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Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

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ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
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НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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G. K. Ergaliev, V. G. Zhemchuzhnikov, T. Ye. Pirogova

Satbaev University, Institute of Geological Sciences named after K. I. Satpaev", Almaty, Kazakhstan.
E-mail: svenax@bk.ru, vyacheslav-zhemchuzhnikov@yandex.kz, ta.pira@mail.ru,

CAMBRIAN OF THE NORTH-WESTERN BALKHASH AREA

Abstract. For the first time in recent decades, the revision of the Cambrian sequence of the northwest Balkhash area was carried out, basing on a comprehensive study of the observed earlier and newly acquired field and archived data, as well as on information, published in professional geological literature. The stratigraphic correlation of different facies of terrigenous-carbonate-siliceous deposits was established utilizing both the collected fossil marine fauna and flora and the lithological characteristics. The sections were measured, and the lithostratigraphic units (suites) specified and incorporated within the modern International Stratigraphic Scale.

Key words: cambrian, stratigraphy, suite, section, carbonate and terrigenous, siliceous, trilobite, conodont, Balkhash.

Research history. The Early Paleozoic successions dated by the Cambrian are known in the northwest of the Balkhash lake. This vast area was named the Atasu-Zhamshi watershed [1], that is, the area located between the rivers Atasu and Mointy. In geological literature, one can find also another naming of the Atasu-Mointi watershed. Starting from the 1980s, 40 km west of the Balkhash town, near the Sarykum railway station, a section was studied in full sequence, dated by the interval from the middle Cambrian to the middle Ordovician, lying on dolomites and limestones of the Bosaga suite conditionally dated to the undifdferentiated Vendian to Lower Cambrian. The Bosaga dolomites were also studied in the original outcrops to the south from the Gulshad gore. These facts expand the presence of geologically homogeneous deposits to the east, up to the longitude of the Balkhash town, and this area is limited to the drying-up valley of the Zhamshi River (figure 1A).

The history of the stratigraphic study of the Atasu-Zhamshi watershed successions is described by E.V.Alperovich [1] and D.V.Voznesensky [32]. The Lower Paleozoic formatuions here are known since long ago. For long, their stratigraphic age and volume were conditional. The first finds of the Early Paleozoic trilobites were made in 1952 by A.G. Gokoev, and then in the 1950s, basing on results of the first systemic geological survey and academic studies, the so-called "Silurian Carbonates" were divided into the Cambrian and Ordovician sediments [6, 17, 32].

Until the mid-1980s, sites with fossil fauna of the Cambrian trilobites and brachiopods were known in the mid-reaches of the Shazhagai river (figure 1B), in the carbonates of the Kyzylzhar suite [1] and in the Shundy mountains (fig. 2A) - these are the sections near the mount Aksuran and the Zhaksybulak spring in the terrigenous sandstone units of the Aksuran suite [1, 29, 32]. Definitions of the faunistic remnants were made: for trilobites by G.K.Ergaliev, N.V.Pokrovskaya, N.K.Ivshin, L.N.Kraskov and M.K.Apollonov, and for brachiopods by E.A.Balashova, I.F.Nikitin and L.E.Popov [1, 29, 32, 33].

The first recorded on Late Cambrian trilobites and inarticulate brachiopods of the Sarykum railway station are in publication A.V.Zaichkina et al. [33], with reference to definitions of the fossil fauna collection by L.N.Kraskov and L.E.Popov. In 1984-86, in the territory of the Sarykum block, geologists of the Balkhash Geosurvey Expedition I.I.Kolesnikov and D.K.Muratbekov carried out prospecting works for lead and zinc. Several trenches were dug out there, also small exploratory wells drilled, so that in two trenches no.11 and no.20, V.G.Zhemchuzhnikov discovered Cambrian trilobites in 1985 [34]. He collected rock samples for the microfauna study, where S.V.Dubinina and L.E.Popov [4, 9, 19] discovered the

conodonts and inarticulate brachiopods. The first definitions of Cambrian and Ordovician fauna of trilobites from the Sarykum section were made by M.K.Apollonov [4] and A.V.Zakharov (1989, not published data).

In 2004, T.E.Pirogova and N.A.Azerbaev, under the guidance of the academician G.K.Ergaliev, carried out thematic works in sections of the Kyzylzhar suite along the Shazhagay river and the Aksuran suite of the Shundy mountains. As a result, trilobite fauna collections were repeated from the known sites, and in 2018, under the paid thematic works T.E.Pirogova and V.G.Zhemchuzhnikov, guided by G.K.Ergaliev, repeated collections of trilobite fauna from the trench no.20 at the Sarykum railway station and in the area of the Aksuran mount.

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Geological settings. The complexity of the geological framework of the area is explained by the tectonics and the fact that the Lower Paleozoic sediments are covered by the Upper Paleozoic ones. This fact and the fragmented nature of the outcrops do not allow establishing the initial configuration of the basin through direct observations. Having stratigraphic and facial features of the Lower Paleozoic sediments, obtained in late 1980s [4, 34], three facial zones of Shazhagai, Sarykum and Kiik were individuated in the paleobasin from east to west (figure 1A).

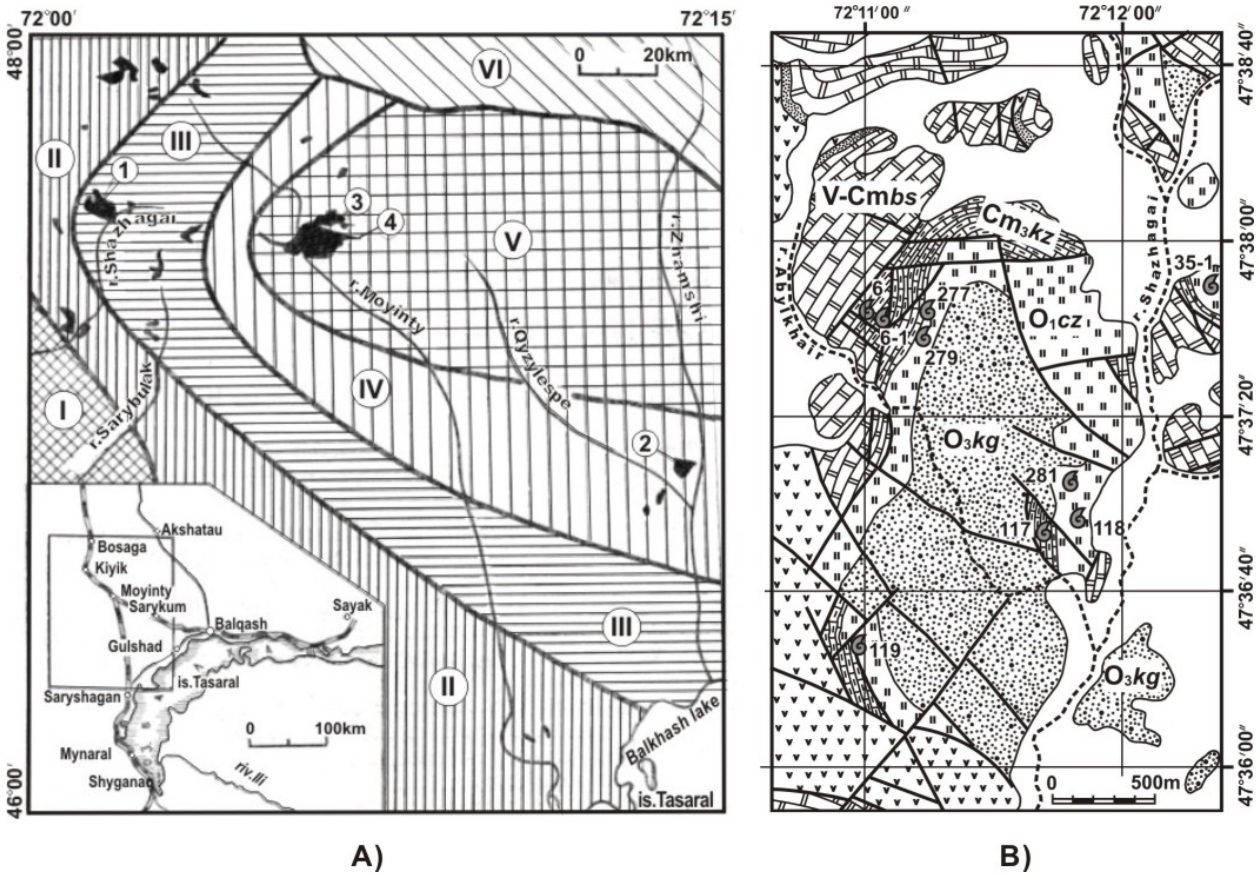

Figure 1A – Regional geological subdivisions of Cambrian deposits of the North-West Balqash area:
I. the Buryntai zone, II-V. the Atasu-Zhamshi zone; subzones: II. Kyzyltau, III. Shazhagai, IV. Sarykum, V. Kiik;
VI. Agadyr-Qyzyl-Yespe zone. Stratotype section: 1. Shazhagai, 2. Sarykum, 3. Zhaksybulak, 4. Aksuran.
Figure 1B – Geological scheme of the Shazhagai site (figure 2: the legend).

Generally, the boundaries of the Early Paleozoic paleobasin coincide with the outlines of the Vendian and Early Paleozoic folded structure and to some extent repeat the outlines reconstructed by A.E.Alperovich [1], but are more detailed. Main criteria to determine the facial zones are the nature and completeness of the sections, composition and facial features of the Lower Paleozoic beds (see figure 3).

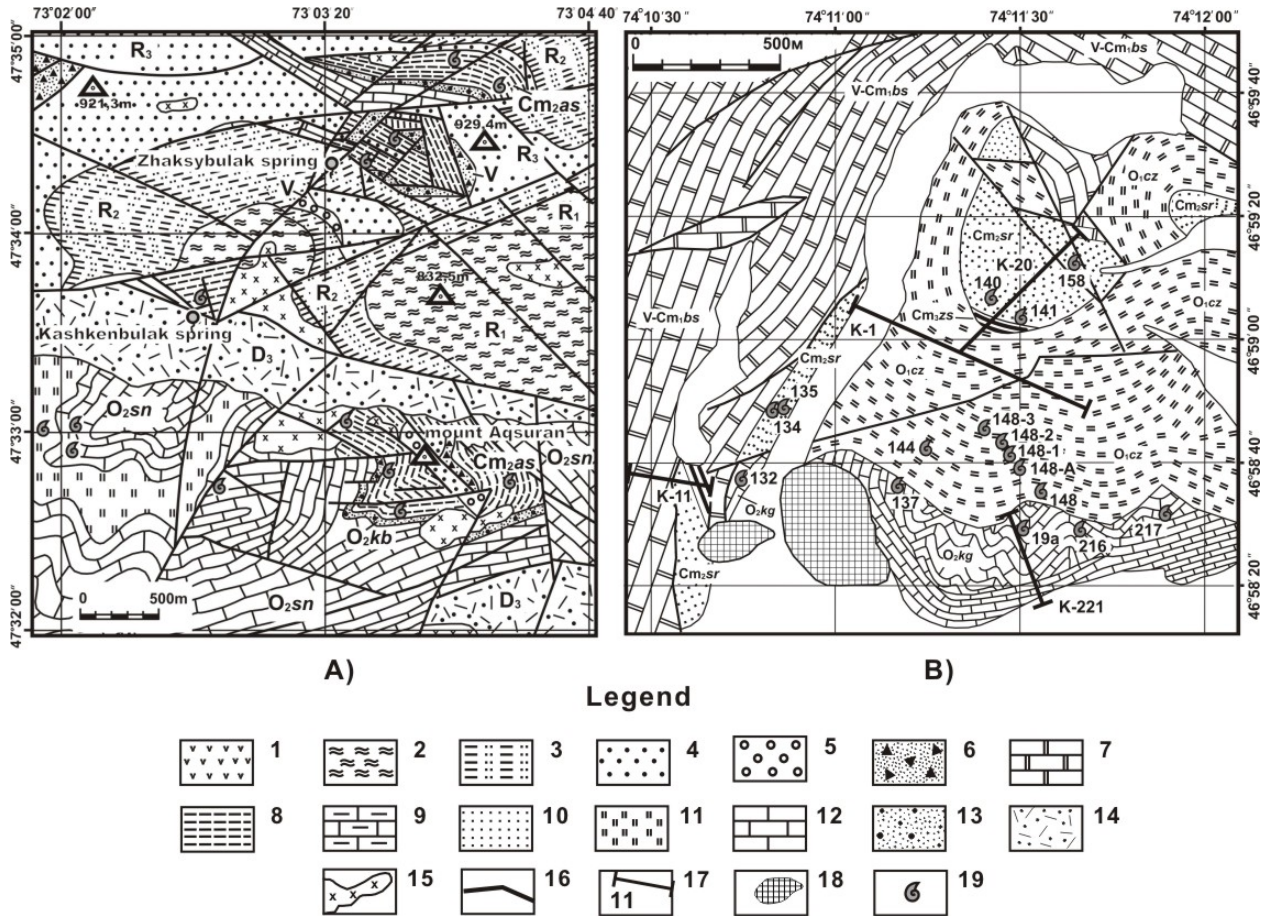

Figure 2A – Geological scheme of Kiyik location. (Pupyshev and others, 1973).
Figure 2B – Geological scheme of Sarykum location [30].

Legend: 1 - Vendian porphyric granite, Upper Riphean suites; 2 - shales, 3- carbon-rich-shales & carbonate-terrigenous shales, 4 - quartzite sandstone; 5 - Vendian conglomerate and sandstone, 6 - Vendian tillite, sandstone and dolomite, 7 - dolomites of Bosaga suite, 8 - thin bedded and fine grain terrigenous rock, 9 - thin bedded detrital limestone, 10 - alternating carbonate-terrigenous beds, 11 - black chert, 12 - Ordovician limestone, 13 - Ordovician conglomerate, 14 - Devonian acidic volcanic rock, 15 - Devonian acidic intrusive rock, 16 - fault, 17 - exploration trench and sequential number, 18 - carbonate quarry, 19 - fauna locality. Suite symbol on the map: bs – Bosaga, sr – Sarykum, zh – Zhamshi, cz – Shazagai, kc – Kurshilik, kg – Kogedei, ak – Aksuran, kb – Kashkenbai, sn – Shundy.

In the Kiik facial zone, the Lower Palaeozoic succession is represented by a terrigenous units with interlayers of limestones and phosphorites, dated to the Middle-Late Cambrian. Above are carbonate deposits of the Llandeilian-Caradocian. The sequence of the upper Cambrian and lowermost Ordovician deposits is not proved here by fauna dating.

The succession of the Sarykum zone is the most complete one [4]. There is a continuous sedimentary sequence from the Middle Cambrian to Llanvirnian inclusive. The section's structure is the most complit. It is composed of successive terrigenous, carbonate and siliceous beds. Proven by fauna Cambrian units are underlain by the carbonate beds of Bosaga suite, conditionally dated to the Vendian-Lower Cambrian and composed of massive dolomites, with oncolites and stromatolites.

The succession of the Shazhagai facial zone is represented by carbonates and flints covering the interval from the Middle Cambrian to the Llanvirnian. There are also no proven deposits of the Upper Cambrian and Tremadocian in this subzone. The Middle Cambrian part of the section is also underlain by Bosaga suite dolomites.

Cambrian Stratigraphy. Cambrian units of the Atasu-Zhamshi area are reliably studied on the Shazhagai, Aksuran, Zhaksybulak and Sarykum locations (figure 3). In the west, in the middle course of the Shazhagai river, they are composed of multifacial rocks, massive thin-bedded limestones of grey and

dark-grey colour, and at several localaties trilobites of the Mayan stage of the uppermost Middle Cambrian were collected. Further to east of the railway station Kiik, in the central part of the region in the Shundy mountains, in the section near the Aksuran town, they are replaced by thin-bedded terrigenous siltstones and fine-grained sandstones also with trilobites of the Mayan stage of the Middle Cambrian. In the section near the Zhaksybulak spring they are underlain by terrigenous sandstones, which contain Amgian stage trilobites. In the same place, Middle Cambrian phosphorites were explored in trenches. Here, the section concludes with the Upper Cambrian terrigenous Zhaksybulak suite with carbonate interlayers, where trilobites of the lowermost Upper Cambrian were found.

At the Sarykum railway station, trenches opened an intermediate section represented by interlayered terrigenous green and brownish sandstones and massive dark-grey bedded limestone, referred to the Sarykum suite with trilobites and inarticulate brachiopods of the Mayan stage of the uppermost Middle Cambrian. Above they are replaced by interlayered massive brecciated limestone and thin-bedded fine-grain detrital limestone with layers of black cherts of the Zhamshi suite with trilobites and conodonts of the Upper Cambrian.

In the Shazhagai and Sarykum zones, the lowermost complex is represented by the Bosaga suite, which has no reliable faunal dates. It consists of two sub-suites; the first one is composed of oolitic, brecciated and massive thin-layered dolomites, which reach a thickness of 800-2500 m, and the second one is the same massive carbonates, mainly dolomites, with columnar stromatolites up to 1400 m thick. Of these, B.Sh.Klinger described: oncolites *Osagia caudate* Kor., *O.gigantea* Kor., *O.granulata* Kl., *O.senta* Z.Zhur., *O.kingbreensis* Zabr., *Volvatella gigantean* Kl., *V.lancea* Kl., as well as catagraphies *Nubecularites punctatus* Z.Zhur., *N.catagraphus* Reitl., *N.parvus* Z.Zhur., *Hieroglyphites mirabilis* Reitl., *H.rotundus* Z.Zhur. [1, 32]. In the east part of the district, near the Sarykum railway station, on the right bank of the Zhamshi river and the Akkirek mountains, the pattern was also observed here, when the Bosaga suite is split in two parts: the lower part, darker, with the thin-layered structure and oncolites, and the upper one, of lighter colour, with black cherts interlayers, the lower part with columnar stromatoliths, often forming biohermes and biostromes, stretched for 200m and 5-25m thick. Oncolites and catagraphies here were studied by N.S.Krylov, with marking of some of them: *Osagia ukka* N.Kryl., *O.monolamellosa* Z.Zhur., *O.carticosa* Nar., *O.balchashensis* Kryl., *Volvatella vadosa* Z.Zhur., *V.zonalis* Nar., *Nubecularites* sp., *Vesicularites bothrydiaformis* (Krasnop.), *V.*cf. *šubinensis* Zabr., *Medullarites lineolatus* Nar., *Conferta* sp. [32].

The middle part of section the Bosaga carbonates contains stromatolites: layred, columnar and domal, of which K.N.Konyushkov defined: *Linella* sp., *Stratifera* sp., *Jurusania* sp., *Paniscollenia emergens* Komar?, *Boxonia* sp. [33].

The above stromatolites and microphytolites belong to the Upper Proterozoic-Lower Cambrian intermediate complex [1, 29, 32], so the stratigraphic volume of the Bosaga suite is still defined as the Vendian to Lower Cambrian one.

The Bosaga suite in the Shazhagai zone lies on fornmations which N.A.Pupyshev attributed to the Bylkyldak suite, composed of interlayered dolomites and sandstones, among which there are layers of fine pebble conglomerates. It reaches thickness of 20-250 m. This suite, in turn, is underlain by the Kazan-Syngan suite 400-850 m thick, dominated by coarsely clastic terrigenous sediments: crossbedded sandstones, gravelites, and fine pebble conglomerates [29]. The age of this pair of suites was conventionally dated by the Vendian, which is consistent with the regional model of the Uppermost Proterozoic formations, when the section is coarsened by the "tillite-like" conglomerates of the Baikonur suite in the Big Karatau and Ulutau, as well as the Kyrshabakti suite of the Lesser Karatau. This coarse-clastic complex of the Upper Proterozoic everywhere covers by fauna proven Cambrian sediments [10, 11, 23, 24].

The stratigraphic interval overlying the Bosaga carbonates is represented by the Kyzylzhar suite formed by gray and dark-grey thin-layered limestone, their more granular detrital and brecciated differences. The most complete section of this suite, up to 460 m thick, is exposed on the western part of the Shazhagai syncline (fig. 1A). Trilobites collected by N.A.Pupyshev [29], among which G.K.Ergaliyev and M.K.Apollov identified *Acrocephalus sp., Lisania sp., Fuchouia sp., Goniagnostus sp, Dorypyge sp., Solenopleura sp., Hypagnostus sp., Peronopsis sp., Nepeidae and Anomocaridae,* dating these sediments by the Mayan stage of the Middle Cambrian age.

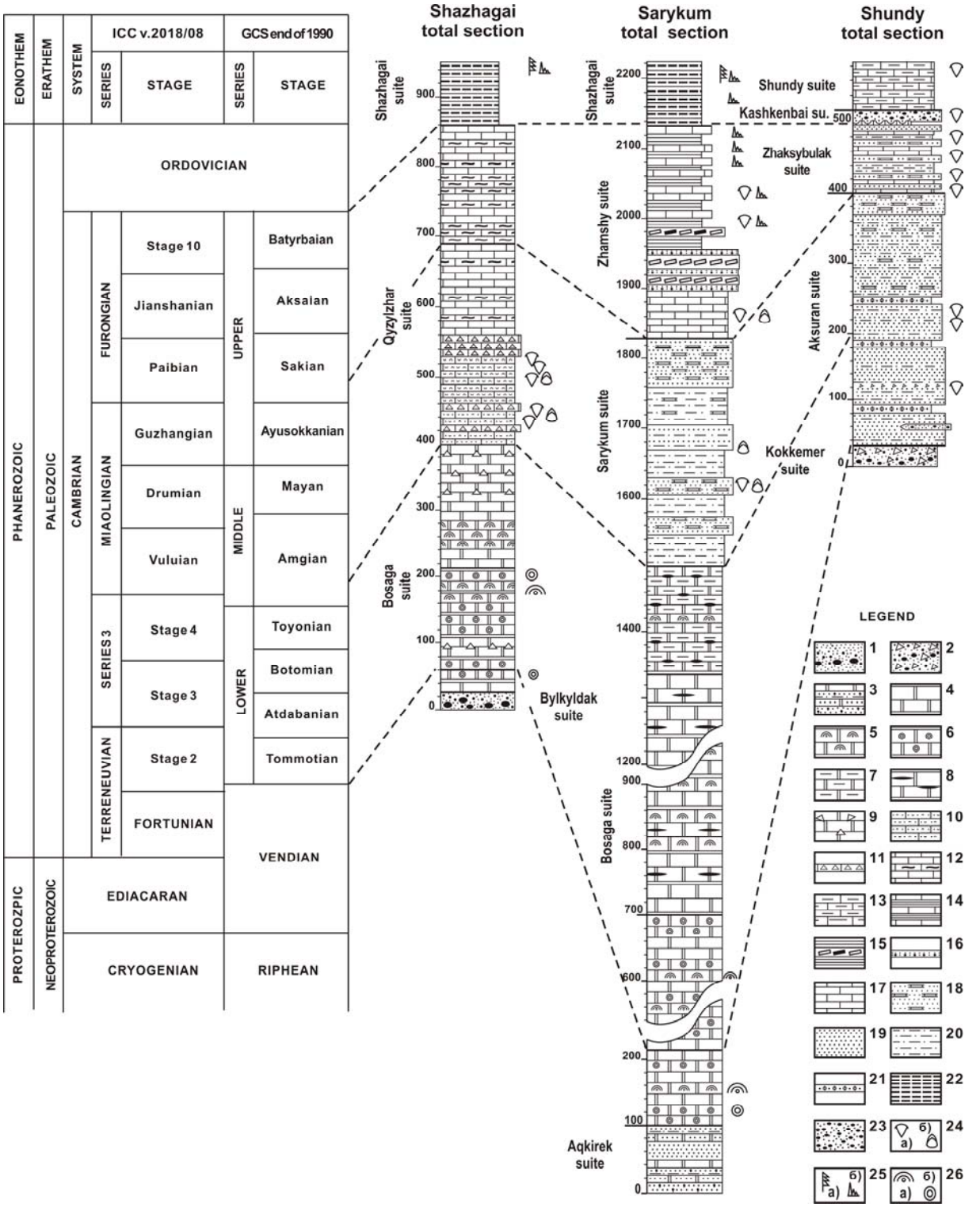

Figure 3 – Correlation of stratigraphic columns of Cambrian deposits of the North-Western Balkhash area.

Legend: 1 - coarse grain conglomerate, 2 - tillite, 3 - alternation sandstone, glauconitic sandstone and dolomites, 4 - massive dolomite, 5 - stromatolitic dolomite, 6 - oncolitic and coated grain dolomite, 7 - thin-bedded dolomite, 8 - dolomite with black chert nodules, 9 - brecciated dolomite, 10 - detrital limestone, 11 - carbonate breccia, 12 - thin wavy-laminated limestone, 13 - thin parallel-laminated limestone, 14 - alternation of shales and parallel bedded limestones, 15 - braccia with carbonate and chert fragments, 16-carbonate turbidite, 17 - thin-bedded dark grey limestone, 18 - terrigenous sandstone with carbonate matrix, 19 - sandstone, 20 - siltstone, 21 - phosphorites, 22 - cherts, 23 - basal conglomerate, 24 - trilobite(a) and inarticulate brachiopod(b), 25 - graptolite(a) and conodont(b), 25 - stromatolite(a) and oncolite(b).

The coordinates of the beginning of the Shazhagai section: 47°37'52.5" N, 72°10'20.29" E. In 2004, at the location of 47°37'52.2" N, 72°10'20.4" E, trilobites were re-collected in grey, fine-grained limestone with prevailing fine horizontal and sparsely cut undulating layering of 3.1 m from the base of the ditch: *Peronopsis sp., Ptychagnostus sp., Doryagnostus sp., Bailiella sp., Agraulos ? sp., Amphoton sp.*, the inarticulates *Obolellidae gen. et sp. indet., Prototreta? sp. Botsfordia ? sp.*, and at 5,25 m above the section, found were the trilobites *Ptychagnostus sp., Elyx? sp., Bailiaspis sp*.

Then, at the point of 47°37'51,9" N, 72°10'24,2" E, in dark-grey fine-grained organogenic clastic limestone, an abundant fauna of trilobites was gathered: *Doryagnostus sp., Peronopsis sp., Ptychagnostus sp*., *Bailiella sp.* and the rare inarticulates: *Obolellidae gen. et sp. indet., Acrotretidae gen. et sp. indet.*, the rare inarticulates *Prototreta sp., Anabolotreta? sp., Botsfordia? sp., Obolellidae gen. et sp. indet.* the conodonts of *Phakelodus tenuis* (the fauna P-2163). 22.85 m to south found were the trilobites *Doryagnostus sp., Peronopsis sp., Amfoton sp*. at the locatiion of 47°37'51,9" N, 72°10'24,54" E.

The coordinates of the end of the section: 47°37'51,84" N, 72°10'28,2" E.

A different Cambrian section represented by the Sarykum suite of interlaying terrigenous and carbonate rocks [2, 19, 34] was found to east of the Sarykum railway station in the trench no.20 (figures 2B and 3). The coordinates of the beginning of this trench are 46°59'14,45 "N and 74°11'40,72 "E, and the end of the trench is 46°58'54,20" N and 74°11'20,40 "E. The suite structure includes interlayered packages of siltstones, polymytictic and feldspar quartz medium-fine sandstones, interlayers of thin-bedded sandy limestone. The upper part is dominated by limestone breccias and detrital limestone of packstone. The rocks' limestone content increases noticeably in the upper part of the section. The feldspar-quartz sandstones can be divided to very, medium and slightly calcareous ones. The colour of the rocks varies from brownish red and grayish-brown to yellow-green, light and dark grey.

The Sarykum suite can be divided into two sub-suites.

The lower subsuite is characterized by a rhythmic interlayering beds. Each rhythm at the base is composed of coarser layers of limestone sandstones, and on the top, the rhythms are represented mainly by siltstones. The brownish-red and red polymictic sandstones and siltstones at the base above are changing for yellow differences. Turbidites with gradational layering are also noted here. In such beds one can distinguish the chanal forms of base. The upper part of the lower subsuite has a coarser up composition, i.e., different granular turbidite sandstones of green and yellowish-green colour. Packages of siltstones are typical. The thickness of the subsuite is 320 m.

The upper subsuite is composed mainly of limestone. Terrigenous sandy material is present in turbidites in the Buma rhythm Ta. Limestones are mainly represented by fine grain differences. In the lower part they are of light tones with red, yellow or brown tincture. At the top of the interlayers are small unsorted pebble-flat polyclast breccias represented by fragments of limestone turbidite beds, which alternate the fine-grained dark grey limestone. The thickness of the subsuite is 100 m.

The lower boundary of the suite is sharp and is lined-up along the first layer of terrigenous rocks, overlaying of the Bosaga dolomites. The upper boundary of the suite is determined by the first appearance of black and dark grey chert layers with layers of breccias, relating to the Zhamshi suite.

The age of the Sarykum suite has been established by trilobites found here and inarticulate brachiopods as the Middle Cambrian [34]. Among trilobites, A.V.Zakharov (1989) determined *Hypagnostus parvifrons* Linnarsson, *Goniagnostus (Allodochus) buckleyi Tago, G.bicanes Zhen*, *Pseudophalacroma praecox* (*Öpik), Lejopyge aff. calva Robins., L. armata (Linnarsson), L.laevigata (Dalman), Kormagnostus* sp. et al. Inarticulate brachiopods are represented in the lower part of the section by such forms as *Linnarssonia ophirensis (Walcott), Anabolotreta diversa Koneva, Stilpnoreta magna Henderson and MacKinnon, Treptotreta cf. jucunda Henderson and MacKinnon*, which correspond to the Mayan stage of the Middle Cambrian [19]. In the section's tops, in the upper subsuite M.K.Apollonov [4] defined *Pseudagnostus* sp. и *Parakoldinia* sp., and L.E.Popov determined inarticulate brachiopds *Anabolotreta diversa Koneva, Stilpnoreta minuta Canthilotreta tenuis sp.nov., Dactylotreta septata sp.nov., Picnotreta karakichiensis sp.nov*. They referred this faunistic complex to base of the Upper Cambrian [19].

The total thickness of the suite reaches 420 m.

The Zhamshi suite overlies of the Sarykum suite units and is studied in the trenches 20 and 11. It has also been opened with shallow wells. The suite is composed of interlayered packs of various dark thin-

layered chert, grey limestone, and sometimes carbonate-siliceous brown rocks on the weathered surface, but of dark grey colour of fresh chips. The suite is characterized by an upward decrease in the granularity of deposits. There are siliceous limestone breccias and large-plated gradation detrital limestone in the lower reaches. Among cherts, the most common are thin-layered and massive black phthanites. The uppermost suites are characterized by lime-siliceous shales.

The trilobite fauna, revealed in sediments of the suite, is represented by: *Rhaptagnostus sp., Neoagnostus sp., Lotagnostus (Eolotagnostus) scrobicularis* Ergaliev*, Lotagnostus asiaticus* Lu*, Lotagnostus hedini (*Troedson*), Hedinaspis sp., Charchaqia sp.* [4, 34]. Here also have been found the conodonts *Cordylodus lindstromi* Druce et Jones*, Cordylodus prion* Lindström*, Cordylodus proavus* Müller*, Eoconodontus notchpeakensis (*Miller*), Prooneotodus rotundatus (*Druce et Jones*), Phakelodus tenuis (*Mùller*)* [4, 9]. It is necessary to note that the entire faunistic complex is currently considered as confined to the Upper Cambrian and establishes the 10 terminal Cambrian stage of the Upper Furongian series [5].

Immediately above this complex, or 3m below, under the black Shazhagai flints, in the well 51 at depth of 84 m, in the carbonate-siliceous rocks, trilobites Micragnostus sp., et Koldiniodia sp., were found together with conodonts *Chosonodina herfjurti* Mùller, *Rossodus manitouensis* Repetski et Ethington, *Cordylodus rotundatus* Pander, *Acanthodus linearis* (Furnish), *Scalapodus* sp., *Drepanoistodus* sp., *Hertzina* sp., *Phakelodus* sp., which is currently considered as confined to the most bottoms of the Tremadocian stage of the Ordovician period [8]. Immediately above them there are the flints of the Shazhagai suite, where found in the 148, 148-A, 148-1, 148-2 and 148-3 were high Tremadocian and Lower Arengian conodonts *Drepanoistodus deltifer* (Lindström), *D.proteus* Lindström, *D.acuatus* Pander, *Paracordylodus gracilis* Lindström et al. [4]. Close conodont complexes corresponding to the Cambrian tops and Ordovician base were studied by T.Yu.Tolmacheva [31] on the western shore of the lake Balkhash in several siliceous sections of the Burubaital suite.

Below the Sarykum suite there is the Bosaga suite, which already described. This suite is underlain by the Vendian-Lower Cambrian carbonate-terrigenous unit, which is considered in this article as a new Akkirek suite, composed of brown, gray, greenish-gray quartz and oligomitic sandstones, siltstones, clay shales, glauconite sandstones, sandstones with lime-dolomite cement, limestone, clayish and sandy dolomites. The rocks are mainly thin-bedded, and sandstones are often bimodal cross-bedded. Its thickness is estimated at 100-500 m. The given suite by structure and stratigraphic position can correlate with Kyrshabakti suite of the Lesser Karatau [28] which is dated by the upper Vendian and where available the absolute age dating of 570 million years, received on glauconites from sandstones.

A completely different Cambrian section was studied in the Kiik subzone (figure 3), which is represented by terrigenous rocks of argillites, siltstones and sandstones, and where the fossil fauna of trilobites was studied at several levels corresponding to the Middle and Upper Cambrian. As elsewhere, the section at the base of the Cambrian is underlain by a coarse-clastic "tilloid" Akkelenti suite with conglomerates of sandstones and dolomites, dated to the Upper Vendian and is preceded by the Keneli suite of the Lower Vendian, composed of boulder conglomerates and sandstones. Just above them, deposits belonging to the Kokkemer suite formed by phosphate-bearing siltstones, sandstones and gravelites have been studied, but there is no phosphate material at the base of the suite. Only sponges were found here from organic remnants [21]. The thickness of this suites is 10-50 m and maximally measured at 73 meters; it is compared to the Chulaktau suite, which is represented by carbonate-siliceous phosphate thickness with well-proven micro- and skeletal fauna of the Lower Cambrian age [11, 24].

The Aksuran suite deposits lay stratigraphically higher and conformably to the phosphorite sandstones.

The bottom part of the Aksuran suite is fully distributed around the Zhaksybulak water source (figure 2A) and is represented by siltstones, phosphate-bearing sandstones and phosphorites. Found were trilobites *Schistocephalus sp., Olenoides sp., Chondagraulos sp., Dawsonia sp., Pseudanomacarina sp., Peronopsis (Acadagnostus) sp. Pokr.,* which allowed G.K.Ergaliyev, N.V.Pokrovskaya and N.K.Ivshin give a conclusion about their belonging to the Amgian stage of the Middle Cambrian [29]. Here the Aksuran suite bottoms reach 170 m.

The coordinates of the beginning of the section are 47˚ 34' 26.04" N., 73˚ 04' 31.56" E.

The upper part of the Aksuran suite is fully represented in the section to the west of the Aksuran town (figure 2A). Here it is composed of siltstones, mudstones, clayey and siliceous clayey shales. Sandstones and limestones are rarer. Numerous trilobites have been collected here and, according to L.N.Kraskov's conclusion, they are represented by trilobites of the Mayan stage, such as *Lejopyge laevigata (*Dalm*.), Hypagnostus sulcifer (*Wall*.), Goniagnostus nathorsti (*Brogg*.), G.spinifer* Wgard*, Ptychagnostus aculeatus (*Ang*.), Triplagnostus sp., Cotagnostus* ex gr. *confuses (*Wgard*)*. Locations of this trilobite complex were also found at the Zhaksybulak spring and the Kokkemer gorge [29].

Coordinates of the beginning of the section are 47˚32' 52.3" N, 73˚ 03' 36.2" E.

The Upper Cambrian Zhaksybulak suite completes the Cambrian section of the Kiik subzone and is composed of sandy dolomites, limestone, clay shale, polymytictic and limestone sandstones. At its base, a marker horizon of glauconite limestones and sandstones can be traced. Trilobites were found in the suites' deposits, which L.N.Kraskov defined as *Agnostus aff. simplexiformis* Ros*. and Phaldagnostus longus sp.nov.* Kras*., Agnostoglossa* aff*. bassa* Opik*., Onchonotellus sp., Agnostus sp., A.inexpectans* Kob*.* associated with the lower Upper Cambrian. The thickness of the suite is 82-104m.

Cambrian deposits are uncomformably covered by the Lower Ordovician sediments of the Kashkenbai suite, overlaid by the Ordovician limestone of the Shundi suite [4].

Conclusion. The International Sub-Commission on the Cambrian Sratigraphy is currently working to establish global stratigraphic standards for the Cambrian system and to define the global stratotype and boundary points (GSSP) for its series and stages [18, 30]. After many years of work and analysis of biostratigraphy of the Cambrian unites on separate continents, and discussion in the mid-2000s, researchers of this Sub-Commission decided that the Cambrian system should be divided into four series, as opposed to the classical three series division, for details see discussion in [27]. It was also recommended that series should be divided into ten stages: two stages in the two lower series and three tiers in the two upper series. Index-species of the levels of the first appearance of taxons for stages [5, 18, 30] were also established. These data were published as International Chronostratigraphic Scale of the International Stratigraphy Commission (www.stratigraphy.org). There are also cross-references to the relevant literature. The current status of study of the Cambrian Stratigraphy, as well as the representation of the hierarchy of stratigraphic units at different levels, can be found on the same site, more over representation such information can also be seen on the site of the Sub-Commission on Cambrian Stratigraphy at (www.paleontology.geo.uu.se). Both of these resources are regularly updated, so it is possible to follow the progress made so far.

To date, the International Cambrian Sub-Commission has identified three series that have already been ratified and officially approved by the International Commission on Stratigraphy. It is the lowest Terraneuvian series, as well as the third series called Miaolingian and the upper fourth series called Furongian. Out of the 10 stages, already individuated, ratified and approved for use in the International Stratigraphic Scale, six stages include the lowest Fortunian stage, at the base of which determined was the boundary of the basis of the Phanerozoic Eonothema. The lower boundary of the Cambrian system and he entire Phanerozoic was determined by the first appearance datum (FAD) of ichnofossil *Trichophycus pedum* in the section near the Fortune town in Newfoundland, Canada [7, 23].

This boundary will determine the so-called "the Cambrian explosion" or "the Cambrian radiation", the practically instant and sudden appearance, blossoming and spread of marine skeletal fauna. The work on the second, third and fourth stages continues and should be completed in the near future. The Vuliuan, Drumian and Guzhangian stages, belonging to the Miaolingian series have been ratified and approved, as well as the Paibian and Jiangshanian stages, belonging to the Furongian series; and there remains a vacancy for the set-up of a global stratotype and naming of the last 10th terminal Cambrian stager. The upper boundary of the Cambrian system or the base of the Ordovician system was established in 1998, ratified and approved by the ISS on the first appearance of the conodontic species *Iapetognatus fluctivagus* [8].

In Kazakhstan, Cambrian deposits became known with the discovery in 1932 by the R.A.Borukaev in the Boschekul district (North-East Central Kazakhstan) in the well core of the Upper Cambrian trilobites. In South Kazakhstan, the first trilobites *Kootenia* sp. in the Karatau mountains have been known since the late 1930s, but originally they were erroneously defined as Middle Cambrian. In 1960s, these locations

G.K.Ergaliev re-tested and in the Tamdy limestone a more representative collection of trilobite fauna was obtained just above the Chulaktau phosphorites and defined as Lower Cambrian [11]. At the same time, in base of Chulaktau phosphoritic beds the "small shelly fossil" was found, which made it possible to date the base of Chulaktau suite to the lowermost Cambrian, and the underlying "Lower dolomites" of Burkuti suite to the topmost of Vendian [24].

Reliably, the Archaeocyatha fossil fauna of the Lower Cambrian deposits dated as top of the Aldanian stage was discovered in 1965, in the North-East Kazakhstan, in the Chingiz range, close to the Balkibek river. Thus, by early 1970s, Cambrian sediments had been established in many areas of northern, central, southern and eastern Kazakhstan. The work carried out in the 1960-80s by Kazakhstan stratigraphers was successful and its achievements were expressed in general adoption of the Upper Cambrian Ayusokkanian, Sakian and Aksai stages, singled out by G.K.Ergaliev in the Lesser Karatau [12, 13, 14], supplemented in the late 1990s by the Batyrbaian terminal stage, proposed by M.K.Apollonov, also singled out in the Lesser Karatau [26].

Already in the 1980s and 1990s, specialized work was carried out to establish the upper boundary of the Cambrian system [2, 3, 14], which made it possible to develop in the sections of the Small Karatau and Atasu-Zhamshi a biostratigraphic sequence based on conodonts from the index species of *Cordylodus proavus* to *Cordylodus lindstromi* [4, 9]. Later, the same sequence of the transient conodontic fauna was found in flints in the Zhalair-Naiman zone, in the north-east of Central Kazakhstan and in the Chingiz range [31].

In recent years, new collections of Lower and Middle Cambrian trilobites were collected in the Chingiz range by G.K.Ergaliev and T.E.Pirogova [15, 16], and these data were published.

In the Atasu-Zhamshi region in the North-West of the Balkhash area, the Cambrian deposits are reliably established only for its upper part, that is, there is a sequence, limited to the Cambrian and Ordovician boundary, somewhere in the interval of the conodontic zone of *Cordylodus lidstrome*, which in practical terms almost coincides with the base of flints of the Shazhagai suite and the bottom interval of the Aksuran suite, with trilobites of the Amgian stage. The base of the Cambrian can be assumed as based by presence of a coarse-clastic terrigenous-carbonate level with "tillite-like" conglomerates, which now should be correlated with the tops of the Neoproterozoic or a new individuated system of Cryogeny, corresponding to the lower Vendian, previously widely used in the Kazakhstan geology. This interval is interrupted by thick Bosaga dolomites, at base of which there is a terrigenous-carbonate package with glauconite sandstones, which can be correlated with the Kyrshabakta suite of the Lesser Karatau and is represent by deposits of the Ediacaran system, previously called the Upper Vendian.

Thus, we can conclude that within the Atasu-Zhamshi region there is the Cambrian sequence of deposits (fig. 3), which should be further detailed for the upper half and studied in detail to detect fauna and proofs of the lower half of the Cambrian in the Bosaga suite and base of the Aksuran suite.

Ғ. Қ. Ерғалиев, В. Г. Жемчужников, Т. Е. Пирогова

Сәтбаев Университеті, Қ. И. Сәтбаев атындағы Геологиялық ғылымдар институты,
Алматы, Қазақстан

СОЛТҮСТІК-БАТЫС БАЛХАШ ӨҢІРІНІҢ КЕМБРИЙ

Аннотация. Соңғы онжылдықта алғаш рет ерте және жаңа далалық және қор деректерін кешенді зерттеу, сондай-ақ ашық басылымда жарияланған геологиялық әдебиеттерді кешенді зерттеу негізінде Солтүстік-Батыс Балқаш өңірінің кембриялық бірізділігіне тексеру жүргізілді. Жиналған қазба теңіз фаунасы мен флорасын анықтау негізінде де, литологиялық белгілері бойынша да әртүрлі фациальды терригендік-карбонатты-кремнийлі шөгінділердің корреляциясы орындалды. Тіліктерді бөлу жасалды, литостратиграфиялық бірліктер (свиттер) орнатылды және олар қазіргі Халықаралық Стратиграфиялық Шкаламен біріздендірілген.

Түін сөздер: кембрий, стратиграфия, свит, разрездер, карбонатты және терриген шөгінділері, кремний, трилобиттер, конодонттар, Балқаш.

Г. К. Ергалиев, В. Г.Жемчужников, Т. Е. Пирогова

Сатпаев Университет, Институт геологических наук им. К. И. Сатпаева, Алматы, Казахстан

КЕМБРИЙ СЕВЕРО-ЗАПАДНОГО ПРИБАЛХАШЬЯ

Аннотация. Впервые за последние десятилетия на основе комплексного изучения ранних, новых полевых и фондовых данных, а также опубликованной в открытой печати геологической литературы проведена ревизия кембрийской последовательности Северо-Западного Прибалхашья. Выполнена корреляция разнофациальных терригенно-карбонатно-кремнистых отложений как на основе определения собранной ископаемой морской фауны и флоры, так и по литологическим признакам. Сделано расчленение разрезов, установлены литостратиграфические единицы (свиты), и они унифицированы с современной Международной Стратиграфической Шкалой.

Ключевые слова: кембрий, стратиграфия, свита, разрезы, карбонатные и терригенные отложения, кремни, трилобиты, конодонты, Балхаш.

Information about authors:

Ergaliev G. K., Doctor of Geological and Mineralogical Sciences, Academician of NAN RK, professor, Institute of Geological Sciences named after K. I. Satpaev, Almaty, Kazakhstan; svenax@bk.ru; https://orcid.org/0000-0001-7005-3659

Zhemchuzhnikov V. G., Candidate of Geological and Mineralogical Sciences, Institute of Geological Sciences named after K. I. Satpaev, Almaty, Kazakhstan; vyacheslav-zhemchuzhnikov@yandex.kz; https://orcid.org/0000-0002-1729-0038

Pirogova T. E., Master of Technical Sciences, Institute of Geological Sciences named after K. I. Satpaev, Almaty, Kazakhstan; ta.pira@mail.ru; https://orcid.org/0000-0001-5875-4401

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