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NEW EVIDENCE ON GRAPTOLITE SUCCESSION ACROSS THE ORDOVICIAN-SILURIAN BOUNDARY IN THE ASIAN PART OF THE USSR

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Continuous sections of the Upper Ordovician-Lower Silurian terrigenic-carbonate deposits in the Basin of the Kolyma River, Southern Kazakhstan and Tien Shan display a sequence of the following biostratigraphic units: the *supernus* Zone with the *longispinus* and *pacificus* subzones, the *extraordinarius*, *persculptus* and *acuminatus* Zones. Graptolites from the above sections are associated with diverse benthic fauna, namely: brachiopods, trilobites and corals. The *persculptus* Zone of Kazakhstan and its analogues in the basin of the Kolyma River are distinguished by the occurrence of the *Dalmanitina — Hirnantia* assemblage.

The *supernus extraordinarius* and *persculptus/acuminatus* boundaries are the most distinct correlative levels as far as graptolites are concerned. The former is marked by full disappearance of typically Ashgillian graptoloids, while the latter displays distinct renewal of diplograptid fauna due to the simultaneous appearance of various morphologic features in several new lineages. The *extraordinarius* and *persculptus* Zones are distinguished by the development of impoverished diplograptid assemblages. They contain a few new elements, while species of the genus *Climacograptus* have broad Ashgillian-Llandovery biozones. The bottom of the *acuminatus* Zone coincides with the disappearance of brachiopod and trilobite associations which were traditionally believed to be Ordovician.

K e y w o r d s: Graptolites, stratigraphic boundaries, Ordovician, Silurian, Asia.

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INTRODUCTION

The Ordovician-Silurian boundary deposits have recently become the subject of detailed investigations with a view to establishing more accurately the system boundaries in different regions. The focus of attention is the composition and sequence of graptolite assemblages in the boundary beds together with the correspondence of graptolite zonation to the subdivision differentiated on the basis of benthic fauna. But correlation of the *Hirnatia* stage of the Upper Ordovician with the graptolite standard

is still debatable both in the stratotype area and in other regions. Therefore, new biostratigraphic data as obtained for the Ordovician-Silurian boundary deposits of the USSR are of considerable importance. Such deposits can be found on small areas of the Taimyr peninsula, in Kazakhstan, in the Southern Tien Shan, Gorny Altai and in the upper reaches of the Kolyma River. Being composed of terrigenous and carbonate rocks with mixed shelly-graptolite taphocoenoses, they have variable completeness of stratigraphic succession and different paleontological record.

On Taimyr, the Upper Ordovician comprises beds of black argillaceous shales bearing Ashgillian graptolites which do not give evidence enough to establish the zonal age of the deposits. Graptolites of the *acuminatus* Zone have not been recorded in this area. The Lower Llandovery is represented by the *vesiculosus* and *cyphus* Zones (Obut and Sobolevskaya 1964; Obut, Sobolevskaya and Bondarev 1965).

Recently, Sennikov (1976) has discovered late Ordovician graptolites of the *ornatus-supernus* Zone in Gorny Altai. The oldest Silurian graptolites are of *acuminatus* Zone, but there are no continuous sections of the transient stratigraphic interval.

As to Southern Tien-Shan, the Ordovician-Silurian boundary was investigated in the Zeravshan-Gissar Region, the Schahriomon pass (Kim *et al.* 1975). These deposits are composed of typical shelly facies with diverse benthic fauna (fig. 4). Graptolites occur at three stratigraphic levels in thin-layered siltstone and sandstone (Koren' 1979). The Upper Ordovician layers yield *Pacificograptus pacificus kimi* Koren' 1978 and

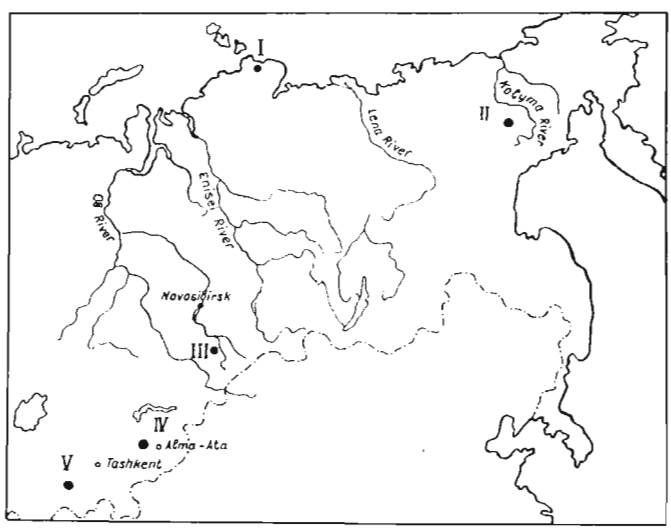

Fig. 1. Schematic locality map for Ordovician/Silurian boundary sections with graptolites. Asiatic part of the USSR. I Taimyr, II Upper Kolyma basin, III Gorny Altai, IV South Kazakhstan, V Southern Tien Shan.

P. p. pacificus (Ruedemann). The Lower Silurian deposits contain a graptolite assemblage of the *acuminatus* Zone. The transient interval of the section is represented by a member of dolomitized limestone bearing *Proconchidium münsteri* (Kiaer).

Good exposures of the Upper Ordovician-Lower Silurian sections containing a succession of graptolites and benthic fauna have been discovered and studied in detail in the upper reaches of the Kolyma River and in Southern Kazakhstan. In the key section of the Upper Ordovician of the Northeastern USSR, along the Mirny Creek, they are assigned to the Padun, Tirekhtjakh and Chalmak horizons (Nikolaev *et al.* 1974; Koren' and Sobolevskaya 1977). Coeval deposits bearing diverse graptolite assemblages can be also found along the Levaya Hekandya, Ina and Drevnjaya Rivers (Sobolevskaya 1970, 1971, 1974).

In Kazakhstan, the boundary graptolite-bearing layers occur in the southeastern Chu-Ili Mountains (the Ashysu, Ojsu, Zhideli, Karasai sections) and in the Chingiz Range. Here, the Upper Ordovician deposits can be subdivided into the Dulankara, Tshokpar and Ulkuntas horizons, while those of the Lower Silurian age (the *acuminatus* Zone) are assigned to the Alpeis horizon. Geological structure, description of the sections as well as the first identifications of graptolites, brachiopods and trilobites along the Aschysu and Zhideli Rivers have been discussed in numerous papers (Mikhajlova 1970*a*, *b*, *c*, 1973, 1974; Nikitin 1971, 1972, 1976; Apollonov 1974; Tsai 1974). The major advantage of the Kazakhstan sections is the variety of graptolite, brachiopod and trilobite assemblages.

In spite of some differences at the specific and subspecific level, the taxonomic composition of graptolite assemblages of the Kolyma Region and Kazakhstan is so close as to allow correlation of widely separated sections.

The following biostratigraphic units were established in the Upper Ordovician-Lower Silurian:

Orthograptus quadrimucronatus Zone;
Climacograptus longispinus supernus Zone with the subzones:
C. longispinus and *Pacificograptus pacificus*;
C. ? extraordinarius Zone;
Glyptograptus ? persculptus Zone;
Akidograptus ? acuminatus Zone.

ZONAL STRATIGRAPHY

The above zones will be discussed from the point of view of their various characteristics such as scope, boundaries, graptolite assemblages, distribution and correlation with the zonal units of Great Britain and North America.

O. quadrimucronatus Zone. — In the basin of the Kolyma River this zone can be traced in the Upper Ordovician sections (the Padun horizon) along the Mirny Creek and the Kharkindzha and Drevnjaya Rivers (fig. 2). In the key section along the Mirny Creek, it is identified with the upper part of member L bearing *Dicellograptus pumilus* Lapworth, *Climacograptus* aff. *typicalis* (J. Hall), *Orthograptus quadrimucronatus* (J. Hall) and *O.* ex gr. *calcaratus* Lapoworth (Nikolaev *et al.* 1974). In that section one cannot trace the limits of the zone, for the under- and overlying deposits contain benthic fauna only.

In Kazakhstan, the lower boundary of the Upper Ordovician is recognized at the base of the Dulankara horizon which bears *Climacograptus styloideus* Lapworth and *Orthograptus quadrimucronatus* (J. Hall). The layers of the Chingiz Range containing *Agetolites mirabilis*, also display *Dicellograptus pumilus* Lapworth, *Pseudoclimacograptus clevensis* Skoglund and others (Nikitin, 1972). The latter, being described from Fjaka shales in Sweden, enables correlation of these layers with the *linearis* Zone though they may as well belong to *clingiani* Zone. The upper limit of the *O. quadrimucronatus* Zone in Kazakhstan could not be established due to the lack of continuous sections across the Dulankara/Tshokpar boundary.

C. longispinus supernus Zone. — In the Kolyma basin, this zone has been recognized in the sections of the Tirekhtjakh horizon, along the Mirny Creek, the Levaya Hekandya and Drevnjaya Rivers and along the tributaries of the Iriudi River (fig. 2).

In Southern Kazakhstan, investigations of this zone were based on the graptolite assemblage from the Tshokpar horizon of the southeastern Chu-Ili Mountains (the Ojsu, Aschysu, Karasai and Zhideli sections) as well as from the Chingiz Range (fig. 3).

The *supernus* Zone of the Kolyma River has been traced in continuous sections with under- and overlying zones along the Drevnjaya River. The most typical for this zone are: *Dicellograptus complanatus complanatus* Lapworth, numerous subspecies of *Climacograptus longispinus* T. Hall, as well as *Pacificograptus pacificus pacificus* (Ruedemann) and *Orthograptus amplexicaulis* (J. Hall). Comparative analysis of graptolite assemblages shows that they have a certain stratigraphic differentiation within the zonal interval. According to taxonomic composition and predominant species, the *supernus* Zone can be divided into the lower and upper subzones — *longispinus* and *pacificus*, respectively.

Prevailing in the *longispinus* subzone of the areas under study are representatives of the group *C. longispinus* which are particularly diversified in the sections of the Kolyma Region (figs 2, 3). *Dicellograptus complanatus* Lapworth and abundant diplograptids of the group *O. amplexicaulis* (J. Hall) are the more representative members of the assemblage. Graptolites are associated with rare benthic fauna (Table 1).

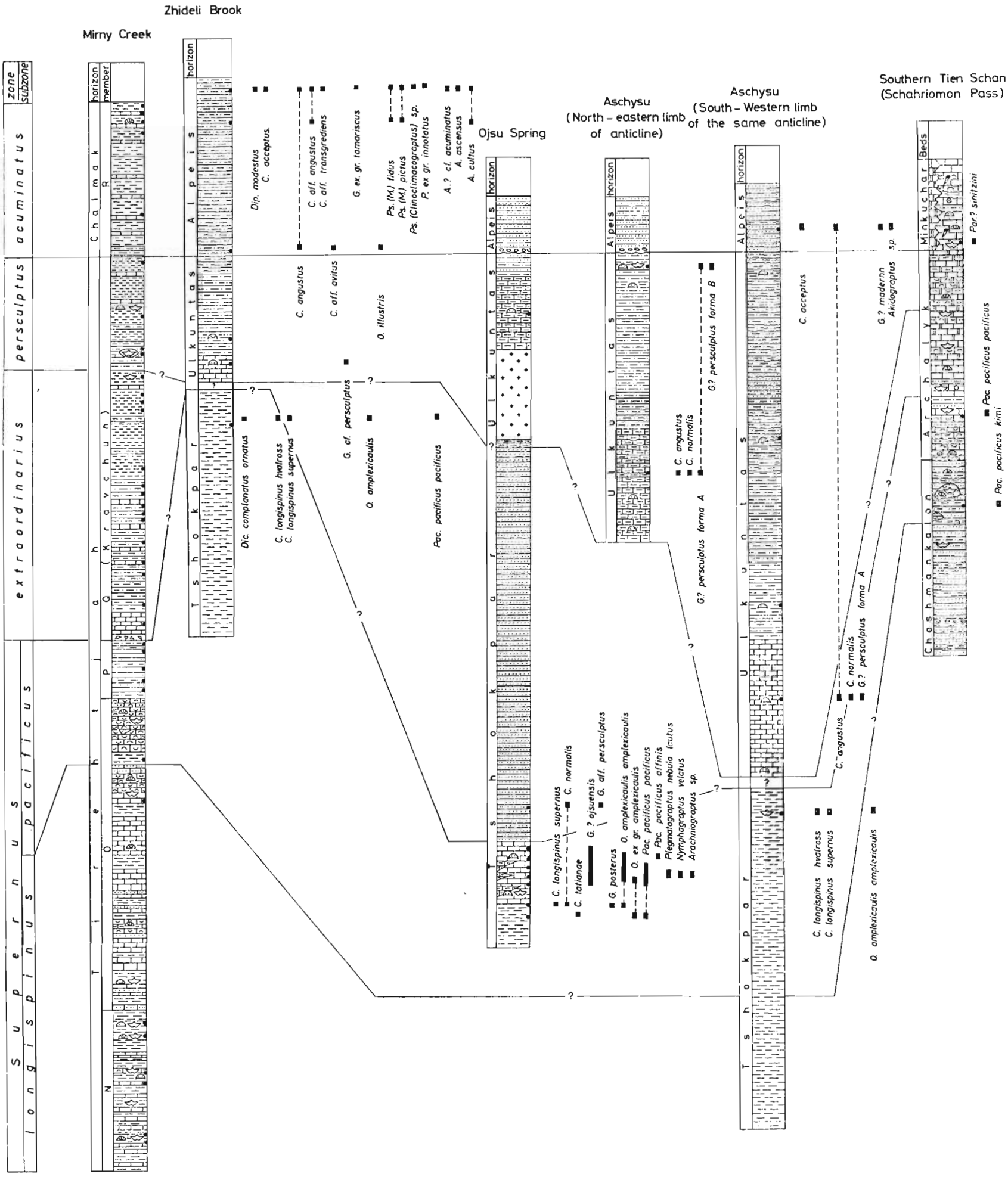

Fig. 2. Correlation chart for Ordovician/Silurian boundary sections in the Kolyma area. Legend the same as to fig. 3.
Editor' note:

Following species names used in fig. 2 and 3 are to be publishe during 1978 (Koreń 1978) and 1979 (Koreń 1979, in preparation): *Pacificograptus pacificus kimi* Koren, *P. pacificus affinis* Koren et Tsai, *Glyptograptus ojsunensis* Koren et Mikhajlova, *G. posterus* Koren et Tsai, *Plegmatograptus nebula lautus* Koren et Tsai, *Climacograptus acceptus* Koren et Mikhajlova, *Orthograptus illustris* Koren et Mikhajlova, *Diplograptus modestus primus* Mikhajlova, *Pseudoclimacograptus (Metaclimacograptus) fidus* Koren et Mikhajlova, *Ps. (M) pictus* Koren et Mikhajlova, *Glyptograptus madernii* Koren et Mikhajlova.

Following species names used in the fig. 2 are invalid: *Dip. improvisus* should be read *Dip.* sp.n. *C. extraordinarius productus* should be read *C. extraordinarius* subsp. n. 1. *C. extraordinarius proximus* should be read *C. extraordinarius* subsp. np. 2. *C. lucavensis* should be read *C.* sp.n. *G. malus* should be read *G.* sp.n. 1. *G. longispinus hekandensis* should be read *C. longispinus* subsp. n. *G. startikensis* should be read *G.* sp.n. 2

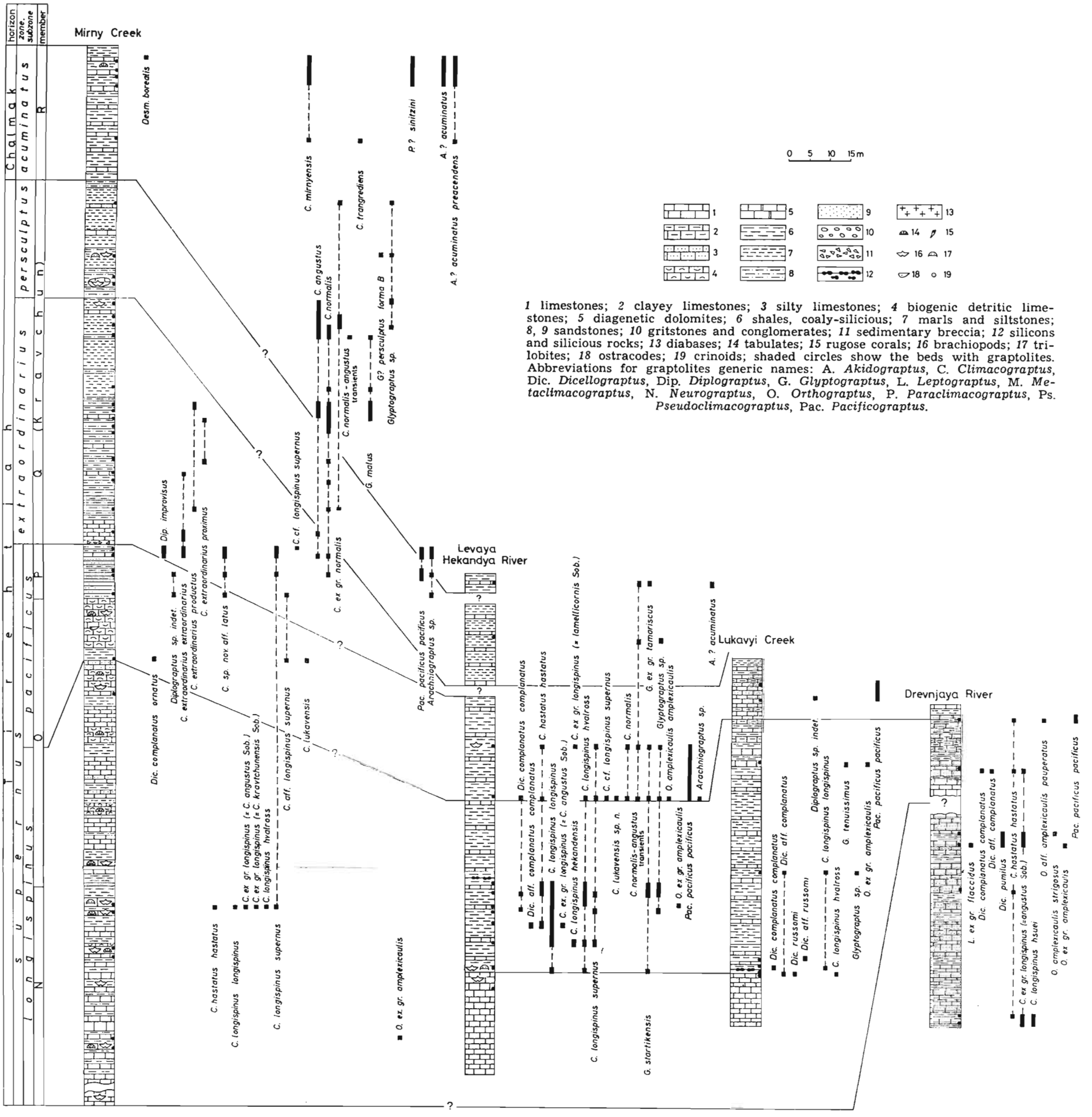

Fig. 3. Correlation chart for Ordovician/Silurian boundary sections in the Kolyma area (Mirny Creek), Southern Kazakhstan (Zhideli, Oisu, Ashisi) and South Tien Shan (Shakhriomon).

Table 1

Assemblages of shelly fauna associated with graptolites in the Ordovician/Silurian boundary bed in the Asiatic part of the USSR

Graptolite zone	shelly fauna		
	North-East of USSR (Kolyma region)	Southern Kazakhstan	Southern Tien Shan
acuminatus		*Dicantaspis* sp.	*Palaeofavosites hirtus, Estonia asteriscus, Propora cancellata, Grevingkia contexta, Crassilasma crassiseptatus, Calostilis denticulatum, Resserella* cf. *neocrassa, Stricklandia* ex gr. *lens, Zygospiraella* sp., *Lichas gotlandica, Stenopareia thomsoni, Eobronteus norilskensis*
persculptus	*Drabovia agnata, Hirnantia sagittifera, Dalmanella* cf. *testudinaria, Eostropheodonta hirnantensis lucavica, Dalmanitina* cf. *olini*	*Dalmanella testudinaria, Hirnantia* ex gr. *sagittifera, Aegiromena ultima, Leptaenopoma trifidum, Eostropheodonta* sp., *Dalmanitina mucronata, D.olini, Platicoryphe sinensis*	*Nyctopora* sp., *Lyopora* sp., *Agetolites* sp., *Palaeofavosites paulus, Proconchidium muensteri, Illaenus schmidti, Conolichas aequilobatus*
extraordinarius	*Eostropheodonta* cf. *hirnantensis lucavica*	indeterminable brachiopods	
supernus	*Primitiella* sp., *Platybolbina* sp., *Agetolites aseptatus, Calapoecia anticostiensis mediana, Catenipora admira, Fletcheriella evenkiana, Heliolites digitalis, Holorhynchus* sp., *Tcherskidium unicum, Parastrophinella distorta*	*Dalmanella* aff. *testudinaria, Comatopoma* sp., *Leptaena rugosa, Streptis moutilifera*	*Holorhynchus giganteus, Catenipora tapaensis, Agetolites asiatica, Palaeofavosites indubius, Plasmoporella convexotabulata, Acdalopora elegantis, Grewingkia contexta, Platylichas laxatus*

In the North-East of the USSR and in Kazakhstan, the *pacificus* subzone yields abundant *P. pacificus pacificus* (Ruedemann), *O. amplexicaulis* (J. Hall) (with subspecies), *C. longispinus supernus* Elles et Wood, *C. l. hvalross* Ross et Berry, *C. hastatus* T. Hall, individual transitional forms *C. angustus-normalis, D. complanatus* Lapworth etc. The upper part of this subzone displays a diverse graptolite assemblage where *C. longispinus supernus* Elles et Wood and *P. pacificus pacificus* (Ruedemann) concur with *Climacograptus tatianae* Keller, *Pacificograptus pacificus*

affinis Koren' et Tsai, *Glyptograptus? ojsuensis* Koren' et Mikhajlova, *Nymphograptus velatus* Elles et Wood and others (fig. 3).

The *pacificus* subzone of Southern Tien Shan contains a monospecific graptolite assemblage observed only on two stratigraphic levels in shelly facies, namely: *Pacificograptus pacificus kimi* Koren' and *P. p. pacificus* (Ruedemann) in the Chashamankolon and Archalyk beds respectively (fig. 3).

The distribution of cosmopolitan *Dicellograptus complanatus complanatus, D. complanatus ornatus, Climacograptus longispinus supernus* and some others in the Upper Ordovician deposits of North America, Eurasia and Australia makes it possible to establish correlations within this stratigraphic interval. But lack of a continuous faunal succession in the stratotype area of Great Britain, geographic variation of graptolite assemblages, an overall incompleteness of sections — all these are stumbling blocks to a detailed zonal subdivision and global correlation.

In graptolite zonation of the Asian part of the USSR, the standard *complanatus* and *anceps* Zones have not been distinguished in spite of the presence of some common species. The local *supernus* Zone is the equivalent of that stratigraphic interval in the sections under study. The graptolite assemblage of the *supernus* Zone has many species in common with the *complanatus* Zone in Great Britain or the *ornatus* Zone of western North America and China (Berry 1960; Churkin 1963; Churkin *et al.* 1971; Jackson 1966; Jackson and Lenz 1962; Lenz and Pedder 1972; Ross and Berry 1963; Thorsteinsson 1958; Toghill 1970; Mu *et al.* 1960).

The *pacificus* subzone of Southern Kazakhstan yields not only graptolites characteristic for the Cordillera assemblages but also *Glyptograptus posterus* Koren' et Tsai (the group *G. lorrainensis*). Representatives of this group have not been recorded previously outside the North-American Platform (Manitoba; Jackson 1973) and the Appalachians (Riva 1974). The Kazakhstan assemblages of the age display *Nymphograptus* and *Plegmatograptus* common in the *anceps* Zone of Great Britain and unknown in the post-caradocian graptolite assemblages of the Pacific belt.

The *complanatus* and *ornatus* Zone of western North America as identified on the basis of the occurrence of *P. pacificus*, is likely to correspond to the *pacificus* subzone of the Asian part of the USSR. Correlation with the zones of eastern North America involves difficulties due to differences in the composition of their graptolite assemblages with those of the western regions of the continent (Riva 1969, 1974). The *supernus* Zone of the Asian part of the USSR may correspond to *complanatus* of Anticosti Island.

C. ?extraordinarius Zone. — For the first time this zone has been recognized in the upper part of the Tirekhtjakh horizon of the Kolyma Region, namely: in the Upper Ordovician key section along the Mirny Creek.

Here, it comprises the layers immediately overlying the *supernus* Zone and overlain with deposits which could be correlated with the *persculptus* Zone (fig. 2).

Within the zonal interval, graptolites are abundant and uniformly distributed across the section. The lower limit of the zone is marked by the disappearance of almost all characteristic members of the Ashgillian assemblage of *C. longispinus supernus*. The lower part of the *extraordinarius* Zone bears numerous *Climacograptus ?extraordinarius* (Sobolevskaya), *C. normalis* Lapworth, *C. angustus* Perner, *C. ?extraordinarius* subsp. n. 1, *C. ?extraordinarius* subsp. n. 2 and *Glyptograptus* sp. n. 1. The second and third of these forms also occur in the top of the *supernus* Zone, while the rest of them are to be found in the *extraordinarius* alone. The taxonomic composition of the graptolite assemblage from the upper part of the *extraordinarius* Zone is less diverse. But these few taxa are represented by abundant specimens. The bulk is made of *Climacograptus normalis* Lapwort, *C. angustus* Perner and their transients. Less frequent are *Glyptograptus* sp. n. 1 and *Glyptograptus* sp. In the upper part of the zone graptolites are associated with rare brachiopods *Eostropheodonta* cf. *hirnantensis lucavica* Orad *et. al.* (Table I). Outside the key section, graptolites of this zone were reported from the Levaya Hekandya and Ina Rivers.

In Southern Kazakhstan, analogues of the lower part of the *extraordinarius* Zone have been observed in one section only — around the Ojsu Spring. Here, abundant *Glyptograptus?* aff. *persculptus* concur with scarce *C. normalis* Lapworth in the lower part of the bed of coarse greyish-yellow sandstone which overlies the limestone member in the top of the *P. pacificus* subzone. There are no graptolites in the 75 m thick upper part of the sandstone bed overlain with *Dalmanitina mucronata*-bearing limestone, but by its position in the section it is correlative with the *extraordinarius* Zone. Up to now, this zone has not been recorded in other Upper Ordovician sections of Kazakhstan. So, *Dalmanitina* limestone overlying the Tshokpar shales of the *supernus* Zone along the Zhideli, Aschysu and Karasai Rivers yield *Glyptograptus ? persculptus* Salter forma *A*. But no graptolites were observed in the intermediate interval of the section.

Thus, the *extraordinarius* association has less representative diagnostic elements than the typically Ashgillian assemblage discussed above. According to its graptolite composition *extraordinarius* is a transient zone, for it contains species which occur in both over- and underlying deposits. A fairly complete faunal characteristic as obtained along the Mirny Creek allows this interval to be recognized as a separate biostratigraphic zone. It can be correlated with the upper part of the Hartfell Shales in Great Britain which lie immediately above the latest occurrences of graptolites of the *anceps* Zone. That correlation has been corroborated

by new graptolite findings of similar taxa at the Dobbs Linn section of the Moffat area (dr. R. B. Rickards' personal communication). This suggests that the new zone may be used for wide interregional correlations.

In eastern North America the stratigraphic interval in question may be correlated with the *Climacograptus prominens-elongatus* Zone in the Voreal Suite of Anticosti Island (Riva 1969, 1974). But an accurate correlation is difficult owing to rare findings of graptolites in the Voreal Suite and to the lack of species in common with the *extraordinarius* assemblage of the North Eastern USSR.

G ? persculptus Zone. — This zone has been most fully traced across the sections of the Ulkuntas horizon of Southern Kazakhstan (Mikhajlova 1970*a*, *b*; Nikitin 1971, 1976; Apollonov 1974; Tsai 1974). In the sections along the Aschysu, Zhideli and Karasai, argilliceous shales bearing *Dalmanitina mucronata* (Brogniart) and *D. olini* (Temple) (Apollonov 1974) also yield *Glyptograptus ? persculptus* Salter forma *A*, *Climacograptus normalis* Lapworth and *C. angustus* Perner (fig. 3). At the north limb of the Aschysu anticline, the overlying member of green aleurolites contains numerous *Glyptograptus ? persculptus* Salter forma *B* associated with *D. mucronata*, the hirnatian brachiopod assemblage and abundant other shelly fauna (Table 1). The Ulkuntas desposits have been best of all studied along the Aschysu and Zhideli, where they are overlain with argillites and aleurolites yielding a diversified graptolite assemblage of the *acuminatus* Zone. The lower limit of the *G. ? persculptus* Zone in these sections is not quite distinct, since the Zone of *extraordinarius* has not been established there. Besides, underlying the Ulkuntas limestone are the Tshokpar shales of the *C. longispinus supernus* Zone. The *G. persculptus* Zone of Southern Kazakhstan can be correlated with the uppermost part of the Tirekhtiakh horizon of the Kolyma Region which crops out along the Mirny Creek (the top of member Q) and on the Levaya Hekandya River. On the Mirny Creek, *Glyptograptus ? persculptus* Salter forma *B* has been found above the last graptolites of the *extraordinarius* Zone in association with the hirnantian brachiopod assemblage and with *Dalmantina* cf. *olini* (Temple) (fig. 2; Table 1). In the beds lying immediately above member Q there occur abundant graptolites of the *acuminatus* Zone (member R).

Thus, the *persculptus* Zone as recognized in the Asian part of the USSR embraces the entire range of index-species. It is not clear whether it has an exact counterpart in the *G. persculptus* Zone of Great Britain. The part of the section assigned to the *G. persculptus* Zone in the Asian part of the USSR is likely to correspond in Great Britain not only with the Zone of the same name but also with the upper part of the *Hirnantia* stage from which the occurrence of *G. ? persculptus* has also been reported.

A. ? acuminatus Zone. — The layers which bear the zonal graptolite assemblage are to be found within the Chalmak horizon in the upper reaches of the Kolyma River and the Alpeis horizon of Southern Kazakhstan. The *persculptus/acuminatus* zonal boundary has been recognized at continuous sections along the Mirny Creek of the Kolyma Region as well as in the Chu-Ili Mountains (along the Aschysu, Zhideli and Karasai Rivers). It is distinguished by a distinct renewal of graptolite assemblage both at the specific and generic levels. At the section along the Mirny Creek, the *acuminatus* Zone yields *Akidograptus ? acuminatus acuminatus* (Nicholson), *A. ? a. praecedens* Münch, *Climacograptus mirnyensis* Obut et Sobolevskaya (= *Hedrograptus mirnyensis*, Obut *et al.* 1967), *Paraclimacograptus ? sinitzini* Chal. (= *Orthograptus sinitzini*, Obut *et al.* 1967) and *Cystograptus praepenna* Obut et Sobolevskaya. In the top of the zone graptolites are associated with corals (Table 1).

A more complete and diverse assemblage of graptolites of this zone has been found in Kazakhstan, along the Zhideli River (Mikhajlova 1974). Here, 20 m above the *G. ? cf. persculptus* Salter layers, the base of the Alpeis horizon displays *Glyptograptus* aff. *avitus* Davies and *Orthograptus illustris* Kor. et Mikh. These species are closely morphologically related with Silurian orthograptids and glyptograptids, therefore the deposits bearing them are tentatively assigned to the *acuminatus* Zone despite the absence of akidograptids. The next graptolite-bearing stratigraphic layer was observed 10 m above the bottom of the Alpeis horizon (Bandaletov, in press). Here occur *Diplograptus modestus primus* Mikh, *Climacograptus acceptus* Kor. et Mikh., *C. angustus* Perner, *C.* aff. *angustus* Perner, *C.* aff. *transgrediens* Waern, *Glyptograptus* ex gr. *tamariscus* Nicholson, *Akidograptus ?* cf. *acuminatus* (Nicholson), *A. ascensus* Davies, *A. cultus* Mikhajlova and some new species of *Pseudoclimacograptus* (fig. 3).

CONCLUSIONS

The zonal subdivisions recognized in the Upper Ordovician-Lower Silurian sections of the Asian part of the USSR correspond to certain stages of the diplograptid fauna development.

Typical for the *quadrimucronatus* Zone is succession of major types of morphological structure of Late Caradocian graptolites. Species of the genera *Leptograptus, Dicellograptus, Climacograptus* and *Orthograptus* prevail in the assemblages. The combination of narrow stratigraphic and broad geographic distribution of graptolites allows for global correlation of this zone. This stage is terminated by the disappearance of *Pleurograptus* and *Leptograptus* together with the impoverishment of dicellograptid fauna. The *quadrimucronatus/supernus* limit is marked by the renewal of

Climacograptus species composition and a wide distribution of such morphologically remarkable groups as *C. longispinus* and *C. hastatus*. The beginning of the *supernus* Zone is also associated with the appearance of transient Ashgillian-Llandovery forms: climacograptids of the *C. angustus-C. normalis* lineages. The end of this zone (the *pacificus* subzone) features a distinct brief acme in the diplograptid evolution, namely: the appearance and broad geographic distribution of the genus *Pacificograptus* Koren' which concurs with new species of the genera *Climacograptus*, *Diplograptus* and *Glyptograptus*. The limit of the *supernus/extraordinarius* Zones is marked by a complete disappearance of typically Ashgillian forms.

The *extraordinarius* and *persculptus* Zones yield impoverished diplograptid assemblages with a few new elements, whereas species of the genus *Climacograptus* occur both in the Ashgillian and Llandovery assemblages. Their boundary is difficult to define.

The *persculptus/acuminatus* limit is associated with a distinct renewal of diplograptid fauna at the specific level almost throughout all generic categories; it is also expressed by the appearance of new genera (*Akidograptus* and others) having a remarkable, hitherto unknown structure of the proximal end.

From the point of view of taxonomic practice and stratigraphic value, the *supernus/extraordinarius* and *persculptus/acuminatus* boundaries are the most distinct correlative levels as far as graptolites are concerned. The first is marked by a full disappearance of typically Ashgillian graptoloids, while the other exhibits a pronounced renewal of diplograptid fauna due to the simultaneous appearance of various morphological features in several new phylogenetic lineages.

The bottom of the *acuminatus* Zone coincides with the disappearance of the brachiopod and trilobite assemblages which traditionally were believed to be Ordovician.

The evidence obtained suggests the necessity of further improvement in correlation of the Ordovician-Silurian boundary deposits; without such correlation it is impossible to finally establish the above boundary between the Ordovician and the Silurian.

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