Cambrian Faunas of Siberia

By

Teiichi KOBAYASHI

WITH THREE PLATES

REPRINTED FROM THE
JOURNAL OF THE FACULTY OF SCIENCE
IMPERIAL UNIVERSITY OF TOKYO
SEC. II, VOL. VI, PT. 12

October, 1943

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(With Plates I–III)

PREFACE

On reading OBRUTSCHEW's "Geologie von Siberien" the reader will realize that the Cambrian formations had already been studied extensively before 1926 and that their stratigraphic successions in various regions are now fairly well known. On the other hand, our knowledge on the fossils contained therein is still meager and accordingly the concept of the faunal aspect is not yet clearly figured out, although SCHMIDT and TOLL have made valuable contributions in the latter part of last century and later advancements were made by HOLM and WESTERGÅRD, VOLOGDIN, LERMANTOVA, POLETAYEVA and other palaeontologists.

During my stay in the United States I had an opportunity, in 1933, to make a study of some older Palaeozoic faunas of Siberia which were collected by TOLMACHOFF in the Chatanga-Anabar region. I completed my manuscript after a few months, but it remained unpublished for some ten years except for a brief note on the Cambro-Ordovician fauna (1933) and a description of *Tolmachovia concentrica*, a peculiar Ordovician notostracan, which I had written jointly with HOWELL (1936). Lately a grant was given to my section of our institute from the Department of Education for the purpose of resuming my work on the manuscript, and I have thus brought this study to completion.

OBRUTSCHEW mentions that "Leider sind die Resultate der Chatanga-expendition von 1904 bis 1905 durch Tolmatschew bis jetzt nicht öffentlicht". I report here the palaeontological results of my study on the Cambrian trilobites in the collection. At the same time I wish to outline the aspect of the Cambrian faunas as far as I can figure it out on the basis of the facts obtained from this and other materials already published.

OBRUTSCHEW's and others' compilations on the Siberian Geology were indeed a great help to me in acquiring the geological concept of the region. As to more recent contributions I have tried to refer to Russian papers as much as possible, but some of the references given are to the résumés which I was able to read. Furthermore I fear that my research in the literature on this subject has been somewhat incomplete. I believe however that this sketch of the Cambrian faunas of Siberia will serve to clarify the Cambrian palaeogeography of the world. And further descriptions of the fresh material from the Chatanga-Anabar region which are given in the latter part of this paper are an addition to our knowledge on the Cambrian faunas of Siberia.

From the palaeontological point of view most Cambrian trilobites in Siberia can be classified into six major groups as follows:

I. Early Middle Cambrian *Tollaspis* fauna.
II. Middle Paradoxidian *Ciceragnostus* fauna.
III. Late Paradoxidian *Centropleura* fauna.
IV. Latest Middle Cambrian *Solenoparia* fauna.
V. Early Upper Cambrian *Koldinia* fauna.
VI. Late Upper Cambrian "*Dictyites*" fauna.

These six faunas of Cambrian trilobites are the main subject to be discussed in the first part of this paper, but brief notes are given also on the archaeocyathid limestone and a few Lower Cambrian trilobites.

I wish here to express my most sincere thanks to the Department of Education for the research grant, to Dr. I. P. TOLMACHOFF of the Carnegie Museum, Pittsburgh, Pa. for the privilege of studying his valuable collection, to Prof. B. F. HOWELL of the Princeton University at Princeton, N. J. for his assistance and comments on my study and to Mr. N. USHIJIMA for helping me in reading some Russian reports.

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I. Cambrian Faunas in Central Siberia

1. The *Tollaspis* fauna and *Ciceragnostus* fauna

The first known Cambriam trilobites in Siberia :—It was as early as 1886 that SCHMIDT first described a few trilobites from Siberia as follows :—

1) *Agnostus czekanowskii* SCHMIDT in a boulder on the Olenek near the mouth of the Koika river.
2) *Proetus* (*Phateon*) *slatkowskii* SCHMIDT and *Cyphaspis sibirica* SCHMIDT (Pl. I, fig. 19) at Torgoshino near Krasnoyarsk on the Yenissei river.
3) *Anomocare pawlowskii* SCHMIDT (Pl. I, fig. 18) and *Liostracus* ? *maydelli* SCHMIDT at the mouth of the Little Batobiji between Witimsk and Olekminsk on the Wiliu river.

Trilobites from Torgoshino and the Wiliu :—He considered the two trilobites from Torgoshino to be the Devonian forms, but in 1899 TOLL placed *P.* (*P.*) *slatkowskii* in *Dorypyge* and *Cyphaspis sibirica* in *Solenoleura* (?). This opinion was accepted by LERMANTOVA (1926) when she gave precise descriptions of these trilobites. Prior to this WALCOTT (1914) suggested *Anomocarella* for the generic position of *Anomocare pawlowskii* and *Liostracus* ? *maydelli*. The last two trilobites in addition to *Solenopleura* ? *sibirica* however, bear many features quite distinct from any one of these suggested genera, notably in the presence of the trapezoidal area in the front of glabella. Therefore I proposed in 1935 a new name, *Tollaspis*, to include them and selected *A. pawlowskii* for the type of this genus.

Subsequently WHITEHOUSE (1936, 1939) suggested the reference of *Tollaspis sibirica* to Australian *Dinesus*, ignoring the large trapezoidal elevation which is distinctly outlined in the Siberian species. In the presence of this peculiar elevation I still believe in its alliance to *Tollaspis*, but now I think it proper to distinguish this species from *Tollaspis* because of its narrow cylindrical glabella and other characteristics. Therefore *Paratollapis* is proposed for *Cyphaspis sibirica* in this paper.

When LERMANTOVA restudied *Dorypyge slatkowskii*, she missed comparing it with *Kootenia*. Between *Olenoides* and *Dorypyge* with which she compared it the latter is closer to this species because it has no interpleural furrow on the pygidium. But at the same time the fact must not be overlooked that the spines on its pygidium are all, as is usual in *Kootenia*, about the same length. Therefore its name must be *Kootenia slatkowskii*.

Of the age of the Torgoshino red limestone which yielded the two trilobites, LERMANTOVA cautiously mentioned that the „ the affinity of *D. slatkowskii* to the Middle Cambrian species of *Dorypyge* suggests that the position of these strata must be close to the Middle Cambrian." Accepting this conclusion, the limestone is generally located in the basal part of the Middle Cambrian in most correlation charts (OBRUTSCHEW, 1926, LEUCHS, 1935 and NALIVIKIN, 1936 B).

Although its early Middle Cambrian age is, I think, most probable, it cannot be established, because *Paratollaspis*, though intimately related to *Tollaspis*, is a new genus and *Kootenia*, though more common in the Middle Cambrian faunas, comprises a few Lower Cambrian species. *Kootenia fordi* (WALCOTT), *K. marcoui* (WHITFIELD) and *K. nana* (FORD) are such examples (RESSER, 1937). From the occurrence of *Kootenia* however, it can be concluded with confidence that in the Torgoshino stage the Siberian region was connected with tha Arcto-Pacific province. Incidentally it is noted that the two Torgoshino trilobites were found in association with *Spirocyathus*, *Nisusia* and *Kutorgina cingulata* in a limestone in the Minussinsk mountains. (EDELSTEIN, 1925).

Ciceragnostus fauna of Ssinjaja:—In 1889 the Cambrian fauna of Siberia was amplified by TOLL. Beside the archaeocyathid fauna of Torgoshino, he described the following from the Ssinjaja between Olekminsk and Pokrowskaja on the Lena. The names on the right side of the list show my generic references.

Kutorgina cingulata BILLINGS	
? *Obolella chromatica* BILLINGS	
Hyolithes ? sp. undt.	
Microdiscus kochi TOLL	*Ciceragnostus*
Microdiscus lenaicus TOLL	*Ciceragnostus*
Microdiscus sp. undt.	
Agnostus schmidti TOLL..	*Phalacroma*
? *Olenellus* sp. undt.	
Ptychoparia czekanowskii TOLL	*Levisia*
Ptychoparia meglitzkii TOLL..	*Lorenzella* ?

TOLL considered that this fossil bed is synchronous with the Torgoshino limestone but the two are heteropic from each other. Precisely, the former indicates a deep facies whereas the latter represents a shallow one. Furthermore he correlated these two with the *Olenellus* (*Holmia*) *kjerulfi* zone and placed the *Agnostus czekanowskii* zone of the Olenek formation in the Paradoxidian.

For *Ptychoparia czekanowskii* and *P. meglizkii* WALCOTT (1914) however suggested *Levisia* and *Inonyia* respectively, the two genera occurring in the

Middle Cambrian of Eastern Asia. COBBOLD (1931) on the other hand referred them to *Pagetia*, noting their close alliance to *Ptychoparia attleborensis* SHALER and FOERSTE which is the type of Olenellian *Hebediscus* by WHITEHOUSE (1936, KOBAYASHI, 1943 A).

Although the Lower Cambrian age of the Ssinjaja fauna has long been maintained by Russian geologists, (OBRUTSCHEW, 1926, LEUCHS, 1935 and NALIVKIN, 1936 B), I think that the age must be Middle Cambrian and most probably in its middle part because *M. kochi* and *M. lenaicus* belong in my opinion to *Ciceragnostus* and *A. schmidti* to *Phalacroma*.

As discussed thoroughly in my monograph on the Agnostidea (1939), the Lower Cambrian agnostids so far described are quite a few and they are entirely different from these Siberian species. Furthermore it is known that a species of *Ciceragnostus* occurs in England in the middle part of *Paradoxides hicksi* zone and another in the *Paradoxides bennetti* zone of Newfoundland. In Sweden it ranges from the *Conocoryphe aequilis* zone to the *Paradoxides davidis* zone where it is represented by one species in the former and by two in the latter zone. Furthermore one species of *Ciceragnostus* has been described from the *Centropleura* zone of Bennett island. *Phalacroma* comprising many species and varieties has a wider range from the *hicksi* zone to the Echinosphaeritenkalk, but attained the acme of its development in the Middle Cambrian when two-thirds of the total number of its forms lived.

Therefore, insofar as can be judged from the agnostids, the age of the Ssinjaja fauna must be the middle part of the Middle Cambrian period if not its latter part. This opinion is in support of WALCOTT's suggestion as to the resemblance of *Ptychoparia czekanowskii* with *Levisia agenor*. The inclusion of *Olenellus* (?) sp. in the fauna is not an objection to this conclusion, because it can be excluded from the Olenellidae, and this is because it is understood from TOLL's description that its facial suture is not fused. *P. meglitzki* may be left out of the consideration because no one has reached any definite conclusion as to it, although it somewhat resembles *Lorenzella* as well as *Strenuella*, as I have suggested before (1935 A).

Incidentally, *Protolenus asiaticus* LERMANTOVA (nov.) and *Solenopleura bituberculata* LERMANTOVA (nov.) are said to have been found in association with *Ciceragnostus lenaicus* and *Phalacroma schmidti* in the same place as the preceding (OBRUTSCHEW, 1926), but whether *Protolenus* extended into the middle Paradoxidian requires a careful reexamination.

Trilobites from the Sanashtikgolsky limestone:—In 1926 (B) LERMANTOVA described *Olenoides obrutchevi* LERMANTOVA from the Ussol stage in the Tcherenhoka mining district, Irkutsk. Subsequently in 1936 POLETAYEVA brought to light a rich Cambrian fauna of West Sayan. It was collected from the Sanashtikgolský limestone at Sanashtikgolsky spring in a tributary on the left side of the river Abakan. It comprises *Corynexochus* (3 spp. undt.), *Klotziella*, *Poliellina* (3 spp. and 1 var.) *Dolichometopus* (2 spp. undt.), *Neolenus*, *Dorypyge*, *Chaskasshia*, *Solenopleura*, *Erbia*, *Inouyina* und *Ptychoparia* among which *Chakasshina* and *Inouyina* are new genera instituted by her on the basis of *C. minussensis* POLETAYEVA and *I. quadratica* POLETAYEVA respectively. Another new genus is *Poliellina* which as I have pointed out already (1942, A B), is a subgenus of *Poliella*, and *Olenoides obrutchevi*, *Bathyuriscus* (*Poliella*) *powersi* and POLETAYEVA's *Klotzilela* sp. may referred to it.

POLETAYEVA's illustrations of these trilobites are not good enough to make an exact comparison, but a few comments may be added here. Because *Dorypyge* sp. (POLETAYEVA, pl. 2, fig. 7) is represented by a pygidium having fairly well fused pleura and spines of unequal length, it is more likely a *Kootenia* than an *Olenoides*. An unnamed pygidium of *Neolenus* sp. (pl. 2, fig. 7) on the other hand, if it is not identical, bears a close resemblance to that of *Neolenus abacanicus*, and the presence of interpleural furrows in it suggests *Olenoides* for its generic position. The small cranidia of two indeterminable species of *Corynexochus* (pl. 2, figs. 4–5) appear to me more suggestive of *Bonnia* than *Corynexochus*.

One of *Solenopleura* spp. (pl. 3, fig. 8) resembles *Solenopleurella* closely while the other (pl. 3, fig. 7) agrees with *Manchuriella* in most aspects except for the distinct palpebral ridge. It may possibly belong to the same species as *Manchuriella sibirica* below mentioned (p. 280). Finally if importance is attached to the preglabellar elevation it is much more reasonable to place *Ptychoparia* sp. (pl. 3, figs. 5–6) in *Tollaspis* than in *Ptychoparia*. It is more closely allied to *T. meydelli* than to *T. pawlowskii* in the outline of the glabella but can be distinguished from *meydelli* by the much stronger furrows on the glabella with a straight anterior margin. Therefore a new name, *T.* (?) *poletayevae*, is proposed here for this species. (See pl. I, fig. 20 in this paper).

Looking over these trilobites there is none which definitely shows the Lower Cambrian age of the fauna, though *Bonnia*-like cranidia and a doubtful *Solenopleurella* are contained. On the other hand it is known that *Poliella* (*Poliellina*) *powersi* WALCOTT is a species of the Middle Cambrian Gallatin fauna in Montana. *Manchuriella* is a common member in the Changhian fauna in Eastern Asia; *Olenoides* is also a Middle Cambrian genus which is extensively distributed around the Pacific. *Kootenia* is, as has been mentioned already, more developed in the Middle Cambrian than in the Lower Cambrian. Therefore in agreement with POLETAYEVA I think it is much more reasonable to consider the age of the Sanashtikgolsky fauna to be early Middle Cambrian rather than late Lower Cambrian. Furthermore these trilobites are related to the Arcto-Pacific fauna. The Sanashtikgolsky limestone which contains archaeocyathids, stromatoporids and brachiopods besides the trilobites, can roughly be correlated with the Torgoshino limestone.

Trilobites from the Esseigan river-bank:—It is interesting to see that a few trilobites of the same or a little younger age are contained in the Chatanga-Anabar collection. *Tollaspis* cfr. *pawlowskii* was found in association with *Manchuriella septentrionalis* KOBAYASHI in a gray limestone on the left shore of the Esseigan river, about 25 miles above its mouth. A pygidium similar to the one which I tentatively referred to the former species, was collected together with an indeterminable agnostid also on the left shore of the same river, 21 miles above its mouth. The latter species was on the other hand found together with *Manchuriella sibirica* KOBAYASHI on the right shore of the same river, 24 miles above its mouth. As has been noted already, the last mentioned looks so similar to one of POLETAYEVA's *Solenopleura* spp. from Sanashtikgolsky that, I think, they possibly belong to the same species.

Tollaspis fauna:—In looking over the trilobites discussed above, the fact that there is only one or two species common among the Esseigan, Sanashtikgolsky and Wiliu faunas cannot be overlooked. Therefore there may be some difference in age, but at the same time it is certain that the difference is not great. For this reason they may be grouped into one fauna for which the *Tollespis* fauna is proposed.

This fauna comprises

Kootenia abacanicus (POLETAYEVA)
Poliella (*Poliellina*) *obrutchevi* (LERMANTOVA)
Poliella (*Poliellina*) *laermantovi* POLETAYEVA
Poliella (*Poliellina*) *laermantovi* var. *alta* POLETAYEVA
Poliella (*Poliellina*) *sayanicus* POLETAYEVA
Poliella (*Poliellina*) ? *anomalis* POLETAYEVA
Tollaspis pawlowskii (SCHMIDT)
Tollaspis maydelli (SCHMIDT)
Tollaspis poletayevae KOBAYASHI
Chakasshia minussensis POLETAYEVA

Inouyina quadrata POLETAYEVA
Manchuriella septentrionalis KOBAYASHI

beside indeterminable solenopleurids and some other trilobites. Among them some species belong to endemic genera but the others indicate a faunal relationship with the Arcto-Pacific ones. There is none which is thought to be a Paradoxidian member. Although neither *Kootenia slatkowskii* (SCHMIDT) nor *Paratollaspis sibirica* (SCHMIDT) has as yet been discovered in the three localities, the Torgoshino limestone may differ very little from the *Tollaspis* beds in age as well as in the trilobite fauna contained.

Peledui and Argasala faunas:—Two more faunas ought to be mentioned in this chapter. As I was not able to see the original papers, no detailed discussion can be given. One is the Peledui fauna which was found in a siliceous limestone at three localities on the Peledui river which joins the Lena below Witimsk (OBRUTSCHEW, 1926) and comprises the following:

Kutorgina ? sp.
Hyolithes sp.
Olenoides sibericus LERMANTOVA (nov.)
Solenopleura bella LERMANTOVA (nov.)
Ptychoparia ? *rschonsnizkii* LERMANTOVA (nov.)

This Middle Cambrian fauna should be added to the general faunal group with the preceding because it contains *Olenoides*. The other is the Argasala fauna. The Argasala series on the southern slope of the Anabar massive begins with a thin basal conglomerate which is overlain by a *Collenia* limestone and the latter in turn by an archaeocyathid limestone. About 200 to 300 m. above the last mentioned there is a bed yielding the following fossils:

Acrotreta rojkovi LERMANTOVA (nov.)
Pagetia ferox LERMANTOVA (nov.)
Agnostus anabarensis LERMANTOVA (nov.)
Oryctocephalus sp.
Ptychoparia tkatschenkoi LERMANTOVA (nov.)
Dorypyge moori LERMANTOVA (nov.)

Although the Middle Cambrian age of this fauna is beyond doubt, whether it is in the early or middle part of the Middle Cambrian is a matter of discussion, it is known that this fossil bed is located more than 3000 meters below the Muna series containing the *Centropleura* fauna, showing that the age of the Argasala fauna is much older than late Middle Cambrian. The superposition of the trilobite beds above the archaeocyathid limestone on the other hand suggests that the trilobites fauna is a little younger than the *Tollaspis* fauna. Furthermore its intimate relationship with the Pacific fauna can hardly be overlooked, because *Pagetia*, *Oryctocephalus* and *Dorypyge* are contained. In the *Ciceragnostus* fauna of the Ssinjaja on the other hand, as has been discussed already, its faunal alliance with the Paradoxidian can clearly be recognized, though it is not so close as the still younger *Centropleura* fauna to be mentioned in the next chapter. From these facts it may be concluded that the fauna is younger than the *Tollaspis* but older than the *Ciceragnostus* fauna. Finally *Dorypyge delicatulla* (nov.?) is reported to occur in a limestone of the Kuznetsk basin, (Yavorsky, 1937). This, I presume, may be a member of the major group of the early Middle Cambrian faunas comprising *Paratollaspis*, *Tollaspis*, *Poliellina* and *Oryctocephalus*.

2. The Centropleura and Solenoparia fauna

Centropleura fauna of Bennett Island:—The wide distribution of the *Centropleura* fauna in Siberia, is indeed of extraordinary interest to Cambrian palaeogeographers because *Centropleura* and its associates are typical members of the late Paradoxidian fauna. During the Russian Polar expedition, 1900–1903, Toll discovered the fauna in Bennett island, north of the New Siberian islands in a rather coarse and hard black or dark gray, arenaceous clayey shale occasionally containing calcareous nodules or thin seams. In describing the fauna listed below, Holm and Westergård arrived at the conclusion in 1930 that it is a definite correlative of the fauna of the *Paradoxides forchhammeri* zone in Scandinavia.

Micromitra (?) sp.	
Lingulella (?) sp.	
Acrotreta sp.	
Indeterminable brachiopod	
Agnostus pisiformis Linné var. *pater* Holm and Westergård......	*Agnostus* s. str.
Agnostus glandiformis Angelin	*Phalacroma*
Agnostus bituberculatus Angelin..	*Phoidagnostus*
Agnostus nudus Beyrich var. *hyperboreus* Holm and Westergård	*Phalacroma*
Agnostus arcticus Holm and Westergård	*Linguagnostus*
Agnostus repandus Holm and Westergård..............................	*Clavagnostus*
Agnostus 5 spp.	
Centropleura loveni (Angelin)	*Centropleura* s. str.
Anomocare excavatum (Angelin)	
Anomocare sibiricum Holm and Westergård	
Anomocare (?) sp. indet.	
Solenopleura (?) sp.	

Agraulos difformis (ANGELIN) .... *Proampyx*
Agraulos acuminatus (ANGELIN) .... *Proampyx*
Indeterminable trilobites

Centropleura fauna of the Maja tributary:—Faunas quite similar to the preceding were later found at two other places. One was obtained from a conglomeratic limestone exposed along the Maja river between the mouth of the Tscharskaja and Tschabda rivers (OBRUTSCHEW, 1926). According to LERMANTOVA this collection made by TSCHERNYCHEW, contains the following trilobites:

Agnostus aculeatus ANGELIN var. *micropunctatus* LERMANTOVA (nov.). *Goniagnostus*
Agnostus laevigatus DALMAN (or *A. altus* GRÖNWALL)................. *Lejopyge* (or *Cotalagnostus*)
(?) *Agnostus gibbus* LINNARSSON var. *hybrida* BRÖGGER.............. (?) *Triplagnostus*
(?) *Agnostus parvifrons* LINNARSSON .... (?) *Hypagnostus*
Centropleura sp.
Corynexochus macrophthalmus LERMANTOVA (nov.)
Anomocare limbatus (ANGELIN) (=*Coosia* ? *limbata* WALCOTT)
Anomocare excavatum (ANGELIN)
Agraulos difformis (ANGELIN) .... *Proampyx*

Centropleura fauna of the Muna Series:—The other was found on the southern slope of the Anabar massive in the Muna series, 350 m. thick, which is composed of red limestone, calcareous shale and mudstone (VOLOGDIN, 1937). According to LERMANTOVA the trilobite bed of the series contains the following species:

Agnostus glandiformis ANGELIN.. *Phalacroma*
Agnostus bituberculatus ANGELIN .... *Phoidagnostus*
Agnostus nudus BEYRICH var. *hyperboreus* HOLM and WESTERGÅRD *Phalacroma*
Agnostus fallax LINNARSSON .... *Peronopsis*
Centropleura loveni ANGELIN
Anomocare sibiricum WESTERGÅRD
Anomocare limbatum ANGELIN
Anomocare excavatum (ANGELIN)
Anomocare acuticosta LERMANTOVA (nov.)
Corynexochus Aff. *bornholmensis* (GRÖNWALL)
Solenopleura cfr. *zwerevi* LERMANTOVA (nov.)

Centropleura fauna of the Kuznetsk basin and its adjacence:—Furthermore, SPÉRANSKY and OUSSOV (1927) mentioned that a greenish purple sandstone and shale formation containing porphyrite-sills in the Salair Mountains yields trilobites of the *Paradoxides forchhammeri* zone, but the specific names of these trilobites were not mentioned. It is however quite interesting to know that a variegated sandstone shale formation containing limestone lenses and porphyrite-sills is found beneath the preceding and yields *Agnostus* (*Peronopsis*) *fallax* LINNARSSON, *Agnostus* (*Hypagnostus*) *parvifrons* LINNARSSON and *Eoorthis wichitaensis* WALCOTT. This relation of superposition suggests that this fossil zone is approximate to the *Ciceragnostus* zone of the Ssinjaja river in age.

Several more agnostids of the same age or a little older than the *Centropleura* fauna are known to occur in the Kuznetsk region as follows:

1) *Agnostus* (*Phalacroma* ?) *glandiformis* ANGELIN var. *angustifrons* (now. ?) and *Agnostus* (*Phoidagnostus*) *bituberculatus* ANGELIN in limestones in the Kuznetsk basin (YAVORSKY), 1937).

2) *Agnostus globiceps* LERMANTOVA (nov.) (comp. *A.* (*Hypagnostus*) *parivifrons* LINNARSSON), *A.* (*Phoidagnostus*) *bituberculatus* ANGELIN, *A.* (*Linguagnostus*) *kjerulfi* BRÖGGER and *A.* (*Peronopsis*) *fallax* LINNARSSEN in a pyroclastic formation on the southwestern border of the Kuznetsk basin (FOMITCHEV, 1937).

Prior to these SCHMIDT described *Agnostus czekanowskii* contained in a boulder in the Olenek river. Subsequently TOLL added *Bathyuriscus howelli* WALCOTT and *Helminthoidichnites* sp. to the fauna of the Olenek formation which was found exposed in the divide between the Olenek and Monjere rivers. According to WESTERGÅRD *B. howelli* is most probably identical with *Anomocare sibiricum*, while *Agnotus czekanowskii* belongs in my opinion to the Peronopsinae and especially close to either *Clavagnostus* or *Peronopsis* (KOBAYASHI, 1939). Therefore the age of the Olenek fauna suggested by these trilobites is not much different from that of the *Centropleura* fauna.

Distribution of the Centropleura fauna in Northern and Central Asia:— Thus the *Centropleura* fauna is widely distributed in Central Siberia. Since its discovery in Bennett island in the Arctic Ocean, it was found in the surroundings of the Anabar massive on the northwest side of Central Siberia, in the Maja-Aldan region on the southeast and in the Kuznetsk basin and its environs on the southwest. Thus its distribution appears to cover the whole Cambrian terrain in Siberia, and is farther extended into Central Asia. In the Kazak (or Kirghiz) Steppe region there is a thick series of slate and sandstone lying on the Pre-Cambrian basement. Limestone beds near the top yield *Anomocare* and *Agnotus*. Local intercalations of spilite and andesitic lava there indicate that the zone of Cambrian intrageosynclinal volcanism extends from the Kuznetsk region to the southwest. (NALIVIKIN, 1936).

Distribution of Centropleura:—*Centropleura* is distributed from Bennett island in the East to Vermont in the west (HOWELL, 1932, 1938) through Sweden where it occurs in the *Paradoxides forchhammeri* zone. In the Atlantic province this zone as well as the *Paradoxides davidis* zone serve as better keys for correlation than most other Cambrian ones. The former is not noly found in nearly all upper Paradoxidian sections of Northern Europe but is distributed also in Southern France, but not in North America. The latter zone on the othet hand is known to exist in eastern North America and is extensive in Northern Europe, but unknown in Southern Europe. (COBBOLD and POCOCK, 1934).

It is quite probable that the wide distribution of the two zones depends upon the expansion of the Paradoxidian sea and that the expansion facilitated the Paradoxidian fauna in migrating so far east into Central Siberia. The *Ciceragnostus* fauna shows the connection of the provinces which began in the *Paradoxides hicksi* hemera or the *Paradoxides davidis* hemera, but the migration became much more free in the next younger *Paradoxides forchhammeri* hemera. It is noteworthy, however, that in spite of the intimate relationship of the *forchhammeri* zone with the *Centropleura* fauna in Siberia, *Paradoxides* has not yet been discovered, although the occurrence of the genus is recorded from Novaya Zemlya (YERMOLAEW, 1937). *Centropleura* on the other hand provides an interesting example of isolated occurrences. It is found in Vermont and Scandinavia but not in other places in the Atlantic province. In Siberia it is more common.

A note on isolated occurrences of Centropleura:—What is the reason for the fact that the occurrences of *Paradoxides forchhammeri* are much more continuous in a more restricted area than in the case of *Centropleura* which occurs in places widely apart, though these trilobites have very similar carapaces? The former is a species while the latter is a genus, and accordingly the latter is more extensively distributed than the former. *Paradoxides* is found neither in Vermont nor in Central Siberia and its distribution is concentrated in Europe as well as in Acadia.

Because they are found in the same bed in Sweden they are not inhabitants in different environments. It may therefore be said that the difference above mentioned depends chiefly upon the difference in their ability to migrate or in the speed of their dispersal, which occured in the same hemera. The Centropleurinae comprising *Clarella*, *Anopolenus* and *Centropleura* (HOWELL; 1933, HOWELL and POULSEN, 1933) appear first in *Paradoxides hicksi* zone of Newfoundland. Later its descendants migrated, and at the same time underwent generic mutation.

Composition of the Centropleura fauna of Siberia:—The *Centropleura* fauna comprising *Phalacroma*, *Phoidagnostus*, *Lejopyge* (or *Cotalagnoscus*), *Hypagnostus*, *Calvagnostus*, *Linguagnostur*, *Goniagnostus*, *Triplagnostus*, *Anomocare* and

Proampyx is indeed typical of the late Paradoxidian fauna. There is none in the fauna, which is thought to be a member of extra-Paradoxidian province while all of the older and younger Cambrian faunas of Siberia contain a few or numerous trilobites of the extra-Paradoxidian provinces. Such a remarkable difference between the *Centropleura* fauna and the others in Central Siberia suggests that the Siberian Sea at that time was connected with the Paradoxidian sea.

Solenoparia fauna:—In a collection of trilobites procured by TOLMACHOFF in a red marl on the left shore of the Kotui river, 10 miles above the mouth of the Giranda river there are some which resemble the members of the *Centropleura* fauna. This fauna consists of seven species of trilobites as follows:

Homagnostus euryrachis KOBAYASHI
Clavagnostus repandiformis KOBAYASHI
Girandia typa KOBAYASHI
Kotuia anomocaroides KOBAYASHI
Solenoparia megalops KOBAYASHI
Solenoparia brevifrons KOBAYASHI
Manchuriella (?) *disparilis* KOBAYASHI

Clavagnostus repandiformis is intimately related to *Clavagnostus repandus* and *Kotuia* to *Anomocare*. *Solenoparia* however, is a common genus in the Middle Cambrian fauna of Eastern Asia; *Homagnostus* is a cosmopolitan in the Upper Cambrian faunas. The balance of these facts leads me to consider that the age of the *Solenoparia* fauna is more probably latest Middle Cambrian rather than earliest Upper Cambrian.

Assuming this age-determination to be correct, it may be concluded that the Siberian province was disconnected from the Atlantic, causing the endemic mutation of the descendants of the Paradoxidian trilobites. On the other hand, the Siberian sea became confluent with that of Eastern Asia, with the result that *Solenoparia* migrated toward the north.

3. The Upper Cambrian Faunas

Koldinia fauna of Novaya Zemlya:—During the Norowegian expedition in 1921, Older Palaeozoic fossils were discovered by HOLTEDAHL (1924) in calcareous sandstones in Gribovii Fjord and in the mountains 7 km. northwest of the head of Bessimyami Fjord, both in the south island of Novaya Zemlya. As a result of WALCOTT's study on brachiopods (1924) and WALCOTT and RESSER's on trilobites (1925) 26 species were described as follows:

1. *Obolus* (*Westonia*) sp. undt.
2. *Lingulella arctica* WALCOTT
3. *Lingulella* cfr. *desiderata* WALCOTT
4. *Acrotreta* sp. undt.
5. *Billingsella holtedahli* WALCOTT
6. *Billingsella* (?) *oppinus* WALCOTT
7. *Eoorthis sabus* WALCOTT
8. *Huenella triplicata* WALCOTT
9. *Agnostus pisiformis* LINNÉ var.
10. *Agnostus holtedahli* WALCOTT & RESSER
11. *Agnostus septentrionalis* WALCOTT & RESSER
12. *Koldinia typa* WALCOTT & RESSER
13. *Acrocephalites vigilans* WALCOTT & RESSER
14. *Solenopleura arctica* WALCOTT & RESSER
15. *Kaninia lata* WALCOTT & RESSER
16. *Kaninia divaricans* WALCOTT & RESSER
17. *Kaninia* (?) *speciosa* WALCOTT & RESSER
18. *Kaninia* (?) *crassimarginata* WALCOTT & RESSER
19. *Dolgaia megalops* WALCOTT & RESSER
20. *Orlovia arctica* WALCOTT & RESRER
21. *Orlovia* sp. undt.
22. *Pesaia latifrons* WALCOTT & RESSER
23. *Pesaia exsculpta* WALCOTT & RESSER
24. *Kazelia speciosa* WALCOTT & RESSER
25. *Irvingella septentrionalis* WALCOTT & RESSER
26. *Irvingella* (?) *arctica* WALCOTT & RESSER

Upper Camrian age of this Koldinian fauna :—Notwithstanding the fact that WALCOTT noted its resemblance to the Chaumitien fauna of Shantung. WALCOTT and RESSER determined the age of the fauna at lower Ozarkian. Later in 1932, LERMANTOVA and LAVROVA reported the occurrence of the same Ozarkian fauna in Powerskaya Fjord of Novaya Zemlya, a side branch of Matochkinscharr Strait. This collection comprised *Billingsella holtedahli*, *Kaninia lata* and *Kaninia* (?) *crassimarginata*. In support of their belief in its Ozarkian age FREBOLD (1940) and some others consider that there is no Upper Cambrian in Novaya Zemlya.

Because this fauna is so different from the other Lower Palaeozoic ones in that almost all of them are new species, it is very difficult to determine its age exactly. But RESSER himself withdrew his statement on the Ozarkian age (1929) of his fauna. As I have mentioned on several previous occasions (1935 C, 1937 B, 1943 B), it is certain that its age is early Upper Cambrian instead of Ozarkian. This conclusion is arrived at from the analysis of the fauna as follows:

1) The unnamed variety of *Agnostus pisiformis* appears to be a young form of the species which is the indicator of the *pisiformis* zone in Scandinavia and Britain. *Agnostus holtedahli* and *Agnostus septentrionalis* on the other hand are based respectively on a cephalon and a pygidium most probably of the same species of *Homagnostus* which is a cosmopolitan genus characteristic of the Upper Cambrian fauna. (KOBAYASHI, 1939).

2) Although *Acrocephalites vigilans*, *Irvingella septentrionalis* and *Solenopleura arctica* are new species, it is known that *Acrocephalites* occurs in the *Lejopyge laevigatus* zone, the *Agnostus pisiformis* zone and probably in the *Olenus* zone; *Irvingella* is an Franconian genus in North America but

occurs in the Olenidian of England (STUBBLEFIELD, 1932) and Sweden KORAYASHI, 1935 A) and probably also in the Torsqu tagh in Tienschan, Central Asia (TROEDSSON, 1937); and *Solenopleura* s. str. is characteristic of the Atlantic Middle Cambrian (KOBAYASHI, 1935 A).

3) Most other trilobites belong to new genera, but if we consider their morphic resemblance, *Kaninia* and *Dolgaia* are allied to *Anomocarella* and *Eymekops* respectively; *Orlovia* is intimately ralated to *Manchurilla*; *Koldinia* is allied to *Chuangia* on one side and to *Illaenurus* on the other; and *Kazelia speciosa* and *Coosia carime* are probably congeneric, (KOBAYASHI, 1935 A).

4) Among the brachiopods *Lingulella* cfr. *desiderata*, *Lingulella arctica*, *Billingella holtedahli* and *Huenella tripllcata* bear specific resemblances to Upper Cambrian or lower Ozarkian forms. Incidentally lower Ozarkian, as has been discussed already on several occasions (KABAYASHI, 1933-1934 A), must be the same as late Upper Cambrian.

Subsequently in 1939 HOWELL and LOCHMAN arrived at the same conclusion saying that "this fauna is the approximate equivalent of the *Agnostus pisiformis* zone." Further, not only the inclusion of *Irvingella* but also the close alliance of *Pesaia* to *Elvinia* "permit a close correlation of the fauna with that of the Ironton horizon of North America." In addition, it ought to be noted here that *Kaninia* (?) *platys* RAYMOND (1937) was described from the Rockledge conglomerate in Vermont and *Kaninia sulcata* KOBAYASHI (1938) from the *Iddingsia* and *Taenicephalus* limestone in British Columbia. Thus, the early Upper Cambrian age of this fauna is now quite warranted. It can be recognized that *Koldinia* is related to *Chuangia* on one side and to *Illaenurus* on the other as I grouped them in the Leiostegiidae KOBAYASHI, (1935 A), but the relationship of this Koldinian fauna to the Chaumitian in Eastern Asia is not so intimate as was first thought by WALCOTT and RESSER.

Koldinian fauna of the Chatanga-Anabar basin:—It is certainly interesting to see that *Koldinia* is contained in TOLMACHOFF's collection obtained from a green marl formation in the upper part of the Giranda river in the Chatanga-Anabar basin. Beside an unnamed hypostoma there are six species in the collection as follows:

Schmidtaspis sibiricus KOBAYASHI
Koldinia micropthalmus WALCOTT & RESSER
Koldinia (?) *minor* KOBAYASHI
Modocia obrutschewi KOBAYASHI
Bowmahia lermantovae KABAYASHI
Lecanopleura (?) *glabella* KOBAYASHI

Because of the inclusion of *Koldinia* it is quite certain that it is almost coeval with the *Koldinia* fauna of Novaya Zemlya, and the Upper Cambrian age of the fauna is in support of the inclusion of *Modocia, Bowmania* and *Lecanopleura*. More precisely, *Bowmania* is known from the Hamburg limestone (?) of Eureka District, Nevada (WALCOTT, 1925); *Modocia* from the Deadwood of South Dakota and Wyoming and from the Ironton of Minnesota (RESSER, 1935, 1936); and *Lecanopleura* from the Rockledge conglomerate of the Hangerford shale and the lowest zone of the Gorge formation, both in Vermont. (RAYMOND, 1937). The cranidium of *Lecanepleura* (?) *glabella* is somewhat similar to that of *Blainia* which is an important Conasauga member of the Appalachians, and also to *Meteoraspis* which occurs in a range from the upper *Cedaria* to the lower *Crepicephalus* zone in Missouri, Texas and the Rocky Mountains and farther in Newfoundland. Its resemblance with *Meteoraspis* is however superficial, if the reference of the associated pygidium to *Lecanopleura glabella* is correct. Furthermore it is noted that *Koldinia minor* more or less resembles *Kingstonia vagrans* LOCHMAN (1938) from the Cow Head breccia in West Newfoundland on one hand and to *Plethometopus laevis* RAYMOND) (1924, 1937) from the upper Gorge in Vermont.

Thus the close relationship of the Giranda fauna with the Croixam can hardly be overlooked, but at the same time it is markedly different from the Koldinian fauna of Novaya Zemlya in that there is no Olenidian representative in it. Therefore a slight difference of age can be expected between the two Koldinian faunas. Did the morphic difference between *Schmidtaspis* and *Irvingella* take place in this time-interval?

Koldinia minor was found by TOLMACHOFF in association with an indeterminable pygidium of trilobite and a few linguloids in a gray limestone on the left shore of the Moyero river, about 16 miles above the mouth of the Uchukcha river. This horizon may be of about the same age as the *Koldinia* beds of the Giranda.

Cambrian fossils from the Kuznetsk basin and its adjacence:—Upper Cambrian faunas of simillar age and younger are known from several localities far south in the Kuznetsk basin and its vicinities as cited below.

1) Variegated crystalline limestones in the Salair Mountains yield *Billingsella coloradensis* SHUMARD, *Agnostus* (*Pseudagnostus*) *cyclopyge* TULLBERG and *Agnostus pisiformis* LINNÉ (SPÉRANSKY and OUSSOV, 1927).

2) New species of *Koldinia. Orlovia*, and *Acrocephalites* were found in a pyroclastic formation in the southwestern borderland of Kuznetsk, (FORMITCHEV, 1937).

3) *Agnostus pisiformis obesus* BELT (=*Homagnostus obesus*) was found in association

with new species of *Pagodia*, *Kingstonia* and *Apatokephaloides* in a still higher horizon in the same formation as the preceding, (Formitchev), 1937).

4) *Pseudagnostus cyclopyge* Tullberge and *Pagodia walcotti* (nov. ?) occur in a limestone formation of the Kuznetsk basin, (Yavorsky, 1937).

5) *Dictyites* cfr. *dictys* (Kobayashi) was obtained in a variegated marly limestone in the Telbess region in the Chorie Mountains, (Batourine and Oussov, 1937).

The second and probably the first faunule belong to the *Koldinia* fauna. The third which has been stratigraphically proved to be younger than the second, contains *Pagodia* and *Apatokephaloides*. The latter genus is a member of the Gorge in Vermont whereas the former is a Fengshanian genus in Eastern Asia. *Dictyites* is another Fengshanian genus. Therefore the third to the fifth faunules are younger than the two others. The presence of the Eastern Asiatic members and absence of non-agnostidian trilobites of the Atlantic province in them are remarkable characteristics of the late Upper Cambrian fauna which are different to the early Upper Cambrian one in Siberia.

A question on the Oka fauna of the Irkutsk basin:—Beside these *Lingulella*, *Acrothele*, *Acrothyra*, *Eoorthis wichitaensis* (Walcott), *Eoorthis remnicha sulcata* (Walcott), *Helcionella*, *Matherella* and *Euomphalus* are said to occur in the Oka stage in the Irkutsk basin (Korowin, 1928, Leuchs, 1935). Whether *Helcionella*, *Acrothyra* and *Euomphalus* really occur in the same bed however demands a careful examination because *Helcionella* is a genus more common in the Lower Cambrian than in the Middle Cambrian (Resser, 1938), *Acrothyra* is restricted to Middle Cambrian in other localities (Walcott, 1912), and *Euomphalus* is a post-Cambrian gastropod (Wenz, 1938). Nevertheless the fossil bed is located at the top of the Cambrian section and *Matherella*, *Eoorthis wichitaensis* and *E. sulcata* (Schuchert and Cooper, 1932) are all Upper Cambrian members.

Late Upper Cambrian trilobites from the Chatanga-Anabar basin:—Little is known of the late Upper Cambrian fauna in the Lena-Yenissei tableland, but two trilobites contained in Tolmachoff's collection appear to me to be representatives.

I. *Esseigania tolli* Kobayashi described here was procured from a dark gray marl on the right shore of the Esseigan river, about 25 miles above its mouth. The form bears typical aspects of tsinanid commonly seen in Upper Cambrian faunas of Southern and Eastern Asia and North America. It appears to be similar especially to *Jubileia grandifrons* Kobayashi (1938) from the *Taeinicephalus* limestone in British Columbia.

II. *Plethopeltis stenorachis* Kobayashi was also collected from the right shore of the same river but at a point about 21 miles above its mouth in a dark gray limestone. Except for a relatively narrow glabella it is typical of *Plethopeltis* which occurs in the Trempealeau.

Characteristics of the Upper Cambrian faunas of Siberia:—Although little can be mentioned of the late Upper Cambrian fauna of Siberia, it may be said that it comprises *Pseudagnostus, Homagnostus, Apatokephaloides, Pagodia, Kingstonia, Plethopeltis, Dictyites* and *Esseigania*. Judging from this generic assemblage it can be concluded that the Siberian fauna at the time was related to the Fengshanian of Eastern Asia on one side and to the Trempealeau-Franconian of North America on the other.

More is known of the Koldinian fauna extending from Novaya Zemlya to Central Siberia. As I have already pointed out (KOBAYASHI, 1935 C, 1937 B, 1943 B) it certainly reveals a distinct zoopalaeogeographic province well defined by many endemic genera, such as *Koldinia, Dolgaia, Orlovia, Pesaia, Kazelia* and *Schmidtaspis*. But some connection was maintained with the Olenidian as well as Franconian provinces.

Remarkably enough, the Koldinian fauna is quite distinct from the Torsqu tagh fauna in Eastern Tienshan (TROEDSSON, 1937) notwithstanding the fact that *Agnostus hedini, Pseudagnostus acutifrons, Lotagnostus asiaticus, Diceratopyge, Charchaquia, Hedinia, Westergardites* and *Acrocephalina* show as a whole an intimate relationship of the Torsuq tagh with the fauna of the *Agnostus pisiformis* zone plus *A. laevigatus* zone. The difference between the faunas of about the same age in Central Siberia and Tienshan suggests a land barrier in between, which emerged as a result of the crustal movement of the Salair phase.

4. Brief Notes on the Archaeocyathid Limestone and the Lower Cambrian Trilobites

Distribution of the archaeocyathid limestone in the Eurasiatic Continent:— One of the recent advancements made in the research of the Cambrian geology was the discovery of the extensive distribution of the archaeocyathid limestone in Eurasia and Northern Africa. It was thought rare in Eastern Asia, although an occurrence of the archaeocyathid in the Wutai district in the Shansi basin (WALCOTT, 1913) has long been known. Another occurrence reported by OGAWA (1905) from South Manchuria has not yet been confirmed. Recently however CHI (1940) reported that it is wide spread in Hupeh, Hunan, Kweichou and Szechuan, in Central China.

In Siberia, Torgoshino near Krasnoyarsk is a classical locality of the archaeocyathid limestone as cited in many geological works. Incidentally

Calamites cannaeformis from this red limestone which MEGLIZKI had thought a Carboniferous plant in 1850, was noted by HEKKER (1928) to be most probably an archaeocyathid. This kind of fossiliferous limestone is now known to be distributed extensively in the Central Siberian platform from the Aldan and Maja tributaries on the southeast to the Chatanga-Anabar basin on the northwest side. TOLMACHOFF's collection from the basin contains numerous specimens of the archaeocyathid-bearing red limestone. VOLOGDIN (1937 A) has described archaeocyathids and algae from the southern slope of the Anabar massive. On the southwest side of the Central Siberian platform archaeocyathids were discovered in the Salair and other mountains in the borderland of the Kuznetsk basin, in the East and West Sayans and further in the Sumulta river basin in the Altais, (NECHOROSCHEW, 1927, 1932, KOMAROW, 1828), Southwestern Tienshan and Kirghiz steppe (NALIVIKIN, 1937 B).

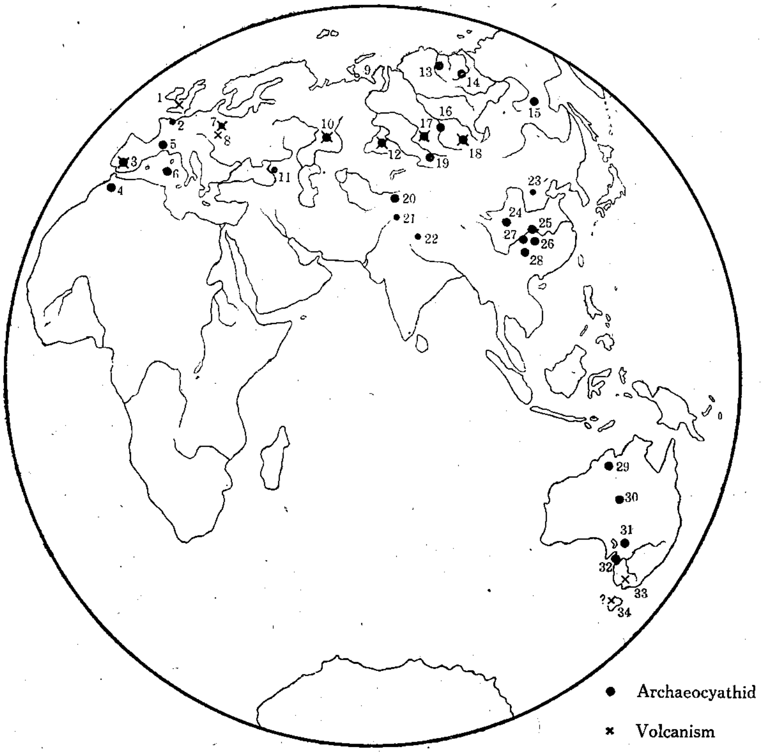
The archaeocyathid in the Parahio valley in Spiti is well known among Cambrian students. A doubtful archaeocyathid in the Tanymas valley in Pamir and a reef probably algal, in the Karatau which were lately discovered (NALIVIKIN, 1936 A) appear to link the Himalayas with Central Asia.

The occurrence of the archaeocyathid at Waigatch (or Vaygatch) Island south of Novaya Zemlya (GEIKIE, 1903, TAYLOR, 1910) is however doubtful because the locality is said to consist of Devonian rocks only (HOLTEDAHL, 1924) and the Ordovician is the oldest fossiliferous formation in the island in which CHERNYSCHEW has found *Tetradium* (ERMOLAEF, 1937). Because this fossil is a characteristic member of the Arcto-American fauna the archaeocyathid in question might have been an *Archaeoscyphia*. It was however found to be extensive in the South Urals by Russian geologists (GARAN, RAZUMOVSKAYA, 1937). Further South in the Laba river basin in North Caucasus *Archaeocyathus* and *Caelocyathus* were found by VOLOGDIN (1934).

To the west its distribution is known in Germany, France, the Iberian peninsula, Sardinia and Northern Africa. Thus the distribution of the archaeocyathid in the Eurasiatic continent is really much more extensive than has been thought.

On the age of the archaeocyathid limestone:—When DAVID summarized the distribution of the archaeocyathid in 1927, he concluded that "the Archaeocyathinae limestones of the world appear to lie on about the same geological horizon in regard to one another, appear to be of about the same age as those of Siberia and Sardinia, viz., base of Middle Cambrian

Text-figure 1. Map showing the Cambrian Volcanic Zone and the distribution of the Archaeocyathid Limestone in the Eurasiatic Continent



1. Wales
2. Normandy
3. Sevilla
4. Atlas Mountains
5. Montagnes Noires
6. Sardinia
7. Oberlausitz
8. Bohemia
9. Waigatch Island
10. South Ural
11. Laba Basin
12. Chinghiz Mountains
13. Chatanga-Anabar Basin
14. Olenek River
15. Maya-Aldan Highland
16. Krasnoyarsk
17. Kuznetsk Basin
18. West Sayan Mountains
19. Alatau
20. Western Tienshan Mountains
21. Tanymas Valley in Pamir
22. Parahio Valley in Spiti
23. Wutaishan (五台山) in Shansi
24. Kuangyuan (廣元) in Shensi
25. Ichang (宜昌) in Hupeh
26. Tzuli (慈利) in Hunan
27. Shihchu (石柱) in Szechuan
28. Eastern Kweichou
29. Kimberly
30. Macdonnell Range
31. Flinders Range
32. York's Peninsula
33. Walhalla Basin
34. West Tasmania

or top of Lower Cambrian," and further " Only in the case of *Coscinocyathus* has it been so far proved that it ascends somewhat above the base of Middle Cambrian." *Coscinocyathus* spp. in the Wutai and Spiti districts are the exceptional cases he had in mind.

He placed the *Archaeoscyphia* of the Durness limestone in Middle Cambrian with some doubt while GRABAU (1924) once considered the age of the archaeocyathid limestones of Siberia and Central China to be Lower Ordovician. GRABAU's opinion has been maintained by Chinese geologists for years with the result that the stratigraphy of the Yangze Gorge was confused. This confusion of the age-determination depends upon the confusion of Canadian *Archaeoscyphia* with the Cambrian archaeocyathid.

It is generally accepted by Australian geologists that the archaeocyathid limestone is located below the *Redlichia* beds, (KOBAYASHI, 1942). But it is intercalated within the *Redlichia* beds in the Yangtze Gorge according to CHI, HSU and WANG's revision of this section (CHIH, 1940), In the section of the Parahio valley in Spiti *Coscinocyathus* was found in association with *Oryctocephalus*, *Mesopagetia* and other Middle Cambrian fossils (REED, 1913) and so in the case of *Coscinocyathus* in the Wutai district, Shansi (KOBAYASHI, 1942). In the correlation chart of the Cambrian system compiled by COBBOLD in 1934, all of the archaeocyathids in Europe are considered to be early Middle Cambrian except one in Southeastern Germany. (SCHWARZBACH, 1936).

As I have discussed before, the Sanashtikgolsky limestone of West Sayan must be early Middle Cambrian, insofar as can be judged from the trilobites contained, and the Torgoshino limestone also differs very little from the Sanashtikgolsky in age, Therefore it is reasonable to consider that not only in Siberia but in the Eurasiatic Continent as a whole, the archaeocyathid was much more developed in the early Middle Cambrian than in the Lower Cambrian formation, probably in its lower part, as in North America (RESSER, 1933).

The vertical range of the archaeocyathid is much wider in Eurasia if the one from the Chinghiz mountains is referred to, because it is accompanied by *Orthoceras antiquus*, *Syringopora*, *Marpolia* and *Rhabdoperella*. The oldest true cephalopods so far known are late Upper Cambrian (KABAYASHI, 1935 D) and the other associates above mentioned are of post-Cambrian age. Therefore VOLOGDIN (1931) suggested Upper Cambrian for this peculiar conglomerate of fossils. Whether this archaeocyathid is a link between the older ones and *Archaeoscyphia* is an interesting question in the evolution of Porifera. The collection at this locality may yield the answer to this question.

Lower Cambrian trilobites in Siberia :—Of the age of Cambrian stromatoperoid limestones (KOROWIN, 1928, YAWORSKY, 1932) and also of the algal limestones I cannot say much. Although the archaeocyathid ranges from Lower Cambrian probably to Upper Cambrian in Eurasia, most of them in Siberia are early Middle Cambrian. I am prompted to ask: Is there any trilobite facies of the Lower Cambrian age?

As has been mentioned before, TOLL's *Olenellus* (?) sp. from the Ssinjaja cannot be an Olenellid because its facial suture is unfused; *Protolenus* from the same place still remains to be checked because the associated agnostids are Middle Cambrian members.

The only Lower Cambrian representative which I can think of is *Bathynotus holopyga* which is reported from a limestone of the Namana, a branch of the Lena between Olekminsk and Tschurskaya. It was found there in association with *Agraulos namanensis* LERMANTOVA (nov.) which resembles *Ptychoparia teneer* WALCOTT (OBRUTSCHEW, 1926). As I unfortunately do not have access to their description or their illustration, I cannot present any palaeontological comment on their identification. But I am convinced of the presence of *Bathynotus* in Novaya Zemlya by ERMOLAEF's illustration of a complete trilobite (1931). Therefore it is not improbable that *Bathynotus* was distributed farther to the east into the upper Lena tributaries.

5. Summary Note on the Cambrian History of Siberia

Distribution of the Cambrian formation in Siberia :—The Cambrian terrain in Central Siberia can be classified into the Siberian platform and the folded zone of Southern Siberia where in the latter the intrageosynclinal volcanism took place during the Cambrian period. (VOLOGDIN 1937 A, B). This zone suffered from a disturbance in the Salair phase after the deposition of the Middle Cambrian formation. Little is known of the patches of the Cambrian formation to the east of the Lena. The thickness of the Cambrian deposits measures 400 m. in the Yenissei horst and 1100 m in the Lower Angara (LEUCHS, 1935). But the formation is thicker in the northern part of the platform. On the southern slope of the Anabar massive it is some 5000 m. thick, of which the middle part of 3000 metres' thickness is unfossiliferous.

Cambrian volcanic zone on the Eurasiatic continent :—The distribution of the facies containing volcanic and pyroclastic rocks shows that the geosynclinal zone extends to the west through Kazakstan into South Ural where the effect of the Salair movement is also recognized (SERGHIEVSKI, 1937). The fact that the Cambrian formation on the border between South and Middle Ural is similar to that of the Siberian platform is certainly interesting (POLUTOFF, 1940).

Farther west in Bohemia the Upper Cambrian is represented by volcanic rocks and tuff; diabase and its tuff are intercalated in the Lower Cambrian formation in the province of Sevilla in South Spain. It is certainly interesting to see that the zone of the Cambrian volcanism runs across the Eurasiatic continent in a direction a little oblique to the parallel at 40 degrees of latitude.

Cambrian climatology of Siberia:—In marked contrast to the cold climate in the late Proterozoic period as indicated by extensive tillite deposits in the upper Yenisei series and its equivalents in Siberia (TSCHRAKOW, 1937, ESKORA, 1938), it was warm in the Cambrian. The salt and gypsum deposits are found mostly in the Siberian platform and are common in the passage beds from the Lower to the Middle Cambrian formations but occur also in the Upper Cambrian. More precisely, the saliferous deposits are commonly met with in the Upper Cambrian formation in the Anabar region, the Olenek and Wiliu tributaries and in the Upper Anabar river, while the older ones are more extensive in the West Sayans and the Baikal region. Farther to the south beyond Mongolia pseudomorphs of salt were lately discovered in the Lower Cambrian in Shansi and Jehol. (KOBAYASHI, 1942 D). They are products of warm or even hot and dry climates.

Facies of the Cambrian formations in Siberia:—It can generally be recognized that limestone is predominant in the middle part of the Cambrian system in Siberia but variegated clastic rocks take its place in the upper and lower parts, some of which show false bedding and ripple marks. Combined with the saliferous deposits this mode of sedimentation indicates the regressive facies. The extensive archaeocyathid reefs and the salt and gypsum deposits in the passage bed were made in the shallow sea and lagoon when the sea shrank. The preponderance of endemic genera in the early Middle Cambrian faunas depends probably upon the localization due to this retreat of the sea.

Lower Cambrian trilobites:—Before this regression there may have been a transgression along the northwestern coast of the Eurasiatic continent, because *Bathynotus* which is a typical member of the *Olenellus* *thompsoni* zone in the Appalachians occurs in Novaya Zemlya and probably in the Olenek tributary. Little however can be said as yet about the Lower Cambrian transgression in Siberia.

Early Middle Cambrian faunas :—More is known of the next younger faunas among which there are at least three different kinds, but their stratigraphic relation has not yet been determined. Though very tentative, they are enumerated from the old one as follows:

1. *Paratollaspis* zone :—*Paratollaspis* and *Kootenia* at Torgoshino near Krasnoyalsk and Minussinsk mountains.

2. *Tollaspis* zone :—The fauna comprising *Kootenia, Poliella* (*Poliellina*), *Tollaspis, Chakasshia, Inouyina, Manchuriella* etc., at Sanashtikgolsky in West Sayan, at the junction of the little Batobiji with the Wiliu river and on the Esseigan in the Chatanga-Anabar basin.

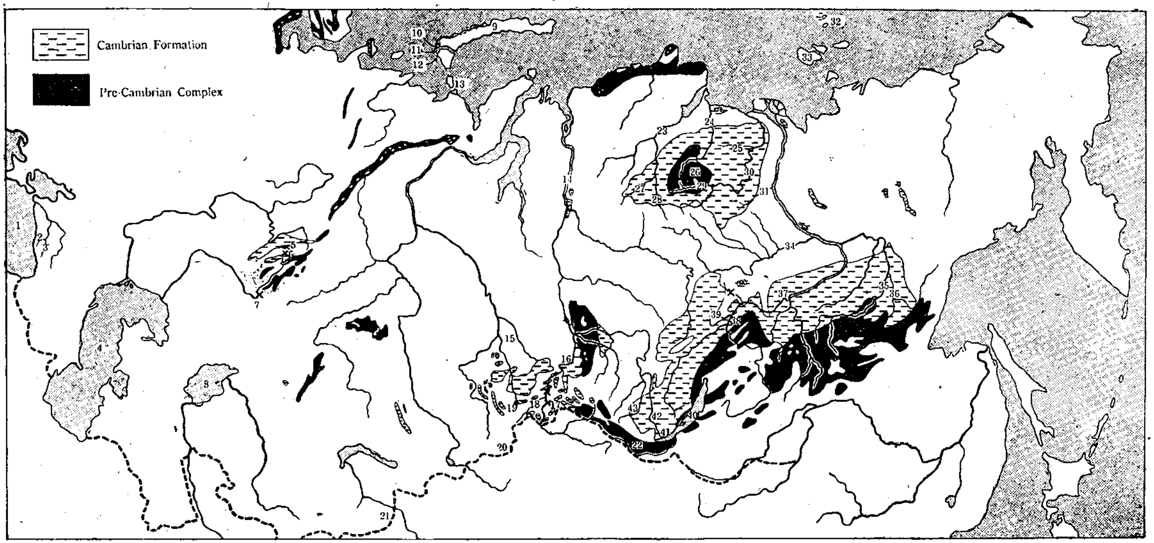
3. *Oryctocephalus* zone :—The fauna comprising *Pagetia*, "*Agnostus*", *Oryctocephalus*, "*Ptychoparia*" and *Dorypyge* in the Argassala series on the south side of the Anabar massive.

It is certain that the Peledui fauna containing *Olenoides* belongs to the general group with those three. The age of the Torgoshino trilobite fauna appears to be early Middle Cambrian rather than late Lower Cambrian. The age of the second and the third of the three must be in the older half of the Middle Cambrian period, and the third is probably younger than the second.

If the endemic genera are eliminated most of the remainder of these faunas are members of the Arcto-Pacific or Pacific province. The known distributions of *Pagetia* s. str. and *Oryctocephalus* extend from western North America to Australia through Southeastern Asia and *Dorypyge* s. str. is a typical Changhian member of Eastern Asia. Thus there are no trilobites in the third fauna, which is distributed in Greenland. If the occurrence of *Dorypyge* in a limestone of the Kuznetsk Alatau (TSCHURAKOW, 1932) is taken into consideration, it probably entered into the northern Siberian platform through Central Asia. Incidentally it must be noted that the trilobites of the second fauna, as those of the first, are contained in the archaeocyathid limestone at Sanashtikgolsky, but at three other localities of the same fauna they are not found associated with the archaeocyathids. This fact may suggest that the former horizon is a little lower than the latter.

Late Middle Cambrian faunas :—In the latter half of the Middle Cambrian period there were also three different faunas as follows:

Text-figure 2. Map showing the Distribution of the Cambrian Formation in U. S. S. R.



1. Black Sea
2. Malaja-Laba
3. Bolschaja-Laba
4. Caspian Sea
5. Bakalsk
6. Satka
7. Orsk
8. Aral Sea
9. Novaya Zemlya
10. Matochkin-scharr Strait
11. Bassimyamt
12. Powerskaya
13. Waigatch Island
14. Yenissei River
15. Salair Mountains
16. Krasnoyarsk and Torgoshino nearby
17. Minussinsk
18. Abakan River
19. Kuznetsk basin
20. Alatau Mountains
21. Tienshan Mountains
22. Sayan Mountains
23. Chatanga or Khaṭanga River
24. Anabar River
25. Koike River
26. Anabar Massive
27. Kotui River
28. Moyero River
29. Argassala River
30. Olenek River
31. Muna River
32. Bennett Island
33. New Siberian Islands
34. Wiliu River
35. Aldan River
36. Maja River
37. Ole'minsk
38. Witim
39. Peledui River
40. Baikal Lake
41. Irkutsk
42. Balagansk
43. Oka

4. *Ciceragnostus* zone :—*Ciceragnostus, Phalacroma, Levisia?* etc. at Ssinjaja.

5. *Centropleura* zone :—The fauna including *Phalacroma, Phoidagnostus, Lejopyge,* (or *Cotalagnostus*), *Hypagnostus, Clavagnostus, Linguagnostus, Goniagnostus, Triplagnostus, Centropleura, Anomocare* and *Proampyx* on Bennett Island, on the southern slope of the Anabar massive, the Maja tributary, the Kuznetsk basin and probably in the watershed of the Olenek and Monjere rivers.

6. *Solenoparia* zone :—*Homagnostus, Clavagnostus, Girandia, Kotuia* and *Solenoparia* on the Kotui river, a branch of the Chatanga system.

In the fourth fauna the relationship to the Pacific fauna which was distinct in the third becomes obscure, while the Atlantic affinity can be recognized. It is remarkable indeed that the trilobites of the next younger fauna are exclusively Atlanlic members. From these facts it can be concluded that the Siberian sea was connected with the Atlantic sometime in the middle Paradoxidian and the migration became free in the *Paradoxides forchhammeri* hemera. The trilobites migrated into Siberia along the northern route through Novaya Zemlya where *Anomocare* and *Paradoxides* are reported to occur (Eremolaef, 1931). The wide distribution of the *Anomocare-Centropleura* fauna from Bennett island to Kazakstan shows that the Cambrian transgression in Northern Asia attained its highest tide at this time. Sooner or later however this connection was cut off. In the *Solenoparia* hemera on the other hand the sea became confluent with Eastern Asia whence some emigrants were sent.

Upper Cambrian faunas :—In the Upper Cambrian formations in Siberia there are more than two fossil horizons but they are roughly classified here into two groups as follows:

7. *Agnostus, Pseudagnostus, Schmidtaspis, Koldinia, Modocia, Bowmania, Lecanopleura?, Orlovia* and *Acrocephalites* in the upper Giranda of the Chatanga-Anabar basin and the Kuznetsk-Salair region.

8. *Pseudagnostus, Homagnostus, Apatokephalaides, Pagodia, Kingstonia, Plethopeltis, Dictyites* and *Esseigania* in the Kuznetsk-Salair region and the Esseigan river of the Chatanga-Anabar basin.

While the former is related to the early Olenidian and Franconian or Ironton-Franconian faunas, the latter is allied to the Fengshanian and Franconio-Trempealeau faunas. The Ṭorsuq tagh fauna of Tienshan is approximate to the former in age but they are quite different in their aspect, the difference probably suggesting a land-barrier which appeared in the above mentioned folded zone as a result of the Salair movement.

Cambrian faunas in the Arctic regions:—Finally the relation of the Cambrian faunas in the Circum-Polar regions ought to be discussed. As a result of the studies on the Cambrian faunas in Greenland, POULSEN (1927, 1932) ascertained that Wulff-River fauna in Northwest Greenland and its equivalent in East Greenland which contain *Botsfordia caelata*, *Callavia*, *Olenellus* and *Strenuella* reveal the typical Atlantic aspect. *Bathynotus* in Novaya Zemlya shows that the Atlantic sea extended its elbow to the east.

As noted already the inclusion of *Kootenia* and *Solenopleurella*-like trilobites in the *Tollaspis* zone of Siberia might suggest the alliance of the Siberian fauna with that of Greenland. But *Kootenia* does not necessarily imply the faunal connection with Greenland because it is widely distributed in the Arcto-Pacific province. POLETAYEVA's *Solenopleura* sp. has to be restudied to ascertain its resemblance to the Greenland species of *Solenoparella*.

In marked contrast to the Wulff River, the late Lower Cambrian Cape Kent fauna in Northeast Greenland is closely related to the Mt. White of western North America. The relation of the Cape Wood and later Greenland faunas to the Cordilleran ones was, as proven by POULSEN, maintained throughout the Middle Cambrian period, and this connection was made through the Mackenzie valley as I have shown in 1936. This is the reason why the Middle Cambrian faunas of Siberia are totally different from those of Greenland. This fact is quite inconsistent with the opinion on the Arctic origin of Siberian and North American faunas, (RESSER, 1929).

None of the so-called Lower Ozarkian faunas in Greenland is now considered to be Upper Cambrian. *Illaeuraus* sp. and *Ptychoparia* sp. from Backe Peninsala (HOLTEDAHL, 1913) are, as has been pointed out already (KOBAYASHI, 1935) most probably a *Symphysurina* and a *Hystricurus* respectively. Thus the Upper Cambrian formation is apparently absent on this side of the Arctic pole, where NALIVIKIN's suggestion (1937) on the Upper Cambrian emergence can be recognized. On the other side of the Pole however, his opinion is untenable, because how far the sea flooded over Central Siberia and Novaya Zemlya is shown by the distribution of Koldinian and later faunas.

The Upper Cambrian sea also flooded over the northwestern part of North America as shown by the *Briscoia* fauna which was found in the Yukon-Alaska Boundary (KOBAYASHI, 1935). Whether *Kaninia* migrated into British Columbia from the east or west side is an interesting question. It is however difficult to answer at present because nothing is known of the Cambrian fauna in Eastern Siberia.

Wherever the route of migration may be, the above presented facts lead to the conclusion that one side of the Arctic pole was submerged when the other side emerged in the Upper Cambrian period. Furthermore this kind of movement appears to have been repeated through the Cambrian period because the Pacific fauna invaded Central Siberia when the Atlantic one retreated or vice versa.

6. Brief Notes on the Stratigraphy of Cambrian Formations in U. S. S. R.

Note on the succession of the Cambrian formation near Krasnoyarsk:—On the right bank of the Yenissei on the opposite side of Krasnoyarsk the archaeocyathid-bearing formation overlies the Proterozoic with a conglomerate bed at its base (BASHENOW and NAGORSKI, 1936). This formation consists of greywacke sandstone with intercalation of limestone in the lower, fossiliferous red limestone of Torgoshino in the middle and the *Osagia*-bearing shaly sandstone in the upper part. At present Russian geologists appear to agree with one another as to the early Middle Cambrian age of the Torgoshino limestone containing algae, archaeocyathid and trilobites, but VOLOGDIN considers that TOLL's archaeocyathid fauna of the Davydov (?) valley is late Lower Cambrian. (VOLOGDIN. 1937 D).

Note on the succession of the Cambrian formation on the south side of the Anabar massive:—On the southern slope of the Anabar massive the Cambrian formation overlies pre-Cambrian rocks of the massive and is overlain by Mesozoic sandstone. It is terrigenous and sandstone is predominant on the north side but limestone and dolomite take its place on the south side.

The Argasala series which is its lower division begins with a thin conglomerate bed, followed by a limestone containing *Collenia*. Archaeocyathids are found in a limestone 200 to 300 m. above this algal limestone and *Oryctocephalus* zone in the upper part of this series. Gypsum bands are intercalated with red limestone, dolomite and mudstone in the top division of 150 metres' thickness. In the middle of the Cambrian formation there is an unfossilifereus formation of great thickness measuring some 3000 meters, which is overlain by the Muna series. The lower Muna, 350 m. thick, which yields the *Centropleura* fauna, consists of red limestone, calcareous shale and mudstone, the upper Muna, 400 m. thick, of compact conglomeratic limestone.

The algal and archaeocyathid zones are placed in the Lower Cambrian by VOLOGDIN while the *Oryctocephalus* and *Centropleura* zones are considered respectively middle and late Middle Cambrian by LERMANTOVA, (VOLOGDIN, 1937).

Cambrian formation of Novaya Zemlya:—Any unquestionable pre-Cambrian rock is not yet known in Novaya Zemlya. The oldest is the Cambrian formation which is exposed along the axis of the anticlinorium on the west side of the Matochkin Shar Strait. Its lower part, 600 m. thick, is chiefly composed of phyllites and black shales in which some conglomerate layers containing minute round pieces of the black shale some calcareous lenses and nodules containing fossils are intercalated.

Bathynotus and *Paradoxides* found in the Pormorskaya bay shows that the age of this part ranges from Olenellian to Paradoxidian.

Above it there is a phyllite formation containing lenses of fossiliferous dolomite. The *Kolodinia* fauna was found in them in the Karpinsky peninsula, Pomorskaya bay, Gribovaya bay and Bakan bay. (YERMOLAEV, 1937).

Note on the Cambrian formations of the Ural mountains:—The crystalline schist group in the central range of the Urals merges upward with the phyllite and quartzite formation containing limestone beds (KUZNETSOV, 1937).

In South Ural archaeocyathids were found in the lower limestone and *Niobe* in the upper limestone and orthids in the upper quartzose sandstone all in the formation. In the Bakal, Satka and Kusa regions in the northern part of South Ural the *Collenia*-bearing Sinian (?) Kataska series at the top of the pre-Cambrian complex is overlain by the Inzer series which is composed of variegated quartzite and arkose sandstone in addition to sandy shale. Above it there is a gray, somewhat siliceous limestone and dolomite formation called the Miniar which yields archaeocyathids. The Asha series which consists of green quartzite, arkose sandstone, shale and subordinate coarse sandstone is probably Ordovician (GARAN, 1937).

In Orsk, Khalilob and Blava region in the southern part of the South Urals archaeocyathid limestones occur in the form of outlier along tectonie lines as well as in the form of xenolithes in diabasic rocks. (RAZUMOVSKAYA, 1937).

Note on the Cambian formation of Caucasus:—The Cambrian formation in the northwestern Caucasus which overlies the pre-Cambrian metamorphics without any angular disordance in between, is mostly composed of argillaceous and arenaceous rocks much less metamorphosed than the pre-Cambrian ones. Between the Malaia Laba and Bolaia it consists mainly of argillaceous rocks in the lower 800 metres or less, calcareous rocks in the middle 300 metres and argillaceous ones in the upper part. The limestone in the middle part yields *Archaeocyathus* and *Coelocyathus*. The Cambrian formation there contains eruptive rocks and tuffs. At Lopanis-tskhali on the eastern margin of the Dziroula massive *Archaeocyathus* sp. and *Coscinocyathus caucasicus* were found in marbles intercalated in the metamorphosed argillaceous rocks. (Guerassincov, 1937, Robinson, 1937, Kouznétov, 1937).

Table showing a Tentative Correlation of the Cambrian

Age \ Area		Novaja Zemlya	Bennet Island	Chatanga-Anabar Basin	SE Side of Arabar Massive	Maja-Aldan
Cambrian	Upper			*Plethopeltis* of Essergan *Esseigania* of Esséigan		
	Upper	*Koldinia*		*Koldinia* of Giranda & Uchukcha		
	Upper / Middle			*Solenoparia* of Giranda		
	Middle	*Anomocare*	*Centropleura*		*Centropleura* of Mura	*Centropleura* of Maja
	Middle				*C. czekanowskii* of Olenek	
	Middle / Lower			*Manchuviella* of Esseigan Archaeocyathid	*Oryctocephalus* of Argassala Archaeo-cyathid	Archaeo-cyathid
	Lower	*Bathynotus*				

Fossil-Beds in Siberia, Central Asia and Novaya Zemlya

Upper Lena	Irkutsk	Krasnoyarsk Minussinsk	Kuznetsk Salair	West Sayan	Central Asia
Oka fauna(?)			*Dictyites* & *Pagodia* of Kuznetsk		*Orthoceras antiquus* of Chinghiz Mts. (?)
			Acrocephalites of SE Kuznetsk		*Lopnorites* of E. Tienshan
			Linguagnostus of Kuznetsk		*Anomocare* of Kazak
			fallax-parvifrons of Salair		
Olenoides sibiricus	*Poliellina obrutschevi*	*Tollaspis* & archaeocyathid	*Dorypyge delicatula* (?) Archaeocyathid	*Poliellina* & Archaeocysthid	Archaeocyathid of SW Tienshan
Bathynotus of Namana					

II. Description of the Cambrian Trilobites from Siberia

The Cambrian formation in the Chatanga-Anabar basin has not experienced any strong disturbance. In his letter to me TOLMACHEFF writes that

> "Geological condition of the area where the fossils were collected are such that it is extremely difficult to get exact stratigraphic relations of the different localities. In most of them the strata are almost horizontal, but with some local disturbances in some places at the same time. Since, in many cases, the different localities are separated from each other, you could easily imagine the difficulties referred to. There are only two localities in which I met with more than one horizon. In one of them, both horizons were Cambrian, with the *Archeocysthus* horizon below, and that with Brachiopods above."

In this status the zonation of the Cambrian fossil beds depends chiefly upon the palaeontological evidence. In my opinion the archaeocyathid zone in a red limestone is the lowest and the *Paterina* (?) zone which is located above the preceding in a similar red limestones must be the next higher.

Disregarding these faunas which are now being studied, nineteen species of trilobites in addition to indeterminable specimens which were procured at eight localities can be classified into six zones and their ages are suggested as follows:

I. Early Middle Cambrian; upper subzone of the *Tollaspis* zone; this may be a little higher than the *Poliellina* zone of the Sanshtikgolsky limestone.
   Loc. A. Gray limestone on the left shore of the Esseigan river about 25 miles above its mouth.
   Loc. B. Gray limestone on the right shore of the Esseigan river about 24 miles above its mouth.
   Loc. C. Gray limestone on the left shore of the Esseigen river about 21 miles above its mouth.

II. Latest Middle Cambrian; *Solenoparia* zone.
   Loc. D. Red marl on the left shore of the Kotui river, 10 miles above the mouth of the Giranda river, a tributary of the Chatanga river.

III. Early Upper Cambrian; *Koldinia* zone; this may be a little younger than the *Koldinia* zone of Novaya Zemlya.
   Loc. E. Green marl in the upper part of the Giranda river.

IV. Early Upper Cambrian; *Koldinia* zone.
   Loc. F. Gray limestone on the left shore of the Moyero river, about 16 miles above the mouth of the Uchukcha river. The Moyero is a tributary of the Chatanga river.

V. Late Upper Cambrian; *Esseigania* subzone; this, I presume, is located in the lower part of the late Upper Cambrian fossil beds, Loc. G. Dark gray marl on the right shore of the Esseigan river about 25 miles above its mouth.

VI. Latest Upper Cambrian; *Plethopeltis* subzone; this may be the highest in the late Upper Cambrian fossil beds in Siberia.

Loc. H. Dark gray limestone on the right shore of the Esseigan river about 21 miles above its mouth.

Thus the Cambrian succession of the Chatanga-Anabar basin provided with eight fossil zones may be one of the best in Siberia. It is noteworthy that the red limestone occurs once in the lower part; the limestone in the higher horizon is overlain by green marl.

Beside the descriptions of these trilobites brief notes are giver on *Inouyina*, *Chaskassia* and several other genera and families. One new family and five new genera are established in this paper as follows:

Tollaspidae	*Girandia*	*Kotuia*
Schmidaspis	*Paralollaspis*	*Esseigania*

Family **Peronopsidae** Westergård

Subfamily **Peronopsinae** Kobayashi

Genus ***Clavagnostus*** Howell

1937. *Clavagnostus* Howell, Bull. Geol. Soc. Am. vol. 48, p. 1164.
1938. *Tomorhachis* Resser, Geol. Soc. Am. Sp. Pap. no. 15, p. 51.
1939. *Clavagnostus* Kobayashi, Jour. Fac. Sci. Imp. Univ. Tokyo, Sect. 2, vol. 5, pt. 5, p. 120.
1939. *Clavagnostus* Kobayashi, Jour. Geol. Soc. Japan, vol. 44, p. 578.

Type:—*Agnostus repandus* Holm and Westergård, 1930.

Remarks:—As has been pointed out already, *Tomorhachis spinosa* Resser from the Nolichuky of Tennessee which is the type of *Tomorhachis* is represented by the pygidium of this genus.

Distribution:—Late Middle Cambrian of Siberia, Sweden and eastern North America; early Upper Cambrian of the Southern Appalachians.

Clavagnostus repandiformis Kobayashi, new species

Plate II., figures 18–19

Description:—*Clavagnostus* having a short conical unfurrowed glabella, neck-ring and a preglabellar axial furrow on the cephalon and a postaxial furrow and a pair of long lateral spines on the pygidium.

Observation:—In the holotype cephalon of this species (Pl. II, fig. 18) a small lunate neck-ring is clearly marked by a transverse furrow, but the basal side-lobes are absent. Among the variant forms of *Clavagnostus repandus* a cephalon (Holm and Westergård, 1930, fig. 35, pl. 1) has a short groove in front of the glabella. In another cephalon (fig. 40) which is provisionally referred to the same species by Holm and Westergård, the groove is much more distinct and longer than in the preceding, but the clear-cut basal side-lobes serve to distinguish this species.

Because there are gradations in the strength of the axial groove, it is reasonable to include these grooved and ungrooved forms in *Clavagnostus.* For distinguishing it specifically from *C. repandus* more weight must be laid on the presence of the neck-ring, the absence of the basal side-lobe and the absence of constriction in the axial lobe of pygidium. It is certainly interesting to see that this species is a developed form of the Peronopsidae with reference to the axial furrows but retains the primitive nature in the neck-ring.

Comparison :—*Agnostus gladiator* Clark (1923–24) has very long spines on its pygidium but is quite distinct from this species in most other features.

This species agrees on the other hand with *Clavagnostus repandus* Holm and Westergård (1930) in many respects, notably in the presence of posterior spines on the cephalon and pygidium, narrow unfurrowed glabella with a blunt axial keel, long conical axial lobe of the pygidium the rear part of which is distinctly depressed and has a pair of pits.

There are however several differences between the two species. In this pygidium the axial lobe is not constricted in its anterior part and a distinct axial groove extends behind the lobe. The median tubercle can hardly be seen on the lobe. A distinct axial groove is found also on the cephalon in front of the glabella. The spines on the cephalon as well as the pygidium are incomparably longer in this species than in *Clavagnostus repandus.*

In *Clavagnostus aequilis* Howell as well as in *C. spinosa* Resser which are represented by the pygidia only, the spines are not so long as in this species. The pygidium of *C. aequilis* has a subquadrate outline, rapidly narrowing backwards; the axial lobe of *C. spinosa* has a constriction in its anterior part. These serve to distinguish them from this species.

Occurrence :—Loc. D; *Solenoparia* zone.

Clavagnostus cfr. *repandiformis* Kobayashi

Plate II, figure 20

A cephalon from the same locality as the preceding, appears to have a more quadrate outline and longer glabella than the preceding. Because this has a neck-ring it is certainly closer to *C. repandiformis* than *C. repandus.* When a better specimen is obtained, specific separation should be made between these two allies.

Occurrence :—Loc. D ; *Solenoparia* zone.

Family **Agnostidae** McCoy

Subfamily **Agnostinae** Kobayashi

Genus ***Homagnostus*** Howell

Hamagnostus euryrachis Kobayashi, new species

PA1925-2-15
PA1926-2-16
PA1927-2-17

Plate II, figures 15–17

Description :—Cephalon fairly convex, more or less parallel-sided on the posterior and rounded on the anterior side ; glabella subcylindrical and trilobed; posterior lobe much longer than the two others and the middle one carries a median tubercle ; a small triangular lobe found on each side of the posterior lobe ; axial furrow straight across the preglabellar area ; marginal border of moderate breadth in front but apparently narrows backward.

Pygidium much more strongly convex than the cephalon ; axial lobe much broader than the glabella ; this lobe long, slightly constricted at a short distance from the anterior, and in expanding behind, extends back to the margin ; a deep transverse furrow clearly marks off a large articulating half-ring ; two lateral-furrows behind it are weak ; anterior furrow bent up rectangularly at a short distance from the side of the axis ; a long median tubercle lying on the posterior furrows.

Remarks :—The pygidium in fig. 17 is selected for the holotype and the cephalon in fig. 15 for the paratype. The third specimen in fig. 16 is tentatively referred to this species because, although the axial furrow is obscure in front of the glabella, it is diagnostic of this species in all other characteristics. It is possible that the obscurity of the furrow is due to erosion.

The periphery of the holotype pygidium cannot be seen clearly. But the characteristics above mentioned are enough to place this species in *Homagnostus.* Its large axial lobe shows that it is especially related to *H. socialis* Tullberg (Brögger, 1882, p. 55, pl. 1, figs. 10 a-b), but the trilobation of the glabella is an important difference from *H. socialis.* The rectangular course of the anterior lateral furrow on the axis of pygidium is another distinction.

Occurrence :—Loc. D; *Solenoparia* zone.

Family **Komaspidae** KOBAYASHI

Genus ***Schmidtaspis*** KOBAYASHI, new genus

Diagnosis :—Komaspidae with a semi-ovate unfurrowed glabella, a prominent median tubercle on a clear-cut occipital ring and large eye-band.

Type :—*Schmidtaspis sibiricus* KOBAYASHI, new genus and species.

Remarks :—Since I established the Komaspidae to include *Komaspis*, *Chariocephalus*, *Irvingella* and possibly *Bathynotus* (1935), *Irvingelloides*, *Dartonaspis* and *Komaspidella* were added to them and *Irvingella* was split into two subgenera, *Irvingella* s. str. and *Parairvingella* (KOBAYASHI, 1938). Subsequently RESSER (1938) suggested that *Dartonaspis* is congeneric with *Chariocephalus*. The eye-band is, however, much larger in *Dartonaspis* than in *Chariocephalus*.

One more genus is here added to the family. Among others *Schmidtaspis* is most allied to *Chariocephalus* and *Irvingella*, but can readily be distinguished from the former by its long eye-band and from the latter by its obscurity of lateral glabellar furrows. The distinct median tubercle on its neck-ring provides a further distinguishing feature. *Dartonaspis*, like this genus, has a large eye-band, but the quadrate glabella and deep lateral furrows are distinctions from this genus.

Distribution :—Early Upper Cambrian of Siberia.

√ *Schmidtaspis sibiricus*, KOBAYASHI, new genus and species

PA1928-3-5,6.

Plate III, figures 5–6

Description :—Cranidium semicircular and moderataly convex, most elevated in its postero-median part and rather abruptly inclined on the anterior and lateral sides; glabella broad at the rear, but gradually taprering toward the rounded front; dorsal and occipital furrows deep; neck-ring thickened toward the middle; a median tubercle on it very prominent; fixed cheek half as wide as the glabella and bordered by a long palpebral band; frontal limb absent; frontal rim as broad as the anterior of the glabella, relatively thick, convex and separated from the glabella by a deep groove.

Observation :—An axial ridge is impressed on the glabella more or less distinctly; test of the carapace is exfoliated.

Occurrence :—Loc. E; Upper *Koldinia* zone.

Family **Damesellidae** Kobayashi

Subfamily **Damesellinae** Kobayashi

Genus ***Inouyina*** Poletayeva

1939. *Inouyina* Poletayeva, Rec. Geol. West. Siberian Reg. No. 35, p. 45.

Type :—*Inouyina quadratica* Poletayeva, 1936 (Pl. I, fig. 19).

Diagnosis :—Small damesellid with four pairs of lateral furrows on the parallel-sided glabella and small postero-lateral limbs of the free cheeks.

Remarks :—It is quite interesting to know that such a dameselloid as *Inouyina quadrata* occurs in Siberia in a horizon much lower than the Kushan stage. It is unfortunate that only the cradium is known of the species. Therefore if the other parts of the carapace are found, it may be proved that it is not so intimately related as I now presume.

Insofar as the cranidium is concerned however, this genus is more similar to *Damesella* (Kobayashi, 1941) than any other Cambrian trilobite that I know. The outline of its glabella does not taper forward as in *Damesella* and the postero-lateral limb of the fixed cheek is less developed. The presence of four lateral furrows on the glabella shows that this species is more primitive than the Taitzu as well as Kushan species of *Damesella*.

Walcott's species of *Inouyia* to which Poletayeva made a comparison is now split into *Inouyia*, *Lorenzella* and a few other genera (Kobayashi, 1935), but all of them are smooth, instead of granulated as in this. None of them looks to me to be very similar to *Inouyina*.

Distribution :—Early Middle Cambrian of Siberia.

Genus ***Chaskasskia*** Poletayeva

1636. *Chaskasskia* Poletayeva. Rec. Geol. West. Siberian Reg. No. 35, p. 44.

Diagnosis :—Small dameselloid with a long glabella narrowing forward and protruding into the frontal border; three pairs of oblique lateral furrows close-set in the posterior half of the glabella.

Type :—*Chakasskia minussensis* Poletayeva, 1936 (pl. I, fig, 21).

Remarks :—The features of the cranidium are all that is so far known of this trilobite; though not so similar to *Damesella* as the preceding, yet it appears closer to *Damesella* than any other genus. Its long glabella which is projected into the frontal border is the most important characteristic which distinguishes it from *Damesella* and other dameselloids. Like *Inouyina* as well as *Damesella* the surface is granulated.

Distribution :—Early Middle Cambrian of Siberia.

Family **Leiostegiidae** BRADLEY

Snbfamily **Eochuanginae** KOBAYASHI

Genus ***Giradia*** KOBAYASHI, new genus

Diagnosis :—Eochuanginae with a large lunate frontal border and large eyes,

Type :—*Girandia typa* KOBAYASHI, new genus and species.

Remarks :—This genus is provisionally placed in the Eochuanginae becanse it has a chuangioid-cranidum with granulated test. It differs from *Eochuangia* in the size of the eyes, absence of eye-ridge and the aspect of the frontal border.

Distribution :—Latest Middle Combrian of Siberia.

H *Girandia typa* KOBAYASHI, new genus and species

PA1929-2-6 P
PA1930-2-7

Plate II, figures 6–7

Description :—Cranidium granulated; glabella moderately convex; truncate-conical, so long that it leaves no space for the frontal limb; dorsal furrows oblique to the axis; fixed cheek less than half the glabella in breadth; eyes very large; eye-ridges absent; frontal border lunate and inclined forward from the inner margin which is sharply edged; marginal groove narrow and deep; a short genal spine present on the free cheek.

Comparison :—The cranidium in fig. 6 on pl. II is the holotype. This species looks somewhat simillar to "*Inouyina*" *divi* WALCOTT (1913, p. 152, pl. 14 figs. 13–14) and also to "*Ptychoparia*" *meglitzkii* TOLL, (1899, p. 22, pl. 1, fig. 2), but can easily be distinguished from the former by its furrowed glabella and by the absence of the eye-ridge from the latter. Furthermore the latter is incomparably smaller than this. Those two have smooth carapaces while this has a granulated one. The resemblance is probably superficial.

Occurrence:—Loc. D; *Solenoparia* zone.

Subfamily **Leiostegiinae** Kobayashi

In 1935 I referred *Chuangia*, *Leiostegium*, *Koldinia*, *Leiostegioides*, *Prochuangia* and *Chuangiella* to this subfamily. The following year Lochman established a new genus *Genevievella* on the basis of *G. neunia* Lochman from the Bonneterre Dolomite of Missouri. As she suggested, its cephalon is quite similar to that of *Chuangia*, although the associated pygidium is different between the two genera.

Subsequently in 1938 (A) she added another new genus, *Llanoaspis*, when she described *L. modesta* Lochman and *L. undulata* Lochman from Cape Mountain (*Crepicephalus* zone) of Texas. But immediately after her paper came out, Resser (1938 A) mentioned that the two species of *Llanoaspis* belong to *Genevievella*, and he described eleven species of *Genevievella* from the Nolichucky of the Southern Appalachians (1939 B).

While Resser noted that *Genevievella* inclusive of *Llanoaspis* is confined to the *Crepicephalus* zone of North America, Howell and Lochman expressed their opinion in 1939 that the *Chuangia* fauna of Asia is the approximate equivalent of the *Cedaria* fauna of North America because of the presence of *Genevievella* in the *Cedaria* fauna. It is quite reasonable to refer *Genevievella* together with *Llanoaspis* to this subfamily and further it is quite probable that the Eau Claire is appoximate to the Changshanian in age, but I think it is going too far to correlate the *Chuangia* zone of Asia with the *Crepicephalus*, *Cedaria* or any other fossil zone of North America definitely on account of a pair of similar genera, one in each zone.

Genus ***Koldinia*** Walcott and Resser

Koldinia micropthalma Kobayashi, new species

Plate III, figures 9–15

Description:—*Koldinia* having a cranidium remarkably convex in its posterior and small eyes close to the posterior margin.

Observation:—The cranidium in figs. 9–10 on pl. III is the holotype. Due to the exfoliation of the test the outline of the glabella and long oblique eye-ridges are seen on the two cranidia. The glabella is broadest at a short distance from the neck-ring and becomes gradually narrower; the anterior margin of the glabella is more or less rounded. A blunt keel is found along the axis and a shallow furrow on each side of it. The frontal limb is a little longer than one-ninth the cranidium.

In two pygidia of this species it is seen that the doublure is as wide as one-third the length and divided into right and left side by an axial suture.

Comparison :—This cranidium is most convex in the posterior, instead of in the anterior part as in *Koldinia typa;* in this species the posterior margin is projected behind along the neck-ring while it is almost straight in *K. tvpa.* The eyes are small and far to the posterior.

Compared to the pygidium of *K. typa* this is somewhat longer and has a more distinct segmentation, notably on the axial lobe on which about ten rings can be counted in addition to an articulating half-ring.

Occurrence :—Loc. E; upper *Koldinia* zone.

Koldinia minor KOBAYASHI, new species

Plate II, fig. 12–13; Pl. III, figs. 7–8

Description :—Cranidium a little broader than long and strongly conxex especially so in the rear part; glabella broader than half the cranidium and its posterior side distinctly protruded backward; in starting from the extremities of this protruded part, dorsal furrows rapidly converge and become very obscure in the anterior half; except these there is no furrow on the cranidium; frontal edge or doublure sharply elevated and transversely striated; eyes small and located at about mid-length of the fixed cheek; facial sutures subparallel to each other in front of the eyes and diagonal behind the eyes.

An associated pygidium semicircular; axial lobe almost equal to the pleural one in breadth, marked by wide and deep axial grooves which are nearly parallel to each other and die out more or less abruptly at a point about two-thirds from the anterior margin; no segmentation except the articulating segment which is fairly well marked on the pleural lobe; marginal furrow absent; lateral and posterior borders convex and sloping down; surface smooth.

Observation :—The cranidium in fig. 7 on pl. III is the holotype. Not only in this but also in the cranidium in fig. 8 on the same plate, the outline of the glabella is shown. It is similar to that of the preceding but forward tapering is most abrupt. In this species the dorsal furrow is straight on the lateral side of the glabella whereas it is gently arcuated in the preceding. The frontal limb is narrower in this.

Comparison :—Smooth trilobites are difficult to identify. I once thought that this was an *Ucebia*, but the outline of this glabella seen on the exfoliated surface is the same as that of *K. microphthalma*. In *Ucebia*, on the other hand, it is quadrate.

Compared with the young cranidia of *Koldinia typa* WALCOTT and RESSER (1924, pl. I, figs. 8–10) the posterior margin of the glabella is always remarkably projected backwards and the eyes are smaller and located more anteriorly. Compared to the small pygidium of *Koldinia typa* WALCOTT and RESSER (1924, pl. II, fig. 12–13) this pygidium is longer, the axial lobe broader, its posterior outline obscured and the periphery quite convex.

The glabella is broader and longer and the eyes are located more anteriorly in this than in *K. micropthalma*. The axis of the pygidium is also broader in this. This somewhat resembles *Plethometopus laevis* (RAYMOND) (1924, p. 446, pl. 14, fig. 4) from Vermont but the dorsal furrow becomes practically obsolete in *laevis*.

Occurrence :—Locs. E and F; Upper *Koldinia* zone.

Family **Tollaspidae** KOBAYASHI, new family

This family is proposed here to include *Tollaspis* and *Paratollaspis* both being characterized by the peculiar subtrapezoidal area which increases its breadth forward. There is a deep furrow on its lateral side which extends diagonally from the antero-lateral corner of the glabella.

It is probable that *Dinesus* belongs to this family rather than to the Dolichometopinae, Ellipsocephalidae, or any other family, because if the glabella were to be elongated and projected into this area, a pair of triangles as seen on the cranidium of *Dinesus* would remain. Complete carapaces are known of *Dinesus ida* ETHERIDGE and its pygidium is small, short and has a nearly straight anterior margin. No pygidia similar to that of *Dinesus* is however found in the *Tollaspis-Manchuriella* bed along the Esseigan River. For this reason I hesitate to refer this Australian genus to this family.

Genus ***Tollaspis*** KOBAYASHI

Tollaspis cfr. *pawlowskii* (SCHMIDT)

Pl. I, figures 6–8

1886 cfr. *Anomocare pawlowskii* SCHMIDT, Bull. de l'Acad. Imp. des Sci. de St. Pétersbourg, vol. 12, p. 408, figs. 1-2.

1889 cfr. *Anomocare pawloskii* Toll, Mém. de l'Acad. Imp. des Sci. de St. Pétersbourg, VIIIe ser. Cl. Phys.-Math. vol. 8, no. 10, p. 32, pl. 2, fig. 14.
1914 cfr. *Anomocare pawlowskii* Walcott, Smiths. Misc. Coll., vol. 32, no. 1, p. 8.
1935 cfr. *Tollaspis pawlowskii* Kobayashi, Jour. Fac. Sci. Imp. Univ. Tokyo, Sect. 2, vol. 4, pt. 2, p. 262.

Toll appears to have included two different species in one, because the specimens in figures 14 and 15 are quite different in the outline of the glabella and other features. Here the former is selected for the type. As discussed below the latter is very close to *T.* (?) *poletayevae*.

Though fragmentary, a cranidium from the left shore of the Esseigan river 25 miles above its mouth, bears most of the characteristic features of this species, in the outline of the glabella, deep dorsal and lateral furrows, large eyes, distinct eye-ridges, convex frontal rim, slightly diverging anterior facial sutures and notably in the preglabellar elevation. Compared to the holotype the lateral furrow of the elevation is however weaker.

In an associated pygidium (Pl. I, fig. 7) the axis is subconical, highly elevated above the pleural lobes which are gently inclined toward the broad flat border; five pleural ribs and furrows die out more or less abruptly near the margin. The reference of this pygidium to the species is very tentative.

A similar pygidium (Pl. I, fig. 8) was found on the left shore of the same river 21 miles above its mouth. This differs somewhat from the preceding in the outline of the axial lobe which is subcylindrical except for the terminal lobe which is short and conical. The main part of the axis consists of four rings.

Before leaving this description, it must be noted that the cranidium and two pygidia are quite similar to the respective parts of "*Conokephalina*" *vesta* Walcott (1913, p. 139, pl. 13, figs. 9–9 c) from the early Changhian of Shansi, except for the absence of the trapezoidal area. *Vesta* is referable to neither *Conokephalina* nor *Tollaspis*, but it appears to be related to this species. It must be noted, however, that the occurrence of similar pygidia accompanied by similar cranidia in two localities which are widely apart may not be accidental.

Occurrence:—Locs. A and C; *Tollaspis* zone. The type specimen was collected at the mouth of the little Batobiji on the Wiliu River.

Tollaspis (?) *poletayevae* Kobayashi, new species

Plate I, figure 20

1936. *Ptychoparia* sp. Poletayeva, Rec. Geol. West Sib. Reg. No. 35, pl. 3, figs. 5–6.

1899. Comp. *Anomacare pawloskii* TOLL, Mém. de l'Acad. Imp. des Sci. de St. Péters 6, VIIIe ser. Cl. Phys.-Math. vol. 8, no. 10, p. 32, pl. 11, fig. 15 only.

In POLETAYEVA's specimen in figs. 6–6_1 which is the lectotype of this species the trapezoidal area is seen in front of the glabella and a median tubercle on the neck-ring where it is thickened (figure 6). But the area is not so clearly defined as in typical *Tollaspis* and the frontal border is unusually thick and its convexity is relatively gentle.

In the outline of glabella and the courses of four lateral furrows however, this species is quite similar to the second specimen (pl. 2, fig. 15) of TOLL's *pawlowskii*, but this cranidium has a remerkably arcuate anterior outline and larger eye, in which respect it agrees with *Tollaspis maydelli*. In *I. maydelli* however the lateral furrows are not so deep and the most posterior one is not so oblique. Furthermore the frontal border is much more arcuated in this than in *T. maydelli*.

Occurrence :—Sanashtikgolsky limestone near the Sanashtikgolsky spring, on the left tributary of the river Abakan, on the northern slope of the West Sayans.

Genus ***Paratollaspis*** KOBAYASHI, new genus

Diagnosis :—Tollaspid with cylindrical glabella having only a pair of posterior furrows close to the occipital ring.

Type :—*Cyphaspis sibirica* SCHMIDT, 1886 (pl. I, fig. 19).

Remarks :—This is represented only by the type species.

Compared to *Tollaspis*, it has a much narrower glabella. Though TOLL's drawing of *P. sibirica* (1899) shows three short anterior lateral furrows obscurely, they can scarcely be seen in LERMANTOVA's photograph of the topotype (1926, pl. fig. 13). Excepting the occipital furrow, only the posterior one is distinct and, though it becomes somewhat shallow, it joins with its fellow on the axis. The course taken by the pair of furrows is geniculated as is the occipital ring. The trapezoidal preglabellar area is striated by subparallel lines; the rest of the cranidium is finely granulated.

As suggested by WHITEHOUSE (1936, 1939) this cranidium looks similar to *Dinesus ida* ETHERIDGE, but in *E. ida* the preglabellar area is divided into two triangular elevations by the long glabella and the surface is smooth.

Distribution :—Early Middle Cambrian of Siberia.

Family **Ellipsocephalidae** MATTHEW

Subfamily **Plethopelitinae** RAYMOND

When I discussed the family-relationship of Cambrian genera of trilobites in 1935, I noted that there were at least two series among the smooth trilobites which were thought to be terminals of the Ellipsocephalidae, but they were tentatively grouped in the Kingstoninae. One was the *Plethopeltis-Plethometops* series for which RAYMOND later proposed the Plethopeltidae RAYMOND in 1937.

Genus ***Plethopeltis*** RAYMOND

1913. *Plethopeltis* RAYMOND, Vict. Mem. Mus. Bull. 1, p. 64.
1915. *Plethopeltis* FIELD, Ottawa Naturalist, June-July, pp. 32–37.
1924. *Plethopeltis* RAYMOND, Proc. Boston Soc. Nat. Hist. vol. 37, pp. 412–419.
1931. *Plethopeltis* ULRICH, in BRIDGE's Emmince Quadrangle, pp. 219–220.
1933. *Plethopeltis* KOBAYASHI, Jour. Geol. Geogr. vol. 11, p. 133.
1933. *Plethopeltis* KOBAYASHI, Jour. Fac. Sci. Imp. Univ. Tokyo, sect. 2, vol. 3, pt. 7, p. 280.
1935. *Plethopeltis* KOBAYASHI, Jour. Fac. Sci. Imp. Univ. Tokyo, sect. 2, vol. 4, pt. 2, p. 202.
1936. *Plethopeltis* RESSER, Smith. Misc. Coll. vol. 95, no. 4, p. 26.
1937. *Plethopeltis* RAYMOND, Bull. Geol. Soc. Am. vol. 45, p. 1097.
1938. *Plethopeltis* KOBAYASHI, Japan. Jour. Geol. Georg. vol. 15, p. 177.
1937. *Plethopeltis* KOBAYASHI, Jour. Fac. Sci. Imp. Univ. Tokyo, sect. 2, vol. 4, pt. 4, p. 472.

Remarks:—There are some twenty species which were once referred to this genus. In 1931 ULRICH excluded

Bathyurus armatus BILLINGS, 1860,
Plethopeltis arenicola RAYMOND, 1924,
Plethopeltis convergens RAYMOND, 1924,
Plethopeltis laevis RAYMOND, 1924,
Plethopeltis angusta RAYMOND, 1924 and
Plethopeltis latus RAYMOND, 1924.

from the genus and, together with *Illaenurus convexus* WHITEFIELD, 1882, he included them in his *Plethometopus* where *P. armatus* was the type of his genus. *Agraulos hemispherica* BERKEY, 1898, and probably *Plethopeltis arenicola* belong to *Camaraspis* ULRICH and RESSER, 1924, which is based on *Arionellus convexus* WHITFIELD, 1882. Lately RESSER referred *Arionellus levis* WALCOTT, 1899, to *Plethopeltis* but the outlines of its cranidium and glabella are not characteristic of the genus.

Thus, after excluding them, there remain the seven species of *Plethopeltis* in North America which are as follows:

1. *Agraulos saratogensis* WALCOTT, 1890, from the Hoyt limestone of Saratoga spring, N. Y. and the Upper Kittatinny limestone near Blairtown, N. J.
2. *Plethopeltis walcotti* RAYMOND, 1924, from the Hoyt limestone of Saratoga, N. Y.
3. *Plethopeltis welleri* RAYMOND, 1924, from the upper part of the Cambrian near Blairstown, N. J.
4. *Plethopeltis buchleri* ULRICH, 1931, from the upper Eminence dolomite, near Eminence, Missouri.
5. *Plethopeltis platymarginatus* ULRICH, 1931, from the Eminence dolomite, near Eminence, Missouri.
6. *Plethopeltis incisa* RAYMOND, 1937, from the lowest Gorge at Highgate Falls, Vermont.
7. *Plethopeltis robusta* KOBAYASHI, 1938, from the *Plethopeltis* limestone near Highgate, British Columbia.

A solitary representative in South America is *Plethopeltis megalops* KOBAYASHI, 1937, from the late upper Cambrian of Guanacuno and Pampa de Tascara.

Compared to these *Pelthopeltis orientalis* KOBAYASHI, 1933, and *Plethopeltis resseri* KOBAYASHI, 1933, both from the Wanwankou dolomits in the Niuhsintai basin, South Manchoukuo, have extraordinarily larger glabellae. The fixed cheek measured across the eye is about one-sixith as broad as the glabella. Such a remarkable difference prompts me to eliminate these Wanwanian species from *Plethopeltis*. A new genus, *Plethopeltella*, is established here to include them. I contend that these descendants of *Plethopeltis* appeared on the scene through the enlargement of the axial part.

In *Plethopeltis ulrichi* KOBAYAHI, 1934 from the *Clarkella* zone at Saishori, South Chosen, on the other hand, the glabella is relatively small but the palpebral lobe quite large for this genus. Although further study is necessary before one can establish a new genus out of this Korean species, it is certainly not typical of *Plethopeltis*.

The generic reference of *Plethopeltis* ? *microlops* KOBAYASHI, 1934, from the *Clarkella* zone at Tomkol, South Chosen also is no more than a suggestion. Glancing these Eastern Asiatic species outside of *Plethopeltis*, the known species of the genus are all American. Here a Siberian species is added to them.

Distribution:—Late Upper Cambrian of North America, South America and Siberia.

Plethopeltis stenorhachis KOBAYASHI, new species

Plate I, figure 5.

Description :—Cranidium moderately convex, gently warping up toward its center; glabella demarcated by a narrow groove, truncato-conical, somewhat contracted at a short distance from its anterior; lateral furrows practically obsolete but occipital furrows distinct, running transversely; an obscure carination observable along the axis only when light is thrown from the lateral side; occipital lobe produced behined forming a triangular outlines; eyes small and located on both sides of the constriction of the glabella; narrow arcuate groove extending from the eye to the antero-lateral corner of the glabella; postero-lateral limb of the fixed cheek large and triangular; pre-glabellar area more or less convex, inclined regularly and rather steeply toward the front; anterior branches of facial sutures divergent from each other; their posterior branches diagonal; surface smooth.

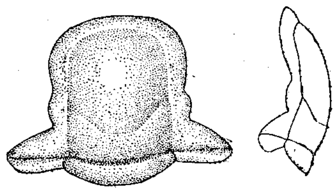
Comparisons :—The facial sutures, size and position of the eyes and many other features of this cranidium are in perfect accordance with *Plethopeltis*.

The glabella is however, smaller than usual in this genus. Its very narrow dorsal and occipital furrows, weak axial carination and arcuate ocular groove are additional characteristics which distinguish this species from all others of this genus.

Occurrence :—Loc. H; latest Upper Cambrian.

Genus ***Plethopeltella*** KOBAYASHI, new genus

Diagnosis :—Plethopeltid with extraordinarily large glabella of sub-square outline which is clearly defined by a narrow dorsal furrow; occipital ring not projected behind in the middle part; fixed cheek and pre-glabellar area form a narrow band of nearly equal breadth surrounding the anterior part of the glabella:



Text-Fig. 3.

Type :—*Plethopeltis resseri* KOBAYASHI (Text-figure 3).

Distribution :—Lowest Ordovician of South Manchoukuo.

Family **Emmerichellidae** KOBAYASHI

Subfamily **Bowmaninae** KOBAYASHI

Genus ***Bowmania*** WALCOTT

Bowmania lermantovae KOBAYASHI, new species

Plate III, figure 19.

In an incomplete cranidium at hand the glabella is quadrate, slightly tapering forward and has three pairs of short lateral furrows; frontal limb convex, inclined forward and roughened by nerve-like lines; frontal rim which is very poorly preserved appears wire-like.

Although fixed cheeks are largely broken, a thick ocular ridge remains on a cheek which extends postero-laterally from the side of the first lateral furrow. The oblique direction of this ridge naturally implies that the broken eye was located far to the posterior as in *Bowmania americana* WALCOTT, (1925, p. 73, pl. 15, figs. 15–16). The chief difference between them lies in the glabellar length which is much shorter in *Bowmania americana.*

Occurrence :—Loc. E; *Koldinia* zone.

Family **Solenopleuridae** ANGELIN

Subfamily **Solenopleurinae** KOBAYASHI

Genus ***Solenoparia*** KOBAYASHI

Solenoparia megalops KOBAYASHI, new species

Plate II, figures 2–5.

Description :—Glabella outlined by a deep dorsal furrow, subovate and strongly convex; only two lateral furrows clearly seen on the glabella, running obliquely to the axis; occipital furrow deep and more or less arcuate; occipital ring thickened toward the middle where a prominent tubercle lies; fixed cheek relatively narrow; eyes equal to the middle one-third of the cranidium in length and connected with the glabella by a weaker eye-ridge; frontal rim narrower than the frontal limb, both fairly convex, and are as a whole inclined forward. Free cheek a little broader than the fixed cheek; and a long spine issues from its genal angle; surface smooth.

Comparison :—The important characteristics of this species are the presence of deep lateral furrows, large eyes and a prominent median tubercle through which it can readily be distinguished from *Solenoparia toxeus* (WALCOTT) (1913, p. 208, pl. 19, figs. 10–10 a) and other species of *Solenoparia*.

Occurrence :—Loc. D; *Solenoparia* zone.

Solenoparia brevifrons, new species

Plate I, figure 11.

This species is very similar to the preceding, but can be distinguished by the following features :—

1. Glabella less convex and glabellar furrows more obsolete.
2. Fixed cheek narrower and eyes located a little posterior to the middle of the glabella.
3. Frontal limb narrower, instead of broader, than the frontal rim, and does not incline forward as much as in the preceding case.
4. Surface pustulated.

Occurrence :—Loc. D; *Solenoparia* zone.

Genus ***Modocia*** WALCOTT

1924. *Modocia* WALCOTT, Smiths. Misc. Goll. vol. 75, no. 2, p. 59.
1925. *Modocia* WALCOTT, Smiths. Misc. Coll. vol. 75, no. 3, p. 105.
1935. *Modocia* KOBAYASHI, Jour. Fac. Sci. Imp. Univ. Tokyo. sect. 2, vol. 4, pt. 2, p. 291.
1935. *Modocia* RESSER, Smiths. Misc. Coll. vol. 93, n. 5, p. 41.
1936. *Modocia* RESSER, Smiths. Misc. Coll. vol. 95, no. 4, p. 25.

Since WALCOTT established this genus for *Arionellus* (*Crepicephalus*) *oweni* MEEK and HAYDEN, 1861, from the Deadwood in the Big Horn Mountains, Wyoming, RESSER has referred the following to it.

1. *Crepicephalus* (*Loganellus*) *centralis* WHITFIELD, 1880, from the Deadwood in Black Hills, South Dakota.
2. *Ptychoparia penfieldi* WALCOTT, 1899, from the Upper Cambrian in the north-western Yellowstone Park, Wyoming.
3. *Acrocephalites* ? *glomeratus* WALCOTT, 1916, from the Deadwood near Rawlings, Wyoming.
4. *Modocia berkeyi* RESSER from the Ironton at Taylor's Falls, Minnesota.

The straight anterior margin of the glabella and the presence of a boss in front of it in the third species throw some doubt on the validity of its reference to *Modocia*.

Distribution :—Upper Cambrian of North America and probably Siberia.

Modocia (?) *obrutschewi*, KOBAYASHL, new species

Plate III, figure 18

PA1950

The glabella convex, conical, a little broader than the fixed cheek, rounded in front, elevated above the cheeks; no furrows on the glabella except the occipital one; occipital ring bent back and thickened in the middle; fixed cheek and frontal limb gently convex and inclined outwardly; eyes small and located at mid-length of the cranidium; no ocular ridge; surface smooth.

The frontal rim which is poorly preserved on the specimen appears to be wire-like.

This agrees with *Modocia oweni* WALCOTT in most features but its unusually long glabella makes me hesitate to place it in *Modocia*.

Occurrence:—Loc. E; *Koldinia* zone.

Family **Anomocaridae** POULSEN

Genus ***Kotuia*** KOBAYASHI, new genus

Because this is represented only by the type species, its distinctions from *Anomocare* and other allied genera are mentioned in the specific description.

Type:—*Kotuia anomocaroides* KOBAYASHI, new genus and species.

Kotuia anomocaroides KOBAYASHI, new genus and species

Plate II, figure 8–11

PA1951-2-8
PA1952-2-9
PA1953-2-10
PA1954-2-11

This anomocaroid has a subsquare glabella gradually tapering forward and bearing three pairs of lateral furrows; the first furrows rudimentary; the second and third oblique to the axis; eye-band large, semicircular and detached from the glabella by a narrow space; frontal limb a little longer than the frontal rim, the former being nearly flat and depressed whereas the latter is convex; facial sutures not widely divergent from each other in front of the eyes; surface smooth.

One specimen is composed of a cranidium and about thirteen segments of thorax; axial ring almost as wide as the pleura which is grooved and falcated on the lateral side. An associated pygidium has a large conical axis; pleural lobes gently sloping down near the margin.

Comparison:—Among the genara of the Anomocaridae this is more similar to *Anomocare* than to *Eymekops* and *Dolgaia*, but the eye-band is not actually in contact with the glabella as in *Anomocare*. Furthermore anterior branches of the facial sutures are not so widely divergent as in *Anomocare*. If the tentative reference of the pygidium to this species is corrected, its border is convex and narrow, though concave and broad in *Anomocare*.

Occurrence:—Loc. D; *Solenoparia* zone.

PA1955-3-1
PA1956-3-2
PA1957-3-3
PA1958-3-4

Family **Asaphiscidae** RAYMOND

Genus ***Lecanopleura*** RAYMOND

Lecanopleura ~~(?) *glabella*, KOBAYASHI, new species~~

Plate III, figures 1–3 and (?) 4.

Cephalon semi-circular, bordered by a convex rim which is projected into a short genal spine; glabella strongly convex, conical, abruptly rounded in front and surrounded by a deep dorsal furrow; two pairs of lateral furrows faintly impressed which run quite oblique to the axis; occipital furrow deep and occipital ring convex backward and thickened in the middle; palpebral lobe of medium size located near the glabella at mid-length of the cranidium; eye-ridge indistinct; fixed cheek broadened on the anterior and posterior sides from the eye; frontal limb a little broader and less convex than the frontal rim; free cheek relatively broad; anterior facial sutures divergent from the eyes with a gentle curvature and, curving inward, take an intramarginal course for some distance on the frontal border; surface entirely smooth.

Having only the cranidium, it is difficult to determine its generic position, because *Meteoraspis*, *Wuhuia*, and *Lecanopleura* have similar cranidia. While *Meteoraspis* has a pair of spines on the pygidium, the pygidium of *Wuhuia* has an entire margin. The cephalon is granulated in *Wuhuia belus* but smooth in *W. dryope* as in this species. It should be noted however that the glabella narrows forward more slowly in those species than in this.

Although the lateral furrows are practically indiscernible on the glabella of *Meteoraspis borealis* LOCHMAN (1938) this agrees with that species in most of the other features of the cranidium. It appears similar to *Lecanopleura interrupta* RAYMOND, (1937) and no less also to *L. inflecta* RAYMOND (1937). Therefore it may be accepted that this species is closer to either *Meteoraspis* or *Lecanopleura* than to *Wuhuia*. Between the two genera I hesitate to refer it to *Meteoraspis* because there is no pygidium having a pair of spines in the collection.

A pygidium in the collection which is presumed to belong to this species is fairly long; seven rings and a long terminal lobe found on the axial lobe; pleural lobe divided into seven ribs; marginal border becomes broader toward the posterior side; surface smooth.

In general outline this resembles the pygidium of *Blainia* such as *B. gregarias* WALCOTT (1916, p. 394, pl. 62, figs. 1–11) but it has no interpleural furrows. If this pygidium is to be combined with the cephalon in one species the resultant form is quite different from *Meteoraspis*. Therefore it is provisionally referred to *Lecanopleura* of which the pygidium is unknown.

Occurrence :—Loc. E; *Koldinia* zone.

Genus ***Manchuriella*** ENDO and RESSER

Manchuriella septentrionalis KOBAYASHI, new species

Plate I, figures 1–4

PA1959-1-1
PA1960-1-2
PA1961-1-3
PA1962-1-4

This species is represented by several cranidia, a free cheek and a pygidium. The cephalon is semicircular with a relatively thick marginal border from which a short spine issues; glabella of moderate size, clearly outlined by a dorsal furrow, subquadrate but a little expanding backward; lateral furrows obscure; eyes of medium size located fairly posteriorly; and palpebral ridge indiscernible.

An associated pygidium has a remarkably arcuated anterior outline; axial lobe slender, long, conical and terminates at a blunt end; pleural ribs divided each into two riblets by an interpleural furrow.

Occurrence :—Locs. A and B; upper *Tollaspis* zone.

Manchuriella sibirica, KOBAYASHI, new species

Plate I, figures 9–10

PA1963-1-9
PA1964-1-10

1936. Comp. *Solenopleura* sp. POLETAYEVA. Rec. Geol. W. Siberian Region, no, 35, p. 52, pl. 3, figs. 7, 71.

The cranidium of this species looks very similar to the preceding but differs chiefly in its much larger glabella and in the presence of a distinct palpebral lobe.

The pygidium found at the same locality is quite different from that of the preceding species in the anterior margin which is much less arcuated than in the other. Furthermore, axial lobe is much stouter.

It is certainly a remarkable fact that this cranidium is almost identical with POLETAYEVA's *Solenopleura* sp. though the latter is smaller.

Occurrence :—Loc. B; upper *Tollaspis* zone. POLETAYEVA's specimen was found in the Sanashtikgolsky limestone near Sanashtigolsky Spring on the northern slope of West Sayan.

Manchuriella (?) *disparilis* KOBAYASHI, new species

Plate II, figure 1

This species is represented by a cranidium having a large truncato-conical glabella, large eyes located quite posteriorly, wide frotal limb and narrow convex brim and anterior facial sutures which are slightly divergent from each other. These features suggest *Orlovia* or *Manchuriella* for its reference but it has relatively strong glabellar furrows not fouud in either of the two genera. The preglabellar area is very distinctly divided into a frontal limb and a rim of quite a different breadth. Secondary depression upon the specimen makes it difficult to determine its exact generic position.

Occurrence :—Loc. D; *Solenoparia* zone.

Family **Tsinanidae** KOBAYASHI

Genus ***Esseigania*** KOBAYASHI, new genus

Diagnosis :—Tsinanids with tiny posterior eyes, small postero-lateral limb of the fixed cheek and well developed frontal border.

Further notes are given in the description of the genotype.

Type :—*Esseigania tolli* KOBAYASHI, new gsnus and species.

Distribution :—Upper Cambrian of Siberia.

Esseigania tolli KABAYASHI, new genus and species

Plate I, figure 1[illegible]

Smooth strongly convex cranidium with a depressed rim and small eyes far to the posterior. Because this specimen is secondarily deformed, its original convexity is presumed to have been accentuated at least in its rear part. There are practically no distinct furrows except for a pair of short axial ones which extend only a very short distance from the posterior margin. The glabellar outline is however faintly marked by a weak groove, which appears subquadrate in the anterior half, but gradually increases in breadth in the posterior half. It does not extend very far beyond the middle of the cranidium.

Comparison :—This would be a terminal form of the Asaphiscidae. If such forms as *Maryvillia* and *Blountia* were to lose their surface-relief and their eyes were to shift a little backward, the acquired form would be *Esseigania*. Under such a supposition this can be said to agree with *Dictyites* which, however, is distinct from this genus in the outline and breadth of its glabella, the position of its eyes and the strength of its frontal brim. This genus appears somewhat similar to *Kazelia* but the latter has no depressed frontal border. Compared to *Jubileia* (KOBAYASHI, 1938) the eyes are smaller and located more posteriorly. The glabella is not so swelled up in this species.

Occurrence :—Loc. G ; late Upper Cambrian.

Hypostoma, gen. et. sp. indet

Plate III, figure 16

A large hypostoma contained in the collection has a large subsquare body which is convex and tapers backward ; a pair of lateral furrows marks a lateral lobe on each side of its posterior part ; two posterior wings large, depressed and separated by a V-shaped sinus.

This is totally different from the hypostome which was formerly referred to *Koldinia* but in this collection there is no trilobite other than *Koldinia* which could have a hypostoma of this size.

Occurrence :—Loc. E ; *Koldinia* zone.

Pygidium, gen. et sp. indet

Plate II, figure 14

Two incomplete pygidia in the Moyero River collection puzzeled me for a long time. Among the Siberian trilobites they appear similar to TOLL's pygidium of "*Bathyuriscus*" *howelli* (1899, pl. 2, fig. 11) which was later identified with *Anomocare sibiricum* by HOLM and WESTERGÅRD (1930). But a difference of this extent can also be recognized between TOLL's and HOLM and WESTERGÅRD's forms.

On account of the proportion between the breadths of the pygidium and the axial lobe the pygidia at hand agree better with that of *Anomocarella albion* WALCOTT (1913, pl. 20, figs. 2a–a1), but their axial lobes are certainly shorter and the marginal brims broader.

Compared to the pygidium of *Paracoosia mansuyi* KOBAYASHI, 1936, (=*Coosia asiatica* MANSUY, 1916, pl. 7, pl. 6a–h) their axial lobes are more slender. With the pygidium only it is difficult to determine its generic reference. In the *Koldinia* fauna of Novaya Zemlya there is no pygidium resembling them. But as they are found in association with *Koldinia minor*, it must belong to an unknown Upper Cambrian species.

Occurrence :—Loc. F; *Koldinia* zone, s. l.

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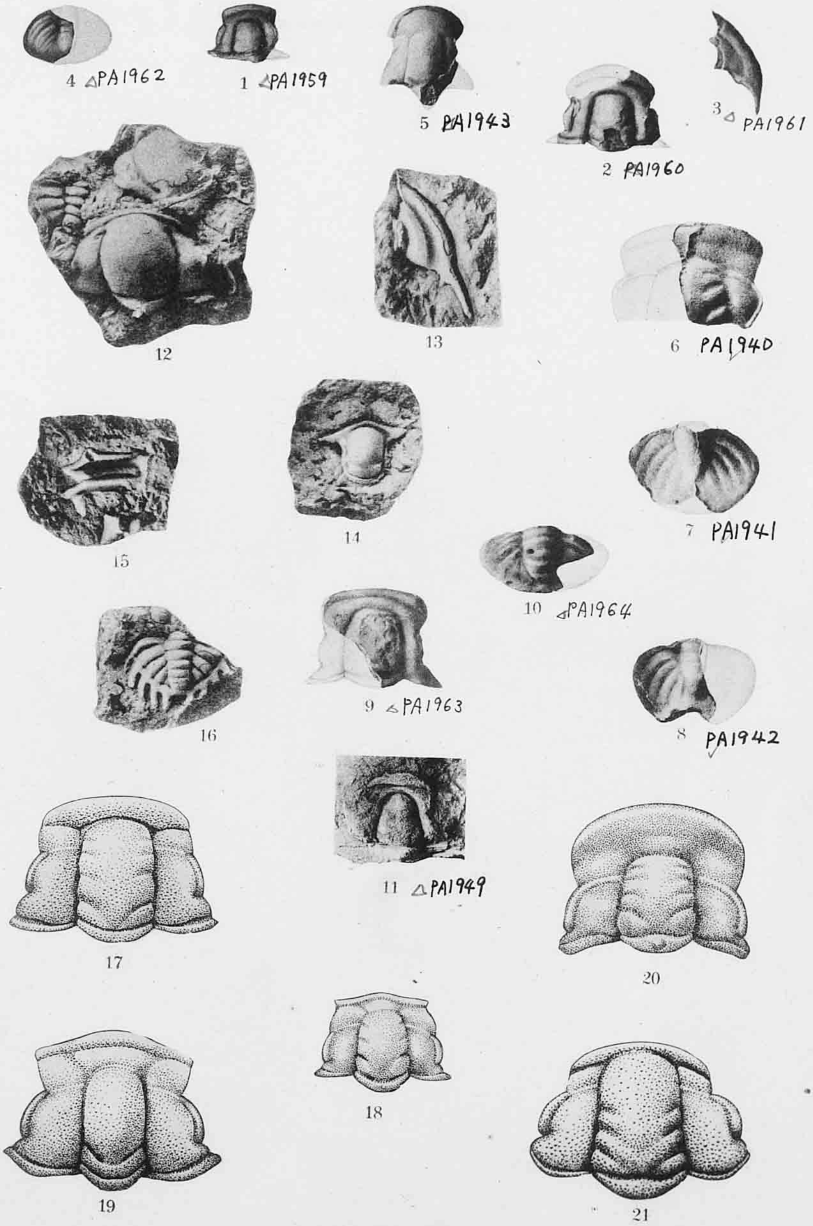
Plate I

Explanation of Plate I

Figure 1. *Manchuriella septentrionalis* KOBAYASHI, $\times 2$ 325
Figure 2. ditto. $\times 3\frac{1}{2}$
Figure 3. ditto. $\times 3$
Figure 4. ditto. $\times 1\frac{1}{2}$
Figure 5. *Plethopeltis stenorachis* KOBAYASHI, $\times 2$ 320
Figures 6–8. *Tollaspis* cfr. *pawloskii* (Toll) $\times 1\frac{1}{2}$ 315
Figure 9. *Manchuriella sibirica* KOBAYASHI, $\times 3$ 325
Figure 10. ditto. $\times 2\frac{1}{2}$
Figure 11. *Solenoparia brevifrons* KOBAYASHI, $\times 2$ 322
Figures 12–14. *Kootenia slatkowskii* (SCHMIDT) (LERMANTOVA, 1929, pl. 17, figs. 2, 3, 8)
Figures 15–16. ditto (LERMANTOVA, 1929, pl. 17, figs. 10–11) $\times 2$ 326
Figure 17. *Inouyina quadrata* POLETAYEVA ($\times 1\frac{1}{2}$) 311
Figure 18. *Tollaspis pawlowskii* (SCHMIDT) 276
Figure 19. *Paratollaspis sibirica* (SCHMIDT) ($\times 3$) 317
Figure 20. *Tollaspis* (?) *poletayevae* (KOBAYASHI) 316
Figure 21. *Chakasskia minussensis* POLETAYEVA ($\times 1\frac{2}{3}$) 311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3 PA1961
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6 PA1940
15
14
7 PA1941
10 PA1964
16
9 PA1963
8 PA1942
11 PA1949
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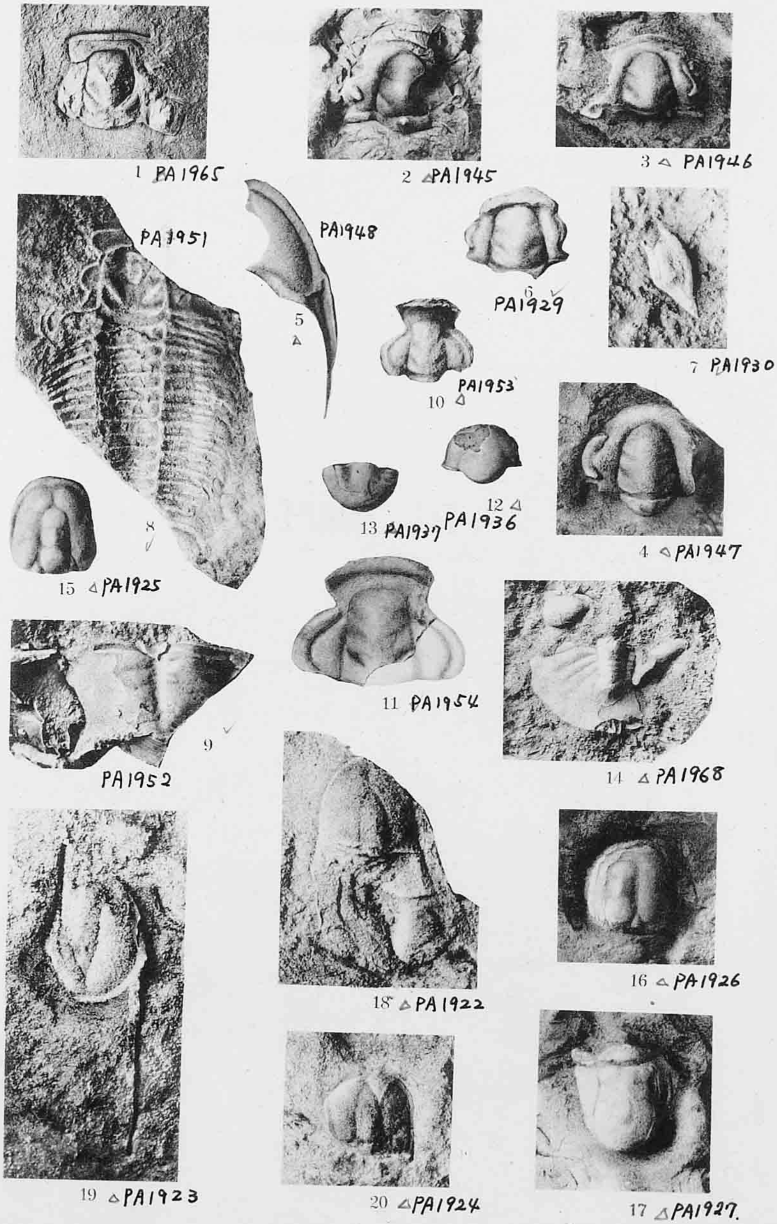
19
21

Explanation of Plate II

Figure 1. *Solenoparia* (?) *disparilis* Kobayashi, ×1⅓ 326
Figures 2–5. *Solenoparia megalops* Kobayashi, ×2 321
Figure 6. *Girandia typa* Kobayashi, ×2 312
Figure 7. ditto., ×3.
Figure 8–9. *Kotuia anomocaroides* Kobayashi, ×1⅓ 328
Figure 10. ditto., ×3.
Figure 11. ditto., ×2.
Figure 12. *Koldinia minor* Kobayashi, ×3 314
Figure 13. ditto., ×2.
Fignre 14. Pygidium, gen. et. sp. indet., ×1½ 327
Figures 15–17. *Homagnostus euryrachis* Kobayashi, ×4 309
Figures 18–19. *Clavagnostus repandiformis* Kobayashi, ×6 307
Figure 20. *Clavagnostus* cfr. *repandiformis* Kobayashi, ×6 308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PA1953
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4 PA1947
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15 PA1925
11 PA1954
9
PA1952
14 PA1968
18 PA1922
16 PA1926
19 PA1923
20 PA1924
17 PA1927.

Explanation of Plate III

Figures 1–3. *Lecanopleura glabella*, KOBAYASHI, (nov.), ×2 324
Figure 4. ditto., ×3
Figures 5–6. *Schmidtaspis sibiricus*, KOBAYASHI, (nov.), ×2 310
Figure 7. *Koldinia minor*, KOBAYASHI (nov.), ×3 314
Figure 8. ditto., ×2
Figures 9–10. *Koldinia micropthalma* KOBAYASHI (nov.), $\times 1\frac{1}{2}$ 313
Figures 11–12. ditto., ×1
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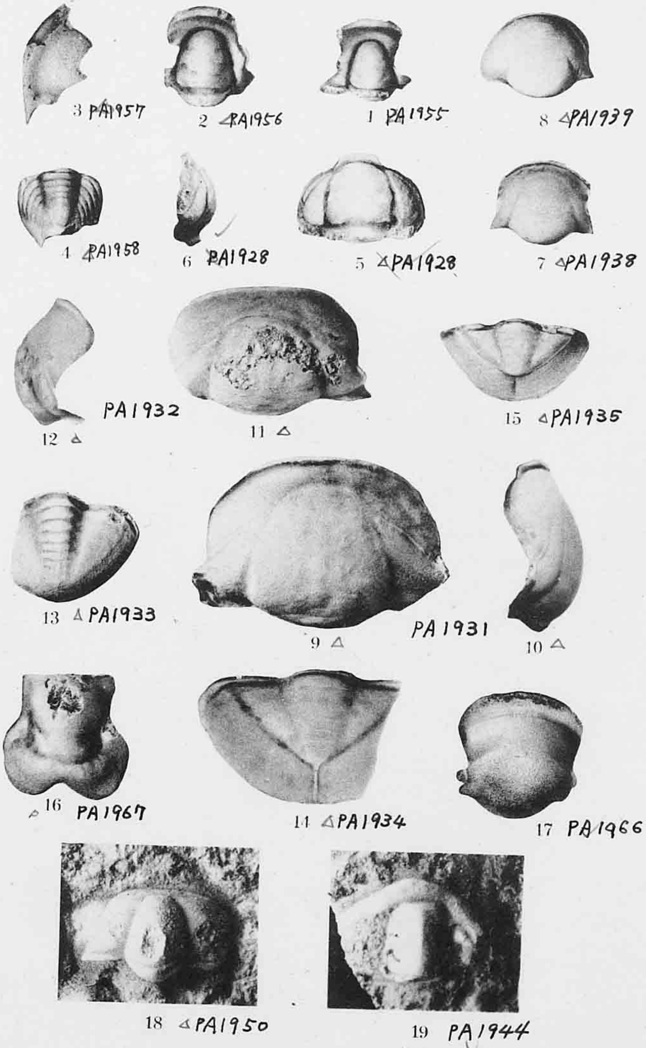
Figure 16. Hypostoma, indet. $\times 1\frac{1}{2}$ 327
Figure 17. *Esseigania tolli* KOBAYASHI (nov.), $\times 1\frac{1}{2}$ ....
Figure 18. *Modocia obrutschewi* KOBAYASHI (nov), ×5 323
Figure 19. *Bowmania lermantovae* KOBAYASHI (now.), ×5 321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PA1931
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16 PA1967
14 PA1934
17 PA1966
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19 PA1944