

Review of the study of the Ordovician in Tajikistan

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Abstract

The article summarizes the data obtained for the entire period of study of the Ordovician of Tajikistan and previously published in scattered articles or monographs. Now, the given review of the study is the most complete. It takes into account, if possible, all the literature published on the Southern Tien Shan and Pamir, starting from the first faunistic finds in the 20s of the last century and ending with the 21st century; that is, it reflects information, accumulated for almost one hundred year period. The collected data give an idea of the state of knowledge of the Ordovician deposits on the territory of Tajikistan and will help researchers to more easily navigate the extensive list of literature on the Ordovician region.

Keywords: Ordovician, Llandovery, Tajikistan, South Tien Shan, Zeravshan-Gissar, Pamir

Introduction

Previously, information about the stratigraphic divisions of Tajikistan was included in general dictionaries, which included data from the entire territory of the Soviet Union. The first edition of the stratigraphic dictionary of the USSR in 1937 [1] contained a description of about 1000 strata, of which several were related to Tajikistan. In the second edition of 1956 [2], out of 4000 descriptions, 156 accounted for Tajikistan. The third edition, published in four books, contained information on 11546 stratigraphic units, of which 1137 were described from the Tajik territory. Considering that the territory of the Republic occupied a little more than 0.6% of the total territory of the Union, the number of the described divisions, equal to almost 10%, is an impressive number [3]. This is due to the good exposure of the region, 93% of which are mountains, as well as to the widespread geological survey and prospecting work in Tajikistan in those years. After the disintegration of the Soviet Union, work on the publication of dictionaries was suspended. The independence of the republics served as an impetus for the creation of dictionaries for individual regions. Thus, the stratigraphic dictionary of Uzbekistan has been published [4] and three dictionaries in Tajikistan were published: the stratigraphic dictionaries of the Pamir [5, 6] and the stratigraphic dictionary of the Phanerozoic of Tajikistan (Northern, Central, and South-Western Tajikistan) [3]. The 2013 edition of the dictionary is an updated edition of 2006 and includes descriptions of 669 local and regional stratigraphic units in the Pamir. The 2012 dictionary included

data on the stratigraphic subdivisions of some adjacent territories (the Fergana depression, the border mountainous regions of Uzbekistan and southern Kyrgyzstan, the southwestern offshoots of the Gissar ridge, the northern regions of Afghanistan), which is associated with the belonging of geological formations to unified sedimentary basins or unified structures. It includes the description of 1018 local and regional stratigraphic units.

Based on the data presented in the dictionaries, the author calculated that the number of Ordovician age units in relation to the total number of strata is slightly more than 3.5% for the territory of Tajikistan, excluding the Pamir, and about 2% for the Pamir [7]. These numbers make it possible to judge the spreading of Ordovician deposits in the territory of Tajikistan. In general, for the territory of Tajikistan, the following regions are distinguished, which are characterized by their peculiarities of the geological structure and complexes of minerals: 1 – Northern Tajikistan (Kuraminsky ridge and Mogoltau); 2 – North-Eastern Tajikistan (western part of the Fergana depression); 3 – Central Tajikistan (mountain structures of the Alai system: Turkestan, Zeravshan, Gissar ridges); 4 – South-West Tajikistan (South-Tajik depression); 5 – South-East Tajikistan (Pamir and Darvaz) [8]. In general, at different periods, various researchers have described and studied no less than fifty Ordovician localities. Below is an overview of the study of the Ordovician deposits in the region.

Study of the Ordovician deposits of the Southern Tien Shan

Northern Tajikistan

Ordovician deposits have established in Mogoltau based on fauna finds by B.N. Nasledov in 1941. In one of the horizons of the thick sandstone-shale pre-Devonian strata, which was previously considered dumb, O.I.Sergunkova identified the remains of *Ogygites* sp., *Receptaculites* sp., *Crania* sp. and *Orbiculoidea* sp., which she assigned to the Ordovician [9].

The age of the strata [10] was controversial (from Proterozoic to Ordovician). According to the stratigraphy scheme refined by E.D. Karpova and P.N. Sokolov, in addition to the Ordovician, Cambrian is probably present in the lower strata [11]. Sandstones and shales of similar composition were found in several localities in Karamazar, but they are conditionally classified as Ordovician due to the absence of organic remains in them.

Central Tajikistan

The territory of the Southern Tien Shan is orographically subdivided into two main zones – Zeravshan-Gissar and Turkestan-Alai mountainous regions. Within Tajikistan, Ordovician finds are concentrated mainly in the Zeravshan-Gissar mountainous region. The stratotype of the Ordovician is also located here, but in administrative position, this part of the area belongs to Uzbekistan. The Tajik geologists, as well as the author, repeatedly visited and studied geological sections of the stratotype area; therefore, below are data on the study of the Ordovician deposits of Tajikistan, taking into account the data on the stratotypic locality.

The first information about the finds of the Ordovician came in the late 1920s. In 1928, A.P.Markovsky (together with S.I.Klunnikov) discovered limestones with *Streptelasma* sp., *Orthis* cf. *testudinaria* Dalm. var. *himalaica* Reed, *Orthis* sp., *Bellerophon* sp., *Iliaenus spitiensis* Reed, etc. [12]. A.P.Markovsky [13] referred to this locality as the unique faunistically characterized for Central Tajikistan. It should be noted that on the working diagram of the stratigraphy of the Ordovician sediments of Central Asia in the decisions of the Meeting [14], data on the Middle, Northern Tien Shan and Pamir appeared, but there was no data on the Southern Tien Shan. Thus, no data on the Ordovician of Tajikistan, excluding the Pamir, have provided.

In 1956, V.D. Saltovskaya and later K.I. Ismailov found the remains of the Ordovician fauna at the watershed of the Kumarg and Yafch gorges (the basin of the Fandarya River)–*Agetoilites* sp., *Palaeofavosites alveolaris* (Goldfuss), *Hemiagetolites extremus* Leleshus, and in the talus, *Reuschia* (?) sp. [15]. Sediments in which organic remains were collected were also mentioned in the work of V.L. Leleshus as Lower Llandovery.

In 1957, sediments with *Palaeofavosites alveolaris* (Goldfuss), *Agetoilites asiaticus* sp. nov., *Plasmoporella* sp. nov., *Holorynchus giganteus* Kiaer and other fossils were identified by A.I.Kim in the upper reaches of the Kashka-Darya River basin southeast of the village of Dzhaus. He interpreted the age of the deposits as Early Llandovery and indicated that prior to his finds these deposits have dated to the Upper Silurian [16].

In 1959, A.I. Lavrusevich and G.S.Grinenko made a section in the upper reaches of the Sarymat River (left tributary of the Arch-Maidan River) at the mouth of the gorge Agba-Shir, where, according to the fauna, a continuous occurrence of sediments from the Upper Ordovician to Ludlow inclusive was established [17]. For the first time, A.S. Shadchinev brought finds of a few fossils from here in 1957, but they have not then identified due to poor preservation. Also in 1959, P.D. Vinogradov and N.S. Torshin discovered sediments with *Basilicus nobilis* Barrande, *Leptaena trigonalis* Schmidt, *Dalmanella* sp. and Orthidae in the valley of the Yagnob River near the Farkau gorge, which, based on these findings, were dated to the Middle Ordovician [18].

A section similar to the Agba-Shir, but more complete, has studied by A.I. Kim in 1961 in the area of the Shakhriomon pass. Faunal remains of a more ancient age (*Synchomalonotus birmanica* (Reed.), *Metopolichas* aff. *sinensis* Sun, etc.) allowed the author to talk about the presence of Ordovician deposits here along with Lower Llandovery deposits [19]. He divided the Ordovician and Silurian section into three members: the Shakhriomon Horizon of the upper half of the Ordovician, and the Archalyk Beds (bottom and top) of the Lower Llandovery. At the same time, he has noted that in the Lower part of the Archalyk Beds, the faunal complex has a mixed Ordovician-Silurian character, and in the upper part of the Archalyk Beds, elements of the Late Ordovician disappear. This served as the basis for further dividing the Archalyk Beds into the Lower Archalyk and Upper Archalyk Beds and assigning the Lower Archalyk Beds to the Ashgillian stage of the Upper Ordovician, and the Upper Archalyk Beds to the Lower Llandovery of the Lower Silurian [20].

In 1963, A.A. Rubanov discovered Ordovician deposits with *Lycopora regularis* Kim, *Plasmoporella* aff. *bifida* Bond., *Pl. ex gr. grandis* Bond. in the Shing-Magian region along the Sor gorge, and a year later – in the South Gissar zone in the Almaly, Chilliksu and Irgailik river basins [21].

A.S. Shadchinev for the purpose of repeated collection of fauna from Ordovician sediments, first established by A.P. Markovsky together with S.I. Klunnikov, visited the right side of the Pakshif River in 1958 (together with A.B.Korovkin) and in 1963 (together with D.A. Starshinin). The need for additional study of the locality, which for a long time remained the unique known one, was dictat-

ed by the fact that attempts by other geologists (I.K.Nikitin, A.P. Nedzvetsky, and P.D.Vinogradov) to repeat the collection of Ordovician fossils were unsuccessful. A.S.Shadchinev and D.A.Starshinin managed to collect the remains of trilobites, brachiopods, rugoses, crinoids and bryozoans. As a result, it was found that the Ordovician deposits are located here not in the primary, but in the secondary occurrence in carbonate boulders, which are an integral part of the terrigenous formations of the Upper Paleozoic [22].

Subsequently, the Paleozoic stratigraphy in the Shakhriomon tract has studied in more detail by the joint efforts of geologists of the Geology Department of the Council of Ministers of the Tajik SSR, the Institute of Geology of the Academy of Sciences of the Tajik SSR and the Ministry of Geology of the Uzbek SSR. The authors [23] faunistically substantiated the age of the Shakhriomon Formation as Llandeilo-Caradoc. They belonged underlying on it the Lower Archalyk Beds to the Ashgillian, and the Upper Archalyk ones – to the Lower Llandovery. The authors also noted that within the Zeravshan-Gissar mountain region, where the most complex scaly-block movements took place, the Shakhriomon section, including deposits from the Middle Ordovician to the Middle Devonian, is the only single for the entire territory of the Zeravshan-Gissar structural-facies zone in terms of its completeness.

Some Ordovician outcrops were identified in the Ak-Ata ridge in the upper reaches of the Dzhindy-Darya and the left tributaries of the Magian, in the Pagna and Ven gorges, along the Zakhona gorge above the Voru village, on the Chore and Fandarya watershed and in some other places [24]. These authors gave a more complete faunistic description of the already known Ordovician localities, including the area of the Shakhriomon pass, and compiled a scheme of the Ordovician distribution in the Zeravshan-Gissar mountain region.

A.I.Lavrusevich [25], based on a comparison of the Silurian stratotype of Mount Daurich and the Ordovician stratotype of the Shakhriomon pass, analysis of faunal complexes and their correlation with complexes of other regions, came to the conclusion that the Lower and Upper Archalyk Beds represent a single stratigraphic subdivision (within the Ashgill). Therefore, the border between the Ordovician and Silurian in the Zeravshan-Gissar mountainous region should be drawn not along the base, but along the top of the Upper Archalyk beds. A little earlier, in 1971, D.A. Starshinin transferred these deposits to the rank of a formation (= Archalyk Formation) [26]. This point of view has supported by N.K.Ospanova [27]. V.L. Leleshus [28] was the first who described the heliolitids of the Upper Ordovician of Tajikistan, and he concluded that the Upper Archalyk Beds, “after A.I.Lavrusevich,” should be assigned to the Ashgill stage. These conclusions did not agree with the decree of the Interdepartmental Stratigraphic Committee [29] on the demarcation of the border between the Ordovician and Silurian in Middle Asia along the top of the Lower Archalyk Beds.

New data on the Ordovician of the Zeravshan-Gissar mountainous region were obtained by geologists [30], who studied and described in detail the Voru section in the upper reaches of the Zakhona gorge (Archa-Maidan river basin) and the Obi-Khundy ridge sections (the upper reaches of the Ak-Su, Dzhindy-Darya, Kashka-Darya and Magian rivers). The authors pointed out that in the Zakhona section, it was possible to characterize a large complex of Late Ordovician fossils of a thick stratum of metamorphic rocks of the Raz Formation (beds C of Daurich Mountain; according to A. Lavrusevich [25], an analogue of the Archalyk Beds in a total volume); and in the Obi-Khundy ridge, in weakly metamorphosed terrigenous deposits of the Upper Ordovician, it was possible to find the complex of fossils closest to the Shakhriomon one.

Because of further study, the Shakhriomon Formation has divided into Obikalon, Obikanda and Chashmankalon Beds. It was decided to keep the name “Archalyk” for the Lower Archalyk Beds, and the Upper Archalyk Beds have named “Minkuchar” [31]. It should be recalled that in the work of 1963 [19], referred to by the listed authors, the Shakhriomon Horizon was distinguished, not the formation. The fauna age of the Obikalonian strata was taken as the end of Llandeilo-beginning of Caradoc of the British Standard. The age of the Obikanda Beds, in terms of their position in the section, was conditionally correlated with the Late Caradoc. The lower part of the Chashmankalon Beds was taken as the base of the Ashgill, and the upper part (together with the Archalyk Beds) was compared with the upper part of the Ashgill. The age of the Minkuchar strata has adopted in the volume of the Llandovery.

Written by a group of paleontologists-stratigraphers a work is devoted to the generalization of data on the boundary sediments of the Ordovician and Silurian Altai and South Tien Shan. It was indicated, regarding the Ordovician-Silurian border in Middle Asia, that “in the modern dissection scheme, in the section of the Shakhriomon tract, the following subdivisions are distinguished: a) the Shakhriomon Formation in the volume of the Obikalon Beds, corresponding to the Caradoc, the Obikanda and Chashmankalon Beds, corresponding approximately to the Lower Ashgill; b) Archalyk Beds of the Upper Ashgill; c) the Minkuchar Beds of the Lower Llandovery, and d) the South Sumsar Formation of the upper Llandovery” [32]. Biostratigraphic analysis of different fauna groups has carried out. As a result, it was concluded that “the Obikanda Beds, overlying the Obikalon ones with some interruption, probably belong to the lower reaches of the Upper Ordovician” [33], and most of the complex of the Chashmankalon fossils testifies to Late Ordovician, Ashgill age. Elements of the Ordovician fauna are present in the Minkuchar Beds, but the suppressing majority of taxa are known from the Lower Silurian.

After the accumulation of a sufficient database on the Ordovician and Silurian, when it became possible to compare different types of sections with each other, it became clear that, in terms of their

facies features, they are clearly discrete. Based on this, V.L. Leshus [34] has combined them into three main groups: Fergana, Gissar and East Pamir. The total thickness of the Ordovician in the Fergana group of sections is the first hundreds of meters; the relationship with the Silurian is unclear. Sediments are widespread in the mountain structures framing the Fergana Depression. The Gissar's group of sections is located to the south of the Fergana and is separated from it by the Zeravshan fault of latitudinal strike. The thickness of the faunistically grounded terrigenous deposits of the Middle and Upper Ordovician is up to 400 meters. Deposits of the Gissar group are developed in the Zeravshan-Gissar mountain region and in the North-Western Pamir. Deposits of the East Pamir's group of sections were known south of Lake Rangkul and in the area of the Akbaital pass. The thickness of the Lower and Middle Ordovician in the Eastern Pamir is about 1000 m, the Upper Ordovician deposits were identified presumably.

A detailed study of Ordovician heliolitids in the Southern Tien Shan allowed the author to speak about the Late Ordovician age of the Upper Archalyk (= Minkuchar) Beds with greater validity [27, 35-39]. In particular, based on the analysis and correlation of heliolitids complexes from the Archalyk and Minkuchar Beds, it was concluded that the Archalyk Beds are compared with beds 5a of Norway, Vormsi and Pirlgu of Estonia, Portrane Limestone of Ireland, the Rassokhinsky Horizon of the Urals, the Shchugor Formation of Central Kazakhstan, with the Dulankara Formation of South Kazakhstan, upper Kulunbulak Formation of the Targatai Ridge, with beds with *Amsassia chaetoides*, *Agetolites mirabilis* and *Catenipora libera* of Kazakhstan, the lower part of the Orlovskaya Formation and the Taarlagan Formation of Gorny Altai, and the Minkuchar Beds are compared with the upper part of the Ellis Bay Formation (subdivision 6) of Anticosti Island, White Head Formation of Eastern Canada, Porkuni Horizon of Estonia, Beds 5b of Norway [27]. It was also proposed [35] that in the case of the debatable age of the stratigraphic units and their boundaries, the specificity of the coexistence of different species should be taken into account. For example, the heliolitid species, traditionally defined in the literature as *Propora conferta* and continuing its existence in the Silurian, is found in Ordovician deposits and in the Minkuchar Beds in association with *P. speciosa* species, the planetary distribution of which corresponds to the Ashgillian time, that is, the biozone of the species does not extend above Ordovician boundaries. Several common species of the Heliolitida are found in the Chashmankalon and Archalyk and several common species in the Archalyk and Minkuchar Beds. The connection between the Chashmankalon and Archalyk Beds is also fixed on rugoses, stromatoporoids, and tabulates, and between the Archalyk and Minkuchar Beds, on trilobites, brachiopods, and algae [36]. The totality of the data indicates the Middle Ashgill age of the Archalyk (= Lower Archalyk) Beds [38, 39]. The conclusions about the Middle Ashgill age of the Archalyk Beds are consistent with

the results of the study of heliolitids by M.G. Sladkovskaya [40], who collected heliolitids from 13 successive stratigraphic levels of the Novabak section. So she points out when establishing the genus *Kimilites* gen. nov. that it occurs in the Chashmankalon and Archalyk Beds, the age of which she accordingly interpreted (based on the study of heliolitids) as Early and Middle Ashgill. Nevertheless, on the presented in the article diagram of the vertical distribution of tabulatomorphic corals in the sections of the Upper Ordovician Shakhriomon-2 (stratotype), Novabak, and Khoja-Kurgan, she assigned the Minkuchar Beds (after A.I. Kim) to the Lower Llandoverly, and not to the Upper Ashgill, which would be logical, given the consonant occurrence of the Archalyk and Minkuchar Beds.

Subsequently, the Ordovician and Lower Silurian of the Dzhindy-Darya – Aksu interfluvium has re-studied by the staff of the “Sarmarkandgeologiya” PGO, E.G. Fedorov and L.E. Kartashova [41]. Attention was paid to the paleontological and facies characteristics of the sections of the Shakhriomon tract and the Novabak brook, as well as the tracing of facies changes in layers along strike outside the studied sections. The authors concluded that the Obikalon strata are of the Early Caradoc and partly the Late Caradoc age and the Chashmankalon strata are of the Middle Ashgill age. Correspondingly, the Obikanda Beds, which are eroded on the Obikalon Beds, can be dated to the Early Ashgill. The presence of a regional break, the difference in fauna complexes separated by the break surface, allowed the authors to raise the question of dividing the Shakhriomon Formation into two independent ones. It should be noted that in the diagram of the comparison of the Ordovician and Lower Silurian sections, given by them, the Shakhriomon Formation includes all beds attributed by them to the Ordovician: Obikalon, Obikanda, Chashmankalon, and Archalyk. Later, the Obikalon and Obikanda Beds were considered as the lower part of the Shakhriomon Formation, and the Chashmankalon (Ashgill) and Archalyk (Upper Ashgill) Beds were considered as its upper part [42]. A.I. Lavrushevich and V.D. Saltovskaya [43] in a brief outline of the Ordovician system indicated that the Lower Ordovician within Tajikistan is known in one place in the Turkestan ridge and in the Pamir. In the Turkestan ridge in the Robut river basin, it includes a stratum (about 250 meters) of siltstones and shales with limestone interbeds with remnants of Tremadocian graptolites *Paraceratopyge* sp. The Stratigraphic Dictionary [3] includes the Rabut formation up to 2250 m thick, the age of which, according to the conodonts, is dated to the Middle-Upper Cambrian. In the Pamir, the Lower Ordovician deposits are indicated by the authors in the Sarykol ridge of the Northern Pamir (Tautash Formation) and in the Vanch and Muzkol ridges of the Central Pamir (the lower part of the Kozyndy Formation). The Middle-Upper Ordovician is known in the Zeravshan-Gissar region of Central Tajikistan and in the Pamir. In the Zeravshan-Gissar region, for deposits of this age, two types of sections have distinguished – Shakhriomon and

Zakhona. The first has developed in the basin of the Sarymat River of the Zeravshan ridge, on the southern and northern slopes of the Obi-Khundy ridge; it is most fully represented in Uzbekistan (the Kashkadarya river basin in the area of the Shakhriomon pass). It includes the Shakhriomon and Archalyk Formations. The Zakhona type of sections is apparently more widespread: the deposits of the Raz formation are known at more than 20 points, from the Magian River basin in the west to the Sardai-Miona and Jindon river basins in the east. In the Northern Pamir, in the Sarykol region, the Middle-Upper Ordovician corresponds to the deposits of the Chelokteke Formation, and in the Central Pamir (Vanch and Muzkol ridges), a large upper part of the Kozyndy Formation belongs to the Middle-?Upper Ordovician. The transition to the overlying limestones of the Lower Silurian is gradual.

D.A. Starshinin in his generalizing work on the stratigraphy of the pre-Paleozoic, Cambrian and Ordovician deposits of the central sector of the Southern Tien Shan [44] identified a number of new subdivisions of the Ordovician: the Varganza Formation (Late Ashgill-Early Llandovery) with a stratotype on the southern slope of the western part of the Chakylkalyan Mountains on the right bank of the Kashkadarya River near the village of Varganza; the Mechetli Formation (Ashgill-Wenlock) with the stratotype on the southern slope of the western part of the Gissar Range in the upper reaches of the Chosh River along the Almaly gorge; the Sagul's Stratum (Lower-Middle Ordovician) with the stratotype on the southern slope of the Tokhtabuz Mountains in the upper reaches of the Suuktanga gorge, west of the Shodymir mine (Turkestan-Alai mountainous region); the Ulkol Stratum of the Lower-Middle Ordovician with a mainstay section on the left bank of the Pitaukul River above the Oyurmasu River (eastern part of Karategin); the Chosh Formation of the Middle-Late Ordovician age with the mainstay section in the headwaters of the Chosh gorge in the Almaly gorge on the southern slope of the western part of the Gissar Range; Shakush Stratum of the Middle-Upper Ordovician with the stratotype along the Shakush gorge (the left inflow of the Suuktanga gorge in South Fergana), Tokhtabuz Mountains; Yafch Stratum of the Middle-Upper Ordovician with the mainstay section on the Kumarg-Yafch watershed (Zeravshan Range) and the number of other subdivisions in adjacent territories. In addition, he has given a characteristic of the subdivisions previously identified by other researchers, but not published by them: the Vardasht Formation (N.A.Kozar, 1985) of the Early-Middle Ordovician age (with an open upper boundary) with the stratotype along the Rukhshif gorge in the upper reaches of the Zeravshan River (Turkestan Range); the Karansai Formation (E.G. Fedorov, 1991) of the Middle-Upper Ordovician with the stratotype along the Karansai gorge in the basin of the Kashkadarya River, Chakylkalyan Mountain; the Narvat Formation (G.V. Fedorov, 1987) of the Late Ashgill-Early Llandovery age with the stratotype in the Chimtarga mountain range along the Narvat gorge, near the village Dzhizhik (parastratotype in the Archamaidan river basin along the Zakh-

hona river near the village of Voru); the Pakhtakishot Formation (V.M. Steblova, 1984) of the Late Ashgill-Early Llandovery age with the stratotype in the upper reaches of the Sorbukh River in the Pakhta-Kishot tract (southern slope of the Gissar ridge); the Yurtykara Formation (A.I. Lavrusevich, D.A. Starshinin, 1978) of the Upper Ordovician-Lower Silurian with the stratotype on the southern slope of the Dukdon ridge on the right side of the Dukdon gorge in the western end of the Yurtykara tract (upper reaches of the Karakul River, northern slope of the Gissar ridge). Many of these subdivisions are of questionable age, we indicate here the age in the author's interpretation. A detailed description of the listed subdivisions of the Ordovician and other strata has given in the Stratigraphic Dictionary [3].

The author has drawn up a diagram of the distribution of Ordovician deposits in the territory of Zeravshan-Gissar (Figure 1). They are shown as black triangles. The Ordovician stratotype locality is outside of Tajikistan (in Uzbekistan), and it is shown in its entirety, without marking individual sections. The only single faunistically characterized Ordovician locality in Northern Tajikistan (Mogoltau Mountains) is near the Khujand city, and it is not figured in the Picture.



Figure 1: Distribution of Ordovician deposits in the Zeravshan and Gissar ridges

1 – valley of the Obilay river; 2 – the upper reaches of the river Obilay; 3 – Ak-Ata; 4 – Obi-Khundy ridge; 5 – the upper reaches of the Shut river; 6 – Sor, Novi-Khushk; 7 – Gizan-Poyon; 8 – Pagna; 9 – Voru; 10 – Agba-Shir; 11 – Kum; 12 – Poymazar; 13 – Kumarg-Yafch; 14 – watershed between the right and left inflows of the Yafch gorge; 15 – Farkau; 16 – Dzhindon; 17 – Pakshif; 18 – Mokshevati; 19 – Gaberud; 20 – Dzhizhikrud; 21 – Pshanza gorge; 22 – Tagobi-Kul; 23 – Yak-Archa; 24 – Hochilyor; 25 – Kunda-Dzhauz, Shargun; 26 – Almaly. On the left, the shaded area shows the stratotypic locality (sections: Dzhauz, Khodzha-Kurgan; Shakhriomon-1; Shakhriomon-2; Shakhriomon-3; Novabak outcrop; Novabak section; Gorlisay outcrop; right inflow of the Novabak gorge). Compiled by the author taking into account the data of A.Lavrusevich, Starshinin, V.Lavrusevich and Saltovskaya [24].

Study of the Ordovician deposits of the Pamir

Administratively, the Pamir has regarded as Southeast Tajikistan. Structurally, there are several main fold-nappe zones, separated from each other by large thrusts (Figure 2).

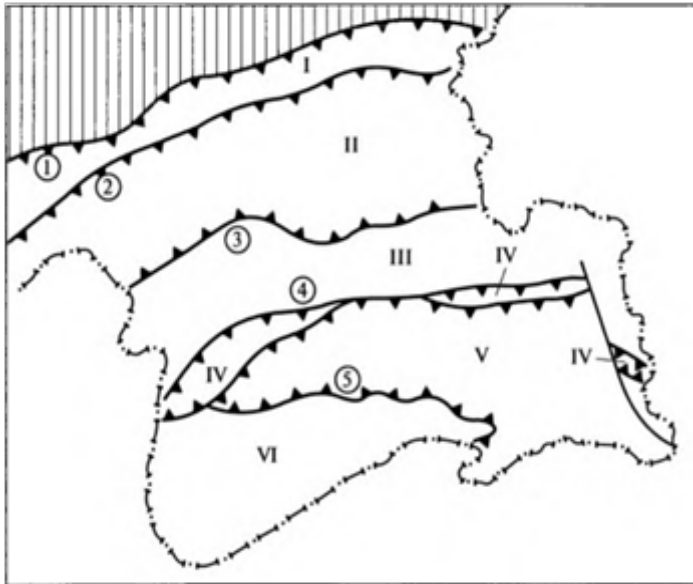


Figure 2: The main fold-nappe zones of the Pamir

I – Darvaz-Zaalaysk; II – Northern Pamir; III – Central Pamir; IV – Rushan-Pshart; V – South-Eastern Pamir; VI – Southwest Pamir. Thrusts (numbers in circles): 1 – Vakhsh; 2 – Karakul; 3 – Tanymas; 4 – Rushan-Pshart; 5 – South Pamir. Vertical shading are folded structures of the South Tien Shan (from the work of Koronovsky [45])

Ordovician deposits were confined to the folded zones of the Northern and Central Pamir and localized in three areas: central part of the Darvaz ridge (basins of the Viskharv, Obikhumbou, etc.), South-Western Darvaz (Vanch and Yazgulem ridges), and Rangkul-Akbaital region (Figure 3).

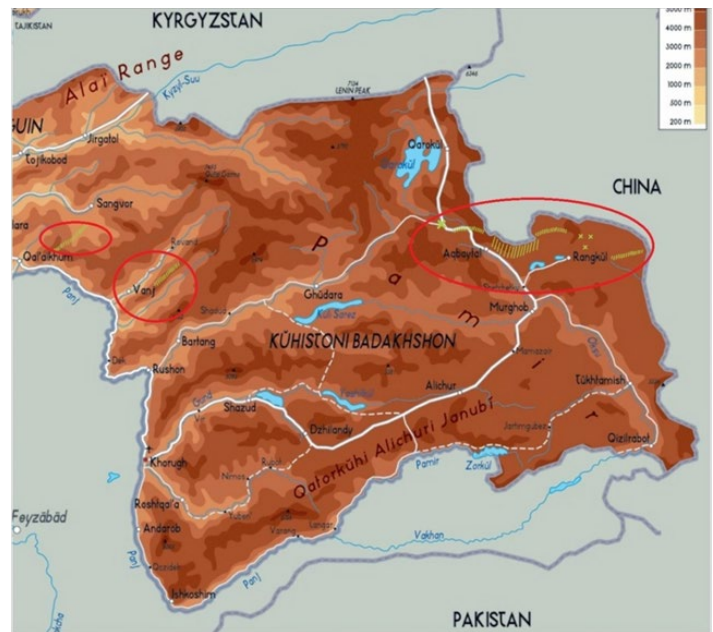


Figure 3: Distribution of Ordovician deposits in the Pamir (hatching and crosses, outlined by red lines). From left to right: central part of the Darvaz ridge (basins of the Viskharv, Obikhumbou, etc.), South-Western Darvaz (Vanch and Yazgulem ridges) and Rangkul-Akbaital region

Northern Pamir

Until 1956, Ordovician deposits in the Northern Pamir were not known. In 1956, the remains of the Ordovician crinoids and cystoids *Aricocystites* sp. have collected by B.P.Barkhatov, V.I.Dronov and G.S.Voskonyants in limestones among shales on the starboard side of the estuary of the Kyz-Ashu River (Tuzguny-Tereskei ridge). Later, the remains of the Middle Ordovician fauna have found on the left slope of the Kyz-Ashu river valley among shale rocks. V.I.Dronov, M.S.Dufour and G.G. Melnik collected from here trilobites *Trinucleus* aff. *bucklendi* Barr, brachiopods *Plectambonites* sp. and crinoids *Pentagonocyclicus parvulus* Yelt., *Cyclocyclicus nummiformis* Yelt.

In 1959, E.Ya.Leven discovered the remains of algae *Radiophycus* sp. in the beds of limestones and shales of the Tautash (Toutash) Formation in the metamorphosed strata of the North Pamir structural-facies zone. He combined the Ordovician deposits of the Tuzguny-Tereskei ridge into the Tuzguny-Tereskei complex, and in general, the deposits have divided into two parts – the Tuzguny-Tereskei Ordovician complex and the Darvaz-Sarykol Middle Paleozoic complex itself. The significant thickness of the deposits (more than 2000 meters) allowed the author to distinguish seven lithologically different strata of the Late Cambrian-Early Silurian age: the Ishibulak (Cambrian; later considered as a synonym for Ishi), Toutash, Kyzashu, Chelokteke, Shorkul, Kanaitart and

Tugurek. A detailed description of them has given by the author [46].

S.S. Karapetov, who worked in 1958 as a member of the Pamir expedition in the Akbaital pass area, has collected together with other geologists (G.S. Voskonyants, A.D. Goldberg and others) numerous remains of the Ordovician and especially the Silurian fauna. The enclosing sediments were dissected and mapped for many tens of kilometers. The Ordovician deposits of the North Pamir structural-facies zone were subdivided into a number of strata: Shorkul, Kanaitart, and Tugurek. The studies carried out made it possible to clarify the border between the Northern and Central Pamir in this area [47]. The boundary is a powerful crushing and gypsum zone separating the Ordovician outcrops (Northern Pamir) from the Paleozoic and Mesozoic deposits of the Central Pamir to the south. During further study, S.S. Karapetov [48] proposed to draw the boundary not along the Ak-Baital fault zone (in this work he uses the name Ak-Baital, not Akbaital), but along the line of the Tanymass thrust; at the same time, the Tuzguny-Tereskei complex of deposits passes to the zone of the Central Pamir. In the author's dissertation for the degree of candidate of geological and mineralogical sciences, dedicated to the Paleozoic of the Central Pamir, S.S. Karapetov [49] has paid attention to the issues of stratigraphy, paleogeography and tectonics of Paleozoic formations. Along with other systems, he characterized the Ordovician system, represented by all three sections, which included four formations: Toutash and Kyzashuy (lower section), Zorabat (lower-middle section) and Kozyndy (middle-upper section). It can be seen from this, that the Toutash and Kyzashu Formations, reckoned by other geologists to formations of the Northern Pamir, are considered by S.S. Karapetov as belonging to the Central Pamir structural-facies zone in accordance with his new views. The divergence of opinions persisted in the subsequent time. Therefore, E.A. Balashova [50], who studied trilobite complexes from the Ordovician and Silurian deposits of the Pamir, concluded that there is a difference between the trilobite complexes of the Ordovician deposits of the Rang-Kul and Ak-Baital regions, on the one hand, and Vanch-Yazgulem, with another. Therefore, she was inclined to assume that the Rang-Kul region should belong to the Northern Pamir. I.A. Bardashev and V.L. Leleshus considered the Tuzguny-Tereskei Mountains as belonging to the Central, not the Northern Pamir. With this interpretation, most of the Ordovician deposits, excluding the discovery at one point of the Peter Great ridge, turned out to be confined to the Central Pamir. Initially, these deposits were attributed to Llandovery [51], but then they were recognized as Ordovician. The point of view of S.S. Karapetov, I.A. Bardashev and V.L. Leleshus was not supported by V.I. Dronov, he considered the Tuzguny-Tereskei Mountains as belonging to the Northern Pamir [6].

In the North-Western Pamir, Yu.A. Sorokin, N.G. Vlasov, and A.Kh. Kafarsky belonged to the Ordovician the Viskharv Forma-

tion, the age of which was established by spore-pollen complexes and conformable occurrence under the faunistically characterized deposits of the Lower Silurian [52]. B.P. Barkhatov [53] pointed to the relatively limited distribution of this formation (basins of the Viskharvi, Jarf, Obikhumbou, Obimazar and Garmo rivers); to the east it is submerged, overlapped by the Lower Carboniferous and does not come to the surface in the east.

The Ordovician of the southern part of the Northern Pamir stretches from Lake Rangkul along the northern border of the Akbaital zone of scales through the valley of the Northern Akbaital River to the middle reaches of the Zortashkol River, where it wedges out. Among the Ordovician deposits of the Northern Pamir, B.P. Barkhatov [53] distinguished three formations: Viskharv, Toutash and Ishi; according to other geologists [48, 54], the latter is older and does not belong to the Ordovician.

According to the latest studies [6], the following Ordovician subdivisions are characteristic of the Northern Pamir: the Viskharv Formation (Vendian? – Ordovician), the Kanaitart Stratum (Middle-Upper? Ordovician), Kyzashuy Formation-Stratum (Lower Ordovician), Toutash Formation-Stratum (Lower Ordovician), Tugurek Stratum-Formation (Middle-Upper Ordovician), Tuzguny-Tereskei complex-series (Cambrian? – Ordovician), Ust'kozyndy Formation (Middle Ordovician-Lower Silurian), Chelokteke Formation-Stratum (Middle-Upper? Ordovician), Shorkul Stratum-Formation (Middle-Upper Ordovician). The Kashalayak Stratum is presumably dated to the Vendian-Lower Paleozoic; its age is conditionally determined by analogy with the Viskharv formation, to which the stratum is similar in seeming and material composition. The Abat Formation was abolished due to the mixing of formations of different ages in it.

Central Pamir

For the first time a consistent description of sedimentary and metamorphic strata of the Pamir, from Precambrian to Quaternary, was given by V.D. Nalivkin *et al.* [55]. At the same time, the Ordovician was not mentioned, only Silurian, and when describing the Silurian, it was said about the Lower and Upper Silurian. In particular, it was said that “the Lower Silurian has so far been found in one place in the Pyanj valley (between Yazgulem and Vanch), in Darvaz” (p. 47). The statement of the Lower Silurian was based on the finds of the tail shields of trilobites, attributed by V.N. Weber to the species *Basilicus nobilis* Barr. It has also noted that the Upper Silurian fauna consists mainly of brachiopods and that “Silurian deposits have been isolated so far only in Darvaz, where they reach considerable thickness” (p. 55). Subsequently, geologists considered as Ordovician sediments that have been attributed to the Lower Silurian, and the named species began to be considered a characteristic form of the Ordovician. It is interesting that in the table “Comparisons of different schemes of division of the complex of Lower Paleozoic sedimentary-metamorphic rocks

of the North-Western Pamir”, compiled by M.Kh. Khamidov in 1953, the deposits overlying the Cambrian and containing the remains of the trilobites *Basilicus (Asaphus) nobilis* Barr., belong to the Lower Silurian [56]. In the named work, the author spoke not about the Cambrian-Ordovician formations, but about the Cambrian-Silurian sedimentary-metamorphic complexes, that is, the Ordovician has not mentioned.

The data on the first faunal finds are contradictory. According to B.R.Pashkov [57], Ordovician deposits in the Western Pamir were first discovered by members of the Geological Committee in 1927 [55] near the Khikhik gorge in the Pyanj River valley, where remains of trilobite *Pseudobasilicus nobilis* (Barr.) were collected from bedrocks and talus, and in 1935, faunistically characterized Ordovician deposits, in addition, were found in Andergoz gorge, in the outcrops of the left side of the Yazgulem river by the participants of the Tajik-Pamir expedition (P.P.Chuenko, P.V. Myshkin and the others), which was founded in 1932. The Ordovician assemblage was replenished with new collections of the same trilobites, and complete specimens were found, as well as single Orthocerathidae and indeterminate brachiopods. P.P.Chuenko [58] pointed out that he first discovered the faunistically characterized Ordovician deposits in the Pamir in 1928 in the lower reaches of the Yazgulem and Pyanj rivers – between their mouths (Southern Darvaz). Here, in the talus of siliceous-argillaceous shales, V.I. Popov and P.P. Chuenko found tail shields of very large trilobites (judging by the remains, complete specimens could reach 0.5 meters), which, according to V.N.Weber’s definition, belong to species *Basilicus nobilis* Barr. (upper horizons of the Ordovician). N.Kh.Khamidov [59] wrote that *Basilicus (Asaphus) nobilis* Barr., single orthoceratids (*Orthis* sp. and others) and brachiopods were first encountered in 1927 by P.P.Chuenko and V.I. Popov. S.S.Karapetov [48] pointed out that for the first time P.P.Chuenko discovered the faunistically characterized Ordovician deposits in the Central Pamir zone in 1927 on the right side of the Pyanj River, near the Khikhik gorge, where he collected numerous remains of the Middle Ordovician trilobites *Pseudobasilicus nobilis* (Barr.).

In 1938, Ordovician deposits became known at the mouth of the Darkh gorge (right tributary of the Pyanj River). The trilobites found here by A.P. Nedzvetsky turned out to be undetectable, but the typical Ordovician genus *Chasmatopora* was present among the bryozoans [57]. In 1938, N.P. Ermakov identified the so-called “phyllite” formation with a thickness of about 2500 m. He compared it with the faunistically characterized Ordovician formations of the lower reaches of the Vanch River. N.G.Vlasov [60] pointed out that there were not sufficient grounds for this; by the position in the section and the low degree of metamorphism, he determined the age of the formation in the range from the Cambrian to Llandovery, inclusive. Yu.A. Sorokin renamed these rocks in 1959 into the “Viskharvskaya” Formation. N.G.Vlasov [60], characterizing the stages of development of South-Western Darvaz in the pre-Ju-

rassic time, gave a description of a number of different-age formations that were identified earlier, but not published by researchers (Viskharv, Dikzankou, Kalaihumb, Aspandou, Ushkharv, Dzhak, Vozgina, and etc.); therefore, the official date of recognition of the Viskharv and the listed formations is 1961 [6].

P.P.Chuenko [61] summarized the results of the work of previous researchers and made a geological map of Darvaz. He subdivided the Lower Paleozoic (Vanch) complex of rocks of South Darvaz into three formations (from bottom to top): Barnavadzh (Pz1a) – Lower Paleozoic, Yazgulem (Pz1b) – Lower Paleozoic, Jamak (Pz1c) – Lower Ordovician. The total thickness of all three strata in South Darvaz is 3.5 kilometers. P.P.Chuenko [62] noted that this thickness is unlikely to correspond only to the bottom Ordovician, apparently, there are also Cambrian deposits. During the geological surveys of 1941-1950 on the territory of the Vanch and Yazgulem ridges, P.P. Chuenko’s scheme was taken as a basis (it was only refined and detailed), and a fundamental refinement in this scheme was introduced by geologists L.P. Smirnov and A.N. Mayorov [63]. In particular, they showed that the Pz1c formation is an analogue of either the faunistically characterized Ordovician or the Pz1a formation and, therefore, should be abolished. They made this conclusion probably based on new finds of the Ordovician fauna, discovered by them in 1940 in the middle reaches of the Yazgulem River above the village of Bdavn. Hence, according to preliminary definitions by A.F.Lesnikova, the trilobites *Basiliella* (?) sp. (presumably a new species) were identified [57], and brachiopods *Orthis* cf. *noctilio* Heritsch (non Shorpe), *Orthis* (?) sp., *Plaesiomys* aff. *subdivisa* Salt., *Leptaena* ex gr. *rhomboidalis* Wilck., *Rafinesquina* (?) sp. In addition, Ordovician deposits with fauna were also discovered among the development field of Mesozoic rocks in the upper reaches of the Zaichkhov River, the left tributary of the Yazgulem River, from where trilobites *Asaphus* sp., similar to *Abmondi* Salter from the Himalayas, and *Basiliella* (?) aff. *titanica* Reed were identified.

A detailed mineralogical and petrographic study of the Lower Paleozoic deposits of the Vanch and Yazgulem ridges begun in the late 1940s and served as the basis for the development of a lithostratigraphic scheme [56, 64]. Four rhythmic thicknesses and five formations of Cambrian age have been identified. The fifth, the slate-marble formation, is replaced higher in the section by the faunistically characterized Ordovician deposits. The author pointed out that Middle and Upper Ordovician deposits have been established in the Vanch and Yazgulem ridges, however the existence of sedimentary formations belonging to the Lower Ordovician could still be judged presumably, because the fauna of the corresponding age was found in talus. A distinctive feature of the Ordovician deposits is a rather variegated lithological composition – from gravelstones to carbonates [56]. The thickness of the supposed Ordovician deposits in the east of the Vanch ridge reaches 1050 meters, and in the west does not exceed 760 meters [59]. The basis of the

last work of the author was the factual material collected by him during the years 1948-1960. At the same time, the total research area covered by numerous routes was 1800 km². The scheme of the division of the Lower Paleozoic (Ordovician-Lower Silurian) deposits of the Vanch Ridge was based on the study of deposits of enormous thickness – 4.5-5.0 km.

The first schemes for the subdivision of the Ordovician deposits in the eastern part of the Central Pamir were proposed by G.G. Melnik and B.P. Barkhatov in 1956, and also by M.S. Dufour in 1958 [65]. Finds of the Early Ordovician trilobites *Biradiolites* cf. *birmanicus* (Reed), *Taihungschania* cf. *shui* Sun, Tremadocian-Early Llandeilian graptolites Dychograptidae, and Upper Ordovician brachiopods in the green shales of the Kalak-Tash and Abat-Dzhilga tracts allowed M.S. Dyufur [65] to attribute to the Ordovician sediments that were previously attributed to the Middle Paleozoic [66], and Silurian (P.D. Vinogradov in 1937). On the basis of these finds, M.S. Dyufur divided the Ordovician deposits of the Rangkul region into two Formations – the Chver', which attributed then conditionally to the Lower Permian [67], and the Abat, which was abolished due to the inclusion in it, as it turned out later, of two Ordovician (Zorabat and Kozyndy) and one Paleogene (Chechekty) formations [68]. These authors collected Early Ordovician trilobites and Early-Middle Ordovician graptolites in the upper part of the limestone Zorabat formation, and they found trilobites and brachiopods in the sandy-shale Kozyndy formation, consonantly lying on Zorabat formation. They noted the similarity of the Ordovician deposits of the Eastern, Western and Central Pamir, as well as a conformable occurrence with both the underlying (?Upper Cambrian) and overlying (Lower Silurian) deposits [52].

It should be noted that at present the Eastern and Western Pamir are understood not as independent structural units, but only as geographically different parts of the single Central Pamir; therefore, modern geologists do not use these terms. As you can see from Picture 2, the Pamir is divided into a number of structural-tectonic (napkin-fold) zones; therefore, the following subdivisions are used in geological descriptions at present: Darvaz-Zaalay zone, Northern Pamir, Central Pamir, Rushan-Pshart zone (Rushan-Pshart Pamir), South-East and South-West Pamir.

Describing the Ordovician of the Central Pamir, B.P. Barkhatov [53] mentioned only one Formation – the Kozyndy (according to Barkhatov – the Kazyndy). E.F. Roman'ko and E.S. Cherner [69] distinguished two series from the Darvaz-Sarykol complex in the middle part of the Pamir – the South Darvaz and Sarykol, and also gave a brief description of the remaining series of the complex – the Tuzguny-Tereskei and Zortashkol. The Ordovician deposits are confined only to the Tuzguny-Tereskei series, the age of which is assumed Cambrian-Ordovician. Following B.R. Pashkov [70], the authors distinguish four (from bottom to top) Formations: Ishi, Toutash, Kyzashu and Cheloktekin (from Chelokteke). In gener-

al, the Ordovician Pamir deposits have been recognized as stratigraphic units and received their name only in the middle of the 20th century.

In the process of geological study of the Pamir, various researchers [47, 48, 57, 71, 72] repeatedly specified the characteristics of the formations, their thickness and age. S.S. Karapetov [48] indicates that in 1961 he repeated the collection of algae from the left side of the Toutash valley, where he first found algae in 1959 together with E. Ya. Leven. As a result, their generic affiliation was clarified – *Radiophycus*, not *Actinophycus* (the conclusion of K.B. Korde and A.G. Volodin), based on which the age of the Toutash Formation was accepted by him as conditionally Early Ordovician. Here he examines a number of other Formations – Kyzashu, Zorabat, Kozyndy and gives a rather detailed lithological and faunistic description of them. Based on new data, S.S. Karapetov [48] specified the upper age boundary of the Zorabat Formation (the lower half of the Llandeilo) and the age of the Kozyndy Formation (from the upper half of the Llandeilo, probably to the Ashgill Stage, inclusive). He also noted that for the first time in the Ordovician, a manifestation of volcanism has noted (on the border of the Zorabat and Kozyndy Formations, the Kalaktash tract).

B.R. Pashkov [57] divided the Kozyndy Formation into three characteristic lithological units (tutus) and drew up a scheme for comparing the Ordovician deposits of the Western Pamir. Based on the analysis of faunal remains, the volume of the Kozyndy Formation was determined from the Tremadocian Stage of the Lower Ordovician to the Lower or partially Middle Llandovery Substage of the Lower Silurian inclusive. The incompleteness of the faunal collections did not allow the author to solve the question of the age of the uppermost part of the tutu and thereby clarify the boundary between the Ordovician and Silurian unequivocally. The Kozyndy Formation lies down on the Zorabat one. Nevertheless, B.R. Pashkov [71, p. 39] pointed out that “despite the large amount of data obtained on the stratigraphy of the deposits under consideration [70], a whole range of issues directly or indirectly related to the age of the Zorabat limestones (and above all the problem of the age of the metamorphic formations of the Vanch and Muzkol ridges) remained unresolved”. At specification of the age of upper boundary of the Zorabat Formation in the Central Pamir, the researcher relied on the preliminary definitions of the trilobite collection made by E.A. Balashova, which he collected additionally from green shales overlying the limestones of the Zorabat Formation, and transferred it to her for definition [70, 71]. The conducted researches have confirmed Tremadocian age of green slates.

Subsequently, the results of a monographic study of trilobites were published [50]. The author noted that the work was the first monograph devoted to the study of the Pamir trilobites. The result was the description of 36 forms from Ordovician deposits and 5 forms from Silurian deposits. The work used the collections of

M.S. Dufour and V.I. Dronov (1957-1958), B.P. Barkhatov (1958), G.S. Voskonyants (1958), N.G. Mashtaler (1958), S.S. Karapetov (1958, 1961, and 1962), I.A. Gusev (1959), B.R. Pashkov (1959-1962). E.A. Balashova redefined as a new subspecies *Pamirochechites nobilis pamiricus* Balashova, which geologists most often referred to the species *Basilicus nobilis* (Barrande). Complexes of trilobites have been identified as: Upper Temadocian, Arenigian, Llandeilo, Upper Caradoc-Ashgill and Silurian.

According to lithological features, the Viskharv Formation was subdivided into two Subformations: the Lower Viskharv Formation, about 400 meters thick, and the Upper Viskharv Formation, about 1200 meters thick [73]. The concordant relationship between these subformations is clearly visible at the base of the right slope of the Pyanj River valley, 1.5 km south of the village of Ruzvay. In the deposits of the Viskharv Formation, in addition to the spores found by N.G. Vlasov in the lower reaches of the Obimangit River (*Trachyoligotriletes laminarites* Tim., *Leioligotriletes compactus* Tim.) spores were also found in the shales of the left side of the Obikhumbou River valley (opposite the village Deu): *Gloeocapsamorpha prisca* Zal., *Protolophosphaeridium granulosum* Tim., *Protoliosphaeridium nitidum* Tim., *P. crassum?* Tim., *Prototylosphaeridium* sp. Age is Late Sinian-Vendian and, possibly, Early Cambrian [74]. In the upper part of the formation, in dark gray dolomitized limestones alternating with shales, on the left side of the Dzhorf River in its middle reaches, numerous remains of poorly preserved branchy colonial rugoses *Palaeophyllum* were found, probably *P. fasciculum* Kutorga [75]. According to these researchers, the genus is most characteristic of the Middle and Upper Ordovician; therefore, based on that, the Viskharv Formation of the Darvaz, which has a predominantly terrigenous composition, can be considered as a stratigraphic analogue of the Raz Formation of sandy-shale composition developed in the Zeravshan-Gissar region.

The divergence of opinions regarding the age of the Zorabat Formation was reflected in the work of V.I. Dronov [72], which, for reasons unknown to us, is not mentioned either in the stratigraphic dictionary of the Pamir [5] or in the Pamir stratigraphic dictionary [6]. He obtained new data for the area of the formation in the southeastern part of the Central Pamir (outcrops of Ordovician deposits east of the Muzkol ridge and south of the development strip of conventionally Precambrian metamorphic strata of the Muzkol complex). He writes that the age of the Zorabat Formation was interpreted by researchers in different ways: completely Cambrian and only in the upper reaches, possibly, Lower Temadocian [70]; Late Tremadocian-Lower Llandeilo [48]; Cambrian-Arenigian [71]; Late Tremadocian [50]; entirely Cambrian [76]. In 1987, V.I. Dronov managed to collect a representative collection of the Middle Ordovician fauna in the upper part of the Zorabat Formation, below all previously known finds of fauna from this stratigraphic hori-

zon (the right slope of the Chver'airyk tract, headwaters against the Kichik-Devutuk Mountain). Several hundred specimens of brachiopods were collected – *Eodalmanella* sp., *Strophomenidae* gen. et sp. indet, *Syntrophiella* sp. and trilobites – *Parabasilicus vodorezovi* (Veber). Based on the finds, the age of the member, from which the faunistic remains were collected, is assumed Late Llandeilo, and the age of the three underlying members, in which no remains were found, is earlier than Late Llandeilo. The overlying Kozyndy Formation has the Middle-Late Ordovician age up to the Lower Silurian, inclusive. Due to the fact that in a number of places the Ordovician sediments form continuous sections with the Lower Silurian deposits, three facies types of the Ordovician and Silurian were established in the Central Pamir: Akbaital [77, 78], Kalaktash and Aksu [79]. When identifying these types, their characteristics are not given and it is not indicated how each differs from the other, it is only said that the Akbaital type of sections is characterized by a substantially carbonate composition of rocks [79]. Judging by the descriptions of some formations given in this work, it can be assumed that the Kalaktash type of sections is characterized by the carbonate-terrigenous composition of the rocks, and the Aksu type is characterized by the substantially terrigenous composition. It should be noted that the Kalaktash type of sections was first identified for the Devonian deposits of the Central Pamir zone [80], and later extended to older (Ordovician-Silurian) deposits [79]. S.S. Karapetov [81] pointed out the gradual transition between the Ordovician and Silurian deposits and between the Silurian and Devonian deposits earlier. Recall that earlier we [37], when compiling an explanatory note of the stratigraphic scheme of the Ordovician deposits of Tajikistan, identified the following types of Ordovician sections for the Pamir: Tuzguny-Tereskei, Toutash, Darvaz, Vanch, Kalaktash-Kozyndy, Guristan. The facies variety of rocks was taken as the basis for the identification; the types of sections were distinguished either by strato-localities or by areas of maximum distribution. For the Silurian deposits of the Pamir, the following types of sections were identified [82]: Darvaz, Vanch, Sarykol, South Rangkul, Kalaktash-Kozyndy, and Senustanian.

The following formations appear in the description of the Ordovician deposits of the Central Pamir: Andergoz-Dustiroz (Cambrian? - Lower Ordovician), Andergoz (Cambrian? - Lower Ordovician), Guristan (Middle Ordovician?), Zorabat (Cambrian?, Lower-Middle Ordovician); Kichikabad (Middle Ordovician), Kozyndy (Middle Ordovician-Lower Silurian), coeval Kozyndy series, and the Ust'kozyndy Formation (Middle Ordovician-Lower Silurian) [6]. For clarity, we have compiled a table that reflects the study of the Tajik region with a mention of the authors who studied the Ordovician in the stratotype area of Shakhriomon. The references to the publications of the authors are given in chronological order.

Table 1: Study of the Ordovician deposits of Tajikistan
(with the inclusion of data on the stratotype location of Shakhriomon)

Folded region	List of researchers
South Tien Shan	Markovsky (1934, 1959a, b, c); Nasledov (1935); Leleshus (1959); Karpova (1959); Kim (1959, 1963, 1966); Vinogradov (1961); A. Lavrusevich, Grinenko, Leleshus (1962); Rubanov (1968); Shadchinev (1969); Muftiev, Starshinin, Leleshus, Korsakov (1971); A.Lavrusevich, Starshinin, V.Lavrusevich, Saltovskaya (1972); A. Lavrusevich (1972, 1976); V. Lavrusevich, A.Lavrusevich, Leleshus (1973); Leleshus (1975, 1979); Kim, Apekin, Erina (1975, 1978); Kim, Apekin, Erina, Kolobova, Lesovaya, Nikiforova, Rozman, Stukalina (1978); Kim, Yolkin, Erina, Korsakov, Tsoi (1984 [83]); Ospanova (1984, 2002, 2005, 2006, 2012, 2014); Fedorov, Kartashova (1986); Sladkovskaya (1987); A.Lavrusevich, Saltovskaya (1991); Starshinin (1996); Kim, Abduazimova, Abdullaev (1998)
Pamir	Chuenko (1938; 1959a, b); Khamidov (1956a, b; 1967); Dufour (1958); Leven (1960); Dronov, Leven, Melnik, Pashkov (1960); Dronov (1963, 1999, 2001); Barkhatov, Melnik (1961 [84]); Vlasov (1961); Karapetov (1961, 1963, 1965); Pashkov (1961, 1962, 1964); Barkhatov (1963); Balashova (1966); Vlasov, Gnilyovskiy (1970); Roman'ko, Cherner (1970); V.Lavrusevich, Karjakin (1977); V.Lavrusevich, A.Lavrusevich, Saltovskaya (1981); Bardashev, Bardasheva (1999, 2009, 2019); Ospanova (2006)

Conclusion

This work summarizes the information obtained by many geologists-stratigraphers and paleontologists for the entire period of study of the Ordovician of Tajikistan and previously published in scattered articles or monographs. The data are arranged in accordance with the territorial division principle: North, Central and South-East Tajikistan. Within Northern Tajikistan, Ordovician deposits are found in the Mogoltau Mountains and probably in Karamazar; Central Tajikistan is the Zeravshan-Gissar mountain region and South-Eastern Tajikistan is Darvaz and the Pamir. Darvaz is an integral part of the Pamir, but it is often spoken as an independent region, for example, as indicated by A.P.Markovsky [8]. The study of the Ordovician deposits of the Pamir is displayed in accordance with the tectonic division: Northern and Central Pamir. Analysis of the literature data was carried out in chronological order, but supplemented by references to more recent sources as necessary. The names of the stratons appear as they were used by the authors who used them.

The collected data give an idea of the state of knowledge of the Ordovician deposits on the territory of Tajikistan. At the moment, the above review of the study of the Ordovician deposits of Tajikistan is the most complete, since it takes into account (whenever possible) all published literature, starting from the first faunistic finds in the 20s of the last century and ending with the 21st century; that is, it reflects information for almost one hundred year period.

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