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THE ORDOVICIAN SYSTEM IN KAZAKHSTAN AND MIDDLE ASIA

Correlation Charts and Explanatory Notes

by

I. F. Nikitin , M. K. Appolonov, D. T. Tzaj, V. G. Koroljov,
A. I. Kim, M. V. Erina, N. M. Larin, and A. N. Golikov

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FOREWORD

This first chart for the U.S.S.R. covers areas of great importance for students of the Ordovician. Not only does it show the interrelationship of a great variety of lithostratigraphic facies, but the authors have divided the System into 12 regional horizons and have shown the key fossils for each horizon - graptolites, conodonts, trilobites, brachiopods, corals, cephalopods, crinoids, and ostracods. A formidable task. Although tied into the standard British Series with graptolites, 19 regional graptolite zones are established and are lettered for convenience from A to S. One enormous chart displays the complexities of the Ordovician in tectonic zones of Kazakhstan and Kirgizia (Plate I). Somewhat less complex stratigraphy of Middle Asia is shown on Plate II. The problem of correlating regional horizons (or series) across the several geologic provinces of the Soviet Union and central Europe is well illustrated. A great contribution to our understanding. — R.J.R.Jr.

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2. CORRELATION CHART FOR THE ORDOVICIAN SYSTEM IN KAZAKHSTAN AND KIRGIZIA

2.1 General characteristics

Ordovician rocks in Kazakhstan and Kirgizia are widespread. They consist of geosynclinal marine terrigenous, volcanogenic, carbonaceous and siliceous sediments of varied compositions, facies types and thicknesses. Organic remains are usually rather numerous and diverse in these sediments. Practically all Ordovician faunal groups namely radiolaria, sponges, echinoderms, bryozoa, brachiopods, ostracodes, molluscs, corals, trilobites, graptolites, conodonts, algae and others are known.

The pioneer works of N.G. Kassin, V.N. Weber, D.I. Yakovlev, M.A. Borisyak, B.M. Keller, V.A. Nikolaev, O.I.Sergunkova, N.M. Sinitzyn, A.F. Lesnikova, L.A. Kolova and others laid the foundation for modern Ordovician stratigraphy of the region.

The Ordovician regional scale of Kazakhstan worked out by B.M, Keller during 1950-1960 (Ордовик Казахстана, v. 1, 1954; v. 2, 1956; v. 3, 1958; v. 4, 1961) is quite up-to-date.

In the following years M.K. Apollonov, I.S. Barskov, V.I. Goncharova, S.V. Dubinina, L.N. Klenina, O.P. Kovalevskyi, I.M. Kolobova, M.N. Koroljova, K.A. Lisogor, V.D. Malinovskaya, L.M. Melnikova, P.O. Misjus, N.F. Mikhailova, B.B. Nazarov, I.F. Nikitin, N.V. Poltavtzeva, L.E. Popov, T.B. Rukavishnikova, G.A. Stukalina, Zh. S. Sultanbekova, R.G. Tenyakova, Yu. A. Tuyutyan, D.T. Tzaj, M.B. Zima and others studied the Ordovician biostratigraphy and fauna of Kazakhstan and Kirgizia. The data of many geologists of the Ministry of Geology of Kazakh SSR (Productive geological Corporations "Yuzhkazgeologia", "Centrekazgeologia", "Vostokkazgeologia", "Sevkazgeologia"), the Geological Service of Kirgiz SSR and the Geological institutes of Academies of Sciences of USSR, Kazakh SSR, Kirgiz SSR, and also the All Union Geological Institute of the Ministry Geology of the USSR (VSEGEI), the Geological faculty of Moscow State University (MGU) and others were used in compiling the chart.

2.2 Regional Stratigraphic Units (Horizons)

Regional stratigraphical units - horizons and graptolite zones serve as regional standards for correlation of local lithostratigraphic units within a distinct region (Стратиграфический Кодекс СССР , 1979), in our case within the Region of Kazakhstan and Kirgizia.

Some horizons in the Regional Scale are divided into graptolite zones. Just these zones (constituting horizons) are regional zones or lones (in sensu of Stratigraphical Codex of the USSR). Some other horizons are not divided into zones and they correspond to distinct zones.

Graptolites are characteristic of the entire Ordovician succession in Kazakhstan (Цай , 1979, 1982 and others). In Kirgizia they are known from the Arenigian to lower Caradocian (Зима , 1974).

In the Ordovician Kazakhstan and Kirgizia were in the subtropical belt that stretched from the east margin of North America to northern Europe and central Asia. Kazakhstanian graptolites resemble those of the Pacific province; brachiopods, at least from Middle Ordovician rocks, are closely related to Appalachian and Norwegian faunas (Розман , 1977). Two divisions can be distinguished in general among graptolite assemblages. Some of them stretched through all the Pacific province, and are sparsely represented in the Atlantic province (dichotomus, approximatus, fruticosus, protobifidus, maximodivergens, tentaculatus, gracilis, multidens, pacificus, extraordinarius, persculptus). The extent of other assemblages is restricted to Kazakhstan (yini, Anisograptus-Bryograptus, romanovskyi, euglyphus, caudatus, pumilus, inuiti). These latter graptolite assemblages together with another group of faunal assemblages help to determine palaeogeographic features of the region.

Complicated folded structure, cut by faults, is the reason why only parts of the Ordovician succession are represented in most sections in Kazakhstan and Kirgizia. The Regional stratigraphical scale is based on the aggregate of the sections, correlated between themselves (Fig. 3).

The figures in brackets further in the text indicate the numbers of the columns in the correlation chart.

The Satpak Horizon was erected by N.K. Ivshin (Стратиграфический словарь , 1975) in north-east Kazakhstan [22]. The stratotype (Satpak Formation) is represented by green sandstones and siltstones with glauconite. The Dendrograptus vini Zone is recognized in the lower part of the formation. This zone is characterised by endemic species related to Chinese species from the Ichan Formation (Mu, 1955).

The Staurograptus dichotomus Zone, with the geographically wide ranging species Anisograptus richardsoni Bulman, is recognized in the upper part of the formation. In the Pacific province the S. dichotomus Zone is easily correlated with the Staurograptus tenuis - Anisograptus richardsoni Zone of Canada (Jackson, 1974) and with the Staurograptus-Anisograptus Zone of China (Sheng, 1980). In the Atlantic province the S. dichotomus Zone has no reliable

analogy. Bienvillia tetragonalis is a characteristic trilobite species for the Satpak Horizon according to N.K. Ivshin.

A better succession correlative with the Satpak Horizon was recently recorded in Malyi Karatau Range [7] (Аполлонов, Чугаева , 1982 and others). The limestone member (about 170 m) in the middle part of the Shabakty Formation contains the conodonts Cordylodus proavus, C. oklahomensis, C. lindstromi and others and the trilobites Euloma limitaris, Batyraspis, Macropyge (Macropyge) and others. The member conformably overlies the Upper Cambrian part of the section. The Satpak horizon corresponds to the lower part of the Tremadocian.

The Olenty Horizon was established by N.K. Ivshin (Ившин , 1953) in north-east Kazakhstan [22]. The horizon stratotype is the section of the Temirastau Formation composed of tuffs, sandstones, siltstones with lenses of pink limestone containing the brachiopods Clarkella, Tetralobula, Apheoorthis, Nanorthis and others. This distinctive assemblage is closely related to the assemblage from the Ibexian (Canadian) of North America. An analogous faunal assemblage is recorded from the Mamat Formation of the Chingiz Range [34]. Similar assemblages are known in the Kendyktas Range [15] and in the Malyi Karatau Range [7]. According to N.K. Ivshin Geragnostus sidenbladhi, Ceratopyge forficula, and Harpides rugosus are of the most importance for correlation. The assemblage is closely related to the assemblage from the Ceratopyge beds of Scandinavia. Graptolites are known in the Olenty Horizon only in the Baykonur Synclinorium [4], where they determine the Anisograptus-Bryograptus Zone. Two-branched and three-branched Anisograptus are found in this zone. According to generic composition (Bryograptus, Adelograptus, Clonograptus) the zone is easily correlated with the Upper Tremadocian zones of Norway, North America, Australia and China.

The Rakhmet Horizon was established by I.F. Nikitin, M.K. Apollonov,D.T. Tzaj (Никитин,Аполлонов, Цай , 1968) The stratotype (middle part of Karasuir Formation) in the Baykonur synclinorium [4] is represented by the member composed of grey and greenish grey siliceous siltstones and mudstones. It is divided into two zones - Paratetragraptus approximatus and Tetragraptus fruiticosus. The first one is the lowermost zone of the Arenigian. Tetragraptids prevail in the zone. The most characteristic species are P. approximatus, P. acclinans, and T. harti. The first Expansograptus appears in the zone. Graptolites of the zone are known, besides the stratotype, in the Zorjevka Formation in the Selety River Region [20] and in the Kokbulak Formation in the Bolshoy Karatau [5].

The T. fruiticosus Zone is recognized in regional scales of the Pacific province (North America, Australia, New Zealand, China). Tetragraptids prevail in the zone, but in combination with various goniagraptids, phyllograptids and expansograpids. Index species are known in many regions. Only graptolites are common in the horizon. However, conodonts are widely distributed in jaspers, cherts, mudstones and limestones in Ulutau-Karatau-Naryn structural zones [4, 5, 7] and in jaspers and cherts in Erementau-Chuili and Chingiz-Tarbagatay structural zones [19, 21, 22, 23, 27, 32, 37]. Prioniodus elegans, Periodon flabellum, Oistodus lanceolatus, Drepanodus proteus and other species, characteristic of the Latorp Stage of Baltoscandia are common in the level. Deposits equal to the Rakhmet Horizon are known in the Malyi Karatau Range [7], where they are represented by carbonates with conodonts and trilobites (Аполлонов, Чугаева , 1982 and others).

The Kogashik Horizon was established by B.M. Keller (1954) in North Betpakdala [12]. The stratotype (the middle part of the Kushoky Formation) is represented by sandstones, and by red, grey, and black siliceous shales with graptolites. The horizon is subdivided into two zones - Didymograptus protobifidus and Isograptus maximodivergens. The protobifidus Zone is typical for the Pacific province. The first species of Acrograptus and Isograptus appear in the zone together with tetragraptids, dichograptids, phyllograptids, didymograptids and expansograptids. Besides Betpakdala the zone is known in the Kamal Formation of Bolshoy Karatau [5] and the Karatal formation of the Chu-Ili mountains [24].

Abundant and diverse isograptids are found in conjunction with loganograptids, pseudoisograpids, phyllograptids, and tetragraptids. This association spread widely in the Pacific province (North America, Australia, New Zealand, Mongolia) and less rapidly in the Atlantic province (Great Britain). Besides the stratotype the whole zonal graptolite assemblage is known in the Zorjevka Formation in the Selety River region [20]. The hirundo Zone is the uppermost zone of the Arenigian. The zonal association is represented mainly by species of Didymograptidae in combination with rare loganograptids, phyllograptids and tetragraptids. This association is characteristic of the Atlantic province (Great Britain, Sweden, Poland, Argentina). Graptolites of the zone are also recorded from the Talsay Formation of the Dzharkainagach anticlinorium [3], in the Nayman Formation of the Chingiz Range [34] and elsewhere. In Kirgizia Upper Arenigian graptolites are known from the lower part of the Dolon Group [18] (Зима , 1974). Trilobites and brachiopods are rare in the horizon. Siliceous rocks of the same area of Kazakhstan and Kirgizia are attributed to the horizon. These rocks contain conodonts of the Prioniodus evae Zone, including Paroistodus

originalis, Prioniodus evae, Oepikodus smithensis, Oistodus longiramis and others.

The Kopaly Horizon was established by B.M. Keller and K.A. Lisogor (1954) in the Chu-Ili mountains [25]. The lower part of Uzunbulak Formation, composed of conglomerates, sandstones, siltstones and limestones serves as the stratotype. The horizon includes only the Paraglossograptus tentaculatus Zone, which is widespread over the Kazakhstan territory [4, 5, 12, 25, 28]. Tetragraptids, phyllograptids, acrograptids, cardiograptids, pseudobryograptids, and diverse Diplograptidae are characteristic of the zone.

A somewhat different graptolite association permitted the erection of the Ptilograptus delicatulus Zone in Kirgizia [18]. Dendrograptids, and ptilograptids together with phyllograptids, and diplograptids dominate here (Зима , 1974).

Abundant and diverse trilobites and brachiopods form the Karakanian assemblage of Whiterock type, which is widespread over Kazakhstan and Kirgizia. Brachiopods Aporthophyla kasakhstanica, Tritoechia, Syntrophinidae and trilobites Bathyuriscops granulatus, Bumastides betpakensis, Endymionia kasakhstanica and others are most characteristic for the horizon. Condonts are known from siliceous rocks compared presumably with the stratotype. The lower boundary of the Kopaly Horizon in the Chu-Ili mountains is not known definitely, as the Usunbulak Formation rests on the Akzhal Formation (Arenigian) with transgressive overlap. The boundary is known in the uninterrupted succession in North Betpakdala [12] and in the Bolshoy Karatau Range [5].

The Anrakhay Horizon was erected during the second Kasakhstan Stratigraphic Meeting in place of the Karakan Horizon. The latter was transferred to superhorizon rank (Решения...., 1976). The stratotype (upper part of the Uzunbulak Formation in Chu-Ili mountains) [25] consists of sandstones, siltstones and limestones with remnants of abundant and diverse shelly fauna and graptolites. The range of the Pseudoclimacograptus romanovskyi Zone equates with the range of the horizon. Endemic species predominate in the zone. Climacograptus riddelensis Harris and Glyptograptus intersitus Harris and Thomas permit correlation of the zone over vast territories from Kazakhstan to North America, Australia and New Zealand. Besides Chu-Ili mountains the Anrakhay graptolite association is recorded from the West Balkhash region [28]. The Glyptograptus dentatus Zone, characterized by glyptograptids, rare isograptids and retiograptids, is erected at the same level in Kirgizia (Зима, 1974). Brachiopods Orthidium fimbriatum, late Idiostrophia and first Camerella are characteristic of the horizon. Trilobites are closely related to Kopalinian.

The beds with Pygodus serrus in successions of siliceous deposits are known to be of Anrakhayian age. The lower boundary of the horizon is well marked in the Chu-Ili mountains [25], but it is possible that conglomerates in the base of the horizon record an hiatus.

The Tselinograd Horizon is established by I.F. Nikitin, M.K. Apollonov and D.T. Tzaj (1968) in the Stepnyak region in the Central Kazakhstan [10]. The stratotype (the lower part of the Lidievka Formation) consists of sandstones and siltstones, with tuff layers. Faunal remnants are numerous and diverse. Graptolites permit dividing the horizon into Glyptograptus euglyphus and Nemagraptus gracilis zones.

The assemblage composition of the euglyphus Zone is intermediate between romanovskyi and gracilis zones. As a rule graptolites are not abundant and are represented mainly by Diplograptidae, accompanied by Dicellograptus vagus, Expansograptus superstes, Acrograptus serratulus. Away from the Stepnyak synclinorium the whole range of the zone is known in the Beke Formation in Chu-Ili mountains [25], and in the Mynaral area in the West Balkhash region [28].

The Nemagraptus gracilis Zone is cosmopolitan. Its association is represented by various dicellograptids and dicranograptids, together with nemagraptids, climacograptids, orthograptids, glossograptids, and retiograptids. Besides the Stepnyak synclinorium the whole zonal association is known in the Beke Formation in the Chu-Ili mountains [25] and in the Bestamak Formation in Chingiz [34].

The brachiopods of the Tselinograd Horizon are represented best in the Bestamak Formation in Chingiz (Кленина et al., 1984). A closely related brachiopod assemblage is known in the lower part of the Baygara Formation in Chu-Ili mountains [25], in the Savid Formation in Betpakdala [12], in the lower part of the Rgayty Formation in Kendyktas [15] and in the lower part of the Andryushenka Formation in the North Ishim Region [1] (Никитин, Попов , 1983).

Trilobites in the Tselinograd Horizon are rare and poorly studied. The abundant and diverse assemblage is known only in the upper part of the Bestamak limestone in Chingiz [34]. Illaenus, Cybelurus, Cybele, Ampyx, Raphiophorus, Amphylichas, Niobe, Telephina, Shumardia and others are known here. In thin black graptolitic shaly limestones and mudstones numerous Telephona, Raphiophorus and others are present. The trilobites Shumardia, Geragnostus, and Cyclopyge occur in the lower part of the Lidievka Formation in the Stepnyak synclinorium.

The beds with Pygodus anserinus represented by siliceous deposits are equated to the Tselinograd Horizon. The lower boundary of the horizon is studied in the Chu-Ily mountains, where the Beke Formation with graptolites of the euglyphus Zone lies conformably on the

Uzunbulak Formation.

The Erkebidaik Horizon was established by R.A. Borukaev and I.F. Nikitin (Стратиграфический словарь , 1975). The section of the Erkebidaik Formation in the Olenty-Shyderty rivers region [22] serves as the stratotype. The best succession of the Erkebidaik Horizon is known in the Stepnyak synclinorium [10], where the upper part of the Lidievka Formation (sandstones and siltstones) equates to the horizon. The graptolite multidens Zone corresponds to the horizon. Dicellograptus and dicranograptids reach their maximum diversity and dominate this zonal association. The first paraclimacograptids and lasiograptids are rare in the zone. Amplexograptids and orthograptids become more diverse than in the previous zone, as is characteristic of correlative deposits of many regions. Besides the Stepnyak region the multidens Zone is distinguished in the upper part of the Andryushenka Formation in the Ishim River region [1] and in the Karagach Formation in the Ayaguz River area [35].

Brachiopods are recorded from many areas [1, 10, 24, 26, 34]. Usually they are represented by local associations of orthids, plectambonitids and camerellids, and it is not a very easy task to correlate these associations. In general, brachiopods of the Erkebidaik Horizon are related to North American genera and species from the Black River and Trenton.

Trilobites are comparatively rare in the horizon. The best associations are known in the Stepnyak synclinorium [10], where they were studied by M.N. Koroleva (1982). M.K. Apollonov (1968) erected two zones in the Lidievka Formation: lower - the Telephina bipunctata - "Robergia" marianna Zone and upper - the Bullacephalus Zone. Shumardia, Trigonaspis, Cyclopyge, Symphysops, Pricyclopyge, Microparia, Sagavia, Dionide, some Odontopleuridae, Ampyxinella and others are very characteristic of the lower zone, and abundant Bullacephalus and Ionchodomas tecturmasi are common taxa for the upper zone. A diverse association is recorded from limestones of the Andryushenka Formation in the Ishim River area [1]. Nileus, Piomerina, Lonchodomas, Illaenus, Glaphurina, Remopleurides, Cybele, Dionide and others are discovered here. "Robergia", Opsimasaphus and Cyclopyge were collected from mudstones in the section.

The lower boundary of the Erkebidaik Horizon is known in the sections of the Lidievka Formation in the Stepnyak synclinorium [10] and in the Erkebidaik Formation in the Selety River area [20]. The multidens Zone alternates with the gracilis Zone in these continuous successions.

The Anderken Horizon was erected by V.N. Weber (1948). The stratotype (the Anderken Formation in the Chu-Ili mountains) consists of polymictic conglomerates, sandstones and siltstones and biohermal limestones. The faunal is abundant and diverse. The range of the graptolite Climacograptus caduceus Zone is equal to the range of the horizon. The zonal association mainly consists of climacograptids, glyptograptids, orthograptids in combination with rare dicellograptids and dicranograptids. Such an association is characteristic for many regions of the world.

Anderkenian graptolites are mostly related to contemporary North American and Australian associations. Besides the Chu-Ili mountains the diverse Anderkenian graptolite associations are known in the Esil Formation in the Ishim River area [1], in the Karagach Formation in the Ayaguz River area [35] and other areas.

Anderkenian brachiopods are numerous and diverse, but mainly endemic and poorly studied. Approximately 50 brachiopod species of 45 genera are known in the stratotype area. These brachiopods were grouped into distinct benthic associations of nearshore facies, bioherm buildups and offshore facies. The generic composition of Anderkenian brachiopod assemblages is related to associations in eastern North America, Scotland, the Altay-Sayan region and Australia. The genera with short vertical range - Palaeostrophomena, Gacella, Parallelelasma, Sphenotreta and others are known in the horizon, accompanied by long ranging genera. Smaller assemblages of this age are known in the Esil Formation in the Ishim River region [1], in the Majatas Formation in the Stepnyak region [10] and in the upper part of the Karagach Formation in the Tarbagatay Range [35].

Trilobites in the Anderken Horizon are numerous and diverse. They are best studied in the Chu-Ili mountains (Вебер , 1948; Чугаева , 1958). Assemblages, closely related to sedimentary facies can be distinguished (Чугаева , 1958; Apollonov, 1975; Аполлонов , 1976). Assemblages with Isotelus romanovskyi and with Basilicus, Lonchodomas, and Dulanaspis are characteristic of sandstones of nearshore origin. The distinctive assemblage with illaenids, lichids, Sphaerexochus, Holotrachelus, Heptabronteus, and Hadromeros is related to biohermic limestones with diverse shelly fauna. The assemblage with Ampyxinella, Telephina, Cyclopyge, Symphysops, Birmanites, and others is closely connected with fine-grained siltstones and mudstones of offshore origin.

The lower boundary of the horizon is known in the Ishim River region [1], where it is based on graptolite data in an uninterrupted succession. The Esil Formation rests conformably on the Andrjushenka Formation with graptolites of the multidens Zone in the upper part. Such

relations between multidens and caduceus zones are known also in the upper part of Karagach Formation in the Tarbagatay Range [35].

The Dulankara Horizon is established by B.M. Keller (1956) with the Dulancara Formation in the Chu-Ili mountains as the stratotype [25]. The type section consists of sandstones, siltstones, conglomerates and limestones with a diverse fauna, mainly benthic. It contains the graptolites of the Dicellograptus pumilis Zone. Climacograptids and orthograptids accompanied by dicellograptids predominate in the zonal association. Besides the index-species, Dicellograptus morrisi and Climacograptus pygmaeus are characteristic of the zone. These species are known from the Ashgillian of Scotland, Sweden and North America. The representative associations of Dulankaraian graptolites are also known in the Akdombak Formation in the Chingiz Range region [34] and in the Burluk Formation of the Ishim river region [1].

Brachiopods of the Dulankara Horizon are as numerous as of the Anderken Horizon. The characteristic brachiopod assemblage of shallow-water nearshore clastic facies is widely distributed all over Kazakhstan and Kirgizia. A great number of orthids, Plaesiomidae, accompanied by rhynchonellids (Zanclorhyncha), and atrypids (Zygospira, Euroatrypa, Sulcatospira, and others) are common for the assemblage [1, 4, 5, 24, 25, 34 and others]. The genera Spirigerina, Parastrophinella and others predominate in the biohermic facies, which are typical for the Dulankara Horizon [15, 25].

Corals play a very important role in the stratigraphy of Kazakhstan and Kirgizia beginning in Dulankaraian time. O.P. Kovalevskyi (Ковалеский , 1971) established a succession of beds based on coral associations. Lower beds with Amsassia haetetoides are known in many regions of Kazakhstan [1, 10, 12, 20, 25, 32, 33, 34, 36]. Beds with Agetolites mirabilis and Catenipora libera were erected in the regions of the Chingiz and Tarbagatay ranges [34, 36]. They are considered to be contemporaneous with the part of the Dulankara Horizon which is represented in the stratotype by unfossiliferous sandstones. The Odak beds of Ekibastuz and Maikain regions [32, 33] with A. mirabilis, Triplesia ex gr. insularis, and Spirigerina mavrae are thought to be equivalent to beds with A. mirabilis.

Trilobites of the Dulankara Horizon are known in many area of Kazakhstan and Kirgizia. Being found in limestones they are closely related to Anderkenian trilobites on the basis of generic composition. Isotelus, Dulanaspis, Pliomerina, and Remopleurides, which are common in sandstones, are characteristic of the horizon and are abundant in some areas [4, 5, 24, 25, 34]. The Zharyk beds with abundant and diverse trilobites including Trinodus tardus, Cyphoniscus socialis, Microparia speciosa, Phyllipsinella parabola (Апполонов, 1974) are considered to be contemporaneous with the uppermost part of the Dulankara Horizon.

The lower boundary of the horizon is established in the stratotype, where the Dulankara Formation rests conformably on the Anderken Formation.

The Chokpar Horizon was erected by B.M. Keller (Келлер , 1956) in the Chu-Ili mountains [25] and is well studied in the region (Граница ..., 1980). The stratotype of the horizon is represented by dark graptolitic siltstones, mudstones and sandstones of the Chokpar Formation. Biohermal and detrital Ulkuntas and Oisu limestones rest on the clastic sediments. Two graptolite zones Amplexograptus inuiti and Paraorthograptus pacificus are distinguished in the stratotype. Amplexograptids accompanied by climacograptids and orthograptids are basic taxa of the inuiti Zone. The same is known to be at this level in North America (Riva, 1969) and China (Mu, Lin, 1983).

The pacificus Zone is well known in many regions of the pacific province. Paraorthograptids of the pacificus group accompanied by orthograptids of the amplexicaulis group, climacograptids of the longispinus group and dicellograptids of the complanatus group predominate in the zonal association. The closely related association is known in Great Britain, North America, China and Australia. Beside the Chu-Ili mountains Chokparian graptolites are discovered in the upper part of the Akdombak Formation in the Chingiz Range region [34].

Brachiopods in the Chokpar Horizon are known mainly at the level of the pacificus Zone and belong to the Holorhynchus giganteus beds association. The association is widely distributed over the Kazakhstan territory [25, 32, 34, 36]. It is connected with biohermal and shoal limestones. The brachiopod association connected with detrital limestones of the Oisu type is of comparatively restricted distribution. It is known in Chu-Ili mountains [25] and in the Akbastau region [37].

Corals of the Chokpar Horizon constitute the distinctive association in the Holorhynchus giganteus beds. The combination of comparatively old genera which appeared in the Middle Ordovician (Lyopora, Saffordophyllum) or in the lowermost part of the Upper Ordovician (Agetolites), with Ashgillian genera (Agetolitella, Hemiagetolites, Priscosolenia) and genera which are common to the Silurian (Palaeofavosites, Mesofavosites, Catenipora) is very characteristic of Chokparian association. The association is known in the Ulcuntas limestones in the Chu-Ili mountain [25], in the Maikain region [33], the Chingiz Range region [34] and in

the Tarbagatay Range [36].

Trilobites of the Chokpar Horizon are well studied in the Chu-Ili mountains. Species of Decoroproetus, Otarion, Bumastus, Dicranopeltis, Dicranogmus and Primaspis are described from the Oisu limestones (Граница..., 1980). Some of them are closely related to species from the Ashgillian and Llandoverian of some regions of Eurasia. Platycoryphe sinensis is known from the Oisu limestone as from the Durben Horizon, where it is represented by numerous specimens. Holotrachelus punctillosus is reported from the Ulkuntas limestone. Endemic species of Ampyxinella, Diacanthaspis and also Raphiophoridae are discovered in dark siltstones.

The lower boundary of the Chokpar Horizon is not quite clear since the transitional interval between the Dulankara and Chokpar horizons is represented by practically unfossiliferous sediments all over Kazakhstan.

The Durben Horizon was established by M.K. Apollonov, S.M. Bandaletov, I.F. Nikitin et al. (Граница ..., 1980) in the Chu-Ili mountains [25]. The lower part of the Zhalair Formation near the Durben serves well as the stratotype. The section consists of green mudstones, siltstones, sandstones and grey thin bedded limestones. The horizon is divided into two graptolites zones - Climacograptus extraordinarius and Glyptograptus persculptus. The association of the extraordinarius Zone consists mainly of climacograptids and rare glyptograptids. The index species is distributed rather widely. It was established in the north-east USSR (Граница ..., 1983) and is known now in Kazakhstan, Scotland, Ireland and China at the same level. The persculptus Zone is the uppermost zone of the graptolite zonal succession in Kazakhstan. The zonal association is comparatively scanty and consists mainly of glytograptids of persculptus type and rare climacograptids.

It is very important to note that graptolites of the extraordinarius and persculptus zones were discovered at the same levels where trilobites and brachiopods of the characteristic Dalmanitina-Hirnantia association had been found. Hirnantia sagitifera, Bracteoleptaena polonica, Leptaenopoma trifidum, Dalmanitina mucronata, D. olini, Leonaspis olini, and Platycoryphe sinensis are the most typical species of the association. Besides the Chu-Ili mountains representatives of the association are known from the upper part of Akdombak Formation in the Chingiz Range [34] and isolated outcrops of sandstones and siltstone in the Sarysu-Teniz region [11]. Biohermal and shoal limestones with large pentamerids Holorhynchus giganteus and Proconchidium munsteri type reported from some regions of Kazakhstan are thought to be synchronous with the Durben Horizon. The brachiopod association characteristic of the Chokpar Horizon is believed to exist up to the latest Ordovician. In the Silurian it was replaced by the Holorhynchus chingizicus association.

2.3 Systemic Boundaries

The Cambrian-Ordovician boundary in Kazakhstan is better studied in the Batyrbay section in the Malyi Karatau Range [7] (Апполлонов,Чугаева , 1982, 1983a, 1983b; Apollonov, Chugaeva, Dubinina, 1981; Chugaeva, Apollonov, 1982 et al.). It is drawn within limestones of the Shabakty Formation at 109 m, defined as the base of the Cordylodus proavus conodont Zone. This Zone succeeds the Eoconodontus alisonae Zone. The boundary in the trilobite succession coincides with the boundary between the Lotagnostus hedini Zone of uppermost Cambrian and Euloma limitaris-Batyraspis Zone of the lowermost Ordovician. However the Cambrian-Ordovician boundary in the officially adopted Regional Scale at present is based on the section in the Olenty - Shiderty region [22] in north-east Kazakhstan (Ившин,Покровская , 1968). The bundary is drawn in the base of Satpak Horizon and coincides with the base of Dendrograptus yini Zone with endemic graptolites. It is probable however that the underlying Shiderty Horizon with the trilobites Lotagnostus asiaticus, Hedinaspis regalis and others and conodonts of the Proconodontus association does not equate to the uppermost part of the Upper Cambrian.

The Ordovician-Silurian boundary in Kazakhstan is best studied in the Chu-Ili mountains [25] (Граница .., 1980). It is drawn at the base of Akidograptus acuminatus Zone of Alpeis Horizon and at the top of Glyptograptus persculptus Zone of the Durben Horizon. Discoveries of G. persculptus Zone graptolites together with the Hirnantia sagittifera-Dalmanitina mucronata brachiopod-trilobite association (Михайлова, , 1970 б) demonstrated the contemporaneity of the persculptus Zone and Hirnantia-Dalmanitina association. It has been suggested to include the persculptus Zone into the Ordovician and to draw the Ordovician-Silurian boundary at the base of the acuminatus Zone (Апполлонов,Бандалетов,Никитин и др. , 1973; Nikitin, 1976; Граница ..., 1980).

Localities of graptolites of the Akidograptus acuminatus Zone in Kazakhstan are rare. The Ordovician-Silurian boundary in other regions in Kazakhstan is drawn at the base of the Holorhynchus chinghisicus beds or the Eospirifer chinghisicus beds of the Alpeis Horizon [32, 33, 34, 36] (Бандалетов , 1969).

2.4 Structural-Facial Regional Zonation

Ordovician successions of Kazakhstan and Kirgizia according to general features of the

geological evolution of regions and the features of volcanism are grouped in five zones (Королев , 1961; Никитин , 1964, 1972, 1973). In this paper Ulutau-Karatau-Naryn, Stepnyak-Betpakdala and North Tien-Shan, Erementau-Chu-Ili, Chingiz-Tarbagatay and Dzungar-Balkhash zones are considered (Fig. 1).

The Ulutau-Karatau-Naryn zone frames the palaeozoides of the Central Kazakhstan from the west and stretches south-eastward to Middle Tien-Shan in Kirgizia. Only sporadic volcanic deposits of lower and uppermost Ordovician age are known in some regions [1, 2, 3, 4]. Lower Ordovician shales, mudstones, thin cherts and mainly pelagic carbonates are characteristic of the zone. The Stepnyak-Betpakdala and North Tien-Shan zone stretches from east edge of the Kokchetau Massif on the north to Betpakdala and North Tien-Shan on the south and southeast. Intensive volcanism in the Middle Ordovician and a great thickness of Ordovician sediments are characteristic features of the zone.

The Erementau-Chu-Ili zone can be traced from the Selety and Shiderty rivers region in the north-east of central Kazakhstan through the west Balkhash region and Chu-Ili mountains to the north foothills of Zailiyskyi Alatau and to Dzungar Alatau at the south-east. Based on the general features of sedimentary composition the zone is closely related to the Ulutau-Karatau-Naryn zone. Volcanics are rather rare and are known only locally in the Lower and Middle Ordovician. The distinction consists of the greater thickness of cherty, clastic and carbonate sediments of the Lower Ordovician and lower part of the Middle Ordovician, and the complete Upper Ordovician succession which in many places are succeeded by Silurian strata. The Chingiz-Tarbagatay zone frames Central Kazakhstan from the east and stretches from the Shiderty right-bank region in the north to the Tarbagatay Range in the south-east. Great amounts of volcanics and sediments in all parts of Ordovician succession and a continuous Ordovician-Silurian succession are characteristic features of the zone.

The Dzungaria-Balkash zone envelopes Ordovician formations of the inner parts of Central Kazakhstan palaeozoides situated to the south and south-east of the Karaganda Basin. Widespread cherty-volcanic formations of the Lower, Middle and probably Upper Ordovician are very characteristic for the zone.

2.5 Alphabetical List of Local Stratigraphic Units (Rock Units)

Abay Formation [34]. Green-grey andesite-basalt porphyrites and tuffs, volcanomictic sandstones, limestones. Amphylichas karakanensis, Illaenus tshernyshovae (Никитин , 1972; Страт. сл. , 1975).

Agalatas Formation [15]. Limestones with Apatokephalus replicare, Geragnostus sidenbladhi, Clarkella testudo, Nanorthis multicostata (Келлер, Рукавишникова , 1961 Страт. сл, 1975).

Ajutor Formation [6]. Green-grey sandstones, siltstones, mudstones, layers of conglomerates (Геология СССР,1972 б; Страт. сл.1975; Королев, Мисюс,1982).

Akdombak Formation [34]. Green-coloured sandstones, siltstones, in lower part-limestones (up to 500 m) with Agetolites mirabilis, A. minor, Catenipora subparallela, Ptychopyge vodorezovi, Sowerbyella akdombakensis, Zygospira parva; above in siltstones Dicellograptus pumilus, Pseudoclimacograptus clevensis, Diplograptus pristis (pumilus zone); higher in sandstones and siltstones Hemiagetolites, ramosus, Catenipora inordinata, Detzetina anticedens, Kassinella globosa, Luchaia bakanassensis, Holorhynchus giganteus, Lepidocyclus laddi, Microparia speciosa, Tretaspis aff. granulata, Remopleurides tenuispinifer, Ampyxinella venulosa, Climacograptus supernus, Amplexograptus inuiti, Orthograptus amplexicaulis (inuiti Zone), Dicellograptus ornatus minor, Glyptograptus posterus, Diplograptus pristis, Orthograptus socialis, paraorthograptus pacificus, Arachniograptus chuchlensis (pacificus Zone); in the upper part in the limestone layer Aegiromena, Leptaena, Dalmanitina, Glyptograptus? persculptus (Durben Horizon) (Никитин , 1972; Кленина, Никитин, Попов , 1984).

Akdym Formation [19, 21]. Light-grey, white, black, yellowish, green and red cherty rocks, jaspers, sandstones and siltstone members [19], basaltic lavas and tuffs. In the lower part in sandstones - Apatokephalus and others, higher in cherts Oistodus lanceolatus, Paracordylodus gracilis, Linnarsonia?, Acrotretidae (Борукаев , 1955 Новикова,Резанцев, Дубинина , 1978 .

Akkayrakty Formation [3]. Green-coloured polymictic sandstones, mudstones, gravelstones. Expansograptus, Glyptograptus (gracilis Zone) (Хабелашвили,Цай,1966; Никитин , 1972).

Aksu Formation (Upper part) [19]. Volcanomictic sandstones, siltstones, lenses of limestones, trachydacite-andesite lavas and tuffs. Apatokephalus, Geragnostus, Niobe (Бабичев ,Борисенок , Великовская и др. , 1977).

Akzal Formation [24, 25]. In the lower part basal conglomerates and quartzose sandstones, limestones with Bumastides cf. betpakensis. Higher [25] andesite-basalt porphyrites and tuffs, sandstones with Dichograptus octobrachiatus, Tetragraptus fruiticosus, Expansograptus extensus (fruticosus Zone) (Келлер , 1956;Страт. сл. , 1975).

Algabas Formation [11, 12]. In the lower part [12] - volcanomictic conglomerates and green-grey, greyish-brown polymictic sandstones with Pseudolingula, in the middle part black cherty siltstones with Glyptograptus euglyphus, Expansograptus superstes, Glossograptus acanthus (euglyphus Zone) and limestones with Plectorthis and others. In the upper part-rhythmically bedded green-coloured sandstones and siltstones. Expansograptus superstes, Dicellograptus perexilis, Dicranograptus brevicaulis, Pseudoclimacograptus stenostoma (gracilis Zone) (Геология СССР , 1972a; Никитин ,Аполлонов, Цай и др., 1980a).

Almaty Formation [17]. Sandstones siltstones. Megalaspis saltaensis, Protopliomerops (Королев , Мисюс , 1982).

Anderken formation [24, 25, 26]. Green-coloured conglomerates, sandstones, siltstones and mudstones, biohermal limestones, replaced by olistostromes and bedded limestones. In the stratotype [25] - beds with "Isotelus" romanovskyi, Palaeostrophomena necopina and others, beds with Lonchodomas tecturmasi, Opsimasaphus almatyensis, Dulanaspis levis, Plectorthis aff. altaica, Anoptambonites orientalis, Glyptomena onerosa and others; Anderken limestones with Heptabronteus romanovskyi, Metapolichas anderkensis, Holotrachelus punctillosus, Austinella, Phragmorthis, Glyptorthis cf. balkhaschiensis, Shlyginia fragilis, Anoptambonites, Acculina acculica, Gacella, Anisopleurella, Craspidella, Christiania, Bellimurina, Limbimurina, Triplesia ainca, Liostrophia, Parstrophina hemiplicata, P. plena, Eoanastrophia kurdaica, Parallelelasma, Rhynchotrema, Cyclospira, Catenipora, Lichenaria?, Discoceras kasachstanense, Gorbyoceras rum. In the upper part Dicranograptus nicholsoni, Climacograptus caudatus, C., spiniferus, Pseudoclimacograptus scharenbergi, Glyptograptus asiaticus, Diplograptus anderkensis, Orthograptus amplexicaulis and others (caudatus Zone) (Келлер,1956;Никитин, 1972; Никитин, Аполлонов, Цай и др., 1980a).

Andryushenka Formation [1]. Rhythmically bedded green-coloured conglomerates, polymictic sandstones, siltstones, in the lower part some limestones. Dicellograptus sextans exilis, Dicranograptus multidens (multidens Zone), in the limestones Plectorthis numirosa, Ishimia ishimensis, Titanumbonites magnus (Четверикова, , 1957; Никитин , 1972;Страт. сл. , 1975;Цай , 1976).

Angrensor Formation [32, 33]. Green-coloured conglomerates, sandstones, siltstones, beds of grey limestones. Heptabronteus romanovsky, Stenopareia linnarssoni, Holotrachelus punctillosus, Glaphurina weberi. Koskarasu beds with Amsassia chaetetoids, Glyptorthis, Phynchotrema, Triplesia and others and Odak beds with Agetolites mirabilis, Triplesia ex. gr. insularis, Parastrophina, Parastrophinella, Spirigerina marvae, Cyclospira? ex gr. elegantula (Никитин , 1972; Страт. сл. , 1975).

Bayan Formation [32, 33]. Greyish-brown andesite porphyrites and tuffs, polymictic sandstones, siltstones, polymictic conglomerates, lenses of limestones. Palaeoalveolites, Paratetradium, Nyctopora, Holotrachelus punctillosus, Bumastus cf. holei (Никитин, Аполлинов, Цай , 1968;Никитин, 1972).

Baydaulet Formation [38]. Dark green, green-andesite-basalt porphyrites, tuffs, volcanomictic sandstones and cherty rocks. Isotelus, Illaenus, Heptabronteus (Стат. сл. , 1975).

Baygara Formation [16]. Green-grey, greyish-brown-red and purple sandstones, siltstones and limestones. Expansograptus superstes, Dicranograptus brevicaulis, Glyptograptus teretiusculus (gracilis Zone), Plectorthis numerosa, Acculina acculica, Atelelasma aff. plana, Bimura buttsi, Christiania subquadrate, Mimella similis, Ancystrorhyncha perplexa (Палец , токмачева , 1971; Никитин, Аполлонов, Цай , 1980a).

Bazarbay Formation [38]. Basalts, jaspers, cherty-terrigeneous rocks. Periodon aculeatus aculeatus, inarticulate brachiopods and others (Антонюк , 1971;Геология СССР 1972a; Новикова, Герасимова, Курковская , 1985).

Beke Formation [18]. Rhythmically bedded green-grey sandstones and siltstones. In the lower part - Acrograptus serratulus, Glyptograptus euglyphus, Glossograptus ciliatus (euglyphus Zone); in the upper part Acrograptus serratulus, Pseudoclimacograptus scharenbergi, Glyptograptus teretiusculus, Glossograptus hincksi, Cryptograptus tricornis, Reteograptus geinitzianus (gracilis Zone). (Келлер , 1956; Михайлова, Цай , 1969; Никитин, Аполлонов, Цай и др. , 1980a).

Belkaragan Formation [23]. Green-grey polymictic sandstones, siltstones, beds of conglomerates, lenses of limestones. Bryozoans, corals, crinoids (Страт. сл. , 1975).

Bercut Formation (Upper part) [9]. Carbonaceous-argillaceous chert, carbonaceous-cherty mudstones. Didymograptus sp., inarticulate brachiopods (Страт. сл., 1975;Королев,Мисюс , 1982).

Besharyk Formation [5]. Rhythmically bedded green-coloured siltstones, sandstones, rarely gritstones and conglomerates. In the lower part - Leptograptus flaccidua, Orthograptus quadrimucronatus, in the upper part - Hebertella brevis, Plaesiomys, Strophomena ajagusensis, Zygospira parva, Dulanaspis levis, Cybele weberi, Opsimasaphus kolovae, Ampyx sergunkovae

(Анкинович , 1961; Страт. сл., 1975).

Beshtor Formation [6]. In the lower part limestones, dolomites with Holotrachelus punctillosus, Cyclopyge umbonata bohemica, Nileus tengriensis; in the upper part - carbonaceous-argillaceous, carbonaceous-cherty mudstones, siltstones, intercalations of sandstones and limestones. Climacograptus pusillus, C. ex. gr. styloides, Glyptograptus sp., Orthograptus cf. gracilis (Геология СССР , 1972б; Королев, Мисюс , 1982).

Bestamak Formation [34]. Green-coloured, commonly rhythmically bedded sandstones, siltstones, beds of agglomerates, at the base-members of grey Bestamak limestones with Opsimasaphus, Niobe, Trigonaspis, Scaphorthis, ex gr. perplexa, Leptellina seletensis, Tshaganella tshganensis, Bajanhorella variabilis, Camerella plicata, Ancistrorhyncha perplexa, Oligorhyncha mica; higher in the sandstones and siltstones - "Robergia" marianna, Telephina bipunctata, Dicellograptus sextans exilis, Dicranograptus nicholsoni, Nemagraptus gracilis, Climacograptus bicornis, C. peltifer, Orthograptus whitfieldi (gracilis Zone) (Страт. сл. , 1975,Кленина,Никитин, Попов , 1984).

Biik Formation [33]. Greyish-brown, greenish andesite porphyrites, volcanomictic sandstones and siltstones (Никитин,Аполлонов, Цай , 1968; Никитин , 1972).

Bolgozha Formation [26]. In the lower part - green and grey rarely greyish-brown andesite porphyrites and tuffs, higher-grey liparites and dacite porphyrites and tuffs, lenses of limestone with Kayseraspis sp.; in the upper part volcanomictic sandstones and siltstones with Tetragraptus bigsbyi, Phyllograptus anna, Didymograptus sp.
(Токмачева, Кузнечевский, Палец 1976; Никитин, Аполлонов, Цай и др. , 1980а).

Burluk Formation [1]. Green-grey mudstones, siltstones, polymictic sandstones, members of limestone. In the lower part (caudatus Zone) - Acculina acculica, Eoanastrophia aff. kurdaica Anoptambonites, Rhynchotrema and others; higher - Climacograptus tatianae, Orthograptus amplexicaulis, O. pauperatus (pumilus Zone), Pliomerina unda, Plaesiomys, Dinorthis, Kassinella globosa, Anoptambonites, Amsassia chaetetoides, Catenipora parallela (Страт. сл. 1975; Решение ..., 1976).

Burubaytal Formation [27]. Light-grey, yellowish, green, black and red cherts, jaspers, phthanites, members of siltstones, sandstones and gritstones. Paracordylodus gracilis, Prioniodus evae, Periodon flabellum, Paraoistodus parallelus (Токмачева, Кузнечевский, Палец , 1976 Страт. сл. , 1975; Никитин, Аполлонов, Цай и др., 1980а,б).

Burultas Formation (Upper part) [27]. Dark-grey polymictic sandstones, siltstones, lenses of gritstones (Токмачева, Кузнечевский,Палец, 1976; Никитин, Аполлонов, Цай и др., 1980а,б).

Chazhagoy Formation [29]. Grey, striped, carbonaceous cherty shales, quartz sandstones, bedded limestones. Expansograptus, Isograptus, Nileus tengriensis (Алъперович , 1971; Пупышев , 1974).

Chelek Formation [16, 17]. Grey, pink polymictic sandstones, conglomerates, siltstones (Геология СССР, 1972б).

Chokpar Formation [24, 25, 26]. Dark-grey black and greenish mudstones, siltstones. In the lower part - Dicellograptus ornatus minor, Climacograptus supernus, Amplexograptus inuiti, Orthograptus amplexicaulis (inuiti Zone); in the upper part - Dicellograptus ornatus, Diplograptus pristis, Glyptograptus ojsuensis, Amplexograptus manitoulinensis, Orthograptus socialis, Paraorthograptus pacificus, Arachniograptus chuchlensis, Nymphograptus velatus (pacificus Zone); Ulkuntas and Oisu limestones with Decoroproetus artus, D. cf. evexus, Otarion curvulum, O. gibberum, Dicranogmus confinis, Platycoryphe sinensis, Giraldibella bella, Streptis altosinuata, Leptaena rugosa, Holorhynchus giganteus, Proconchidium tshuilense, Spirigerina plana, Hemiagetolites ramosus, Catenipora inordinata, Plasmoporella convexotabulata, Propora intercedens, Heliolites parvulus, Beloitoceras summum, Tshuiliceras lobatum, Michelinoceras procurrens, Geisonoceras fustis, Acodus similaris, Eobelodina fornicala, Icriodella and other (Келлер , 1956; Страт. сл., 1975; Граница ..., 1980).

Cholponata Formation (Upper part) [16]. Rhythmically alternated many-coloured polymictic sandstones, siltstones, mudstones, Aletograptus
(Геологиа СССР, 1972б; Королев, Мисюс, 1982).

Chonkaindy Formation [14]. In the lower part polymictic conglomerates, gritstones; in the upper part red siltstones, mudstones, sandstones, Middle and Upper Ordovician conodonts.

Dolon Formation [18]. In the lower part - polymictic conglomerates, gritstones, sandstones; higher flyschoid alternation of sandstones, siltstones, mudstones with rare biohermal limestones and members of andesite-dacite tuffs. Upward four graptolite zones are distinguished: 1 - Expansograptus hirundo, 2 - Ptilograptus delicatulus, 3 - Glyptograptus teretiusculus, 4 - Nemagraptus; Higher beds with: 1 - Ishimia, 2 - Leptellina, 3 - Christiania. In the upper part trilobites of Dulancara Horizon are known (Геология СССР,1972б; Страт. сл., 1975; Королев,Мисюс, 1982).

Dolonata Formation [16]. Organic-detrital and algal limestones with Nuia sibirica; in the

middle part - mudstones, siltstones with Tetragraptus serra, T. quadribrachiatus, Acrograptus acutidens, A. gracilis, Isograptus caduceus, Dichograptus octobrachiatus; in the upper part - limestone conglomerates, limestones, siltstones, sandstones with Pseudotrigonograptus ensiformis, Ptilograptus cf. delicatulus, Glossograptus hincksi, Bumastides betpakensis, Lisogorites striatus (Геология СССР, 1972б ; Королев, Мисюс, 1982).

Dulancara Formation [24, 25, 26]. Green coloured conglomerates, sandstones, siltstones, members of bedded and biohermal limestones. Otar beds with Hebertella brevis, Plaesiomys (Dinorthis) kassini, Shizophorella? kasakhstanica, Shlyginia extraordinaria, Anoptambonites, Sowerbyella, Otarorhyncha otarica, Zygospira parva, Isotelus levis, Dulanaspis levis, Pliomerina unda; Protaraea (?) sp., Proheliolites ex gr. mirandus, Proheliolites (?) sp., Orthograptus almatyensis and others; Degeres beds with Opsimasaphus kolovae, Ampyx sergunkovae, Pragmorthis, Oniella, Glyptambonites musulosus, Shlyginia extraordinaria, Anoptambonites, Sowerbyella insueta, Rhipidomena ?, Tetrapharelella, Holtedahlina, Glyptomena, Platymena and others: Akkol beds with Plasmoporella kasachstanica, Amsassia chaetetoides, Oniella, Glyptambonites musculosus, Spiregerina pennata, Dicellograptus pumilus, Climacograptus pygmaeus, C. typicalis posterus, C. tatinae, Orthograptus amplexicaulis, O. quadrimucronatus (pumilus Zone) (Келлер , 1956; Никитин, 1972; Страт. сл., 1975; Аполлонов, Цай и др., 1980а).

Dulygaly Formation [4]. Rhythmically alternated, green-coloured sandstones and siltstones. In the lower part - Dicellograptus vagus, Climacograptus riddelensis, Pseudoclimacograpus scharenbergi, Glyptograptus euglyphus (euglyphus Zone); in the upper part Opsimasaphus kolovae, Ampyx sergunkovae, Plaesiomys (Dinorthis), Kassinella globosa (Книппер, Никитин , 1962; Страт. сл. , 1975; Никитин 1972).

Dzhartash Formation [14]. Dark argillaceous, cherty shales, siltstones, sandstones, limestone intercalations (Геология СССР, 1972б).

Erkebidaik Formation [19, 20, 22, 32, 33]. Rhythmically bedded, green-coloured polymictic sandstones, siltstones, conglomerates; in some areas [32, 33] tuffs. Dicellograptus intortus, Dicranograptus ramosus, D. nicholsoni, Orthograptus acuatus, Glossograptus hincksi, Lasiograptus costatus (multidens Zone) Борукаев , 1955; Никитин , 1972; Страт. сл. , 1975 Цай , 1976).

Erzhan Formation [22]. Light-grey, red, yellowish cherts, jaspers, cherty siltstones, grey and red siltstones and sandstones. Two members are distinguished: low member cherty and upper member mainly terrigenous. In the cherts two conodont assemblages are known: lower - with Oistodus gracilis, O. cf. forceps, Periodon flabellum, Drepanodus cf. sculpaneus; upper - with Periodon cf. aculeatus aculeatus, Periodon sp., and others (Никитин, Аполлонов, Цай , 1968;Никитин 1972).

Esil Formation [1]. Green-coloured, fine-grained sandstones, calcareous siltstones, limestones. Dicranograptus nicholsoni, Climacograptus caduceus, C. typicalis, Pseudoclimacograptus scharenbergi, Glyptograptus vespertinus, Orthograptus quadrimucronatus, O. pageanus (caduceus Zone), Shlyginia declivis, Ishimia, Anoptambonites, Glyptomena onerosa (Труды ....1960; Геология СССР, 1972а ; Страт. сл., 1975).

Ichkebash Formation [8]. Greenish-grey sandstones, siltstones, mudstones. In the lower part Glyptograptus ex gr. teretiusculus, Diplograptus aff. multidens, Orthograptus ex gr. amplexicaulis; in the upper part Kassinella, Sowerbyella, Plaesiomys (Dinorthis) (Геология СССР, 1972б ; Страт. сл., 1975 ; Королев, Мисюс, 1982).

Iradyr Formation [19]. Jaspers, phthanites, cherty siltstones, quartzose sandstones. Linnarssonia aff. gorjanskii, Acrotreta ulrichi, Paracordylodus gracilis (Борисенок, Герасимова, Зайцев и др., 1979 ; Борисенок, 1981).

Ishkeolmes Formation [19]. Grey, greenish, red siltstones, mudstones, jaspers, phthanites, sandstones and basalt members. In the cherts - Paracordylodus gracilis (Геология СССР, 1972а; Борисенок, Гервсимова, Зайцев и др., 1979).

Isobilinaya Formation [20]. Greenish-grey, red rhythmically bedded mudstones and siltstones. In the lower part - Dicellograptus vagus (euglyphus Zone); in the upper part - Expansograptus superstes, Dicellograptus sextans exilis, Dicranograptus brevicaulis, Nemagraptus sp., Climacograptus bicornis, Pseudoclimacograptus stenostoma, Glyptograptus teretiusculus (gracilis Zone)
(Никитин, Аполлонов, Цай,1968;Никитин, 1972; Цай, 1976).

Itmurundy Formation [39]. Green, greenish-grey amygdaloidal basalts, tuffs, beds of many-coloured cherty siltstones and jaspers. Pygodus serrus, Periodon aculeatus, Spinodus spinatus, Panderodus cf. similaris, Protopanderodus cf. varicostatus, Carposhaera, Cenasphaera (Кошкин , 1971;Антонюк , 1974; Новикова, Герасимова, Дубинина , 1983).

Kalmakkol Formation [2]. Rhythmic alternation of green-coloured siltstones, polymictic sandstones and conglomerates. In the lower part - Dicellograptus sextans, Dicranograptus nicholsoni, Diplograptus multidens, Glyptograptus teretiusculus, Amplexograptus perexcavatus (multidens Zone); in the middle part - Orthograptus almatyensis, O. pageanus (caudatus Zone); in the upper part - Dicellograptus morrisi, Climacograptus typicalis, Orthograptus (pumilus Zone), Sphaerexochus hisingeri, Pliomerina cf. dulanensis (Геология СССР, 1972а;Минервии , Бабичев, Тенякова, 1974).

Kamal Formation [5]. In the lower part - greenish-grey mudstones with Tetragraptus bigsbyi, T. pendens, Expansograptus extensus, Phyllograptus anna (fruticosus Zone); in the middle part - Goniograptus geometricus, Tetragraptus amii, T. bigsbyi, T. reclinatus, Expansograptus sp., Didymograptus protobifidus (protobifidus Zone), Dichograptus maccoyi, Phyllograptus anna, Expansograptus extensus, Isograptus maximodivergens, I. elegans (maximodivergens Zone), Tetragraptus serra, Pseudotrigonograptus ensiformis, Expansograptus hirundo (hirundo Zone); in the upper part - grey cherty mudstones and black jaspers with Tetragraptus bigsbyi, Pseudotrigonograptus ensiformis, Acrograptus cognatus, Glyptograptus dentatus, Paraglossograptus tentaculatus (tentaculatus Zone) and Pseudoclimacograptus romanovskyi, Glyptograptus dentatus, Glossograptus acanthus (romanovskyi Zone) (Анкинович,1961;Никитин, Цай, Никитина, 1978).

Kanachu Formation [5,8]. Green-grey sandstones, siltstones, intercalations of gritstones and conglomerates (Страт. сл., 1975; Королев, Мисюс, 1982).

Karabalta Formation [14]. Green-grey sandstones, siltstones, mudstones, lenses of limestones. Triarthrus turkestanicus, Telephina, Diplograptus, Glyptograptus, Glossograptus, Orthograptus, Reteograptus and others (Геология СССР, 1972б; Страт. сл.,1975;Королев,Мисюс,1982).

Karabatyr Formation [11]. Green-coloured conglomerates, sandstones, siltstones, mudstones, intercalation of limestones. Orthograptus cf. abbreviatus, Illaenus bajanaulicus, Encrinurus, Glyptoglossa ardmillanensis, Agetolites minor, Mesofavosites dubius (Минервин, Бабичев, Тенякова, , 1974).

Karadzhorga Formation (Upper part) [18]. Tuffs of plagioclase porphyrites, dacite porphyrites, polymictic conglomerates, sandstones, members of cherty siltstones, jaspers, massive biohermal limestones with Tremadocian trilobites (Геология СССР,1972б; Страт. сл., 1975; Королев, Мисюс, 1982).

Karagach Formation [35]. Dark-grey sandstones and siltstones. In the lower part - Dicranograptus nicholsoni, D. ramosus, D. hians, Diplograptus deminutus, D. multidens, Orthograptus calcaratus (multidens Zone); in the upper part - Dicranograptus hians, Climacograptus brevis strictus, C. caudatus, C. spiniferus, Pseudoclimacograptus clevensis, Orthograptus quadrimucronatus (caudatus Zone), Remopleurides asiaticus, Opsimasaphus, "Cybele" weberi, Acculina (Страт. сл., 1975).

Karakan Formation [12]. Quartz arkoses, siltstones and limestones with Bathyuriscops granulatus, Westonia, Paterulla cf. perfecta, Elliptoglossa silvanica, Ephippelasma aff. spinosum, Scaphelasma mica, Loganograptus, Pseudotrigonograptus ensiformis, Expansograptus (Келлер, Лисогор, 1954; Страт. сл., 1975 ; Никитин, Аполлонов , Цай и др. , 1980а).

Karakongoy Formation [36]. Greyish-brown porphyrites and andesites tuffs, sandstones, beds of conglomerates (Геология СССР , 1972а; Никитин , 1972).

Karakorum Formation (Upper part) [6]. Carbonaceous-argillaceous, carbonaceous-cherty mudstones, siltstones, beds of limestones and dolomites. Tetragraptus similis, Phyllograptus angustifolius, Didymograptus suecicus, Expansograptus hirundo, Glyptograptus dentatus (Геология СССР,1972б; Страт. сл., 1975).

Karamoynok Formation [14]. Reddish and many-coloured polymictic conglomerates, sandstones (Геология СССР, 1972б; Страт. сл., 1975; Королев,Мисюс, 1982).

Karamurun Formation [38]. Green, greenish-grey volcanics of the basaltic composition, beds of cherty rocks (Страт. сл. , 1956; Новикова,Герасимова, Курковская, , 1985).

Karashoshak Formation [23]. Greenish-grey sandstones, siltstones, beds of many-coloured jaspers, phthanites, lenses of limestones (Бабичев, Борисенок, Великовская и др. , 1977).

Karasuir Formation [4]. In the lower part - green, grey mudstones with Anisograptus communis, Adelograptus kasakhstanensis, Clonograptus limatus, Bryograptus ulutauensis, Schizograptus spectabilis (Anisograptus-Bryograptus Zone); in the middle part - black cherts with Paratetragraptus acclinans, P. approximatus, Tetragraptus aequilis, T. quadribrachiatus, T. harti (approximatus Zone); in the upper part - grey cherty mudstones with Goniograptus sp., Tetragraptus bigsbyi, T. quadribrachiatus, T. pendens, Phyllograptus ilicifolius, Expansograptus extensus (fruticosus Zone) and Phyllograptus, Pseudotrigonograptus ensiformis, Expansograptus suecicus, Glyptograptus dentatus (Tentaculatus Zone) (Книппер , 1959; Никитин , 1972; Цай, 1974а; Страт. сл., 1975).

Karatal Formation [24]. Greenish-grey siltstones, sandstones, conglomerates, beds of the acid tuffs. In the middle part - Goniograptus thureaui, Tetragraptus quadribrachiatus, Phyllograptus anna, Expansograptus extensus, Didymograptus protobifidus (protobifidus Zone) (Маркова , 1961; Палец, 1965;Страт. сл., 1975; Никитин, Аполлонов, Цай и др. , 1980а).

Karatas Formation [23]. Many-coloured jaspers and cherts, carbonaceous, argilleaceous mudstones, siltstones, quartz sandstones with Prioniodus evae, Oistodus triangularis (Страт. сл., 1975;Борисенок, Герасимова, Зайцев и др., 1979).

Kargaly Formation [1, 2, 4]. Andesitic porphyrites and tuffs, sandstones, siltstones, lenses of limestones. In the lower part - Catazyga ex gr. headi, Remopleurides; in the upper part - Dulanaspis levis (Никитин , 1972; Минервин,Бабичев, Тенякова , 1974; Страт. сл. , 1975).

Kashkenbay Formation [30]. Grey conglomerates, gritstones, quartz arkoses and polymictic sandstones with calcitic matrix, siltstones, limestones. Ctenodonta, Pararaphistoma (Пупышев , 1974).

Kazyk Formation [39]. Red, rare greenish, grey jaspers, cherty siltstones, mudstones, beds of andesite-basalt lavas, breccia and sandstones. Pygodus serrus, P. anserinus, Periodon aculeatus aculeatus, Protopanderodus varicostatus, Eoplacognathus lindstroemi, Carposphaera aff. nana (Кошкин , 1971; Антонюк , 1974; Новикова, Герасимова, Дубинина , 1983).

Kendyktas Formation [15]. Dark-grey, greenish siltstones and sandstones. In the lower part - Hysterolenus sp., Shumardia sp., Desmograptus sp.; in the upper part - Rabdinopora asiaticum, Anisograptus richardsoni, Staurograptus dichotomus (dichotomus Zone), Symphysurus, Euloma, agnostids (Келлер, Королева, Рукавишникова и др. , 1956; Келлер, Рукавишникова , 1961; Страт. сл., 1975).

Kendykty Formation [32]. Greenish-grey greyish-brown porphyrites and andesite-basalt tuffs and basalt tuffs, volcanomictic sandstones and conglomerates, ribboned cherty siltstones, cherts. Craniops tennuis, Lingulella lepis, Broeggeria aff. kushanica, Oistodus, Prioniodus, Cenosphaera, Linosphaera (Никитин, Аполлонов, Цай , 1968; Никитин , 1972;Тенякова,Калинин, 1980).

Keptash Formation [13]. Sandstones, siltstones, gritstones, tuffs, andesite porphyrites. In the lower part - Holasaphus aff. moorei, Lloydia aff. saffordi, Bathyurus; in the upper part - Tripteroceras sp. (Геология СССР, 1972б; Страт. сл.,1975; Королев, Мисюс,1982).

Kerimbek formation [31]. Basalt, tuffs, tuffosandstones, siltstones. Broeggeria (Никитченко , 1978).

Keskentas Formation [15]. Andesite porphyrites, tuffs, grey and reddish sandstones, siltstones, limestones. Eoanastrophia kurdaica, Plasmoporella (Рукавишникова,Салин , 1965; Страт. сл. , 1975).

Kogedey Formation [29, 30]. Greenish-grey polymictic sandstones, rarely small-pebble conglomerates, liparite-dacite tuffs (Алъперович , 1971; Пупышев , 1974).

Kokbulak Formation (Upper part) [4, 5]. Limestones, beds of mudstones. In the Baykonur river area - Micragnostus, Niobella, Remizites, Arthrorhachis girvanensis, Geragnostus ex gr. sidenbladhi, Neoagnostus, Leiagnostus, Hysterolenus. In the Bolshoy Karatay [5] - Clonograptus flexilis, Paratetragraptus acclinans, P. approximatus, Tetragraptus harti, T. quadribrachiatus, Expansograptus (approximatus Zone (Страт. сл., 1975 ; Никитин, Цай , Никитина , 1978).

Kokdombak Formation [11]. Greenish-grey and red quartz arkoses siltstones and mudstones, beds of gritstones. In the lower part - Broeggeria salteri, Obolus fesmanteli, Lingulella lepis, Acrotetra seebachi and others; in the upper part - Paracraniops, Pachiglossella eldery, Eodinobolus and others (Геология СССР,1972а;Минервин,Бабичев,Тенякова, 1974).

Koryk Formation [37]. Greenish-grey olivine basalt, tuffs, tuffogenous sandstones, lenses of limestones with Remopleurides pisiformia, Illaenus linnarssoni, Bulbaspis (Звонцов, Фриц , 1974, 1983).

Kosmurun Formation (Lower part) [37]. Green-coloured, red sandstones, siltstones, mudstones, grey limestones, andesite-basalt lavas and tuff members, rarely liparite-dacite lavas and tuffs. In the lower part - graptolites Dicellograptus anceps and corals with Catenipora libera; in the upper part - corals and brachiopods of the Holorhynchus giganteus beds association (Звонцов , Фриц , 1974, 1983).

Kotombuz Formation [11]. Grey, green-grey polymictic sandstones and siltstones. Chonetoidea simorini, Leptelloidea aff. leptelloides (Минервин,Бабичев, Тенякова , 1974).

Koysu Formation [16]. Andesite, andesite-dacite porphyrites, beds of tuffoconglomerates, cherty rocks and limestones. Sphaerexochus hisingeri (Королев ,Мисюс , 1982).

Kubasadyr Formation [3]. Conglomerates, sandstones (Минервин,Бабичев,Тенякова,1974).

Kuyandy Formation [11, 12]. Andesite porphyrites, rudaceous tuffs, volcanomictic sandstones, conglomerates, biohermal limestones, Plaesiomys (Dinorthis), Zygospira, Heptabronteus romanovskyi, Remopleurides pisiformis (Геология СССР, 1972а;Минервин,

Бабичев , Тенякова, 1974).

Kulanbulak Formation [36]. Green-coloured conglomerates, sandstones, grey limestones. In the lower part - Orthograptus quadrimucronatus; higher - beds with Amsassia chaetetoides, Procheliolites koskarasuensis, Protaraea tumulosa, Gorbyoceras cf. simile, Schizophorella kasakhstanica, Kassinella globosa; beds with Agetolites mirabilis, A. multitabulata, A. minor, Catenipora subparallela, Plasmoporella convexotabulata, P. spinosa and others; beds with Catenipora libera, Agetolites, Saryarkia bandaletovi, Visbilites fragilis, Christiania, Illaenus bajanaulicus, Pliomerina dulanensis and others (Никитин, Аполлонов, Цай , 1968; Геология СССР , 1972а; Борисяк, Ковалевский, Колобова 1974).

Kumay Formation [2]. Quartz arkoses siltstones, jaspers, beds of porphyrites and tuffs. In the lower part - Broeggeria salteri, Lingulella lepis, Obolus feistamanteli, Acrotreta sabrinae; in the upper part - Didymograptus, Diplograptus (Хабелашвили, 1966 ; Геология СССР , 1972а; Минервин, Бабичев, Тенякова 1974).

Kuprijanovka Formation [1]. Greenish-grey quartz arkoses, green and red siltstones, limestones, tuffs. In the middle part - Expansograptus extensus; in the upper - Corymbograptus, Glyptograptus dentatus, Climacograptus macoris, Glossograptus (Страт. сл., 1975; Никитин, Попов, 1983).

Kurbakanas Formation [37]. Grey lavas and liparite-dacite tuffs, tuffaceous sandstones, siltstones, limestones. Opsimasaphus, Dindymene, Eodindymene, Cyclopyge, Ptilograptus delicatulum (Фриц 1974; Звонцов, Фриц, 1983).

Kurday Formation [17]. Greenish-grey, brown sandstones, siltstones, beds of limestones. Nanorthis multicostata, Tritoechia kendyktasica, Kayseraspis (Келлер, Королева, Рукавишникова и др. , 1956; Геология СССР , 1971; Страт. сл. , 1975).

Kushoky Formation [11, 12]. Light-grey quartz sandstones and quartz arkoses siltstones, cherts and jaspers. In the Sarysu-Teniz region [11]: in the middle part - Tetragraptus quadribrachiatus, Phyllograptus anna, Corymbograptus deflexus, Isograptus maximodivergens, I. gibberulus (maximodivergens Zone); in the upper part - Pseudotrigonograptus ensiformis, Isograptus divergens, Glossograptus acanthus (hirundo Zone); in the Betpak-Dala [12]; in the lower part - Kinnegraptus sp., Paratetragraptus acclinans, P. approximatus (approximatus Zone); in the middle part - Dichograptus separatus, Tetragraptus harti, Phyllograptus angustifolius, Expansograptus extensus, Didymograptus (protobifidus Zone) and Dichograptus maccoyi, Phyllograptus typus, Pseudotrigonograptus ensiformis, Isograptus lunatus, I. maximodivergens, I. victoria (maximodivergens Zone) (Четверикова , 1960; Геология СССР , 1972а; Никитин, Аполлонов, Цай и др. , 1980а).

Kuvsk Formation [38]. Poly-coloured jaspers, cherty radiolarian - sponge siltstones, sandstones, members of andesite tuffs, lenses of limestones. Agetolites, Catenipora, Heliolites cf. pseudobelus (Никитин , 1972).

Kyzylsay Formation [24, 25, 26]. In the lower part - light-grey sandstones and conglomerates; in the upper part - rhythmically bedded grey sandstones and dark, greenishy-grey siltstones. Climacograptus aff. mississippiensis, Orthograptus amplexicaulis (Келлер, 1956; Страт. сл., 1975; Никитин, Аполлонов, Цай и др., 1980а).

Kyzylzhar Formation (Upper part) [29]. Grey thin-layered or brecciated limestones. In the lower part - middle Cambrian trilobites (Пупышев, 1974).

Lidievka Formation [10]. Green-coloured sandstones, siltstones, intercalations of volcanomictic conglomerates and tuffs. In the lower part - Expansograptus superstes, Climacograptus bicornis, C. peltifer, Shumardia lacrima (gracilis Zone); in the upper part - Dicranograptus nicholsoni, D. ramosus, Glyptograptus teretiusculus, Amplexograptus perexcavatus, Orthograptus calcaratus (multidens Zone), Shumardia analoga, Telephina bipunctata, Trigonaspis fortis (Копяткевич, Фриц, Шлыгин и др. , 1967; Геология СССР, 1972а; Никитин , 1972).

Malkeldy Formation [37]. Grey limestones with beds of greenish siltstones, volcanomictic sandstones, basalt lavas and tuffs. Glaphurina weberi, Remopleurides pisiformis, Sphaerexochus hisingeri (Звонцов , Фриц, 1974, 1983).

Mamat Formation [34]. Grey greenish volcanomictic sandstones, siltstones, tuffs and limestones. Nanorthis ex gr. multicostata, Clarkella supina, Tetralobula latens, Triarthrus, Loganopeltis, Ceratopyge, Niobe (Никитин, 1972).

Mayatas Formation [10]. Green-coloured sandstones, siltstones and limestones with Orthograptus pauperatus, Remopleurides pisiformis, Heptabronteus romanovskyi, Hammatocnemis tetrasulcatus, Spirigerina (Геология СССР , 1972а ; Страт. сл. , 1975).

Maykain Formation [33]. Greenish-grey, greyish-brown basalts, andesite basalts, tuffs, members of cherty siltstones and jaspers. In the upper part - Drepanodus sp., Periodon cf. aculeatus, Cordylodus cf. spinatus, Oistodus, Eliptoglossa aff. ovalis, Lingulella tenuitesta,

Eurytreta curvata (Михайлова, Шебуняев и др. , 1981).

Maykul Formation [27]. Greyish-green, dark-grey sandstones, siltstones, members of light-grey and red cherts and jaspers. Periodon aculeatus aculeatus, Pygodus serrus (Маркова , 1961; Токмачева, Кузнечевский, Палец, 1976; Никитин, Аполлонов, Цай и др. , 1980а, б).

Maylisor Formation [10]. Andesite porphyrites, tuffs, volcanomictic sandstones, siltstones, members and lenses of limestones. Basilicus sp., Heptabronteus romanovskyi, Lonchodomas tecturmasi, Plaesiomys (Dinorthis), Rhynchotrema (Никитин, 1972; Страт. сл. , 1975; Кленина, Никитин, Попов , 1984).

Namas Formation [34]. Greenish-grey, greyish-brown porphyrites and andesite tuffs, rare basalt tuffs, beds of sandstones and siltstones. Dulanaspis levis, Bulbaspis mirabilis, Opsimasaphur kolovae, Sowerbyella akdombakensis, Zygospira parva, Agetolites, Propora, Plasmoporella (Никитин, 1972; Страт. сл., 1975); Кленина, Никитин, Попов , 1984).

Nayman Formation [34, 35]. Dark-grey, black carbonaceous cherty-clay mudstones, greenish siltstones, grey quartz arkoses, polymictic sandstones, limestones. In the lower part - Loganograptus logani, Tetragraptus bigsbyi, Phyllograptus anna, Expansograptus hirundo (hirundo Zone); in the upper part - Expansograptus sp., Climacograptus sp., Glyptograptus dentatus, Pliomerops similis (Никитин, Аполлонов, Цай , 1968; Никитин , 1972; Страт. сл. 1975).

Oisaksaul Formation [26]. Green-coloured polymictic conglomerates, sandstones, siltstones, beds of limestones, olistostromes. Dicellograptus sextans exilis. Dicranograptus ramosus, Climacograptus bicornis, C. peltifer (multidens Zone), Telephina bipunctata, "Robergia" marianna, Parabasilicus, Glyptambonites musculosus (Никитин, Аполлонов, Цай и др. , 1980а).

Oldzhobay Formation [9]. Red-coloured, green-coloured, cherty mudstones, siltstones beds of sandstones. Conodonts and other fossils. (Геология СССР, 1972б; Страт. сл., 1975; Королев, Мисыс, 1982).

Oro Formation [32]. Greenish-grey, greyish-brown, brown polymictic sandstones, conglomerates, green and red siltstones, beds of tuffs and limestones. Climacograptus supernus, Proconchidium munsteri, Holorhynchus giganteus (Никитин, Аполлонов, Цай , 1968; Геология СССР , 1972а; Никитин, 1972).

Rgayty Formation [15]. Porphyrites, andesite tuffs, polymictic conglomerates, sandstones and siltstones. Orthambonites butsi, Scaphorthis, Strophomena, Maclurites magnus, Lesueurilla, Spirotomaria (Рукавишникова, Салин, 1965 ; Геология СССР, 1971; Страт. сл., 1975).

Saga Group [10]. Porphyrites, basalt-andesite tuffs, volcanomictic sandstones, siltstones, lenses of limestones, in the upper part - dacitic lavas and tuffs members. Expansograptus superstes, Dicranograptus brevicaulis, Climacograptus bicornis, Orthograptus whitfieldi (gracilis Zone), Shumardia lacrima (Копяткевич, Фриц, Шлыгин и др. , 1967; Никитин, 1972 Геология СССР, 1972а; Цай , 1976).

Sargaldak Formation [34]. Rhythmically bedded green-coloured conglomerates, sandstones and siltstones, lenses of limestones. Dicranograptus nicholsoni, Climacograptus bicornis, Pseudoclimacograptus scharenbergi, P. stenostoma, Glossograptus hincksi (multidens Zone), Colobinion parallela, Pseudosphaerexochus pahnshi, Lyralichas, Holotrachelus, Archaeorthis opima, Tuvinia extrema, Perimecocoelia semicostata, Eoanastrophia extenuata (Никитин, 1972; Страт. сл., 1975 Кленина, Никитин, Попов , 1984).

Sarybastau Formation [15]. Dacite and porphyrites, in the lower part - conglomerates and sandstones (Рукавишникова, Салин , 1965; Геология СССР, 1971; Страт. сл. , 1975).

Sarybidaik Formation [32, 33]. Grey, greenish-grey, rarely greyish-brown sandstones, cherty siltstones, andesitic porphyrites and tuffs. In the upper part - limestones. In the siltstones - Didymograptus acutus, Expansograptus suecicus; in limestones - Thaleops cf. rectangularis, Plectorthis, Tarphodonta bicornigera, Shlyginia declevis, Ishimia, Strophomena, Camerella (Борукаев, 1955; Никитин, Аполлонов, Цай , 1968; Никитин , 1972 Страт. сл., 1975).

Sarydzhas Formation [9]. Rhythmically bedded members of poorly sorted sandstones and siltstones (Геология СССР, 1972б; Страт. сл., 1975; Королев, Мисыс, 1982).

Saryshoky Formation [34]. Grey, greyish-brown andesite porphyrites and tuffs, volcanomictic conglomerates, sandstones, siltstones, lenses of limestones. Apatokephalus dubius, Pliomerops, Tesselacauda (Никитин , 1972; Геология СССР, 1972а; Страт. Сл., 1975).

Satpak Formation [22]. Greenish-grey glauconitic sandstones, siltstones. In the lower part - Bienvillia tetragonalis tetragonalis, Callograptus olentensis, Dendrograptus yini,

Rhabdinopora asiaticum (yini Zone); in the upper part - Anisograptus richardsoni, Staurograptus dichotomus (dichotomus Zone), Broeggeria salteri, Acrotreta sabrinae, Obolus feistmanteli (Страт. сл.,1975; Цай , 1983).

Satybay Formation [23]. Greenish-grey polymictic sandstones, siltstones, beds of cherty rocks, members of andesite-basalt porphyrites and tuffs, lenses of limestones. Sidericrinus, Partiocrinus (Борисенок, Герасимова,Зайцев и др., 1979).

Savid Formation [11,12]. Andesite-basaltic porphyrites and tuffs, conglomerates, volcanomictic sandstones (Геология СССР , 1972а;Страт.сл1975).

Sazy Formation [19]. Basalt porphyrites and tuffs, volcanomictic sandstones, red jaspers. In the cherts - Paracordylodus gracilis (Борисенок,Герасимова, Зайцев и др., 1979; Борисенок, 1981).

Shabakty Formation (Upper part) [7]. Limestones, dolomites, dolomitized limestones. Upward six trilobite zones are distinguished: 1 - Euloma limitaris-Batyraspis; 2 - Dikelokephalina; 3 - Trinodus; 4 - Szechuanella-Apatokephalus; 5 - Nileus; 6 - Bathyuriscops-Taihungshania; Seven conodont zones are distinguished: 1 - Cordylodus proavus; 2 - C. oklanomensis; 3 - C. lindstromi; 4 - C. prion, 5 - Drepanodus subarcuatus, 6 - Acodus deltatus, 7 - Prioniodus evae (Анкинович , 1961; Страт. сл., 1975;Аполлонов, Чугаева, 1982).

Shakshan Group [22]. Alternation of green-coloured sandstones, siltstones, gritstones and conglomerates, members of tuffs, lenses of limestones. In the lower part - Pseudoclimacograptus, Glyptograptus artschalensis, Orthograptus and others (Erkebidaik Formation); in the middle part - Dicellograptus elegans, Dicranograptus nicholsoni, Pseudoclimacograptus scharenbergi, Glyptograptus asiaticus, Orthograptus amplexicaulis (caudatus Zone), Glaphurina weberi, Stenopareia linnarssoni, Heptabronteus romanovskyi, Spirigerina, Reuschia and others; in the upper part (Zharyk beds) - Dicellograptus, Pseudoclimacograptus clevensis, Orthograptus amplexicaulis (pumilus Zone) Phyllipsinella parabola, Trinodus tardus, Hammatocnemis tetrasulcatus, Cyphonisus socialis, Diambonia septata (Борукаев , 1955; Никитин , 1972;Аполлонов , 1974; Страт. сл., 1975).

Sherbakty Formation [15]. Greenish-grey quartz arkoses, polymictic sandstones, siltstones, carbonaceous cherty mudstones. In the upper part they include a member of grey limestones. Phyllograptus densus, Pseudotrigonograptus ensiformis, Expansograptus suecicus, Glyptograptus dentatus. In the limestones - Bathyuriscops cf. granulatus (Рукавишнркова, Салин , 1965;Геология СССР , 1971; Страт. сл., 1975).

Sholakbulak Formation [30]. Grey, yellowish sandstones, cherty siltstones, argillic limestones. Orthambonites, Basilicus aff. tyrannus (Пупышев , 1974).

Shundy Formation [30]. Grey and black limestones, beds of dolomites. Glyptograptus aff. dentatus, Endymionia kasakhstanica (Геология СССР , 1972а;Пупышев , 1974).

Suyndyk Formation [5]. Green-coloured, in the lower part reddish siltstones, mudstones, rarely sandstones. Glyptograptus euglyphus, Orthograptus (euglyphus Zone) (Анкинович , 1961;Страт. сл., 1975; Никитин, Цай , Никитина , 1978).

Taldyboy Formation [34]. Green, greenish-grey, greyish-brown conglomerates, volcanomictic sandstones, siltstones, limestones, beds of andesite porphyrites and tuffs. Schizophorella kazakhstanica, Plaesiomys abayi, Hebertella brevis, Triplesia subcraigensis, Zygospira parva, Pliomerina unda, Cybele weberi, Opsimasaphus, Reuschia sokolovi densa, Catenipora subparallela, Pseudoclimacograptus scharenbergi, Orthograptus pauperatus (Никитин, , 1972; Страт. сл. , 1975; Кленина, Никитин, Попов , 1984).

Talgar Formation [17]. Poly-coloured arkoses sandstones, siltstones, beds of algal limestones (Королев, Мисыс , 1982).

Talsay Formation [3]. Grey, reddish cherty mudstones, in the upper part quartz and greywacke sandstones. Loganograptus logani, Tetragraptus pendens, T. serra, Expansograptus hirundo, Acrograptus nicholsoni (hirundo Zone) (Хабелашвили, Цай,1966; Цай, 1974а; Страт. Сл., 1975).

Tamdysu Formation [8]. In the lower part - mudstones, beds of limestones; in the middle part - phthanites, carbonaceous-argillaceous mudstones with Tetragraptus amii, T. serra, Expansograptus suecicus, E. ensjoensis, Dichograptus separatus; in the upper part - carbonaceous-argillaceous and carbonaceous-cherty mudstones with Phyllograptus angustifolius, P. anna, Expansograptus robustus, Amplexograptus aff. confertus, A. maxwelli (Зубцов , 1961,Геология СССР, 1972б ;Страт. сл., 1975;Королев, Мисыс, 1982).

Taranchibulak Formation [17]. Andesite porphyrites, tuffs and sandstones. Isotelus romanovskyi, Basilicus aff. tyrannus (Королев, Мисыс , 1982).

Tasoba Formation [2]. Grey, reddish siltstones, cherty-carbonaceous mudstones, jaspers. In the lower part - Craniops aff. attenuata, Obolus murrayi, Eliptoglossa ovalis and others; in the upper part - Pseudoclimacograptus (Минервин, Бабичев, Тенякова , 1974; Страт. сл., 1975).

Tauken Formation [19, 20]. Green-coloured siltstones, sandstones, conglomerates, beds of

limestones. In the lower part - Dicranograptus ex gr. nicholsoni; in the upper part - Cheirurus kasakhstanicus, Heptabronteus romanovskyi, Pliomerina unda, Stenopareia linnarssoni, Plaesiomys (Dinorthis) kassini, Otarorhyncha otarica, Zygospira parva, Amsassia chaetetoides, Lyopora aff. nikitini, Reuschia cf. sokolovi, Tetraporella montyculinporoides, Proheliolites koskolensis (Страт. сл., 1975).

Tekely Formation [31]. Green-coloured sandstones, siltstones, grey, dark-grey carbonaceous cherty-carbonaceous, calcitic mudstones, jaspers, limestones beds. In the lower part - Clonograptus, Tetragraptus fruticosus, T. pendens (fruticosus Zone); in the upper part - Phyllograptus, Glyptograptus dentatus, Glossograptus acanthus, Periodon aculeatus aculeatus (Страт. сл., 1975; Никитченко , 1978; Севрыгин, Цай,Рылъская , 1982).

Tekturmas Formation [38]. Diverse mainly red jaspers, cherty siltstones, breccia, beds of andesite-basaltic volcanics. Pygodus serrus, P. anserinus, Periodon aculeatus aculeatus, P. aculeatus zgierzensis, Microzarkodina ozarkodella, Semiacontiodus cornuformis (Страт. сл.,1956; Новикова, Герасимова, Курковская , 1985).

Temirastau Formation [22]. Greenish-grey volcanomictic conglomerates, sandstones, beds of andesite-basalt lavas and tuffs, lenses of limestones. Nanorthis hamburgensis, Apheorthis ocha, Palaeostrophia orthia, Glyptotrophia, Clarkella supina, C. turgida, Tetralobula latens, Harpides, Niobe (Ившин, Гречушкин, Заравняева и др., 1974; Решение..... 1976).

Tjoz Formation [9]. In the lower part - polymictic arkosic conglomerates, sandstones, higher organodetrital limestones, mudstones, siltstones, beds of sandstones. Encrinurella cantifrons, Heptabronteus romanovskyi, Schizophorella, Dulancarella, Triplesia, Plectatrypa, Zygospira ex gr. parva, Plasmoporella ex gr. convexitabulata, Palaeohalysites aff. pirsaliensis, Grewingkia, Reuschia and others (Геология СССР , 1972б ; Страт. сл.,1975; Королев, Мисыс , 1982).

Tjuretay Formation [39]. Green-coloured aphyric diabases, spilites, sandstones, siltstones, red jaspers. Pygodus anserinus, P. serrus, Periodon aculeatus aculeatus, P. cf. grandis, Protopanderodus insculptus (Кошкин, 1971; Антоныk , 1974;Новикова, Герасимова, Дубинина , 1983).

Tuyksay Formation (Upper part) [13]. Poly-coloured, volcanomictic sandstones, siltstones. Leiagnostus ovalis, Geragnostus terrarius, Rhabdinopleura elliptica, Harpides, Niobe (Геология СССР, 1972 ; Страт. сл., 1975; Королев, Мисыс, 1982).

Ushkyzyl Formation [37]. Grey, greenish and red bedded and massive cherts, jaspers. In the base - cherty mudstones, basal quartz arkoses. In the lower part - Finkelnburgia, Hesperonomiella, Hystricurus, Pliomerops; higher in the cherts and jaspers - beds with Prioniodus cf. elegans, Drepanodus ex gr. proetens, Periodon flabellum, Paracordylodus gracilis, beds with Prioniodus evae, Oepikodus smithensis, Oistodus parallelus, Distacodus stola, Periodon flabellum, Paracordylodus gracilis, beds with Prioniodus alata parvidentatus (Жаутиков, Ившин, 1971; Копяткевич, Конева, Назаров, 1974).

Utmek Formation [13]. Andesite, basalt porphyrites, tuffs (Королев, Мисыс, 1982).

Uzunbulak Formation [25, 26]. Green-coloured polymictic sandstones, siltstones, grey bedded limestones. In the siltstones - Lisogorites striatus, Ampyxinella biloba, "Symhysurus" exactus; in the limestones - Bathyuriscops granulatus, Bumastides betpakensis. In the lower part - Tritoechia, Syntrophinidae, "Strophomena" dubia, Ptilograptus plumosus, Pseudobryograptus incertus, Cardiograptus crawfordi, Acrograptus compressus, Janograptus gracilis, Climacograptus macoris, Pseudoclimacograptus paradoxus, Diplograptus obuti, Paraglossograptus tentaculatus (Kopalyian Horizon, tentaculatus Zone); in the upper part - Orthidium fimbriatum, Camerella, Idiostrophia, Tetragraptus bigsbyi, Phyllograptus angustifolius elongatus, P. nobilis, Pseudoclimacograptus remanovskyi, P. angulatus, Glossograptus horridus (romanovskyi Zone) (Чугаева, 1958 ; Никитин, Аполлонов, Цай и др., 1980а).

Zhalair Formation [24, 25, 26]. Greenish-grey, green siltstones, mudstones, reddish quartz arkoses, dark-grey limestones. Dalmanitina mucronata, D. olini, Leonaspis olini, Dicranopeltis, Dalmanella testudinaria, Hirnantia sagittifera, Anisopleurella novemcostata, Aegiromena durbanensis, Leptaena aff. rugosa, Leptaenopoma trifidum, Bracteoleptaena polonica, Eostropheodonta bublitschenki, Coolinia iliensis and others. Two graptolite zones are established: lower zone Climacograptus extraordinarius with Climacograptus angustus, C. extraordinarius, C. normalis, C. cf. mirnyensis and upper zone Glyptograptus persculptus with Climacograptus angustus, Glyptograptus persculptus (Граница, 1980).

Zhamanshuruk Formation [39]. Grey, greenish conglomerates, sandstones, siltstones, members of andesite-dacite lavas and tuffs, beds of limestones. Heptabronteus romanovskyi, Spirigerina ex gr. mavrae, Cyclospira ex gr. elegantula, Plasmoporella, Heliolites (Страт. сл., 1975).

Zhanasu Formation [10]. Cherty siltstones, jaspers, tuffs, beds of limestones, in the upper part - sandstones and siltstones. Tetragraptus, Glyptograptus dentatus (Копяткевич, Цай, 1974).

Zhartas Formation [35]. Greenish-grey, greyish-brown andesite porphyrites, tuffs, sandstones, siltstones. Symphysops subarmata elongata, Microparia speciosa, Cyclopyge mirabilis (Геология СССР, 1972a; Никитин , 1972).

Zhylandy Formation [31]. Massive, rarely bedded limestones, beds of dolomitic limestones and dolomites. In the lower part - Heliolites, Protaraea, Plasmoporella?, Reuschia, Lygospiriniae, Cystostroma concinnum and others (Страт. сл.,1975;Севрыгин,Цай, Рулъская, 1982).

Zhyrygauz Formation [7]. Green-coloured siltstones, mudstones, beds of limestones. In the lower part Linguella, Elkaniidae, Obolidae, Oistodus cf. parallelus, Cordylodus cf. angulatus, Phragmodus cf. flexuosus (Аполлонов , Ергалиев , Косанов, in press).

Zorjevka Formation [20]. Grey rhythmically bedded quartz arkoses and siltstones, limestones. Upward four graptolite assemblages are distinguished: 1. Paratetragraptus acclinans, P. approximatus, P. akzharensis, Tetragraptus harti (approximatus Zone); 2. Loganograptus, Tetragraptus bigsbyi, Phyllograptus anna, Pseudotrigonograptus ensiformis, Expansograptus pennatulus, Corymbograptus deflexus, Isograptus gibberulus, I. imitata, I. maximodivergens, Pseudisograptus manubriatus, P. dumosus (maximodivergens Zone); 3. Tetragraptus serra, Pseudotrigonograptus ensiformis, Isograptus victoria (hirundo Zone); 4. Tetragraptus quadribrachiatus, Expansograptus suecicus, Isograptus divergens, Glyptograptus austrodentatus, G. dentatus, Glossograptus acanthus (tentaculatus Zone). (Никитин, Аполлонов, Цай, 1968; Никитин, 1972; Цай, 1974a).

3. CORRELATION CHART FOR THE ORDOVICIAN SYSTEM IN MIDDLE ASIA

3.1. General characteristic

In Middle Asia Ordovician deposits are known in the South Tien-Shan fold system, in Pamir and the southern part of Middle Tien-Shan in the Kuroma area (Mogoltau Mountains in Uzbekistan).

Investigations of V.N. Weber, A.F. Lesnikova, B.G. Mukhin, A.P. Markovskyi, B.N. Nasledov, V.A. Nikolaev, O.I.Sergunkova, N.M. Sinitzin, P.P. Chuenko, D.I. Yakovlev in the years 1920-30 laid the foundation of the Ordovician stratigraphy in the region.

These works were continued by Z.M. Abduazimova, R.N. Abdulaev, Yu. N. Apekin, N.M. Chapdarova, A.N. Golikov, A.V. Grigoryev, T.A. Dodonova, S.M. Dyufer, M.V. Erina, T.I. Khairulina, O.N. Khaletzkaya, A.I. Kim, V.I. Knauf, V.G. Koroljov, A.I. Lavrusevich, V.I.Lavrusevich, N.M. Larin, V.L. Leleshus, A.A. Luyk, A.N. Mayorov, B. Ya. Medvedev. G.G. Melnik, M.M. Posokhova, L.P. Smirnov, A.F. Stepanenko, L.I. Turbin and Ye. I. Zubtzov et al.

Many geologists, stratigraphers and palaeontolgists of the Ministry of Geology of Uzbek SSR, Geological service of Tajik SSR, VSEGEI, Geological institutes of Academies of Sciences of Uzbekistan, Tajikistan, USSR, and also the Geological faculty of Leningrad University and others are studying the Ordovician of Middle Asia at present. Their data were used in compiling the chart.

The Ordovician in Middle Asia is represented mainly by geosynclinal marine terrigenous clastic sediments with rare volcanics. Mediterranean cold-water taxa become more characteristic for faunal assemblages compared with Kazakhstan and Kirgizia. This can be noticed especially in the Lower and Middle Ordovician of Zerafshan-Pamir zone.

Three structural-facies zones can be traced according to features of sedimentation and faunal composition (Fig. 1):

1. The Kyzylkum-Alay zone includes terrigenous clastic Ordovician successions of the Kyzylkum-Nurata area and the Turkestan-Alay mountain area. Graptolites are rare, shelly fauna are characteristic for deposits in the zone.
2. The Beltau-Kurama zone (Middle Tien-Shan) according to the deposits and the fauna type is closely related to the previous zone.
3. The Zerafshan-Pamir zone includes the succession of the Zerafshan-Gissar mountain area, the Zirabulak mountains, the Kulzhuktau mountains and Pamir. The shelly fauna is more characteristic of these deposits than graptolites. Carbonates and volcanics are known in the zone.

The Cambrian-Ordovician boundary is fixed in the axial part of Turkestan range in the base of the Apchapkan Formation with Callograptus cf. sinicus, Dictyonema uniformis, Clonograptus cf. smithi, Anisograptus ?, and Bryograptus ?. The formation rests conformably on Upper Cambrian deposits.

The Ordovician-Silurian boundary is best studied at the Shakhriomon pass in the Zeravshan-Gissar mountain area. It is traced at the base of the Minkuchar beds with Orthograptus sinitzini, equal to the Akidograptus acuminatus Zone in Middle Asia. The beds rest conformably on the Upper Ordovician Archalyk beds with Agetolites, Holorhynchus giganteus, Proconchidium munsteri, Paraorthograptus pacificus and others (Ким, Апекин, Ерина и др., 1978). The boundary is known also in the Mogoltau mountains,

where it is drawn at the base of the Urubulak Formation with Akidograptus acuminatus. The formation rests conformably on the Kayrak Formation with Glyptograptus cf. persculptus.

3.2. Alphabetical List of Local Stratigraphic Unit (Rock Unit)

Akchapakan Formation [6^1]. Polymictic siltstones and sandstones, beds of mudstones with Callograptus cf. sinicus, Dictyonema uniformis, Clonograptus cf. smithi, Anisograptus?, Bryograptus?.

Akmulla Formation [6^1]. Mudstones, siltstones, sandstones and conglomerates. Oncograptus, Cardiograptus, Didymograptus, Isograptus, Leptograptidae, Euconnochitina brevis conica, Eisenacochitina conica, Lagenochitina ovoides.

Altyaul Formation [11^1]. Green siltstones, quartz-polymictic sandstones, volcanics, in the upper part limestones. Opikina, Illaenus cf. linnarssoni avus, Agetolites cf. multitabulatus, Palaeofavosites cf. alveolaris, P. schmidti, P. cf. extremus, Plasmoporella, Acdalopora, Vermiporella? (Айсанов, Егоров, 1978).

Besapan Formation [4^1]. Quartzose sandstones, siltstones, mudstones. Diplograptidae, Conochitina aff. parvicolla, Desmochitina aff. amphora, D. minor typica, Lagenochitina aff. baltica and others (Страт. сл., 1975).

Dzhalatar Formation [5^1]. Rhythmically alternated cherts and mudstones. Entachitina cf. complanata, E. aff. elongata, Pylentomona ex gr. insulata, Desmochitina minor ovulum, D. minor typica, Lagenochitina cf. deunffi.

Kayrak Formation [1^1]. Rhythmically bedded polymictic sandstones, siltstones and mudstones. Climacograptus innotatus, C. ex gr. normalis, C. cf. miserabilis, Orthograptus, Glyptograptus cf. persculptus (Геология СССР, 1959; Страт. сл., 1975).

Kazakasu Formation [10^1]. Mudstones, siltstones, intercalations of conglomerates, gritstones, limestones, cherty rocks and volcanics. Nicolella ex gr. actomae, Hesperorthis, Austinella, Plectorthis, Opikina, Rafinesquina, Basilicus cf. nobilis, Synhomalontus, Calliops cf. hancharensis, Isotelus, Cybele, Illaenus cf. talasicus, Ampyxina cf. biloba, Asaphus, Lyopora cf. regularis, Plasmoporella, Receptaculites ? (Айсанов,1966).

Kozyndy Formation [13^1]. Dark-grey, green violet mudstones, calcareous mudstones, beds of sandstones, limestones, in the lower part quartzose keratophyres, tuffs. Dikelokephalina cf. dicraeura, Apatokephalus cf. serratus, Nileus, Dulanaspis cf. levis, Dionide pamirica, Cyclopyge pamirica, Trinucleus pamiricus, Pseudobasilicus nobilis pamiricus (Страт. сл., 1975; Расчленение..... 1976).

Kurusay Formation [1^1]. Metamorphosed quartz-micaceous siltstones and mudstones with intercalations of sandstones (Геология СССР, 1959).

Oydynbulak Formation [10^1]. Dark-grey, grey limestones and dolomites. Lyopora regularis, Acadalopora sokolovi, Palaeofavosites cf. alveolaris, Receptaculites ? (Айсанов, 1966).

Shakhriomon Formation [12^1]. In the lower part (Obikalon beds) green siltstones with beds of quartzose sandstones. Lyopora, Streptelasmatidae, Nicolella strasburgensis alata, Onniella chancharica, Reuschella horderleyensis, Oxoplecia subborealis, Leptestina oepiki, Eoplectodonta semirigata, Kjerulfina, Porambonites cf. kjerulfi, Opsimasaphus (Nobiliasaphus) nobilis, Onnia, goldfussi, Otarion, Calymenesum tingi, Dalmanitina socialis, Metopolichas patriarchus Hemicosmites cf. pulcherrium, H. extraneus, Echinosphaerites auranticum, Eungocystis?, Aristocystis cf. bohemicus, Ristnacrinus marinus. Higher (Obikandy beds) quartzose, rarely polymictic sandstones, conglomerates, beds of siltstones and andesite-dacite tuffs. In the upper part: Chashmankalon beds - sandstones with beds of siltstones, Archalyk beds - sandy-argillaceous detrital limestones, dolomites. In the Chashmankalon and Archalyk beds Agetolites asiaticus, Palaeofavosites corrugatus, Lyopora regularis, Holorhynchus giganteus, Proconchidium munsteri, Rhynchotrema otarica, Platylichas laxatus, Illaenus schmidti, Medinecrinus lenitus, Paraorthograptus pacificus, P. pacificus kimi, Dimorphosiphon magnum, Contexta tumidula and others (Страт. сл., 1975 ; Ким , Апекин, Ерина, и др., 1978; Ким,Елкин, Ерина, 1984).

Ylanchisay Formation [5^1]. Interbedding of sandstones, tuff sandstones, siltstones and mudstones. Amplexograptus aff. fallax, A. ex gr. perexcavatus, Orthograptus ex gr. amplexicaulis, O. aff. quadrimucronatus, Paraclimacograptus aff. asiaticus (Геология СССР, 1972б).

Zaamin Formation [6^1]. In the lower part schistic mudstones with intercalations of dolomitized limestones. Clonograptus flexilis, Loganograptus cf. gracilis, Tetragraptus cf. amii, T. harti, T. quadribrachiatus, T. decipiens, T. cf. fruticosus, Paratetragraptus approximatus, Drepanodus arcuatus, Paroistodus subrectus, Oepikodus?, Pricyclopyge, Niobe, Symphysurus, Tropydopyge?, Leiagnostus, Apatokephalus?, Euloma; in the middle part - mudstones with beds of siltstones. Tetragraptus immaturus, Phyllograptus anna, Azygograptus suecicus, Didymograptus aff. subtenuis, Expansograptus hirundo, E. abnormis, E. prominutus, E. suecicus robustus; in the upper part - alternations of fine-grained limestones and cherty-micaceous

mudstones, beds of sandstones. Drepanoistodus suberectus, Acodus cf. deltatus, Prioniodus?, badly preserved chitinozoans.

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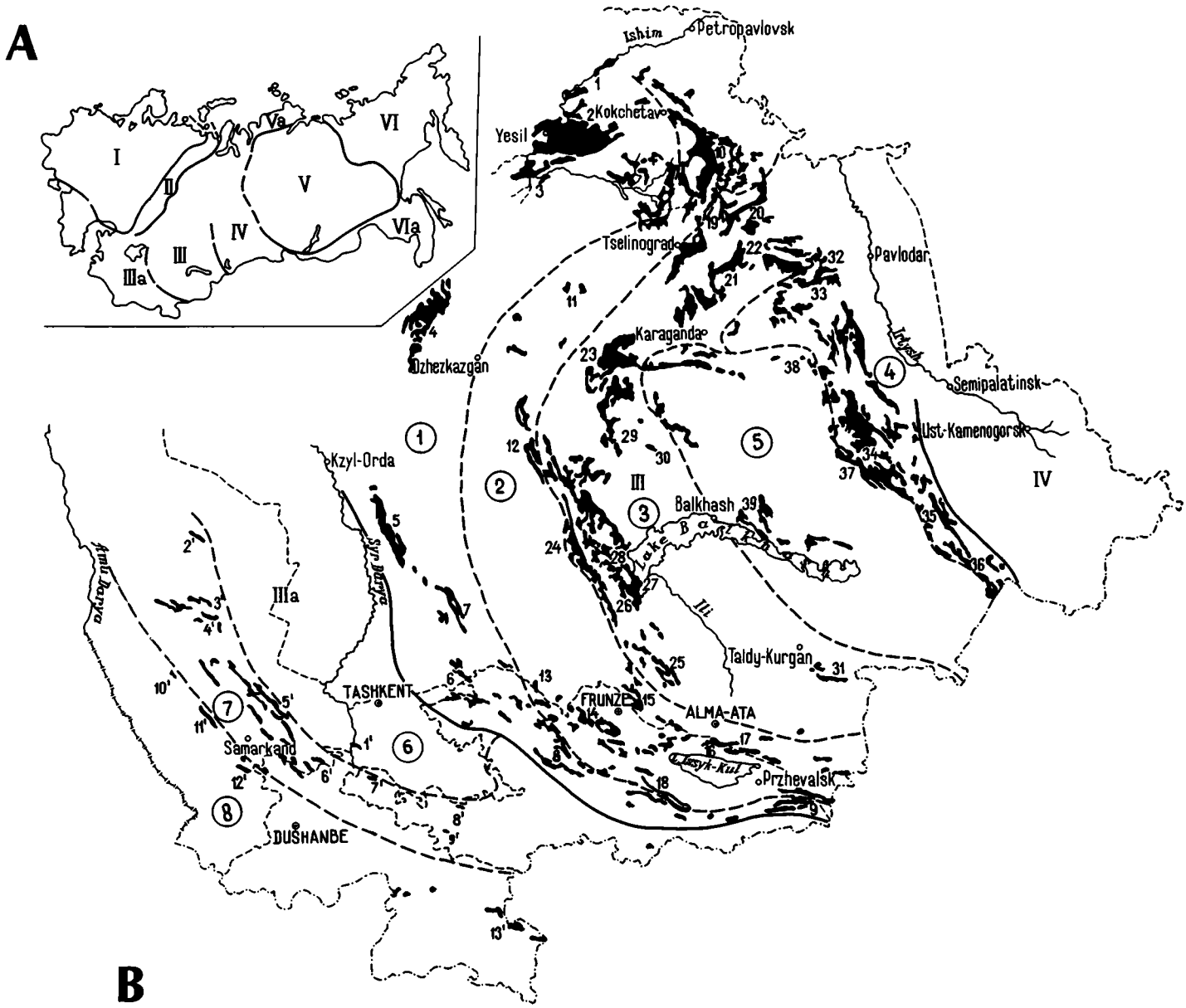

Figure 1: Ordovician structural provinces in the USSR (A) and Ordovician structural zonation in Kazakhstan, Kirgizia and Middle Asia (B). A. I - East European Platform; II - Urals; III - Kazakhstan and Kirgizia; IIIa - Middle Asia; IV - Altay-Sayan Region; V - Siberian Platform; Va - Taymyr and Arctic Islands; VI - North East of USSR; VIa - Far East of USSR. B. Cyphers in the circles correspond to zones. 1 - Ulutau-Karatau-Naryn; 2 - Stepnyak-Betpakdala and North Tien-Shan; 3 - Erementaru-Chu-Ili; 4 - Chingiz-Tarbagatay; 5 - Dzhungaria-Balkhash; 6 - Beltau-Kurama; 7 - Kyzylkum- Alay; 8 - Zerafshan-Pamir.

Cyphers on the scheme correspond to number of columns on the Correlation charts (for Kazakhstan and Kirgizia without apostrophes, for Middle Asia - with apostrophes).

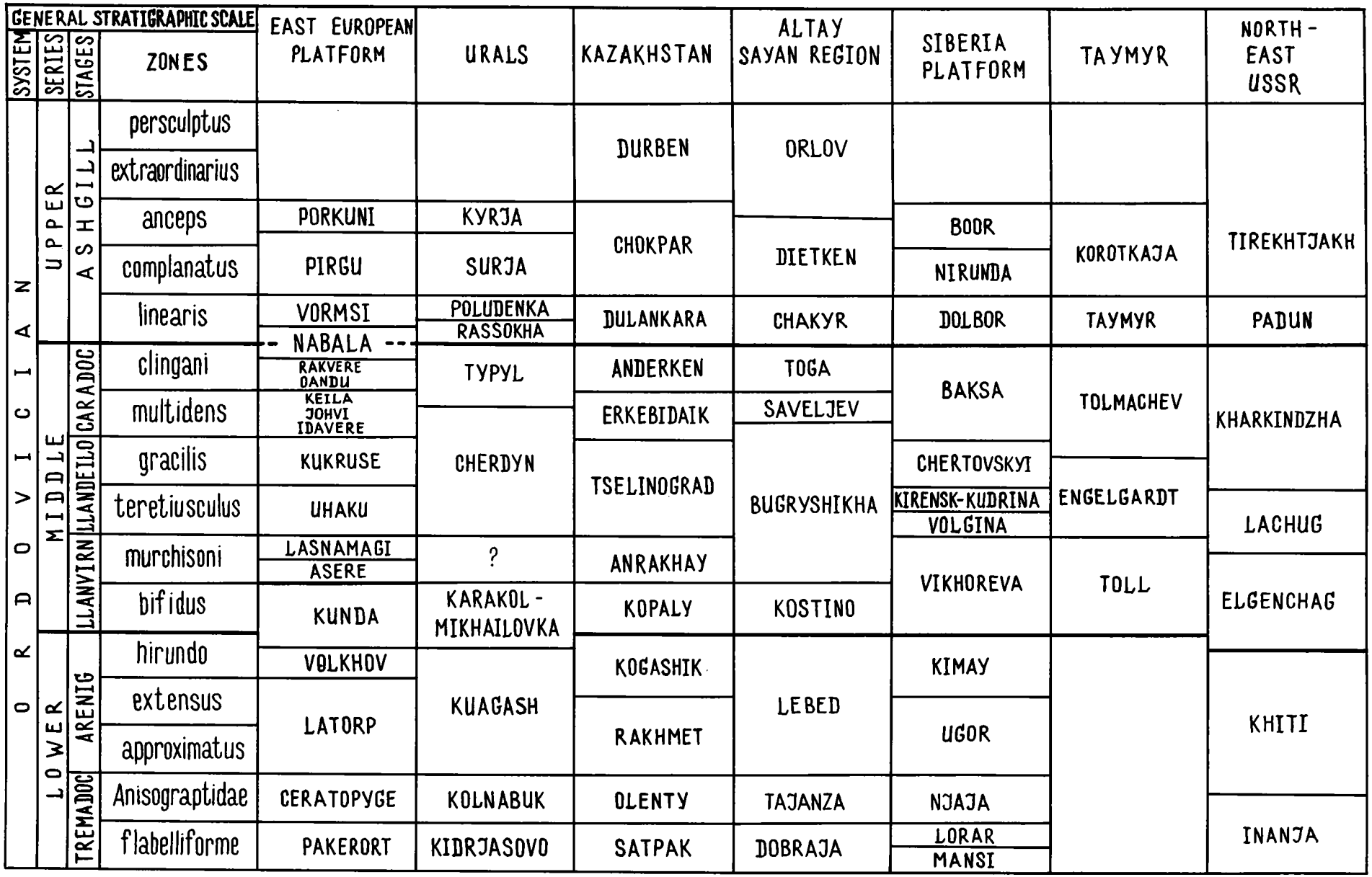

Figure 2: Correlation of Ordovician Regional Stratigraphic Scales of USSR with general scale.

Figure 3: Type successions for regional stratigraphic units of Kazakhstan and Kirgizia.

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GENERAL STRATIGRAPHIC SCALE				FOSSILS					
SYSTEM	SERIES	STAGE	ZONE	GRAPTOLITES	BRACHIOPODS	TRILOBITES	CORALS	CRINOIDS CYSTOIDEA	
OVERLYING UNIT									
ORDOVICIAN	UPPER (ASHGILIAN)		Glyptograptus persculptus				Lyopora regularis Catenipora tapaensis Catenipora tarbagataica Agetolites asiaticus Plasmoporella convexotabulata Acdalopora sokolovi	Pentalobatocrinus simplex	
			Climacograptus extraordinarius						
			Dicellograptus anceps	Paraorthograptus pacificus pacificus	Holorhynchus giganteus Proconchidium münsteri Schachriomonica schachriomonica Hyattidina ?				
			Dicellograptus complanatus	Paraorthograptus pacificus kimi	Holorhynchus giganteus Eoanastrophia antiquata Tetrapharella		Lyopora regularis Streptelasmatidae	Xenocrinus? quadriangulatus	
			Pleurograptus linearis						
	MIDDLE	CARADOC	Dicranograptus clingani		Nicolella strasburgensis alata Boreadorthis cf. togaensis Onniella chancharica Triplesia ex gr. mongolica Oxoplecia subborealis Ishimia sumsarica Eoplectodonta semirugata	Opsimasaphus (Nobiliasaphus) nobilis Broggerolithus broggeri Pharostoma inermis Calymenesum tingi Uralichas schachriomonica Metopolichas patriarchus	Lyopora Streptelasmatidae	Cheirocrinus? tumefactus Hemicosmites cf. extraneus Sumsaricystites radiatus Ristnacrinus marinus Conspectocrinus celticus Ferulacrinus rigidus	
			Diplograptus multidens						
		LLANDEILO	Nemagraptus gracilis						
			Glyptograptus teretiusculus						
		LLANVIRN	Didymograptus murchisoni	Isograptus Cardiograptus Oncograptus Didymograptus					
			Didymograptus bifidus						
	LOWER	ARENIG	Didymograptus hirundo	Clonograptus flexilis Tetragraptus fruticosus Tetragraptus quadribrachiatus Tetragraptus decipiens Acrograptus cf. kurcki		Pricyclopyge Symphysurus, Niobe (Niobe) Tropidopyge Apatokephalus Euloma Raphiophorus			
			Isograptus gibberulus						
			Didymograptus nitidus						
			Didymograptus extensus						
			Didymograptus deflexus						
			Tetragraptus approximatus						
		TREMADOC	Anisograptidae	Bryograptus Anisograptus ? Clonograptus cf. smithi Dictyonema uniformis Callograptus cf. sinicus					
			Dictyonema flabelliforme						
UNDERLYING UNIT									

CORRELATION OF LOCAL STRATIGRAPHIC SECTIONS

BELTAU-KURAMA ZONE	KYZYLKUM - ALAY ZONE								ZERAVSHAN - PAMIR ZONE			
				NORTH NURATAU	TURKESTAN - ALAY MOUNTAIN REGION			KOKSU RIVER				
MOGOLTAU	BUKANTAU	TAMDYTAU	BESSAPAN		KYZYL-MAZAR ZAAMINSU	SHAKUSH	TOGUZBULAK		KULDZHUKTAU	ZIRABULAK	ZERAVSHAN-GISSAR MOUNTAIN REGION	CENTRAL PAMIR AK-BAYTAL, VANCH
1'	2'	3'	4'	5'	6'	7'	8'	9'	10'	11'	12'	13'
S_1			D_1						S_1	S_1	S_1	S_1
KAYRAK FM. ss, si, ms ✳ 800 m	shales, sandstones, volcanics, cherts ⊗ 165 m			YLANCHISAY FM. ss, si, sh ✳ 700 m		sandstones, shales, limestones, tuffs, volcanics ⊗ 150 m	mudstones, sandstones, limestones, cherts, volcanics ⊗ 250-300 m		OYDYNBULAK FM. ls, dol ⊗ 60 m	ALTYAUL FM. si, ss, volc, ls ⊗ 350-500 m	SHAKHRIOMON FM. sandstones, siltstones, limestones, dolomites ✳ ⊗ 76 m	KOZYNDY FM. sh, ss, volc ⊗ 350-800 m
KURUSAY FM. sh, ss 1000 m		sandstones, siltstones, mudstones ✳ 40-50 m	BESAPAN FM. sh, ss, si ✳ 2000 m						KAZAKASU FM. sh, ss, cgl, si, ls, ch, volc ⊗ 400 m		siltstones, sandstones conglomerates, tuffs ⊗ 285 m	
	shales, sandstones, limestones 400 m											
				DZHALATAR FM. ch, ms 600-700 m							shales, sandstones ✳ 150-200 m	
									AKMULLA FM. sh, si, ss, cgl ✳ 1400 m			
									ZAAMIN FM. ms, ls, ch ¢ ✳ ⊗ 1370 m			
									AKCHAPKAN FM. si, ss, sh ✳ 800 m			
			pЄ	$Є_3$		$Є_2$			$Є_3$			$Є_3$

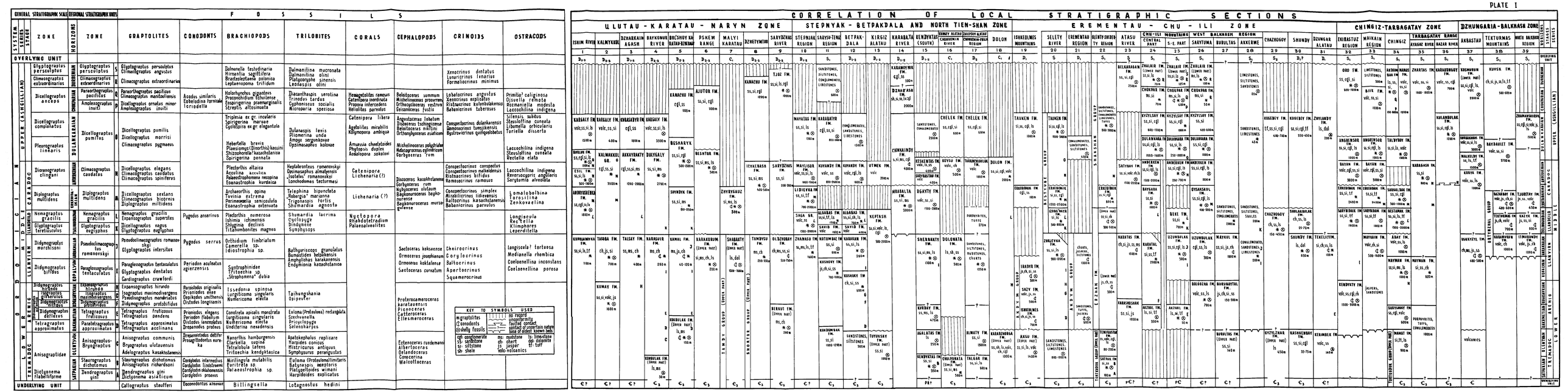
KEY TO SYMBOLS USED

✳ graptolites; ¢ conodonts; ⊗ shelly fossils

no record; unconformity; faulted contact; contact of uncertain nature; base of oldest known beds

cgl: conglomerate; ss: sandstone; si: siltstone; sh: shale; ms: mudstone; ch: chert; js: jasper; volc: volcanics; ls: limestone; dol: dolomite; tf: tuff

CORRELATION CHART FOR THE ORDOVICIAN SYSTEM IN MIDDLE ASIA



CORRELATION CHART FOR THE ORDOVICIAN SYSTEM IN KAZAKHSTAN AND KIRGIZIA