the Jõhvi to Keila buried bedrock strata are represented by the Vangiškinskaya Formation and in the South-Western Structural-Facial Zone the middle part of the buried Navasiolkaŭskaya Formation roughly corresponds to the same stratigraphic interval [7]. Jõhvi to Keila strata are exposed in northern Estonia and in St. Petersburg Region.

The following erratic material is ascribed to the Oandu **(D_{III})** and Rakvere **(E)** Regional Stages:

– loose pygidia of *Toxochasmops* sp. (Figures 18—19) (tentatively), which can be distinguished by comparatively wide pleural sides;

– pebbles of dense grey crinoid-brachiopod detrital limestone with fragments of *Isotelus* (*Isotella*) *remigium* (Eichwald) (Figure 23) and also an erratic pebble of greenish-grey clayey limestone with an isolated hypostome of the same trilobite species (Figure 24).

The above-mentioned or similar trilobite representatives are known from Ordovician bedrock strata in northern Estonia and St. Petersburg Region [10; 21; 23; 35—37] and were revealed also in erratic boulders of northern Germany and Sweden [13; 29].

Probably of Rakvere age is a specimen of *Stenopareia* ex. gr. *linnarssoni* Holm (Figure 12) from a dense light-grey limestone erratic boulder, which is petrographically similar to the Rakvere bedrock limestone exposed in the limestone quarry of "Pechurki" in St. Petersburg Region. The specimen differs from typical *Stenopareia linnarssoni* Holm by a comparatively narrower rachis of the pygidium. This species was reported earlier from Ordovician bedrock strata in Norway, Sweden,

northern Estonia and from the extreme west of St. Petersburg region near Estonia [19; 36; 38—40]; in erratic boulders it occurs in Kaliningrad Region and northern Poland [28].

In the territory of Belarus the Oandu and Rakvere buried bedrock strata are known only within the North-Western Structural-Facial Zone and are represented there by the Smarhonskaya Formation (Oandu Regional Stage), which overlays older Ordovician strata with a regional stratigraphic break, and by the lower part of the Strustaŭskaya Formation (Rakvere Regional Stage) [7]. Both Oandu and Rakvere bedrock strata extend to the north and are exposed in Estonia and in the western part of St. Petersburg Region.

A pebble of dense grey limestone with a fragment of *Valdariops* sp. (Figure 27) is presumably attributed to the interval of the Nabala **(F_1a)** and Vormsi **(F_1b)** Regional Stages. Also collected is a loose pygidium of *Valdariops* sp. (Figure 26). Similar forms of *Valdariops* were reported from Ordovician outcrops in northern Estonia [21; 41] and from Pleistocene erratics in northern Germany [29].

Buried bedrock strata of Nabala and Vormsi Regional Stages in Belarus occur in the North-Western Structural-Facial Zone and are represented by the upper part of the Strustaŭskaya Formation and the Naračanskaya Formation [7]. These strata extend to the north and are exposed in Estonia.

Erratic trilobite material of younger Ordovician age (Pirgu and Porkuni Regional Stages) have not been discovered as yet, although boulders and pebbles of these stratigraphic intervals are quite abundant in Belarus and can usually be identified reliably by enclosed tabulate corals and brachiopods [unpublished data by Yu. Zaika].

Discussion. ***Geographic and stratigraphic confinement.*** As is obvious from the foregoing data, erratic megaclasts in Pleistocene coarse-grained and clayey accumulations represent a major part of the regional Middle and Upper Ordovician succession, which occurs buried in the northwestern and southwestern parts of Belarus and in its bordering areas within the Padliassie-Brest Depression, and the Valyn' and Baltic Monoclines. In this context, it should be taken into consideration that on the basis of previously published regional-geological data Ordovician bedrock strata in Belarus in several places are subjacent directly to Pleistocene deposits, e.g. in a comparatively large area to the north of the towns of Smarhon' and Viliejka as well as in several restricted sites near the towns of Ašmiany, Hlybokaje and Vierchniadzvinsk [5; 7]. In view of this, it can be presumed that Ordovician megaclasts in Pleistocene gravels, sands and sandy loams in the studied territory are not necessarily objects of long-distance transport from the Scandinavian-Baltic region, which is traditionally accepted in most published sources, but might also be a result of natural physical disintegration of local Ordovician deposits in the past and subsequent transportation of their derivative megaclasts over a comparatively short distance (up to several tenth of kilometers). This could be especially likely in those areas where Ordovician bedrock strata are directly covered by Quaternary accumulations. A comparatively dense system of faults cutting pre-Quaternary deposits in Belarus [7] should also be taken into account as a probable factor in the formation of megaclasts and their subsequent delivery to Pleistocene covering strata.

Taxonomic composition of the "trilobite erratic complex". Trilobites revealed in Ordovician sedimentary erratics in Pleistocene accumulations of Belarus comprise a composite complex of taxa that shows quite apparent similarity with erratic trilobite associations from northern Germany, northern Poland and Kaliningrad Region of Russia. At the same time it is not wholly typical for bedrock outcrops of northern Estonia and St. Petersburg Region. Some distinct characteristics of the Belarusian erratic trilobite assemblage are the comparatively frequent occurrence of asaphid and chasmopid trilobites (among which there are peculiar representatives of *Valdariops* with short pygidia) and also the occurrence of megistaspid trilobites possessing an indistinct border of the pygidium. Some other trilobite representatives are common mostly in Estonia and St. Petersburg

Region but are not typical in Scandinavia and are comparatively rare in erratics in Western Europe, for example *Pliomera fisheri fisheri* (Eichwald). Scarcity of available erratic trilobite material from Belarus at this time makes any further reliable conclusions difficult. A more detailed comparison will be possible after more material is studied.

Conclusions. The concept of Quaternary glaciations, which prevails in geological literature, explains the formation of sandy and clayey deposits enriched with boulders and pebbles by former activity of hypothetical Pleistocene Scandinavian glaciations. According to this concept, megaclastic material is mostly *a priori* interpreted as being allochthonous and is considered to have come from bedrock exposures occurring in northern Estonia, in St. Petersburg Region, on islands of the Baltic Sea, from the Baltic Sea bottom and also from some areas in Scandinavia. At the same time an alternative hypothesis, which denies Pleistocene continental glaciations, considers delivery of megaclastic erratics by shore-fast ice transportation during the hypothetical Late Cenozoic cold sea flooding. It could be postulated that formation of megaclastic material along fault zones as well as by activity of some other non-glacial factors could also take place. The authors of the present paper don't absolutely call into question the concept of distant delivery of megaclasts. But in view of the above-mentioned considerations we are not certain that the assumption that erratic megaclasts are predominantly allochthonous should be unconditionally accepted. Instead, we think it could be assumed that buried bedrock strata that are comparatively nearby or local could be likely sources of pre-Quaternary blocks, boulders and pebbles. We expect that further studies will substantially supplement our current incomplete knowledge about Ordovician erratic megaclasts and thereby give us new means of understanding how Pleistocene strata were formed.

In its turn, further detailed investigation of taxonomic composition of the erratic trilobite association occurring in sandy and clayey Pleistocene deposits of Belarus will allow a wider comparison with trilobite assemblages from Ordovician bedrock strata as well as from Pleistocene erratics of nearby areas (e.g. south- and northwestern parts of Belarus, Lithuania and Latvia), as well as of more distant regions.

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Палеанталагічнае вывучэнне мегакластаў даплейстацэнавых асадкавых парод, якія з'яўляюцца кампанентам чацвярцёвых утварэнняў, неабходна для дакладнага вызначэння іх стратыграфічнай прымеркаванасці, што ў сваю чаргу з'яўляецца асновай для атрымання надзейных высноў пра раёны знаходжання іх карэнных крыніц. З гэтымі мэтамі ў мегакластах парод ардовіка (вапнякі і даламіты) з плейстацэнавых пяскоў і супескаў упершыню для тэрыторыі Беларусі праведзена вызначэнне таксанамічнай прыналежнасці выкапнёвых рэшткаў трылабітаў (*Trilobita* Walch). Выяўлены прадстаўнікі 15 родаў і падродаў, пашыраных у карэнных адкладах у розных інтэрвалах сярэдняга і верхняга ардовіка Усходне-Еўрапейскай платформы. Трылабіты з гэтай асацыяцыі трапляюцца ў комплексах фаўны з валунных адкладаў паўночнай Германіі, Польшчы і Калінінградскай вобласці Расіі, а таксама ў агаленнях карэннага ардовіка ў паўночнай Эстоніі і Ленінградскай вобласці Расіі. Выказваецца меркаванне, што даследаваны матэрыял мог мець полірэгіянальнае паходжанне і як з'яўляцца вынікам пераносу на параўнальна вялікія адлегласці з раёнаў выхаду карэнных адкладаў, так і быць перазахаваным з больш блізка размешчаных утварэнняў ардовіка, пераважна ў паўночна-заходняй Беларусі і Балтыйскіх краінах, дзе яны перакрыты маладзейшымі пародамі.

Паступіла ў рэдакцыю 15.02.2017