ISSN 0549-3927

PALAEONTOLOGICAL SOCIETY OF JAPAN
SPECIAL PAPERS
NUMBER 23

CARBONIFEROUS TRILOBITES OF JAPAN

IN COMPARISON WITH ASIAN, PACIFIC AND OTHER FAUNAS

By

Teiichi KOBAYASHI and Takashi HAMADA

PUBLISHED BY THE SOCIETY
December 15, 1980

Special Papers, Palaeontological Society of Japan

*Number 1 (Issued September 25, 1951) Bibliography of Japanese Palaeontology and Related Sciences, 1941-1950 ....Compiled by Riuji ENDO

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Editor: Tsugio SHUTO
Associate Editors: Ienori FUJIYAMA and Juichi YANAGIDA

This publication is printed by
the GRANT IN AID of the MINISTRY of EDUCATION, SCIENCE and CULTURE

All Communications relating to this publication should be addressed to
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c/o Department of Geology, Faculty of Science, Kyushu University, Fukuoka 812

CARBONIFEROUS TRILOBITES OF JAPAN IN COMPARISON WITH ASIAN, PACIFIC AND OTHER FAUNAS*

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Abstract

KOBAYASHI, T. and HAMADA, T. (1980) : Carboniferous Trilobites of Japan with Asian, Pacific and other Faunas. *Palaeontol. Soc. Japan, Sp. Pap. No. 23*, pp. 1-131, pls. 22., 5 tables, 8 fossil lists and 4 text-figures.

This is the third monograph in the series of studies on the Japanese trilobites. Now the Carboniferous trilobites of Japan are considerably enriched as much as they attain forty-one species. They belong to twenty-one genera in the Brachymetopidae and seven subfamilies of the Proetidae, namely the Proetinae, Cyrtosymbolinae, Phillipsiinae, Linguaphillipsiinae, Cumingellinae, Griffithidinae and Ditomopyginae. Twenty-eight of these trilobites are new, beside eight new species already instituted in advanced papers by KOBAYASHI, HAMADA and TACHIBANA in 1978. *Schizophillipsia* and *Parvidumus* are two new genera. They are in the range from Tournaisian to Moscovian. Little is as yet known of Upper Carboniferous trilobites in Japan.

These trilobites were found in non-calcareous rocks in two districts of the Kitakami mountains, North Japan and in limestones of four districts in the Inner Zone of West Japan. None has so far been discovered in the Outer Zone. Seven faunules are distinguishable in the Kitakami trilobites, precisely five Tournaisian faunules and two Visean ones. In West Japan the Hina faunule is middle or upper Tournaisian in age. It is followed by the long-ranged and wide spread *Cummingella* faunule from Visean to Moscovian. Thus the late Tournaisian and Visean trilobites of North Japan and West Japan are contemporaneous with, but quite different from each other in the generic composition. In fact there is no common genus between these two except for a pygidium of *Linguaphillipsia* from the Omi limestone and an aberrant *Brachymetopus* species from the Hikoroichi Series. Such a remarkable difference should depend principally upon the physical environment as indicated by the dissimilar lithofacies between the axial zone of the Chichibu geosyncline and its continental margin.

The trilobite assemblage changed successively in the Kitakami facies from a faunule to another, while the change is very slow and weak in the Inner Zone of West Japan where all

* Studies of Japanese Trilobites and Associated Fossils-XX.

trilobites are contained in similar limestones. Remarkably enough, *Cummingella* survived in the Akiyoshi limestone plateau where its relic species is contained in the *Fusulinella biconica* zone.

The Carboniferous trilobites of Japan reveal their intimate relationship to other Eurasian faunas. Their affinities are evidently closer to the Australian trilobites than the North American ones, although such American genera as *Thigriffides* and *Griffithidella* are contained exceptionally in the Hina faunule. In adding some 20 species of China and Southeast Asia to the Japanese species the Oriental trilobites attain more than sixty species which are distributed in about thirty genera including such indigenous genera as *Cyrtosymbole* (*Dushania*), *Palaeophillipsia, Schizophillipsia, Parvidumus, Thaiaspis* (*Thaiaspis* and *Thaiaspella*) and *Humilogriffithides.*

As the result of comparative study of the Oriental trilobites with other faunas the Carboniferous provinciality is clarified. Here two realms and five provinces are distinguished beside five regions. It is concluded that the Mongolian and Tethyan geosynclinal regions were the main routes of the trans-Eurasiatic migration.

Preface

In Japan Carboniferous trilobites have been represented only by five species from two areas, but now they are profused with fresh materials so amply that they total forty one species beside indeterminable forms.

These trilobites are classifiable into two major groups or biofacies, namely the Kitakami trilobite biofacies in non-calcareous rocks in Northeast Japan and the Akiyoshi trilobite biofacies in limestones in the Inner Zone of Southwest Japan. None is so far discovered from the Outer Zone.

The Kitakami trilobites are found in two areas of the southern Kitakami mountains in strata from Tournaisian to Visean. The Akiyoshi trilobites occur in limestones from middle Tournaisian to Moscovian in four areas. No trilobite is as yet uncovered in Japan in Upper Carboniferous rocks.

These trilobites belong to twenty-one genera in the Proetidae and Brachymetopidae and seven subfamilies of the former family. The Phillipsiinae and the Cummingellinae are restricted in Japan to the Kitakami and Akiyoshi facies respectively.

The Kitakami trilobites constitute seven faunules, precisely, the Karaumedate, Choanji, Higuchi-zawa, Otsubo-zawa, Sakamoto-zawa, Odaira-yama and Yuki-sawa faunules, whereas only two faunules called Hina and *Cummingella* are distinguishable for the Akiyoshi trilobites. The *Cummingella* faunule is particularly monotonous and long ranged. In Japan *Cummingella* has survived in Japan until Moscovian. Some genera of the Cyrtosymbolinae are represented in the two biofacies.

For the purpose of the Carboniferous biogeography an extensive review of trilobites of the Asian, Pacific and other faunas is presented with reference to taxonomic comments by OSMOLSKA, G. and R. HAHN and others. The Oriental trilobites of the period total about 60 species and the Australian ones attain some 30 species. Although there are still little known areas in Asia and other continents, the authors attempted to elucidate the provinciality and migration of Carboniferous trilobites through comparison of these western Pacific trilobites with those of other part of the globe.

Based upon the present knowledge two realms are recognizable. *Cummingella* and *Linguaphillipsia* which thrived in the Old World realm are totally absent in the Mid-Continent of North America which is the principal part of the New World realm. There are, on the contrary, some indigenous genera one of which is *Ameura* known also from the Amazon basin. Eurasia is the main part of the former relam which was, however, extended into Australia as well as Arctic Canada. The Mongolian and Tethyan geosynclines were the main routes of the trans-Eurasiatic migration.

These two routes have joined in the Oriental province extending from Japan to Thai-Malaysia through China and Indochina. The Old World realm extended therefrom to Australia on one side and Arctic Canada on the other. The Oriental fauna comprises five indigenous genera and subgenera.

The palaeontological part of this monograph comprises description of all species of Japanese Carboniferous trilobites including 28 new ones. On this occasion two new genera, *Parvidumus* and *Schizophillipsia,* are instituted. Comments are given on several genera and two subfamilies.

Here the authors express their sincere thanks to Prof. N. E. TCHERNYSCHEVA and Prof. E. A. MAXIMOVA of VSEGEI, Leningrad, Prof. J. ROBERTS of the University, Kensington, New South Wales, Emeritus Professor Sotoji IMAMURA of the Hiroshima University, Prof. K. TACHIBANA of the Iwaté University, Dr. N. KAMBÉ of the Geological Survey of Japan, Prof. T. HANAI and I. HAYAMI of the University of Tokyo, Prof. S. SAKAGAMI of the Chiba University, Prof. J. YANAGIDA of the Kyushu University, Prof. M. MURATA of the Kumamoto University, Dr. M. OTA of the Akiyoshi Museum and Profs. M. KATO and K. NAKAMURA of the Hokkaido University, for assistances in various ways, and Messrs. H. ARAKI, M. FURUHASHI, K. HACHIYA, A. HAGA, T. INABA, Y. ISHIGURO, K. KITAGAWA, H. KOIZUMI, Y. MIZUNO, O. NISHIKAWA, T. ONO, K. SASAKI and M. SATO, K. SHIMIZU and K. YOSHIDA for fossil collection. Finally the authors record with high appreciation that this monograph is an outcome of a research project on the Japanese trilobites and associated fossils undertaken with a grant-in-aid of the Japan Academy and that its publication through Special Papers No. 23 of the Palaeontological Society of Japan is facilitated with a subsidy from the Ministry of Education, Science and Culture.

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Biostratigraphy

I. Carboniferous Trilobites of Japan

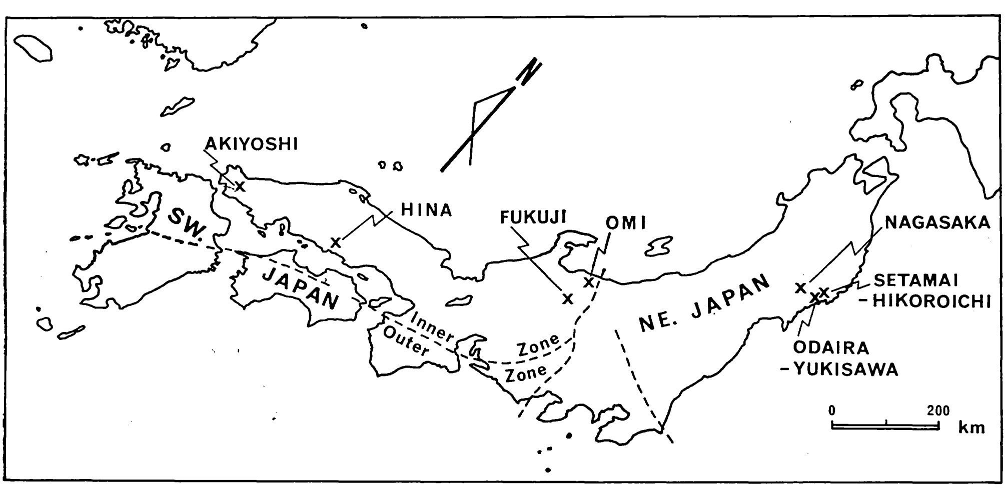
1. The Trilobite-bearing Carboniferous Formations in Japan

Fossiliferous Carboniferous formations are distributed in Japan at various places from Hokkaido to Kyushu, but as yet unknown from the Ryukyu Islands. Recently Moscovian fossils were discovered in the Hida metamorphic complex at Unazuki in the eastern Hida plateau (HIROI et al. 1978). The non-metamorphosed Carboniferous formations are generally associated with the Permian. The Carboniferous exposures are scattered extensively but Carboniferous areas are in total much less than the Permian ones.

In Southwest Japan no Carboniferous trilobite has as yet been discovered in the outer zone, but in the inner zone they are contained in the limestones at Akiyoshi and Hina in the Chugoku region and at Omi in the extreme north of the Japanese North Alps. Among them the Akiyoshi limestone is best zonated by fusulinids.

Recently a trilobite-bearing limestone-boulder was found by MIZUNO at Osobudani, Fukuji district, Yoshiki-gun, Gifu Prefecture. A cephalon of the trilobite is typical of *Cummingella*, but it probably represents a new species allied to *C. subtrigonalis* on one side and *C. mesops* on the other. Because it is known that the Ichinotani formation there ranges from upper Visean to the upper-most Carboniferous, i. e. the *Triticites exsculptus-T. hidensis* zone, it is certain that the boulder was derived from somewhere in the middle or lower part of the formation.

In Northeast Japan the best display of the Carboniferous formation is found in the southern Kitakami mountains where it is composed mostly of clastic and volcanic materials except for its upper part which is rich in limestone. The sequence of the Hikoroichi—Setamai district on the east side is the standard for the Lower Carboniferous of Japan as it is rich in corals and brachiopods. It is supplemented by the Carboniferous of the Nagasaka district on the west side.



Text-fig. 1. Localities of Carboniferous Trilobites in Japan.

2. Carboniferous Trilobites of Japan

The Carboniferous biota of Japan consists of various marine plants and animals among which foraminifers, corals and brachiopods are well profused and clacareous algae, bryozoans, molluscs, crinoids, blastoids and others belong to uncommon or less clarified groups. Recently Carboniferous conodonts are also discovered in Japan.

Little has been known of Carboniferous trilobites. *Palaeophillipsia japonica* SUGIYAMA and OKANO and *Palaeophillipsia* ? *kitakamiensis* SUGIYAMA and OKANO were described in 1944 as two upper Devonian trilobites, but later they were known to be early Carboniferous in age. The third species is *Phillipsia ohmorensis* OKUBO, 1951. All of them were collected from the Hikoroichi Series of Hikoroichi, southern Kitakami mountains, whose age is early Carboniferous.

Subsequently in 1962 ENDO and MATSUMOTO added *Humilogriffithides taniguchii* ENDO and MATSUMOTO and *Brachymetopus* (*Brachymetopina*) *japonicus* ENDO and MATSUMOTO from the lower Moscovian *Fusulinella* zone of the Omi limestone. At the same time they suggested the synonymy of *Palaeophillipsia japonica* with *Phillipsia ohmorensis* in redescribing the latter from Hikoroichi.

Beside these some Carboniferous trilobite occurrences were reported from the Nagasaka and other areas. *Linguaphillipsia* sp., *Griffithides* spp. a & b, *Weberides* ? sp. and *Phillipsia* sp. from the Visean Onimaru Series at Yuki-sawa, Yahagi, Takada city in the Hikoroichi-Setamai district were illustrated by ARAKI and KOIZUMI (1968).

In 1978 we described the following four new species in NISHIKAWA's collection from the Hina limestone and dated this faunule at middle or upper Tournaisian.

Proetus (*Pudoproetus*) *obsoletus* KOBAYASHI and HAMADA
Carbonocoryphe (*Winterbergia* ?) *orientalis* KOBAYASHI and HAMADA
Griffithidella nishikawai KOBAYASHI and HAMADA
Thigriffides ? *hinensis* KOBAYASHI and HAMADA

Then we described additional three new species, namely,

Brachymetopus (*Brachymetopella*) *akiyoshiensis* KOBAYASHI and HAMADA
Cummingella otai KOBAYASHI and HAMADA

from the Akiyoshi limestone and

Paladin longispiniferus KOBAYASHI and HAMADA

from the Onimaru Series.

Furthermore KOBAYASHI and TACHIBANA (1978) described *Conophillipsia decisegmenta*, sp. nov. from the Lower Carboniferous Karaumedate formation of the Nagasaka area. As the result the known trilobites attained thirteen species in eleven genera which were derived from seven trilobite horizons.

The trilobite fauna is so much amplified in this monograph that additional 15 species in 10 genera are distinguishable in the Kitakami trilobites and 11 more species in 4 genera in the trilobites of West Japan. Now the Carboniferous trilobites of Japan total 41 species in 21 genera.

3. Carboniferous Trilobites in the Hikoroichi—Setamai District

The Carboniferous System in the Hikoroichi—Setamai district comprising the Hikoroichi—Setamai area in the north and the Odaira—Yuki-sawa area in the south consists of the following five formations whose ages are cited behind them.

5. Nagaiwa formation········Namurian-Bashkirian
4. Onimaru formation········Upper Visean
3. Odaira formation··········Upper Tournaisian-Lower Visean
2. Arisu formation ··········Middle Tournaisian
1. Hikoroichi formation ······Lower Tournaisian

Trilobites were reported to occur in these formations except for the Nagaiwa formation, but only a few of them have so far been described.

Palaeophillipsia japonica SUGIYAMA and OKANO, 1944

Palaeophillipsia ? *kitakamiensis* SUGIYAMA and OKANO, 1944

from Choanaji, Hikoroichi village, Kesen county, Iwate Prefecture are known now to be two Hikoroichian trilobites, instead of uppermost Devonian ones. The third species of the Hikoroichian trilobites is *Phillipsia ohmorensis* OKUBO, 1951 which was collected from the hill-slope northeast of Ohmori, Hikoroichi village (=Omori, Ofunato city). This species is said to range up into the Arisu formation. *Phillipsia michelini* (L'EVILLE) is simply listed in the Odaira fauna (MINATO et al., 1953).

ONUKI (1956) first discovered Onimaruan trilobites at Onimaru and later SASAKI and KOIZUMI (1968) provisionally determined trilobites in their collection as *Linguaphillipsia* sp., *Griffithides* 2 spp., *Weberides* ? sp. and *Phillipsia* sp. Of the Nagaiwan trilobites which ONUKI (1938) found at Hotoke-zaka, Yuki-sawa, Yahagi village, the fossil locality was referred by him to the Nagaiwa formation, but to the Onimaru formation by others and no mention is given on the Nagaiwan trilobites in ONUKI's later writing (1969).

Beside them *Griffithides* ? sp. and *Phillipsia* sp. were reported by TACHIBANA (1952) from the Karaumedate formation of the Nagasaka area which is now correlated to the Hikoroichi plus Arisu formation.

Among the Yuki-sawa trilobites *Paladin* (*Weberides*) *longispiniferus*, nov. was described by KOBAYASHI and HAMADA (1978) and so *Conophillipsia decisegmenta* by KOBAYASHI and TACHIBANA (1978) among the Nagasaka trilobites.

ENDO and MATSUMOTO (1962) synonymized *Palaeophillipsia japonica* with *Phillipsia ohmorensis* and G. and H. HAHN (1973) referred it to *Linguaphillipsia*. Through this study, however, it was ascertained that the above two species are distinct from each other and the latter does not belong to *Linguaphillipsia* but to *Phillipsia*.

ENDO and MATSUMOTO intended to ignore the validity of *Palaeophillipsia*, but we hesitate to accept this opinion. As pointed out by G and R. HAHN, it is certainly allied to *Linguaphillipsia*. No topotype diagnostic of *P. japonica* has, however, been obtained. On the other hand there is *Palaeophillipsia tenuis*, nov. from the upper stream of Higuchi-zawa which agrees better with *Palaeophillipsia* than *Linguaphillipsia*. At the same time *Linguaphillipsia* is represented by three species in the Hikoroichian fauna. Therefore these two genera are here accepted as both valid.

The Lower Carboniferous trilobite fauna of Kitakami now consists of 20 species in

Fossil list 1. Lower Carboniferous Trilobites of the Hikoroichi-Setamai District, Kitakami Mountains

Trilobites	1	2	3	4	5	6
Brachymetopus (*Brachymetopella* ?) *kitagawai*, sp. nov.	c					
Phillibole arakii, sp. nov.	c					
Liobole (?) sp. indet.				×		
Phillipsia ohmorensis OKUBO	c	o g				
Phillipsia ohmorensis forma *multisegmenta*, forma nov.		o g				
Phillipsia cf. *ohmorensis*			×			
Phillipsia longiconica, sp. nov.				×		
Linguaphillipsia choanjiensis, sp. nov.	c					
Linguaphillipsia higuchizawensis, sp. nov.		g				
Linguaphillipsia aff. *higuchizawensis*		o				
Linguaphillipsia subconica, sp. nov.	c	g				
Linguaphillipsia 2 spp. indet.		g				
Linguaphillipsia (?) sp. indet.				×		
Palaeophillipsia japonica SUGIYAMA & OKANO	c					
Palaeophillipsia tenuis, sp. nov.		g				
Palaeophillipsia (?) *kitakamiensis* SUGIYAMA & OKANO	c					
Palaeophillipsia (?) sp. indet.		g				
Dechenelloides asiaticus, sp. nov.		g				
Schizophillipsia yukisawensis, sp. nov.						×
Schizophillipsia otsuboensis, sp. nov.			×			
Schizophillipsia (?) *platyrachis*, sp. nov.						×
Linguaphillipsid, gen. et sp. indet.						×
Bollandia pacifica, sp. nov.					dmx	
Parvidumus densigranulatus, sp. nov.					←d	×
Paladin carinatus, sp. nov.					×	
Paladin (?) *mizunoi*, sp. nov.	c		×			
Paladin sp.						×
Paladin (*Weberides*) *longispiniferus* KOBAYASHI & HAMADA						×

Hikoroichi Series
1. Choanji Faunule···early lower Tournaisian
   c : Choanji
2. Higuchi-zawa Faunule···late lower Tournaisian
   g : Higuchi-zawa, o : Omori

Arisu Series
3. Otsubo-zawa Faunule···middle Tournaisian

Arisu or Odaira Series
4. Sakamoto-zawa Faunule···upper Tournaisian

Odaira Series
5. Odaira-yama Faunule···lower or lower-middle Visean
   d : Odaira-yama, m : 808 m height, × : uncertain locality of Setamai area

Onimaru Series
6. Yuki-sawa Faunule···upper or middle-upper Visean

11 genera beside *Liobole* ? sp. indet. and several other indeterminable forms all of which were obtained from the Hikoroichi—Setamai district except for *Conophillipsia decisegmenta* from the Nagasaka district.

The Lower Carboniferous trilobite fauna of the Hikoroichi—Setamai district was further amplified in this monograph. As listed here, now it consists of 19 species in 10 genera beside *Liobole* (?) sp. indet. and several other exactly indeterminable forms. Among them 14 species are new to science.

They are classified here into six faunules called Choanji, Higuchi-zawa, Otsubo-zawa, Sakamoto-zawa, Odaira-yama, and Yuki-sawa. The first and second faunules constitute the Hikoroichian fauna which is the richest. Others are younger and the Yuki-sawa faunule contained in the Onimaru Series is the youngest. Thus they reveal as a whole the successive faunal change from lower Tournaisian to upper Visean.

The Hikoroichian fauna comprizes more than ten species. *Linguaphillipsia* and *Palaeophillipsia* are each represented by three species and *Phillibole*, *Phillipsia*, *Dechenelloides* and *Brachymetopus* by one species. *Linguaphillipsia subconica* and *Phillipsia ohmorensis* are characteristic of the Choanji and Higuchi-zawa faunule respectively. Precisely speaking, *Linguaphillipsia subconica* is most common at Choanji, although it occurs also at Higuchi-zawa. *L. choanjiensis* is so far restricted to occur at Choanji. *Phillibole arakii* and *Brachymetopus kitagawai* are two uncommon members of the Choanji faunule, unknown from other places. *Phillipsia ohmorensis*, *Linguaphilipsia higuchizawensis* and *Palaeophillipsia tenuis* are characteristic Higuchi-zawa trilobites, since they are found more commonly there than at Choanji and/or Omori. *Dechenelloides asiaticus* is an uncommon trilobite known only from this locality. Although there are some common species between the Choanji and Higuchi-zawa faunules, the two fossil beds are probably in different horizons. The Choanji faunule is presumably a little older than the Higuchi-zawa faunule.

Phillibole first appeared in high Upper Devonian in Europe and died out in upper Visean. It flourished in the Culm facies of Central Europe and migrated into Kentucky and Tennessee at the transition between Kinderhookian and Osagean. *Brachymetopus* is, on the contray, unknown from the Culm. However, like *Phillibole*, it is another genus appeared in the high Upper Devonian. Then it became wide-spread in Lower Carboniferous in Eurasia, North America and Australia and survived until the late Carboniferous period. *Brachymetopus* (*Brachymetopella* ?) *kitagawai* is a very small aberrant brachymetopid.

Linguaphillipsia is a Lower Carboniferous genus. *Phillipsia* is another Lower Carboniferous one. *Ph. kellyi* PORTLOCK to which *Phillipsia ohmorensis* is allied is a Tournaisian species. OKUBO considered this species an early Lower Carboniferous or Etroeungtian trilobite. *Palaeophillipsia japonica* was primarily described as a late Upper Devonian trilobite, but later it was found to be a basal Carboniferous one. They occur in the lower part of the Hikoroichi formation called Ikawa stage. Therefore the Hikoroichi fauna is here accepted to be early Tournasian in age.

As *Dechenelloides* has been represented only by two upper Tournaisian species from Frankenwald, it is unexpected to find a new species in the Hikoroichi Series in Japan. It looks more primitive than the German species in the slender outline of its glabella.

Finally, a small pygidium from Choanji is closely allied to *Paladin* (?) *mizunoi* from

Otsubo-zawa.

The Arisu formation yields two species of trilobites at Otsubo-zawa. *Phillipsia* cf. *ohmorensis* reveal alliance to the Hikoroichi fauna or Higuchi-zawa faunule. Because the Arisu directly overlies the Hikoroichi formation, it is resonable to consider that the Otsubo-zawa faunule is middle Tournaisian. The second species of the faunule is *Paladin* ? *mizunoi*. Because the known distribution of *Paladin* is upper Tournaisian and higher, *P. mizunoi* from Choanji may be a forerunner.

The Odaira-yama faunule is still younger. *Bollandia pacifica* occurs at Odaira-yama and 808 m height triangulation. It is associated with *Parvidumus densigranulatus* at the former locality. In addition, the Hokkaido University collection contains *B. pacifica* and *Paladin carinatus* from an uncertain locality in the Hikoroichi—Setamai district.

The life range of *Bollandia* and *Paladin* are respectively upper Tournaisian-Visean and upper Tournaisian-Lower Permian. Therefore the age of the faunule must be upper Tournaisian or younger. Because *Parvidumus densigranulatus* is contained in the Yuki-sawa faunule, the Odaira-yama faunule may be lower-middle Visean, if not upper Tournaisian.

Beside the last mentioned species the Onimaru formation yields *Schizophillipsia yukisawensis* and *Paladin* (*Weberides*) *longispiniferus*. The trifurcation on the free cheek is such a characteristic that it is well represented not only in two species of *Schizophillipsia* but also in the Visean species of *Linguaphillipsia* in Australia. The second species has a mucronate pygidium like *Paladin mucronata* (M'COY) whose age is upper Visean to Namurian. *Parvidumus densigranulatus* is quite a distinctive species.

The Onimaru formation is mainly composed of limestone beside clayslate which yielded the above trilobites. It is rich in various corals and brochiopods with which it is correlated to the upper Visean or middle-upper Visean.

Finally, *Phillipsia longiconica* from Sakamoto-zawa was obtained from a horizon below the Onimaru formation. Therefore it is not younger than the Odaira formation. Because it is distinct from *Phillipsia ohmorensis*, it is probably younger than lower Tournaisian and probably also middle Tournaisian. By these reasons its age is presumed to be near Arisuan, but younger than the Otsubo-zawa faunule. In other words its age may be about upper Tournaisian Incidentally, *Liobole* is distributed widely in the upper Visean rocks of Europe and Central Asia, but the occurrence of *Liobole* (?) (?) sp. indet. does not much weight for chronology, because it is represented by a pygidium whose generic reference is not warranted.

In summarizing the above statements the six faunules are tentatively dated as below:

The Choanji faunule................early lower Tournaisian
The Higuchi-zawa faunule..........late lower Tournaisian
The Otsubo-zawa faunule ....middle Tournaisian
The Sakamoto-zawa faunule........upper Tournaisian
The Odaira-yama faunule ....lower or lower-middle Visean
The Yuki-sawa faunule ....upper or middle-upper Visean

4. Carboniferous Trilobite in the Nagasaka District

The Karaumebate formation of the area is mainly composed of sandstone and shale beside some conglomerate and yields Lower Carboniferous brachiopods and other fossils in the lower and upper parts. It is underlain by the Tobigamori formation s. str. containing Upper Devonian brachiopods and other fossils. (NODA, 1934, TACHIBANA, 1952, 1963).

The occurrence of trilobites has long been known from the area (TACHIBANA, 1952, 1963). Trilobite specimens are abundant in the lower part of the Karaumedate formation at Minami-Iwairi, but they are deformed in various manners and degrees. The better ones, however, have shown that they belong to a new species of *Conophillipsia* whose distribution has been known in the Tournaisian-Etroeungtian of Australia and Central Asia. The Minami-Iwairi form is known now by the following name.

Conophillipsia decisegmenta KOBAYASHI and TACHIBANA, 1978.

This species was recently found at Nendo-yama, Minami-Iwairi in the Nagasaka district.

5. Carboniferous Trilobites of the Akiyoshi Limestone

The Akiyoshi limestone in Province Nagato, Yamaguchi Prefecture was investigated repeatedly and intensively by TORIYAMA (1958) and many others since OZAWA's epoch-making study for the Permo-Carboniferous stratigraphy of Japan in 1923. Now palaeontological studies on bryozoans, brachiopods and other fossils are improving by the efforts of SAKAGAMI, YANAGIDA and other paleontologists. The latest zonation chiefly by means of fusulinids is OTA's in which 10 Carboniferous fossil zones are distinguished in descending order as tabulated below.

Table 1. Carboniferous Fossil Zones in Akiyoshi Limestone Plateau
(OTA, 1977, YANAGIDA et al. 1977, TORIYAMA, 1978)

Upper	10 *Triticites* (s. l.) *matsumotoi* zone	Kassimovskian	
Middle	9 *Beedeina akiyoshiensis* zone	upper Moscovian	
	8 *Fusulinella biconica* zone	middle Moscovian	Fb
	7 *Akiyoshiella ozawai* zone	lower Moscovian	
	6 *Profusulinella beppensis* zone	lowest Moscovian	Pb
	5 *Pseudostaffella antiqua* zone	Bashkirian	Ps
Lower	4 *Millerella yowarensis* zone	lower-middle Namurian	My
	3 *Nagatophyllum satoi* zone	middle-upper Visean	
	2 *Zaphrentoides* sp. zone	lower Visean	
	1 *Marginatia toriyamai* zone	upper Tournaisian	Mr

The OTA's zonation reveals the advancement from the compilation of TORIYAMA, 1958, OKIMURA, 1966, OTA, 1968, TORIYAMA and OTA, 1971 and YANAGIDA, 1971 in TORIYAMA (1978). Contrary to them MINATO (1975) expressed the opinion that the *Nagatophyllum* zone containing *N. satoi* is so high as Bashikilian. This opinion contradicts against TORIYAMA and other Akiyoshi worker's conclusion. At the same time it is not accepted in the latest edition of *Geoliogy and Mineral Resources of Japan* by the Geological Survey of Japan, 1977. The *Eostaffella-Millerella* zone is generally considered to range from upper Onimaruan to lower Kamitakaran, i. e. upper Visean to Bashkirian or lower Bashkirian; the *Millerella yowarensis* zone within the range from upper Visean to lower Namurian; and the *Profusulinella beppensis* zone either upper Bashkirian or lowest Moscovian; the *Fusulinella biconica* zone middle Moscovian or main Moscovian.

The occurrence of trilobites in the Akiyoshi limestone was reported some ten years ago (1966). Recently we have described *Cummingella otai* from the *Millerella* sp. zone and *Brachymetopus* (*Brachymetopella*) *akiyoshiensis* from the *Profusulinella beppensis* zone (1978). Now the Akiyoshi trilobite fauna is considerably enriched by fresh materials from old and new localities. As the result it totals more than ten species, as shown in Fossil list 2.

Fossil list 2. Carboniferous Trilobites from Akiyoshi-dai, Yamaguchi Prefecture.

Trilobites	Fusulinid Zone						
Brachymetopus (*Brachymetopus*) *omiensis*, sp. nov.					Ps		
Brachymetopus (*Brachymetopus*) *gracilentus*, sp. nov.					Ps		
Brachymetopus (*Brachymetopella*) *akiycshiensis*		My				Pb	
Br. (*Br.*) *akiyoshiensis* forma *disjuncta*, forma nov.						Pb	
Archaegonus (*Angustibole*) *reliquius*, sp. nov.					Ps		
Archaegonus (*Angustibole*) *impolitus*, sp. nov.					Ps		
Waribole lobatus, sp. nov.					Ps		
Waribole (?) sp. indet.					Ps		
Cummingella otai		My	Mt			Pb	
Cumminella cf. *otai*						Pb	
Cummingella mesops, sp. nov.					Ps		
Cummingella granulifera, sp. nov.							Fb
Cummingella subovalis, sp. nov.				Mi			
Cummingella (?) *euryrachis*, sp. nov.						Pb	
Thigriffides aff. *hinensis*	Mr						
Free cheek and pygidium gen. et sp. indet.					Ps		

Mr: *Marginatia toriyamai* zone; Sumitomo Mine road.
My: *Millerella yowarensis* zone; Ikusei pasture, Iwanaga-dai.
Mt: *Millerella* zone; 275 m. east-south-east from trangulation at Ryuga-ho.
Mi: *Millerella* zone; Iwanaga-dai, 130 m to the south of the stream, Akiyoshi Museum.
Ps: *Pseudostaffella antiqua* zone; Maruyama quarry, Ube-kosan Co.
Pb: Lower part of *Profusulinella beppensis* zone: Nakano Shohoji.
Fb: *Fusulinella biconica* zone; Nakano Shohoji and Iwanaga-dai.

The oldest trilobite is a pygidium from the *Marginatia toriyamai* zone which is upper Tournaisian or lower Osagean according to YANAGIDA's study on brachiopods (1973). This pygidium is *Thigriffides* aff. *hinensis* suggesting alliance to the middle-upper Tournaisian Hina limestone fauna later mentioned.

Because the six zones from the *Zaphrentoides* zone (2 in table 1) to the *Akiyoshiella ozawai* zone (7) of the Akiyoshi limestone are referred to the *Eostaffella-Millerella* zone in the fusuline genus zonation in Japan by TORIYAMA (1978), part of the trilobites from the so-called *Millerella* zone (Mi in Fossil list 2) may be older or younger than *Millerella yowarensis* zone (My). It is, however, certain that the trilobites from the lower part of the *Profusulinella beppensis* zone (Pb) is lowest Moscovian and *Cummingella granulosa* from the *Fusulinella biconica* zone is Moscovian or its main part.

Except for a pygidium from of *Thigriffides* aff. *hinensis* all of the Akiyoshi trilobites are in the time range from early Visean to early Moscovian. The more definite dating of the trilobites can be made for those from the *Millerella yowarensis* zone (My), *Pseudostaffella antiqua* zone (Ps), the *Profuslinella beppensis* zone (Pb) and the *Fusulinella biconica* zone (Fb). *Cummingella otai* and *Brachymetopus* (*Brachymetopella*) *akiyoshiensis* which occur in two or more zones are long-ranged, but others are restricted their occurrences to one zone.

Because the known range of *Cummingella* is from lower Tournaisian to Namurian or lower Namurian, it must be extended as high as Moscovian by the occurrence in the *Fusulinella biconica* zone. Likewise, the upper limit of the range of *Waribole* as well as *Archaegonus* (*Angustibole*) has been lower Visean. Therefore the Japanese species of the genus and subgenus must be the latest survivors.

Brachymetus (*Brachymetopella*) as a subgenus is represented by four species from Yugoslavia, the Urals and Central Asia in the range from Gshelian down to Visean or Dinantian. The life range of *Brachymetopus* is much longer. Therefore all of the Akiyoshi brachymetopids are within the known generic or subgeneric range. The abundance of *Cummingella* is quite characteristic of the Akiyoshi limestone fauna.

6. Carboniferous Trilobites from the Hina Limestone

The Hina limestone at Hina, Shigi, Yoshii town, Shitsuki county, Okayama Prefecture is the southern projection of the Oga limestone plateau in Central Chugoku, West Japan. It was about fifty years ago that OZAWA identified *Nagatophyllum satoi* in a fossil collection made by AKAGI (1930) from the Hina limestone and suggested Lower Carboniferous for the age of the limestone. Some years ago trilobites and other fossils were collected from the limestone by Isao NISHIKAWA. As reported already by KOBAYASHI and HAMADA (1978), four species of trilobites were distinguished and upper Tournasian was suggested for this faunule.

The Hina limestone lens thrusts itself upon the Upper Triassic Nariwa Series on the south side, and on the north side it is limited from the Permian formation by a fault. This lenticular mass is strongly complicated by faulting and folding of different magnitudes. Therefore its stratigraphic sequences is very difficult to determine exactly. According to HASE and YOKOYAMA (1975) it consists of the Main Limestone and the basal Schalstein in the latter of which small limestone lenses, nodules and layers are intercalated. In the Main Limestone two brachiopod faunules are distinguished, namely,

the *Spirifer* sp. aff. *S. besnossovae* faunule of the lower Visean age or the *Endothyra* zone, and

the *Striatifera striata* faunule of the Upper Visean age of the *Eostaffella-Millerella* zone.

In NISHIKAWA collection from the Hina limestone the following species of trilobites were discriminated.

Pudoproetus obsoletus KOBAYASHI and HAMADA, 1978
Pudoproetus obsoletus forma *granulatus*, forma nov.
Waribole (?) sp. indet.
Carbonocoryphe (*Winterbergia* ?) *orientalis* KOBAYASHI and HAMADA, 1978
Cummingella (?) sp. indet.
Griffithidella nishikawai KOBAYASHI and HAMADA, 1978
Thigriffides hinensis KOBAYASHI and HAMADA, 1978
Thigriffides (?) *kibiensis*, sp. nov.
Paragriffithides japonicus, sp. nov.

Pudoproetus was created by HESSLER (1963) as a subgenus of *Proetus*. Its age ranges from lower Kinderhookian through lower Osagean, if *Proetus* (*Pudoproetus*) *hahni* CHAMBERLAIN, 1977, the solitary survivor in the Moscovian of Ellesmere Island is excluded. It was widely distributed in the United States of America on one side and in the Urals, the Kirghiz Steppe, the Altais, Turkestan and further in Australia (New South Wales) on the other. It appeared already in the Etroeungtian in the Urals and most flourished in the early Tournaisian age (HAHN, 1969).

Upper Kinderhookian *Thigriffides roundyi roundyi* (GIRTY, 1926) is the type-species of *Thigriffides*. It is a rare genus, but its close ally is *Griffithidella* which is widely spread in the upper Kinderhookian and lower Osagean rocks. According to G. and R. HAHN (1970) *Griffithidella*, in which they include *Thigriffides* as a subgenus, is distributed not only in North America but also in the Soviet Union in the upper Tournaisian and lower Visean and further in Australia.

According to HAHN and BRAUCKMANN (1975) *Carbonocoryphe* is a middle and upper Dinantian genus except for *C.* (*Aprathia*) *bifurca* which survived until early Namurian from Visean. The known occurrences of the genus have been restricted to the area from Spain to the Urals through North and Central Europe (England, West Germany and Mähren). Therefore this is the first record of occurrence outside the above domain.* The Japanese species is, however, not diagnostic of any of its four subgenera. Nevertheless it agrees best with the subgenus *Winterbergia* which reveals the trunk of the genus most flourished in the late Tournaisian age. Therefore *C. orientalis* would be an isolate branch issued from the trunk in the early stage of the generic evolution.

The range of *Cummingella* as a genus is from lower Tournaisian to Namurian. *Paragriffithides* REED, 1943 was founded on the monotypic species, *Phillipsia carinata* SALTER, 1884 (pygidium) from the Carboniferous limestone of Derbyshire, Great Britain and its more accurate age is unknown.

Insofar as one can judge from the above generic composition the age of the Hina trilobite faunule is definitely within the range from Tournaisian to lower Visean or from Kinderhookian to lower Osagean.

Pudoproetus obsoletus is allied to lower Tournaisian *P. eminens* and early Kinderhookian *P. missouriensis* in one or another aspect. *Thigriffides hinensis* is similar to

* Recently *Carbonocoryphe* (*Aprathia*) *idahoensis* n. sp. was described from the Iron Bog Creek Formation, Idaho. Its close similarity to *C.* (*A.*) *emanueli* from the middle Visean of the German Culm facies indicates a Visean or early late Mississippian assignment to the trilobite-bearing formation (HAHN, PAUL and CHAMBERLAIN, 1980).

upper Kinderhookian *T. rouneyi*. So is *Griffithidella nishidai* to *G. doris* of the upper Kinderhookian—lower Osagean age. It is noted further that *Winterbergia* as a subgenus of *Carbonocoryphe* developed greatly in the late Tournaisian age.

Not only the above specific alliance but also the generic or subgeneric acmic prominence suggest that middle or upper Tournaisian and upper Kinderhookian of North America would be most probable for the age of the trilobite assemblage. In other words the Hina trilobite horizon is possibly a little older than the *Marginatia toriyamai* zone, if the zone is the lower Osagean age.

Finally it is noteworthy that *Thigriffides* shows the faunal affinity to the North

Fossil list 3. Carboniferous Trilobites of the Inner Zone of West Japan.

Brachymetopus japonicus			3	
Brachymetopus (*Brachymetopus*) *omiensis*, sp. nov.		2	3	
Brachymetopus (*Brachymetopus*) *gracilentus*, sp. nov.		2		
Brachymetopus (*Brachymetopella*) *akiyoshiensis*		2		
Br. (*Br.*) *akiyoshiensis* forma *disjuncta*, forma nov.		2		
Pudoproetus obsoletus	1			
P. obsoletus forma *granulatus*, forma nov.	1			
Phillibole (*Angustibole*) *reliquius*, sp. nov.		2		
Phillibole (*Angustibole*) *impolitus*, sp. nov.		2		
Waribole lobatus, sp. nov.		2		
Waribole sp. indet.		2		
Waribole (?) sp. indet.	1			
Carbonocoryphe (*Winterbergia* ?) *orientalis*	1			
Linguaphillipsia sp. nov.			3	
Cummingella otai		2	3	
Cuumingella cf. *otai*		2		
Cummingella subtrigonalis, sp. nov.			3	
Cummingella mesops, sp. nov.		2	3	
Cumuingella granulifera, sp. nov.		2		
Cummingella imamurai, sp. nov.			3	
Cummingella subovalis, sp. nov.		2		
Cummingella sp. indet.				4
Cummingella (?) *euryrachis*, sp. nov.		2		
Cummingella (?) sp. indet.	1			
Griffithidella nishikawai	1			
Thigriffides hinensis	1			
Thigriffides aff. *hinensis*		2		
Thigriffides (?) *kibiensis*	1			
Paragriffithides japonicus, sp. nov.	1			
Humilogriffithides taniguchii			3	
Free cheek & pygidium, gen. et sp. indet.		2		
Pygidia, gen. et spp. indet.		2		

1. Hina limestone; 2. Akiyoshi limestone; 3. Omi limestone; 4. Fukuji district.

American trilobites, while *Carbonocoryphe* and *Paragriffithides* are typical of the Culm and Kohlenkalk fauna respectively. *Cummingella* is an additional Eurasiatic genus. Therefore the Hina trilobites are Eurasiatic, although *Thigriffides* is included among them.

7. Carboniferous Trilobites from the Omi Limestone

Since HAYASAKA (1924) had discovered Lower Carboniferous fossils and distinguished several Permo-Carboniferous fossiliferous horizons in the thick massive limestone of Omi, KAWADA (1954), FUJITA (1958), SAKAGAMI (1962-63), IGO and KOIKE (1964), WATANABE (in IGO, 1969), HASEGAWA (1969) and others elaborated its fossil zonation. Now the *Millerella, Profusulinella, Fusulinella* and *Triticites* zones are well established in the Carboniferous part. HASEGAWA (1969) recognized the *Eostaffella-Millerella* zone and *Endothyra* zone below the *Profusulinella* zone. According to WATANABE, (1969 MS in IGO, 1978, Carbon. Comm. Rep.) the lowest conodont horizon is the *Gnathodus bilineatus* assemblage zone whose age is lower Visean.

ENDO and MATSUMOTO (1962) described two species of trilobites from the Omi limestone as follows:

Brachymetopus (Brachymetopina) japonica ENDO and MATSUMOTO
Humilogriffithides taniguchii ENDO and MATSUMOTO

Both of them are said to have been derived from the lower Moscovian *Fusulinella* zone at Nishiyama limestone quarry of Denkikagaku Company, Omi town.

On this occasion the following trilobites are added to the Omi fauna.

Brachymetopus (Brachymetopus) omiensis, sp. nov.
Linguaphillipsia, sp. nov.
Cummingella otai KOBAYASHI and HAMADA
Cummingella subtrigonalis, sp. nov.
Cummingella mesops, sp. nov.
Cummingella imamurai, sp. nov.

Their horizons are difficult to say exactly with reference to the fusulinid zones. However, *Linguaphillipsia* sp. indet. may be the oldest among them, because the generic range of *Linguaphillipsia* is from lower Tournaisian to upper Visean.

Like the Akiyoshi fauna *Cummingella* is well represented in the Omi fauna. Between them two species are common. As noted already, *Cummingella otai* is long-ranged, but *C. mesops* is found only from the *Profusulinella beppensis* zone whose age is lowest Moscovian.

Brachymetopus omiensis is another species contained in the Akiyoshi fauna. It was collected from the *Pseudostaffella antiqua* zone of the Bashkirian age.

In conclusion the Omi trilobites might be derived from no less than four horizons of the Omi limestone mass, namely from the Visean, Bashkirian, basal Moscovian and lower Moscovian horizons.

8. The Age and Aspect of the Carboniferous Trilobite Fauna of Japan

In the Carboniferous fauna of Japan trilobites have been a minor group represented by five species, but at present it is considerably amplified with fresh materials from old and new localities. They attain as much as forty-one species, besides some exactly indeterminable forms.

These trilobites can be classified into two major groups which represent the Kitakami trilobite facies (Kt) in non-calcareous rocks in Northeast Japan and the Akiyoshi trilobite facies (Ak) in limestone in the Inner Zone of Southwest Japan. The younger trilobites of the Kitakami facies are contemporaneous with the older ones of the Akiyoshi facies. Therefore such a difference between the two faunas depends upon not only the time-displacement but also the difference of lithofacies between the light coloured limestone of West Japan and the dark coloured non-calcareous clastic and pyroclastic rocks of North Japan. In other words this means the difference of the sedimentary environment. No Carboniferous trilobite has so far been discovered from the Outer Zone of West Japan.

The trilobites of these two biofacies belong to twenty genera in two families and seven subfamilies in the Proetidae as follows:

I. Proetidae
  1. Proetinae: *Pudoproetus* (Ak), *Conophillipsia* (Kt).
  2. Cyrtosymbolinae: *Archaegonus* (*Angustibole*), (Ak), *Waribole* (Ak), *Phillibole* (Kt), *Carbonocoryphe* (Ak).
  3. Phillipsiinae: *Phillipsia* (Kt).
  4. Linguaphillipsiinae: *Linguaphillipsia* (Kt, Ak), *Palaeophillipsia* (Kt), *Dechenelloides* (Kt), *Schizophillipsia* (Kt).
  5. Cummingellinae: *Cummingella* (Ak).
  6. Griffithidinae: *Bollandia* (Kt), *Parvidumus* (Kt), *Griffithidella* (Ak), *Thigriffides* (Ak), *Paragriffithides* (Ak), *Humilogriffithides* (Ak).
  7. Ditomopyginae: *Paladin* (*Paladin, Weberides*) (Kt).

II. Brachymetopidae, Brachymetopinae: *Brachymetopus* (*Brachymetopus*) (Ak), *B.* (*Brachymetopella*) (Ak, ? Kt)).

Among the genera in the above list two new genera and one new subgenus are *Schizophillipsia*, *Parvidumus* and *Brachymetopus* (*Brachymetopella*). These two genera in addition to *Palaeophillipsia* are so far indigenous to Japan. *Humilogriffithides* is endemic to the Far East, from Northeast China (South Manchuria) to Japan, but all others are more widely distributed.

The Phillipsiinae and Ditomopyginae are restricted in Japan to the Kitakami facies and so are the Cummingellinae to the Akiyoshi facies, but others are contained in the two facies. In the generic level none is common between the two facies except for *Linguaphillipsia* and *Brachymetopus*. The former is an important genus in the Kitakami facies, but it is represented in the Akiyoshi facies by one pygidium from the Omi limestone. The latter is a common genus in the Akiyoshi facies and the Choanji species is an aberrant one oldest in Japan.

As listed here forty one species of Carboniferous trilobites are recognized now from Japan twelve of which were already described, but the remainder's description is first published through this monograph. The source rocks of the Japanese trilobites are as

Fossil list 4. Carboniferous Trilobites of Japan

Biofacies / Area / Trilobites	Kitakami					Akiyoshi		
	K	Hi	Ar	Od	On	Hn	A	Om
Brachymetopus omiensis							Ps	Om
Brachymetopus gracilentus							Ps	
Brachymetopus (*Brachymetopella* ?) *akiyoshiensis*							My, Pb	
Brachymetopus (*Brachymetopella*) *japonicus*								F
Brachymetopus (*Brachymetopella* ?) *kitagawai*	×							
Pudoproetus obsoletus						×		
Conophillipsia decisegmenta	×							
Archaegonus (*Angustibole*) *reliquius*							Ps	
Archaegonus (*Angustibole*) *impolitus*							Ps	
Waribole lobatus							Ps	
Phillibole arakii		×						
Carbonocoryphe (*Winterbergia* ?) *orientalis*						×		
Phillipsia ohmorensis		×						
Phillipsia longiconica		×						
Linguaphillipsia choanjiensis		×						
Linguaphillipsia higuchizawensis		×						
Linguaphillipsia subconica		×						
Palaeophillipsia japonica		×						
Palaeophillipsia tenuis		×						
Palaeophillipsia ? kitakamiensis		×						
Dechenelloides asiaticus		×						
Schizophillipsia yukisawensis					×			
Schizophillipsia otsuboensis			×					
Schizophillipsia ? platyrachis					×			
Cummingella otai							My, M, Pb	
Cummingella subtrigonalis								C
Cummingella mesops							Ps	
Cummingella granulifera							Fb	
Cummingella imamurai								C
Cummingella subovalis							M, Pb	
Cummingella ? eurypyge							Pb	
Bollandia pacifica				×				
Parvidumus densigranulatus				×	×			
Griffithidella nishikawai						×		
Thigriffides hinensis						×		

Thigriffides ? kibiensis						×		
Paragriffithides japonicus						×		
Paladin carinatus				×				
Paladin ? mizunoi		×						
Paladin (Weberides) longispiniferus					×			
Humilogriffithides taniguchii								F

K : Karaumedate Series, Nagasaka; Hi : Hikoroichi Series, Ar : Arisu Series, Od : Odaira Series, On : Onimaru Series, Hikoroichi-Setamai, Hn : Hina limestone, Okayama Prefecture, A : Akiyoshi limestone, Yamaguchi Prefecture, Om : Omi limestone, Niigata Prefecture.
My : *Millerella yowarensis* zone, M : *Millerella* zone, Ps : *Pseudostaffella* zone, Pb : *Profusulinella beppensis* zone, Fb : *Fusulinella biconica* zone, C : *Cummingella* zone, F : *Fusulinella* zone.

follows :

I. Kitakami trilobite biofacies in the southern Kitakami mountains (Kt).
- Nagasaka district
  - K : Karaumedate Series
- Hikoroichi-Setamai district
  - Hi : Hikoroichi Series
    - Choanji faunule (c)
    - Higuchi-zawa faunule (g)
  - Ar : Arisu formation
    - Otsubo-zawa faunule (k)
    - Sakamoto-zawa faunule (s)
  - Od : Odaira formation : Odaira-yama faunule
  - On : Onimaru formation : Yuki-sawa faunule

II. Akiyoshi trilobite biofacies in the Inner Zone of Southwest Japan (Ak).
- A : Akiyoshi limestone, Yamaguchi Prefecture
  - Mr : *Marginatia toriyamai* zone
  - My : *Millerella yowarensis* zone
  - M : *Millerella* zone
  - Ps : *Pseudostaffella antiqua* zone
  - Pb : *Profusulinella beppensis* zone
  - Fb : *Fusulinella biconica* zone
- Hn : Hina limestone, Okayama Prefecture
- Om : Omi limestone, Niigata Prefecture
  - C : *Cummingella* horizon
  - F : *Fusulinella* zone

8-a. The Kitakami Trilobite Facies

The oldest of these trilobites would be *Conophillipsia decisegmenta* which is a solitary species in the Karaumedate formation, although it yields a few other indeterminable forms. The age of the trilobite is lower Tournaisian, if not Etroeungtian. *Conophillipsia* shows affinities to the Australian fauna on one side and to the Central Asiatic one on the other.

The Hikoroichian formation which is generally considered lower Tournaisian contains, *Phillipsia, Linguaphillipsia, Palaeophillipsia, Dechenelloides, Phillibole* and *Brachy-*

metopus (*Brachymetopella* ?). The last genus is represented by an aberrant form. *Phillibole* was flourished in England and Central Europe, particularly in the Culm facies except for one species occurring in the lower Kinderhookian in the United States of America. This is the first occurrence in Asia. *Dechenelloides* has been a small genus in the upper Tournaisian of Germany. The Japanese species is quite isolated and older. It looks more primitive.

Phillipsia str. is widely distributed in Eurasia and possibly in Australia. The allied phillipsids in North America are distinguished as *Elliptophillipsia*. *Linguaphillipsia* is well represented in Eurasia and Australia, but unknown from the Culm facies and geographically it is not recorded from the Americas. *Palaeophillipsia* is its close ally but endemic to Japan.

The Hikoroichian fauna consistes of the Choanji and Higuchi-zawa faunules of which *Linguaphillipsia subconica* and *Phillipsia ohmorensis* are the respective leading species. It is a copious fauna composed of more than ten species in six genera, but none of them is known from the Americas. If the endemic genera are excluded, they are Eurasiatic, and the distribution of *Linguaphillipsia* and *Phillipsia* is extending into Australia. As discussed elsewhere (1978), *Linguaphillipsia* reveals that the route of its migration was the Tethyan sea which was trifurcated in Southeast Asia and a branch route was directed toward Eastern Australia.

It is certain that the Otsubo-zawa faunule belongs to the Arisu fauna, but the reference of the Sakamoto-zawa trilobite horizon to the Arisu formation is still provisional. These two faunules are poor ones composed of three species in each. *Schizophillipsia otsuboensis* is the most important species. This as well as *Phillipsia* cf. *ohmorensis* suggest the connection of this faunule to the Hikoroichian fauna. *Paladin* ? *mizunoi* may be a progenitor of *Paladin*.

Among three species of the Sakamoto-zawa faunule most important is *Phillipsia longiconica*, since the two others are *Liobole* (?) sp. indet. and *Linguaphillipsia* (?) sp. indet. which are represented by a pygidium and a cranidium respectively. The first species suggests some affinity to the Higuchi-zawa and Arisu faunules.

The Odaira-yama faunule is also composed of three species from three localities, namely *Bollandia pacifica*, *Parvidumus densigranulatus* and *Paladin carinatus*. The third species belongs to the well known cosmopolitan genus. The second species is on the other hand monotypic of a new genus. *Bollandia* is, however, a Eurasiatic genus of the upper Tournaisian-Viséan age.

It is noteworthy that *Parvidumus densigranulatus* has survived until the Onimaru age. In the Yuki-sawa faunule, however, *Schizophillipsia yukisawnsis* and *Paladin* (*Weberides*) *longispiniferus* are more common trilobites than the species. According to WELLER (1959) *Weberides* is distributed in Eur-America. *Schizophillipsia* is endemic, but it is interesting to see that the trifurcate carination on the cheeks was well developed simultaneously among the Visean species of *Linguaphillipsia* in Australia. It is fairly certain that the Onimaru formation is either upper Visean or middle-upper Visean in age. In view of the carination, the long macro of *P.* (*W.*) *longispiniferus*, and the thorny pygidium of *Parvidumus densigranulatus* the high specialization can hardly be overlooked among the Yuki-sawa trilobites. The carination of the cephalic border in the *Paladin carinatus* and the dense granulation in *Parvidumus densigranulatus* indicate that the specialization has already started in the Odaira-yama faunule.

In looking through these faunules of the Kitakami biofacies, the greatest change of the trilobite fauna has taken place between the Odaira-yama and Sakamoto-zawa faunules. It is also noteworthy that there is no typical North American genus among the Tournaisian and Visean trilobites of the Kitakami facies.

8-b. The Akiyoshi Trilobite Facies

Beside a few indeterminable forms twenty-one species in ten genera of trilobites are known from the Akiyoshi facies. They can be divided into two faunules.

The older one is the Hina faunule well represented by the trilobites from the Hina limestone whose age is upper or middle-upper Tournaisian. It yields 6 species in 5 genera, namely, *Pudoproetus*, *Carbonocoryphe*, *Griffithidella*, *Thigriffides* and *Paragriffithides*. Among them *Griffithidella* and *Thigriffides* are two characteristic genera of the American fauna, although *Phillipsia connolli* MITCHELL from Western Australia may be referable to the former genus. *Paragriffithides* and *Carbonocoryphe* are on the contray two Eurasiatic genera and the latter is an important Culm genus, though its distribution is not limited to the Culm facies. This faunal aspect is further emphasized by the associated *Waribole* sp. indet. and *Cummingella* sp. indet.

Pudoproetus is widely distributed in North America, Australia and Eurasia, but not to the west beyond the Urals. Thus the Hina limestone fauna is such an admixture, which with marked contrast to the contemporaneous Kitakami trilobites, includes two North American genera.

The oldest trilobite from the Akiyoshi limestone is represented by a pygidium from the *Marginatia toriyamai* zone of Akiyoshi-dai whose age is determined at upper Tournaisian or lower Osagean by brachiopods. It is *Thigriffides* aff. *hinensis* suggesting its belonging to the Hina faunule.

The younger one is the *Cummingella* faunule known from Akiyoshi-dai, Yamaguchi Prefecture, Fukuji, Gifu Prefecture and Omi, Niigata Prefecture. Its age is from lower Visean to Moscovian or middle Moscovian. It consists of fifteen species in five genera, namely, *Archaegonus* (*Angustibole*), *Waribole*, *Cummingella*, *Humilogriffithides* and *Brachymetopus* (*Brachymetopus*, *Brachymetopella*), beside *Linguaphillipsia* sp. indet.

Cummingella is the leading genus. Hence the name *Cummingella* faunule. In Japan the genus probably appears first in the Hina faunule. Subsequently it flourished so much that it includes seven species occuring in four or more fusulinid zones. *Cummingella* is the typical Eurasiatic genus, although it may occur in Australia. The known range of the genus has been from lower Tournaisian to lower Namurian, but it survived in Japan until the middle Moscovian age, as it is contained in the *Fusulinella biconica* zone.

Likewise, the subfamily Cyrtosymbolinae is said to have died out in the Urals in the early Namurian age. Therefore the authors were surprised to see in the collection from the *Pseudostaffella antiqua* zone some trilobites which reveal close resemblances with *Archaegonus* (*Angustibole*) and *Waribole* in their subconical glabellae and other aspects. It is also surprising that not only in these genera, but also *Carbonocoryphe* occur in Japan in limestones with marked contrast to their great developement in the

Culm facies in Europe.

Brachymetopus is cosmopolitan but absent in the Culm facies. It is so well represented in the Akiyoshi faunule by two species of *Brachymetopus* (*Brachymetopus*) and another two of *Brachymetopus* (*Brachymetopella*).

Humilogriffithides is an endemic genus of the Far East. *H. taniguchii* is not accompanied by *Cummingella* in the *Fusulinella* zone of the Omi limestone. However, it is provisonally included in the Akiyoshi faunule as it occurs in association with *Brachymetopus japonicus.*

The *Cummingella* faunule is as a whole Eurasiatic. *Cummingella* is usually present in the faunule except for the *Humilogriffithides tanigachii* horizon which, however, contains *Brachymetopus*, another common genus. Thus the *Cummingella-Brachymetopus* faunule is very monotonous. It suffered little change from Visean to Moscovian. There was a great faunal change between the Hina and *Cummingella* faunules. It happened almost simultaneously with the pre-Odaira-yama change in the Kitakami biofacies.

8-c. The Correlation of the Carboniferous Trilobite Faunules in Japan and their Bearing on the Geological History

The Carboniferous formation as well as the older and younger Palaeozoic ones in Japan were all deposited in the Chichibu geosyncline. The trilobite-bearing Lower Carboniferous sediments of the southern Kitakami mountains mostly composed of clastic, pyroclastic and volcanic materials were accumulated in the axial zone of the geosyncline where the submarine volcanic eruption was repeated, but the intrageosynclinal volcanism declined and the calcareous rocks became the principal sediment in the Onimaru formation and the Namurian--lower Moscovian Nagasaka formation. The geological age of these formations determined chiefly by corals, brachiopods and other fossils is checked by the trilobites.

In the Inner Zone of West Japan the oldest dated Carboniferous sediment is the Hina limestone formation in the lower part of which limestone layers and lenses are interbedded with pyroclastic rocks. The limestones are, however, well developped in the Visean and higher part of the Akiyoshi facies. They were accumulated in the shallow sea on the continental side of the geosyncline and well zonated chiefly by fusulinids. Because the age determination of the trilobite faunules in the Akiyoshi and Kitakami facies has already been discussed in some length, a tentative correlation on the basis of its result is shown here in table 2.

The Kitakami trilobite facies is represented by seven faunules in two districts which are close-set in the Kitakami mountains. Although the two *Conophillipsia* localitities lie in the isolate Nagasaka district, its horizon may be the oldest, if not coeval with the trilobite beds of Choanji. As detailed already, six faunules are distinguishable in the Hikoroichi-Setamai district, as they are each well designated by its own generic assemblage. In other words, the assemblages have changed one after another from early Tournaisian to late Visean. The greatest change has taken place between the Otsubo-zawa and Sakamoto-zawa faunules on one side and the Odaira-yama and Yukisawa faunules on the other. This change has occurred just about at the transition

Table 2. Age of Carboniferous Trilobite Horizons in Japan

Age \ Area		Northeast Japan		Southwest Japan (Inner Zone)			
		Hikoroichi-Setamai	Nagasaka	Akiyoshi limestone		Hina limestone	Omi limestone
Stephanian							
Moscovian	U						
	M			*Cummingella*	*granulifera*		
	L				*otai*, upper		*Humilogriffithides*
Bashkirian					*mesops*		*C. mesops*
Namurian	A				*otai*, lower		*C. otai*, lower
Visean	U	Yuki-sawa					*Linguaphillipsia*
	L	Odaira-yama					
Tournaisian	U	Sakamoto-zawa		*Th.* aff. *hinensis*		Hina faunule	
	M	Otsubo-zawa					
	L	Higuchi-zawa					
		Choanji					
			Minami-Iwairi				

from Tournaisian to Visean. Assuming that the faunal change is inseparable from the change of the physical condition, these changes have something to do with the crustal unstability of the axial zone in the Chichibu geosyncline. No strong discordance can, however, recognized in the Carboniferous sequence of the southern Kitakami mountains, although the intrageosynclinal volcanism was violent before the Onimaru age.

Only two faunules are known of the Akiyoshi trilobite facies, but it is distributed so extensively that it is found at four separate areas in the Inner Zone of Southwest Japan. Accepting the same assumption, this monotonous aspect and wide distribution of the facies mean probably the stability of the marginal zone of the Chichibu geosyncline in the prolonged period.

Notwithstanding the fact that the Hina faunule is pene-contemporaneous with the Otsubo-zawa and Sakamoto-zawa faunules, there is no common genus. While the former is such an admixture as already pointed out, no American genus is contained in the latter two faunules. The difference between the Hina and *Cummingella* faunules is no less than that between the Sakamoto-zawa and Odaira-yama faunules, if the disappearance of the North American genus in the *Cummingella* faunule is taken into account.

The *Cummingella* faunule ranges from Visean to Moscovian. In the Akiyoshi limestone plateau trilobites occur in four distinct fusulinid zones as follows:

Millerella yowarensis zone: upper Visean-Namurian s. str.
Pseudostaffella antiqua zone: main Bashkirian
Profusulinella beppensis zone: lowest Moscovian
Fusulinella biconica zone: main Moscovian

There are still some disagreements on the correlation of these zones to the European and North American Carboniferous sequenses. Here the age is cited behind each zone, in weighing the opinions of TORIYAMA, OTA and others. In comparison with the other faunules it is certainly a remarkable fact that the *Cummingella* faunule is little localized and very persistent, inspite of its long time-range.

During the Carboniferous period the Inner Zone of West Japan was located near the continental margin. There the *Cummingella*-bearing limestones were successively accumulated without any strong discordance except for a fossil hiatus at the top. The persistent quietude permitted for *Cummingella* and cyrtosymbolids to survive after their disappearance in Europe which was due to a great change in palaeogeography and palaeo-environment by the Variscan orogeny, particularly intense in the Sudetian phase.

In the early Dinantian times submarine eruptions were repeated in the Chichibu geosyncline. The sea bottom was unstable at that time in its axial zone where the Southern Kitakami mountains were located. The strong influrence of these events is indicated clearly in the spatiotemporal variation of the trilobite assemblages. There was, however, no crustal movement comparable to the Variscan orogeny, because it is quite certain at present that there is no strong discordance in the Carboniferous sequence of the southern Kitakami mountains, in the Nagasaka district (TAZAWA and OSAWA, 1979) as well as in the Hikoroichi district (MORI and TAZAWA, 1980).

II. Carboniferous Trilobites in Asian, Pacific and other Areas

9. Carboniferous Trilobites of China

In China *Phillipsia obtusicauda* KAYSER, 1883, is the oldest known species among the Upper Palaeozoic trilobites. It was described from Loping, Kiangsu, Central China as a Carboniferous trilobite, but it is known now to be one of Upper Permian species, as it is a Lopingian member. It was once referred to *Griffithides* by FRECH (1911) and to *Pseudophillipsia* by ENDO and MATSUMOTO (1970) at another. Recently its taxonomic position was exactly allocated at *Pseudophillipsia* (*Pseudophillipsia*) by G. HAHN and BRAUCKMANN (1957) through its type-revision.

The next oldest is LOZCY's which has been described by him as a Permo-Carboniferous trilobite from grey marly limestone at Teng-tjan-tsching, near Lan-tschou-fu, Kansu, North China. It was primarily cited as *Phillipsia* aff. *eichwaldi* (1890). Later in 1899 he proposed *Phillipsia kansuensis* for it with some cephalic fragments and well preserved pygidia among which were illustrated a left cheek and three pygidia but no cranidium. He compared this species with *Ph. eichwaldi* and *Ph. roemeri*, now two *Paladins* and *Ph. sumatrensis* and *Ph. obtusicauda*, two *Pseudophillipsias* but it is referred to *Ditomopyge* by G. and R. HAHN (1970). Its horizon is cited as "Mergeliger Fusulinen-Kalk des Moscovium", while the type locality and horizon are Lower Carboniferous at Shantan, Kansu according to LU et al. (1965). These authors added two other localities of the same species, namely, Middle(?) Carboniferous at Fangshenpu, Yentai, Liaonyang-hsien, Liaoning and the Wushan limestone at Taning-hsien, Szechuan.

When OZAWA (1927) described a pygidium from the *Schwagerina princeps*-bearing limestone at Fangshepu, Yentai coal-field, Liaoning, Northeast China, he identified it to GIRTY's *Phillipsia* sp. a from the Wushan limestone of Taning, east Szechuan whose age was considered by GIRTY (1913) to be Pennsylvanian. According to him *Phillipsia* sp. a is represented by a pygidium resembling *Phillipsia scitula* MEEK and WORTHEN, namely a *Ditomopyge*. On that occasion GIRTY described *Phillipsia* sp. b. from the Pennsylvanian near Tsaikianchuang, Shantung, but it was not illustrated.

Phillipsia cf. *kansuensis* is cited to occur in the Middle Carboniferous Penchi Series near Tsinan in the Table of Areal Stratigraphy in China, 1956, p. 237.

It is said further in the Chinese Carboniferous System by YANG et al. (1964, p. 22) that *Phillipsia kansuensis* is contained in the lower part of the Visean Ch'ouniukou suite on the northern slope of the Kilienshan, i. e. Nanshan. According to G. and R. HAHN (1970) the age of *Ditomopyge kansuensis* is restricted to Moscovian and its occurrences are cited ? Samara (the Soviet Union) and eventually the Carnic Alps, Austria and South Dalmatia, Yugoslvia from the references. It is, however, hardly warranted that the species was so widely distributed in Eurasia in the Moscovian age. It is another question whether its specific range was so long in China from lower Visean to Uralian.

LOCZY's three pygidia of *P. kansuensis* fairly vary in outline and in the relative width of the axis to the pygidium. The outlines of these pygidia and also GIRTY's *Phillipsia* sp. a are comparatively long for *Ditomopyge*. Their axial rings are 15 to 18 in LOZCY's, 18 to 20 in GIRTY's and 18 in OZAWA's pygidium, while they number 11 to

15 in *Ditomopyge* according to WELLER, 1936. As stated by G. and R. HAHN these pygidia are in the transitional domain between *Ditomopyge* and *Pseudophillipsia*. Little is known of their cephala. Whether the so-called *kansuensis* has the median preoccipital lobe is an important question.

Ditomopyge yungchangensis WANG, 1937 from the upper part of the Opo Series, Yungchang, Kansu has the lobe in question. Its pygidium is broader than in the preceding species and its axis composed of 12 to 15 rings. Its age is said Upper Carboniferous, instead of Lower Permian as primarily thought.

Of the Middle Carboniferous or Moscovian trilobites INAI instituted in 1936 a new genus *Humilogriffithides* on *Humilogriffithides divinopleurus*, nov. from Penhsihu, Liaoning. Later *H. someyai* Endo 1942, was added to the genus from Laokuantzukou, Pataochiang, Linchiang, Kirin, Northeast China.

Three Lower Carboniferous species of trilobites are known from East Yunnan, South China as follows:

Proetus ellipticus MANSUY, 1912, was described from Lower Carboniferous shale containing *Spirifer subconicus* at a locality between Tao-kao and Yi-liang, east Yunnan. Recently the present authors (1966) referred it to *Waribole* and suggested its Tournaisian age. Subsequently G. and R. HAHN (1969) placed it in *Archaegonus* ? (*Waribole* ?).

Griffithides cognatus REED, 1927, is represented by a solitary pygidium from a locality east of Yungchang-fu, Yunnan, and the author of the species suggested Carboniferous rather than Devonian for its age from its aspect. According to G. and R. HAHN (1972) it belongs probably to *Cummingella*. Be this suggestion acceptable, it may be lower Namurian or older Carboniferous in age.

One more species of possibly Lower Carboniferous age is "*Phillipsia*" *spinifera* REED, 1927, which was founded on a small semi-elliptical pygidium from Tashiwo, Yunnan. As so denominated, short recumbent median spines issuing from the third and fifth axial rings are most distinctive of this species. According to G. and R. HAHN (1972) it may be an *Eocyphinium* or a *Piltonia*.

Two Upper Carboniferous trilobites are so far known from South China as follows:

Neoproetus ? *sinensis* GRABAU, 1936 from the Maping limestone at Kuomen, Liouchou, Kwangsi.

Phillipsia ? sp. by GRABAU, 1936, from the Maping limestone, Paitsuya, Liouchou, Kwangsi.

The age of the former species is considered Middle Carboniferous by ZHOU (1977), while the Maping formation is correlated to the Stephanian by YANG Jing-zhi et al. (1979).

Recently *Paragriffithides* sp. was described by NAN (1976) from the Upper Carboniferous Taiyuan Series at Shixiagou, Yushuwan, Zhungening-qi, Nei Mongol (i. e. Inner Mongolia).

Two additional trilobites to the Chinese Carboniferous fauna are as follows:

Phillipsia ? sp. 1 by ZHOU, from Middle Carboniferous at Guomen (i. e. Kuomen), Liujiang-xian, Guangxi (i. e. Kwangsi).

Phillipsia ? sp. 2 by ZHOU, 1977, from Lower Carboniferous Ceshui stage, Tatang Series at Hejiagou, Xintian-xian, Hunan.

Finally three new species were instituted by YIN as follows:

Cyrtosymbole (*Dushania*) *dushanensis* YIN, 1978, from Lower Carboniferous Yanguan suite, at Xiasi, Dushan, Guizhou (i.e. Kweichou).
Cyrtosymbole (*Dushania*) *xiasiensis* YIN, 1978, from the same locality.
Weberiphillipsia guizhouensis YIN, 1978, from early Lower Carboniferous Yanguan suite, at Pozhai, Dushan, Guizhou.

In summerizing the above statements, more than twelve species of trilobites are known from China which belong to nine or more genera. Different opinions were expressed for the age of certain species, but these trilobites known from North and South China are tentatively tabulated as below.

Table 3. Carboniferous Trilobite Horizons of China

Age	South China	North China
Late C.	*Neoproetus ? sinensis*	*Paragriffithides* sp. *Ditomopyge yungchangensis* *Ditomopyge ? kansuensis*
Middle C.	*Eocyphinium ? spiniferum*	*Humilogriffithides someyai* *Humilogriffithides divinopleurus*
Early C.	*Cummingella ? cognata* *Weberiphillipsia guizhouensis* *Waribole elliptica* *Cyrtosymbole* (*Dushania*) *dushanensis* *Cyrtosymbole* (*Dushania*) *xiasiensis*	

10. Carboniferous Trilobites of Laos, Annam and Viet-Nam in Indochina

When STUBBLEFIELD instituted *Linguaphillipsia* in 1948, he considered that *Phillipsia* cf. *propinqua* MANSUY, 1913 and *Phillipsia* sp. ? MANSUY, 1913 from the Lower Carboniferous Nangpo shale, Tran-ninh, North Laos are allied to the genus, though probably distinct generically. OSMOLSKA (1970) assigned not only them but also *Phillipsia propinqua* var. *nongpoensis* PATTE, 1922, from Visean of Nongpo, Laos to *Linguaphillipsia*. She noted further that *Phillipsia truncata* var. *mansuyi* HOFFET, 1931 is a younger synonym of *L. nongpoensis* as a valid species.

G. and R. HAHN (1973) accepted this species as well as *Phillipsia propinqua* MANSUY, 1913, from Carboniferous between Bai-Duc and Phuc-Trach, Muong-Khe Sheet, North Annam as two distinct species of *Linguaphillipsia*.

11. Carboniferous Trilobites of Thailand and West Malaysia

In 1920 REED reported the occurrence of *Proetus* cf. *coddonensis* WOODWARD and *Phillipsia* aff. *silesiaca* SCUPIN in the Kulm of Kuan Lin Son, Pattalung, Peninsular Thailand. The former is represented by a pygidium and the latter by a cranidium neither one of which allows one an exact specific determination. *Proetus coddonensis* and *Phillipsia silesiaca* are, however, now located respectively in *Phillibole* or *Archae-*

gonus (*Phillibole*) and *Linguaphillipsia* by OSMOLSKA (1962, 70), and G. and R. HAHN (1969, 72, 73). The latter two authors are, however, of opinion that REED's *Proetus* cf. *coddonensis* belongs possibly to *Proetus* (*Pudoproetus*), a pre-Visean subgenus.

In 1948 STUBBELFIELD erected *Linguaphillipsia terapaiensis* gen. et sp. nov. with the trilobites from the Sungei Terapai shales, Kuantan, Pahang, Malaysia which contains a copious Visean fauna. Beside the species he distinguished ? *Linguaphillipsia terapaiensis* and "*Phillipsia*" sp.

Later 1961 the senior author instituted another new genus with *Thaiaspis sethaputi* gen. et sp. nov. which was procured from the Upper Carboniferous of Haui Luang near Wang Saphung, Loei district, east Central Thailand. Recently the Huai Luang fauna was amplified with the following trilobites.

Paladin opisthops KOBAYASHI and HAMADA
Paladin veeraburasi KOBAYASHI and HAMADA
Thaiaspis euryrachis KOBAYASHI and HANADA
Thaiaspis (*Thaiaspella*) *aliger* KOBAYASHI and HAMADA
Thaiaspid. gen. et sp. indet.

The upper Moscovian age of the fauna was determined by fusulinids and brachiopods by IGO (1972) and YANAGIDA (1975) respectively.

Prior to this KOBAYASHI and HAMADA (1966, 1973) described a few cyrtosymbolids from the Devonian-Carboniferous passege beds called Langgon red beds as follows:

Langgonbole vulgaris KOBAYASHI and HAMADA from Pulau Langgon
Waribole perlisensis KOBAYASHI and HAMADA from Perlis
Macrobole kedahensis KOBAYASHI and HAMADA and *Diacoryphe* ? sp. from Kedah

As discussed already by the authors (1973), the *kedahensis* horizon is probably lower Tournaisian and the *perlisensis* horizon upper Fammenian. The *Langgonbole* horizon near the base of the red beds in the Langkawi Islands may be a little older than the latter.

Now we have four Carboniferous trilobite horizons in Thailand and Malaysia, namely
1) The upper Moscovian Huai Luang horizon
2) The Visean Sungei Terapai horizon
3) The Tournaisian ? Kuan Lin Son horizon
4) The lower Tournaisian *kedahensis* horizon.

12. Carboniferous Trilobites of the Oriental Province

This province covers the Japanese Islands, the major part of China, Indochina, Thailand and Malaysia where some thirty genera and subgenera are known of its trilobites. As tabulated here, most of them are Lower Carboniferous, but several genera range from Visean to Bashkirian beside a few Moscovian ones and also a few Upper Carboniferous ones.

Indigenous elements are Tournaisian *Cyrtosymbole* (*Dunshania*) of South China, Visean *Parvidumus* and *Schizophillipsia* of Japan, Moscovian *Humilogriffithides* of Japan and Northeast China (former Manchuria) and upper Moscovian *Thaiaspis* (*Thaiaspis* and *Thaiaspella*) of Thailand. *Linguaphillipsia*, *Cummingella* and cyrtosymbolids well represented in the oriental fauna are all typical of the Eurasiatic faunas.

The oriental sea was confluent with the neighbouring ones of the Mongolian and Tethyan geosynclines. Some genera represent the faunal connection with the Australian fauna, but only a few with the American fauna of the Mid-Continent.

Fossil list 5. Carboniferous Trilobites of Oriental Province

Age and Area / Trilobites	Carboniferous			Japan		China		SE Asia	
	Lower	M	U	Kt	Ak	N	S	LA	TM
Brachymetopus		×			×				
Brachymetopus (*Brachymetopella*)	×				×				
Pudoproetus	T				×				(×)
Conophillipsia	T			×					
Cyrtosymbole (*Dushania*)	×						×		
Archaegonus (*Angustibole*)	T				×				
Waribole	×				×		×		
Phillibole	T			×					×
Carbonocoryphe	T				×				
Phillipsia	T			×					
Eocyphinium or *Piltonia*	?						(×)		
Linguaphillipsia	T V			×				×	×
Palaeophillipsia	T			×					
Weberiphillipsia	×						×		
Cummingella	×				×		(×)		
Dechenelloides	T			×					
Schizophillipsia	T V			×					
Bollandia	V			×					
Parvidumus	T V			×					
Griffithidella	T				×				
Thigriffides	T				×				
Metagriffithides			×			×			
Paragriffithides	T				×				
Humilogriffithides		×			×	×			
Neoproetus			?			(×)			
Thaiaspis		×							×
Thaiaspis (*Thaiaspella*)		×							×
Paladin	V	×		×					×
Paladin (*Weberides*)	V			×					
Ditomopyge	?		×						×

× : occurrence, brackets: provisional, question mark: doubtful, T: Tournaisian, V: Visean, M: Middle, U: Upper, Kt: Kitakami facies, Ak: Akiyoshi facies, N: North, S: South, LA: Laos and Annam, TM: Thailand and Malaysia.

12. Carboniferous Trilobites of South Asia

Two Himalayan trilobites were compared to Carboniferous species. One of them is *Phillipsia* sp. indet. aff. *seminifer* PHILLIPS by LYDEKKAR, 1883 and DIENER 1899 from north of Eishmakam (or Aishmuquam), Lidar valley, Kashmir, in a dark blue limestone with numerous fenestellae. *Asaphus seminifera* PHILLIPS from the Carboniferous limestone of England is the type species of *Metaphillipsia* REED, 1943. The Kashmir trilobite is however, insufficient for its exact determination.

The other trilobite is *Phillipsia* aff. *cliffordi* WOODW. by DIENER, 1915, from Lipak limestone, Carboniferous or Lower Carboniferous. *P. cliffordi* is probably synonymous with *P. leei* and belongs to *Kulmiella* according to G. and R. HAHN (1970). The Lipak trilobite, however, does not allow its generic or specific identification.

LAPPARENT and PILLET (1967) reported the following trilobites from Afghanistan.

Cyrtosymbole sp., basal Moscovian between Boakan and Wakak.
Phillipsia sp. cf. *furezanensis* WEBER, 1937, lower Moscovian, Wakak.
Ditomopyge sp., lower Moscovian between Pokan and Wakak.
Ditomopyge ? *roemeri* (MOELLER, 1867), upper Moscovian, Bokan.

Incidentally, *Cyrtosymbole* sp. resembles *Archaegonus* (*Weiania* and *Belgibole*) according to G. and R. HAHN (1969).

In Oman occur the following Uralian or Permian species.

Pseudophillipsia lipara GOLDRING, 1957
Pseudophillipsia steatopyge GOLDRING, 1957

According to FRECH (1917) three species of Lower Carboniferous trilobites occur at Yerkorprii, Asia Minor as follows:

Griffithides cf. *globiceps* PHILLIPS
Phillipsia strabonis FRECH, 1916....*Linguaphillipsia*
Phillipsia gemmunifera PHILLIPS....*Phillipsia* (*Phillipsia*)

Incidentally, *Asaphus globiceps* PHILLIPS, 1836 is the type-species of *Griffithides* (*Bollandia*) which was erected by REED, 1943 as a subgenus of *Permoproetus*, but now it is made a subgenus of *Griffithides* (G. & R. HAHN, 1970). The second species was redescribed by G. & R. HAHN (1973) as a species of *Linguaphillipsia*. Its age is lower Tournaisian. The third is typical of *Phillipsia* s. str. in the Carboniferous limestone.

In short there are three faunules in South Asia, namely

1. Lower Carboniferous trilobites in Asia Minor, Turkey
2. Middle Carboniferous trilobites in Afghanistan
3. Upper Carboniferous or Lower Permian trilobites in Oman.

14. Carboniferous Trilobites of Central Asia and Siberia

In "Trilobites of the Turkestan" WEBER (1932) and NETSCHAJEW described some twenty species of Carboniferous trilobites including the following five new species beside many indeterminable ones.

Phillipsia kirgisica WEBER
Phillipsia bitumulata WEBER
Griffithides kasykurti WEBER....*Griffithides* (*Particeps* ?)
Griffithides (?) *netchaevi* WEBER....*Ditomopyge*
Phillipsia tschernyschewi NETSCHAYEW....*Paraphillipsia*

The last two species from Darvaz, Pamir are known now to be Permian, instead of Upper Carboniferous. Most trilobites in the monograph were referred to *Phillipsia* and *Griffithides*, but one from the Tournaisian of Talass Alatau was identified with *Brachymetopus maccoyi* PORTLAND.

Subsequently in 1937 WEBER monographed Carboniferous trilobites of the Soviet Union. It includes the trilobites from the Kirghiz Steppe, Karatau Range, Turkestan, Kuznetsk Basin and the Altai Mountains beside a Visean species from Irkutsk.

NALIVIKIN distinguished four beds in the Carboniferous rocks of the Kirghiz Steppe and WEBER dated the trilobites collected therefrom as follows:

1. Passage beds ......Lowest Carboniferous
2. Kassin beds........Lower Tournaisian
3. Rusakov beds......Upper Tournaisian
4. Ishim beds ....Visean

In the Karatau Range the trilobites were mostly collected from the Upper Tournaisian *Spirifer bisulcatus* beds. The Turkestan collection consists of many Tournaisian trilobites and some Visean ones. The Kuznetsk collection contains also Tournaisian and Visean trilobites. A small amount of trilobites were procured from the Tournaisan Bukhtarma Series of the Altai Mountains.

These Lower Carboniferous trilobites from Central Asia attain a considerable number of forms including some 25 new species beside many new varieties. These new taxa instituted in the monograph are as follows:

Proetus pila (Kirghiz, basal Carbon.)....*Proetus* (*Pudoproetus*)
Proetus pila var. *longa* (Kirghiz, Tourn.)....*Proetus* (*Pudoproetus*)
Proetus pila var. *inflata* (Kirghiz, low. Tourn.)....*Proetus* (*Pudoproetus*)
Proetus pila var. *convexa* (Kirghiz, Tourn.)....*Proetus* (*Pudoproetus*)
Proetus pila var. *marginata* (Kirghiz, Tourn.)
Proetus pila var. *angusta* (Kirghiz, low. Tourn.)
Proetus ussuilensis var. *altaica* (Altai, Tourn.)
Proetus eminens (Kirghiz, Tourn.)
Cytosymbole (*Waribole*) *baiburensis* (Kirghiz, low. Tourn.)....*Archaegonus* (*Waribole*)
C. (*W.*) *baiburensis levigatus* (Kirghiz, low. Tourn.)....*Archaegonus* (*Waribole*)
Cyrtosymbole euryaxis (Kirghiz, Namur., Ural, Vise.)....*Archaegonus* (*Belgibole*)
Phillipsia ? *Cyrtosymbole* ? *antonovi* (Trukestan, Vise.)....*Cyrtoproetus*
Phillipsia labrosa (Kirghiz, Low. Carbon.)....*Conophillipsia*
Phillipsia labrosa var. *platylimbata* (Kirghiz)....*Conophillipsia*
Phillipsia kazakensis (Kirghiz)....*Conophillipsia*
Phillipsia ? *kazakensis* var. *multicostata* (Kirghiz, Tourn.)....*Conophillipsia*
Phillipsia ? *kazakensis* var. *paucicostata* (Kirghiz, Tourn.)....*Conophillipsia*
Phillipsia kazakensis var. *longa* (Kirghiz, Tourn.)....*Conophillipsia*
Phillipsia kazakensis var. *aryssica* (Turkestan Kirghiz, Tourn.)....*Linguaphillipsia*
Phillipsia kazakensis var. *sonculica* (Turkestan, Tourn.)....*Conophillipsia*
Phillipsia meisieri (Turkestan, Kirghiz, Tourn.)
Phillipsia truncatula var. *granilimbata* (Kuznetsk, Vise.)....*Phillipsia* (*Phillipsia*)

Phillipsia konincki (Turkestan, Altai, Tourn., Vise.)
Phillipsia altaica (Altai, Tourn.)
Phillipsia laticaudata var. *kuzneciana* (Kuznetsk, Tourn.-low. Vise.)....*Weberiphillipsia*
Phillipsia laticaudata var. *amarginata* (Kuznetsk, Tour.)
Phillipsia laticaudata var. *convexa* (Turkestan, Kuznetsk, Vise.)
Phillipsia kassini (Kirghiz, low. Tourn.)
Phillipsia karatauensis (Turkestan, up. Tourn.)
Phillipsia mitchellli (Kirghiz, Tourn.)
Phillipsia krasnopolskii (Kirghiz, Tourn.)....*Griffithidella* (*Griffithidella*)
Phillipsia karagandensis (Kirghiz, Tourn.)....*Archaegonus* (*Waribole* ?)
Phillipsia karagandensis var. *longa* (Turkestan, Tourn.)
Phillipsia ? *nurataensis* (Turkestan, Vise)....*Piltonia* ? (*Piltonia* ?)
Phillipsia abscisa, (Altai, Kuznetsk, up. Tourn.)....*Paladin* (*Kaskia* ?)
Griffithides longiceps var. *rotundipleurata* (Kirghiz, Vise.)....*Paladin* (*Kaskia*)
Griffithides trapezoidalis (Kirghiz, low Carb.)....*Paladin* (*Paladin*)
Griffithides ? *sosvensis* (Turkestan, up. Tourn.)....*Paladin* (*Paladin*)
Griffithides (*Cyphinium*) cf. *alapaicus* (Turkestan, Vise.)....*Eocyphinium*
Brachymetopus (*Brachymetopus*) (Kirghiz)

Later in 1960 MAKSIMOVA described the following species of trilobites from the Rudi Altai beside a few specifically indeterminable ones.

Proetus (*Semiproetus*) aff. *saragaensis* WEBER
Proetus (*Semiproetus* ?) *ussuilensis* NALV. var. *altaica* WEBER
Cyrtosymbole sp.
Phillipsia konincki WEBER
Phillipsia ? *abscisa* WEBER
Phillipsia altaica var.
Phillipsia buchtarmensis MAXIMOVA, nov.
Phillipsia ? *minuta* MAXIMOVA, nov. ....*Cummingella* ?
Phillipsia aff. *scabra* WOODWARD

Taxonomic comments are added behind the specific names from G. and R. HAHN's "Trilobiti cabonici et permici, 1969-72".

As the result of a thorough revision of the Tournaisian-Namurian trilobites of the Proetidae exclusive of cyrtosymbolids OSMOLSKA (1970) summarized their geographic and stratigraphic distribution in form of a table from which those in the area under consideration are extracted and here tabulated.

As shown in list 6, OSMOLSKA distinguished 21 species in 7 genera of trilobites among which three species of *Pudoproetus* and three of *Conophillipsia* are in the range from uppermost Devonian to upper Trournaisian, while *Cyphinioides micheevi* from the upper Visean and lower Namurian is the latest survivor among them. The trilobites of the remaining genera are exclusively Tournaisian in age.

Carboniferous trilobites occur in four areas, namely the Kuznetsk basin, the Altais, the Kirghiz Steppe and Kazakhstan. There is, however, no species occurring in two or more areas of them. The Kazakhstan faunule containing thirteen species in seven genera is richest, followed by five species in three genera of the Altai faunule. Only two species of *Bollandia* are known from the Kirghiz steppe. *Weberiphillipsia kuzneciana* is solitary in the Kuznetsk basin. Incidentally, it is noted that the Kirghiz steppe is used somewhat in different ways between WEBER's and OSMOLSKA's publications.

Among the seven genera *Conophillipsia* is represented by five species and *Piltonia*

Fossil list 6. Tournaisian-Namurian Proetidae exclusive of Cyrtosymbolids in Central Asia and Siberia. (OSMOLSKA, 1970)

Trilobites	Ki	Ka	Al	Ku	D	T	V	N
Pudoproetus pila (WEBER, 1937)		×			u	T		
Pudoproetus ussilensis (NALIVIKIN, 1933)			×			u		
Pudoproetus eminens (WEBER, 1937)		×				T		
Conophillipsia labrosa (WEBER, 1937)		×			u	l		
Conophillipsia kazakensis (WEBER, 1937)		×			u	l		
Conophillipsia antonovi (WEBER, 1937)		×				u		
Conophillipsia meisteri (WEBER, 1937)		×				T		
Conophillipsia cervicontinens (WEBER, 1937)		×				T		
Weberiphillipsia kirgisika (WEBER, 1932)		×				u		
Weberiphillipsia kuzneciana (WEBER, 1937)				×		u		
Weberiphillipsia inostrazevi (TOLMATSHOV, 1924)			×	?		u		
Piltonia kassini (WEBER, 1937)		×				l		
Piltonia altaica (WEBER, 1937)			×			u		
Piltonia buchtarmensis (MAKSIMOVA, 1960)			×			m		
Piltonia konincki (WEBER, 1937)			×			m u		
Griffithides kasykurti (WEBER, 1932)		×				u		
Cummingella ? minuta (MAXIMOVA, 1960)			×			m		
Bollandia karatauensis (WEBER, 1937)		×				u		
Bollandia sonkulensis OSMOLSKA, 1970	×					T		
Bollandia kirgisiana OSMOLSKA, 1970	×					T		
Reediella mitchelli (WEBER, 1937)		×				l		
? *Reediella karagandensis* (WEBER, 1937)		×				l		
Cyphinioides micheevi (WEBER, 1937)		×					u	l

Ki: Kirghiz, Ka: Kazakhstan, Al: Altai, Ku: Kuznetsk, D: Devonian, T: Tournaisian, V: Visean, N: Namurian, l: lower, m: middle, u: upper

by four species. *Pudoproetus*, *Weberiphillipsia* and *Bollandia* include three species in each, and *Reediella* does one or two species. *Cyphinioides* is represented only by a single species. *Pudoproetus*, *Bollandia* and *Cyphinioides* are known from the Urals and *Piltonia* from the Mugodzhars.

Now, accepting the above taxonomic comments, one species of brachymetopid, three species of cyrtosymbolids, and ten species of other proetoids are added to the regional fauna as follows:

Brachymetopus (*Brachymetopella*) *vyssitzkii* WEBER, 1937, Kirghiz, low. Tourn.
Archaegonus (*Belgibole* ?) *euryaxis* (WEBER, 1937), Kirghiz, Namur.
Archaegonus (*Waribole*) *baiburensis* (WEBER, 1937), Kirghiz, low. Tourn.
Archaegonus (*Waribole* ?) *kargandensis* (WEBER, 1937), Kirghiz, low. Tourn.
Cyrtoproetus antonovi (WEBER, 1937), Turkestan, Ural, Vise.
Griffithides (*Particeps* ?) *kasykurti* WEBER, 1932, Turkestan, Vise.
Paladin (*Paladin*) *sosvensis* (WEBER, 1937), Ural, Turkestan, Tourn.-Vise.
Paladin (*Paladin*) *trapezoidalis* (WEBER, 1937), Kirghiz, Ural, Vise.
Paladin (*Kaskia* ?) *rotundipleurata* (WEBER, 1937), Kirghiz, Ural, Vise.

Paladin (*Kaskia* ?) *abscisus* (WEBER, 1937), Altai, Kuznetsk, Ural, up. Tourn.
Griffithidella (*Griffithidella*) *karanopolski* (WEBER, 1937), Kirghiz, Tourn.
Cummingella ? *minuta* (MAXIMOVA, 1960), Altai, Ural, Tourn.-Vise.
Phillipsia (*Phillipsia*) *granilimbata* WEBER, 1937, Kirghiz, Vise.
Linguaphillipsia aryssica (WEBER, 1937), Turkestan, Kirghiz, Tournais.

It is noteworthy that *Linguaphillipsia aryssica* occurs in Turkestan and the Kirghiz steppe and *Paladin* (*Kaskia* ?) *abscisus* in the Kuznetsk basin as well as the Altai mountains. Among other trilobites 8 species were found in the Kirghiz steppe, 2 in Turkestan and another two in the Altai mountains. In adding these trilobites the fauna of the region attains eighteen genera as follows:

Generic composition, Central Asia

Proetidae s. l.
Proetidae: *Cyrtoproetus, Pudoproetus, Conophillipsia*
Griffithidinae: *Particeps, Bollandia, Reediella, Cyphinioides*
Ditomopyginae: *Paladin* (*Paladin, Kaskia*), *Griffithidella*
Linguaphillipsiinae: *Linguaphillipsia, Weberiphillipsia*
Phillipsiidae: *Phillipsia, Pitonia, Eocyphinium, "Angustibole"*.
Cyrtosymbolinae: *Waribole, Belgibole*
Brachymetopidae: *Brachymetopus* (*Brachymetopella*)

Finally, it is noted that *Griffithides seminiferus kuleschi*, var. nov. IVANOV in WEBER, 1937 was described from the lower Visean of Irkutsk, and *Griffithides* (*Metaphillipsia*) was suggested for its taxonomic position by G. and R. HAHN (1970).

15. The Carboniferous Trilobites of the Donetz Basin

In "Trilobites of the Donetz Basin," 1933, WEBER described some twenty-five species in addition to many varieties and specifically indeterminable forms mostly from the Donetz basin. These trilobites were divisible into two groups, namely the Lower Carboniferous trilobites and the Middle and Upper Carboniferous ones, by a discontinuity between the two faunas as he pointed out. In the latter fauna the early or Bashkirian faunule is represented only by two forms of *Griffithides* and the late one of about the Stephanian or the Gzhelian-Orenburgian age in the modern chronology by 6 (or 8) forms, while the middle or Moscovian faunule is so rich that it comprises about 20 forms. Two indeterminable species of *Griffithides* were contained in the Lower Permian rocks.

The Donetz species are listed below and some taxonomic comments in HAHN's catalogue were cited behind the species.

A. Lower Carboniferous trilobites
Phillipiia derbyensis MART.
Ph. derbyensis var. *gapeevi*, var. nov.....*Cummingella gapeevi*, Vise.-Namurian
Ph. derbyensis var. *kargini*, var. nov.....*Cummingella kargini*, Namurian
Ph. eichwaldi FISCH.
Ph. eichwaldi var. *mucronata* M'COY
Ph. cf. *scabra* var. *parva*, var. nov.....*Paladin* (*Paladin*) *scabra parvus*, Namurian
Ph. ? *biradiata*, nov.....*Cyphinioides* ?, Visean
Ph. meramecensis SHUM. ?
Griffithides longiceps var. *angusta* WOODW.
? *Gr. seminiferus* PHILL.

Griffithides ? *carringtonensis* ETH. ...*Cummingella*
Brachymetopus uralicus VERN.
Br. densituberculatus, n.

B. Trilobites younger than Lower Carboniferous
Griffithides lutugini, n. ...*Paladin* (*Paladin*), Westphalian-Stephanian
Gr. lutugini v. *robustus* v. n. ...*Paladin* (*Paladin*), Stephanian
Gr. lutugini v. *multisegmentata*, v. n.....*Paladin* (*Paladin*), Westph-Steph.
Gr. lutugini v. *longicauda*, v. n. ...*Paladin* (*Paladin*), Westph.
Gr. cervilatus, n. ...*Paladin* (*Paladin*), Steph. A
Gr. planus, n. ...Synonym: *P.* (*P.*) *cerviculus*
Gr. transilis, n. ...*Paladin* (*Paladin*), Westph. D-Steph. A
Gr. roemeri MOELL. ?
Gr. ? *praepermicus*, n. ...*Pseudophillipsia*, Steph. C
Gr. bigranulatus, n. ...*Paladin* (*Kaskia* ?), Westph. D-Steph. A
Gr. rotundus, n. ...*Ditomopyge*, Steph. B-low. Perm.
Cyphinium granulatum, n. ...*Ditomopyge*, Westph.
C. acanthicaudatum, n. ...*Ditomopyge*, Westph. A
C. kumpani, n. ...*Ditomopyge*, Westph. C-Steph. B
C. kumpani v. *crassicrusta*, v. n. ...Syn. *Ditomopyge kumpani*
C. kumpani v. *planiloba*, v. n. ...*Ditomopyge*, Steph.
C. kumpani v. *gibbosa*, v. n. ...Syn. *Ditomopyge rotunda*
C. productum v. *granulata*, v. n. ...Syn. *Ditomopyge granulata*

On this occasion WEBER described a few Permo-Carboniferous trilobites from the Ural mountains as follows:

Cyphinium productum, n. ...*Ditomopyge*, Stephanian A
Griffithides roemeri MOELLER
Gr. ovoides, n. ...Syn. *Paladin* (*Kaskia*) *gruenewaldti* (MÖLLER, 1867) from Upper Carboniferous, *Fusulina* limestone
Griffithides ? *praepermicus*, n.
Cyphinium artinskiense....*Ditomopyge*, Middle Permian, Artinskian

16. Carboniferous Trilobites of the Ural Mountains

In 1937 the trilobite fauna of the Ural mountains was greatly amplified with WEBER's monograph, "Trilobites of the Carboniferous and Permian Systems of U. S. S. R." Fascicle 1. Putting aside the Central Asiatic and Siberian ones, it comprised some forty species and many varieties mostly from the Urals, but some of them came from the Timan, Novaya Zemlya, Waigachi Island, the Moscow and Donetz basins. Among the Lower Carboniferous trilobites of the Urals the passage beds or the Etroeungtian, the Tournaisian, the Tournaisian-Visean and the Visean faunules are distinguishable. The Visean fauna is well represented by the trilobites from the a to d beds of the LIBROVITCH's Kizil series on the eastern slope of the Urals and the e bed belongs partly to the Namurian. The Visean trilobites are, however, not so common on the western slope. The Middle and Upper Carboniferous trilobites also occur in the Urals. They are listed here and some comments by G. and R. HAHN and others are added to them.

Proetus sargaensis, n. Ural, Etroeungtian
Pr. ussuilensis NALV. 1933, Ural, up. Tournaisian....*Proetus* (*Pudoproetus*)
Typhloproetus aequalis MEYER, Ural

Typhloproetus ? *aequalis* v. *megalophthalma* n. Novaya Zemlya, Visean....*Liobole megalophthalus, Liobole anteriolata* (OSMOLSKA, 1968)
T. ? *subuliferus*, n., Ural, Upper Carboniferous....*Carbonocoryphe*
Cyrtosymbole librovitchi, n. Ural, Vise....*Archaegonus* (*Weiania*)
C. librovitchi v. *euryaxis*, var. nov. Ural, Vise.....*Archaegonus* (*Belgibole*) *euryaxis*
C. librovitchi v. *latilimbata*, v. n., Ural, Vise.-low. Namur.....*Archaegonus* (*Belgibole* ?) *latilimbatus*
C. ? *kinderliensis*, n., Ural, basal Carbon.....*Cyrtosymbole* (*Pseudowaribole*)
Phillipsia truncatula v. *pustulata* de Kon., Ural., up. Tournaisian
Phillipsia truncatula v. *glabra*, v. n. Ural, up. Tourn.
Phillipsia truncatula v. *multipustulata* SMYTH by WEBER, 1937, Ural, Tourn.....*Eocyphinium podtsheremense* OSMOLSKA, 1970
Ph. aff. *gemmulifera* PHIL., Ural, Low Carbon., Vise.
Ph. conserrata, n. Ural. Vise and up. Tourn ?....*Phillipsia*
Ph. derbyensis v. *shartymensis*, v. n., Ural, and Mugodjar mountains, Vise.-Namur.....*Cummingella shartymensis*
Ph. derbyensis v. *belgica*, v. n., Ural, Vise....*Cummingella* ? *belgica*
Ph. derbyensis v. *kiritchenkoi*, v. n., Ural, up Vise....*Griffithides* (*Particeps*) *kiritchenkoi*
Ph. derbyensis v. *polonica*, v. n., Ural, Vise.....*Cummingella polonica*
Ph. derbyensis v. *producta*, v. n., Ural, up. Low. Carbon.....*Particeps productus*
Ph. ? *carinatoides* NAL., Ural, Tourn.....*Linguaphillipsia* ?
Ph. ? *vilvensis*, n., Ural, up. Tourn.....*Piltonia* ? (*Piltonia* ?)
Ph. ? *mussagatensis*, n., Ural, Tourn.-Vise.....*Griffithidella* (*Griffithidella*)
Ph. ? *acuticostata*, n., Ural, low Vise.....*Griffithides* ? (*Particeps* ?)
Ph. ? *bifurcata*, n., Ural, Vise.....*Carbonocoryphe*
Ph. (*Griffithides* ?) *eichwaldi* Fisch.
Ph. (*Gr.*) ? *eichwaldi* v. ? *mucronata* M'COY, up. Tourn.-Mid. Carbon.....*Paladin mucronatus russicus* OSMOLSKA, 1970.
Ph. ? *Gr.* ? *juezanensis*, n., Ural, Up. Carbon.....*Paladin*
Griffithides longiceps ? v. *obsoleta*, v. n., Ural. Vise.....*Griffithides obsoleta*
Gr. claviger, SCUP., Ural, Vise.-Namur.
Gr. ? *claviger*, v. *uralica*, v. n., Ural, Vise.-Namur.....*Gr.* (*Particeps*)
Gr. cf. *acanthiceps* WOODWARD, Ural, Vise.-Namur.
Gr. spinosus, n., Ural, Vise.....*Eocyphinium*
Gr. micheevi, n., Ural, Namur.....*Cyphinioides*
Gr. ? *asper*, n., Ural, Vise.....*Griffithides*
Gr. glabrocostatus, n., Donetz, Steph. A-Westph. D ?....*Paladin* (*Kaskia*)
Gr. trapezoidalis, n., Ural, Vise.....*Paladin* (*Paladin*)
Gr. ? *praepermicus*, n., Donetz, Ural, Moscov. Steph.-Westph.
Gr. ? *sosvensis*, n., Ural. Tourn.....*Bitumulina*
Gr. (*Cyphinum*) *alapaicus*, n., Ural. low. Tourn.....*Cyphinioides*
Brachymetopus (*Brachymetopina*) *uralicus* VERN. Ural. Vise.-Mid. Carbon. base
Brachimetopus (*Brachymetopina*) *uralicus* v. *inflata*, v. n., Ural.
Brachymetopus (*Brachymetopina*) *uralicus* v. *sagittifera*, v. n., Ural, Vise.
Brachymetopus (*Brachymetopina*) *uralicus* v. *paucituberculata*, v. n., Ural., Tourn.
Brachymetopus (*Brachymetopina*) *moelleri*, n., Ural, Up. Carbon.
Brachymetopus (*Brachymetopina*) *maccoyi* PORTL., Ural, Tourn.
Brachymetopus (*Brachymetopina*) *arenaceus*, n., Ural, Tourn.
Brachymetopus (*Brachymetopina*) *strezelskii* v. *uralicus*, v. n. Ural, Vise.-Namur.....*Brachymetopus* (*Brachymetopella*)
Phillipsia tulensis, n. IVANOV, Moscow Basin, Vise....*Linguaphillipsia*

In her revision on *Brachymetopus* of Poland and U. S. S. R. (1968) OSMOLSKA recognized in *Brachymetopus ouralicus* (de VERNEUILI 1845) three subspecies, viz. *ornatus*

WOODWARD 1884, *inflatus* WEBER 1937 and *sanctacrusensis* nov. beside *B. ouralicus ouralicus.* WEBER's is a Visean subspecies of the South Urals, but WOODWARD's and OSMOLSKA's are Visean subspecies in Britain and Poland respectively. In this paper she named *Brachymetopus weberi* for the from so-called *Br. meolleri* from the Gzhelian?

Fossil list 7. Carboniferous Trilobites of the Proetidae exclusive of Cyrtosymbolids in the European Part of the Soviet Union

Trilobites	Area				Age					
	Mo	D	U	Mu	D	T	V	N	M	C
Pudoproetus sargaensis (WEBER, 1937)			×		u	T				
Bitumulina bitumulata (WEBER, 1932)				×		l				
Bitumulina sosvensis (WEBER, 1937)			×			T				
Piltonia mudodjarica (BALASCHOVA, 1956)				×		l				
Piltonia konincki (WEBER, 1937)			×			l m				
Phillipsia ornata kumakensis OSMOLSKA, 1956			×			T				
Phillipsia moelleri OSMOLSKA, 1970			×			T				
Phillipsia glabra WEBER, 1937			×			T				
Phillipsia magnoculata OSMOLSKA, 1970			×			T				
Bollandia claviceps (BURMEISTER, 1846)			×			u	u			
Linguaphillipsia tulensis (IVANOV in WEBER, 1937)	×						V			
Cummingella shartymensis sharymensis (WEBER, 1937)			×					l N		
Cummingella shartymensis weberi OSMOLSKA, 1970)		×	×					N		
Cummingella gapeevi (WEBER, 1933)			×				l			
Griffithides rotundipleuratus WEBER, 1937			×				u			
Griffithides obsoletus WEBER, 1937			×				u			
Eocyphinium spinosum spinosum WEBER, 1937			×				V			
Cyphinioides micheevi (WEBER, 1937)			×				u	l		
Cyphinioides alapaicus (WEBER, 1937)			×					l		
? *Cyphinioides limbatus* OSMOLSKA, 1970		×							M	
Particeps kiritchenkoi (WEBER, 1937)		×	×					l		
Particeps productus (WEBER, 1937)			×					l		
Particeps kargini (WEBER, 1933)		×						l		
Paladin eichwaldi eichwaldi (FISCHER v. WALDHEIM, 1825)			×				u			
Paladin mucronatus russicus OSMOLSKA, 1970	×	×						l		
Paladin jurezanensis (WEBER, 1937)			×							?G
Paladin lutugini (WEBER, 1933)		×							M	
Paladin cervilatus (WEBER, 1933)		×							M	
Paladin subbakewellensis OSMOLSKA, 1970		×							M	
? *Paladin ailinensis* OSMOLSKA, 1970			×							u

Mo: Moscow, D: Donets basin, U: The Urals, Mu: The Mugodzhars, D: Devonian, T: Tournaisian, V: Visean, N: Namurian, M: Moscovian, C: Carboniferous, G: Ghzelian, l: lower, m: middle, u: upper.

of Vaigatchi Island.

17. Carboniferous Trilobites of European Russia

In her monograph OSMOLSKA (1970) recognized 30 species in 12 genera of trilobites in the European part of the Soviet Union. They were found in four areas, viz. the Moscow basin, the Urals, the Mugodzhars and the Donetz basin. The Ural faunule which is distributed from the Urals to Novaya Zemlya is so rich that two-thirds of them, namely 20 species in which all genera are represented except for *Linguaphillipsia*. *Pudoproetus sarganensis* exceptionally ranges down into Upper Devonian from Tournaisian. *Paladin jurezanensis* and ? *Paladin ailinens* are respectively ? Ghzelian and Upper Carboniferous. Other Ural species are in a range from Tournaisian to Namurian and none is Moscovian.

The next richest is the Donetz faunule comprizing eight species in four genera of which four species are Moscovian and the other four are Namurian or lower Namurian.

Two species in *Bitumulina* and *Piltonia* are known from the lower Tournaisian of the Mugodzhars. Another two from the Moscow basin are Visean *Liguaphillipsia tulensis* and lower Namurian *Paladin mucronatus russicus*.

Among these trilobites ten species occur in the Tournaisian of the Urals and Mugodzhars among which *Bollandia claviceps* ranges up to upper Namurian. There are other six Visean trilobites and seven Namurian trilobites beside *Cyphinioides micheevi* from upper Visean to lower Namurian. They are widely distributed in these three areas, but not in the Mugodzhars.

Cummingella sharymensis weberi, *Particeps kitichenkoi* and *Paladin mucronatus russicus* are Namurian or lower Namurian trilobites. The first and second species are known in the Donetz basin and the Urals and the third in Moscow and Donetz basins. The specific dispersal must have been most easy in the early Namurian age.

Following the comments in the above fossil lists the following species of proetoids may be supplemented to the regional non-cyrtosymbolid fauna.

Griffithidella acuticostata (WEBER, 1937), Ural; Visean
Pseudophillipsia praepermica (WEBER, 1933), Ural, Moscow, Donetz and Turkestan; Westphalian-Stephanian
Ditomopyge acanthicaudata (WEBER, 1933), Doentz, Westphalian
Ditomopyge granulata (WEBER, 1933), Ural-Donetz, Namurian-Westphalian
Ditomopyge kumpani (WEBER, 1933), Donetz, Westphalian-Stephanian
Ditomopyge planiloba (WEBER, 1933), Donetz, Stephanian
Ditomopyge rotunda (WEBER, 1933), Donetz, Stephanian-lower Permian

The subfamily Cyrtosymbolinae is represented in the fauna of the region by nine species is follows:

Cyrtosymbole (*Waribole*) *kinderliensis* (WEBER, 1937), Ural, Etroeungtian
Archaegonus (*Belgibole* ?) *euryaxis* (WEBER, 1937), Ural, Kirghiz, Namur, mid. Carbon.
A. (*Belgibole*) *latilimbatus* (WEBER, 1937), Ural, Visean
A. (*Weiania*) *librovitchii* (WEBER, 1937), Ural, Visean
Liobole anteriolata (OSMOLSKA, 1968), Novaya Zemlya, Visean
Liobole megalophthalmus (WEBER, 1937), Ditto.
Carbonocoryphe bifurcata (WEBER, 1937), Ural, Visean

Carbonocoryphe ? granulineata (BALASHOVA, 1956), Mudodschar, lower Tournaisian
Carbonocoryphe subulifera (WEBER, 1937), Ural, Visean

A further addition must be made to the fauna with the Brachymetopidae as follows:

Brachymetopus (Brachymetopus) arenaceus WEBER, 1937, Ural, Tourn.
Br. (Brachymetopus) moelleri WEBER, 1932, Ural, Up. Carbon (*Fusulina* Limestone)
Br. (Brachymetopus) uralicus VEREUIL, 1845, Ural, Donetz, Turkestan, Tourn.-low. Namur.
Br. (Bpachymetopus) uralicus, inflatus WEBER, 1937, Ural, Vise.
Br. (Brachymetopus) uralicus paucituberculatus WEBER, 1937, Ural, Tourn.
Br. (Brachymetopus) uralicus sagittifer WEBER, 1937, Ural, Vise.
Br. (Brachymetopus) weberi OSMOLSKA, 1968, Waighatch Island, Gshelian (Stephanian)
Brachymetopus (Brachymetopella) strzeleckii uralicus WEBER, 1937, Ural, Vise.-Namur.

Incidentally the subgeneric distinction of *Brachymetopina* from *Brachymetopus* s. str. was ignored by G. HAHN, 1964 on the one hand, while on the other hand subgenus *Brachymetopella* was recently distinguished from *Brachymetopus* s. str. (KOBAYASHI and HAMADA, 1978). Of *Brachymetopus maccoyi* by MAXIMOVA, 1957 from the Urals, G. and R. HAHN (1969, p. 24) commented saying "selbstandige Art ?"

The Carboniferous trilobites of the Ural-Donetz region are distributed in twenty-two to twenty-four genera as follows:

Proetidae s. l.
- Proetinae ;—*Pudoproetus*
- Griffithidinae :—*Griffithides, Particeps, Bollandia, Cyphinioides*
- Ditomopyginae :—*Ditomopyge, Paladin (Paladin, Kaskia), Griffithidella, Pseudophillipsia*
- Cummingellinae :—*Cummingella*
- Linguaphillipsiinae :—*Bitumulina, Linguaphillipsia*
- Phillipsiinae :—*Phillipsia, Piltonia, Eocyphinium*
- Cyrtosymbolinae :—*Cyrtosymbole, Belgibole, Carbonocoryphe, Liobole, Waribole, Weiania*

Brachymetopidae :—*Brachymetopus (Brachymetopus, Brachymetopella)*

18. The Trans-Eurasiatic Migration of Carboniferous Trilobites

Carboniferous trilobites in Central Asia, the Urals and the Moscow and Donetz basins are so intimately related to one another that they constitute a large fauna of European Russia-Central Asia. It consists of some thirty genera and subgenera as follows:

Proetidae
- Proetinae: *Conophillipsia, Cyrtoproetus, Pudoproetus*
- Cyrtosymbolinae: *Archaegonus (Belgibole, Waribole, Weiania), Carbonocoryphe, Cyrtosymbole (Pseudowaribole), Liobole, Weiania.*
- Phillipsiinae: *Phillipsia, Piltonia, Eocyphinium.*
- Linguaphillipsiinae: *Linguaphillipsia, Weberiphillipsia, Bitumulina.*
- Cummingellinae: *Cummingella*
- Griffithidinae: *Griffithides, Particeps, Bollandia, Reediella, Cyphinioides.*
- Ditomopyginae: *Ditomopyge, Paladin (Paladin, Kaskia), Griffithidella, Pseudophillipsia.*

Brachymetopidae: *Brachymetopus (Brachymetopus, Brachymetopella)*

Bitumulina is exceptionally indigenous to the Urals and the Mugodzhars, but most genera occur in the Urals as well as Central Asia and some genera of the two basins occur also in these two areas or one of them.

The following genera are distributed there from westerly into western Europe, but not easterly.

Cyrtosymbole (Pseudowaribole), Particeps, Reediella, Cyphinioides

The genera distributed easterly into Eastern and Southern Asia from European Russia-Central Asia, but not westerly are *Weberiphillipsia. Ditomopyge* and *Griffithidella.* These two kinds of genera show that the area was the junction between the eastern and western faunas of Eurasia.

It is a remarkable fact that many of the European Russia-Central Asiatic fauna are common with the Oriental fauna. Therefore, it is certain that the two faunas were connedted through either the Mongolian or the Tethyan geosyncline, although our knowledge of the Carboniferous trilobites of Mongolia and South Asia is as yet too poor.

The occurrences of *Linguaphillipsia* in Turkey and of *Weiania* (?) of Afghanistan suggests the Tethys sea for their migration from Europe to Australia through Southeast Asia. On the other hand the presences of *Conophillipsia* and *Weberiphillipsia* respectively in Japan and China probably means that the Mongolian geosyncline was their route for migration from Central Asia to Australia. The Mongolian route is further emphasized by the find of *Bollandia* in Japan, since the genus is well represnted by three species in the Kirghiz stepp and Kazakhstan whereas its occurrence in Turkey is still in question.

Cyrtoproetus is known widely from England, Czechoslovakia, the Urals, Kirghiz Steppe and Turkestan. Then it recurs in Queensland. Which of the Tethyan or Mongolian geosyncline was the route for this trilobite between the two areas is a question.

It is noteworthy that *Paragriffithides* sp. was described by Nan (1976) from the Upper Carboniferous Taiyuan Series, Inner Mongolia, because the genus is known from the Lower Carboniferous of England and Tienshan and the Westphalian of Hungary. *Brachymetopus* (*Brachymetopella*) is distributed in the Lower Carboniferous of the Kirghiz Steppe, the Visean and Namurian of the Urals, the Tournaisian ? and lowest Moscovian of Japan and the Upper Carboniferous of Karawaken, Yugoslavia. Such isolate occurrences in Eurasia in different ages are another problem which requires intensive and extensive studies for solution.

19. Carboniferous Trilobites of Australia

The history of the study on Carboniferous trilobites goes back in Australia as far as to McCoy in 1847, followed by ETHERIDGE R. sen. (1872), de KONINCK (1879), ETHERIDGE, R. jr. (1822, 1917, MS), REED (1913), MITCHELL (1918, 24) and so forth. Comments were given by MITCHELL, 1918 on the following 12 old species beside *Griffithides sweeti* ETHERIDGE, 1874.

1. *Brachymetopus strzeleckii* McCOY, 1847*
2. *Phillipsia eichwaldi* KONINCK, non FISCHER, 1825
3. *Phillipsia dubia* ETHERIDGE, jr., 1892 (non *Griffithides dubius* ETHERIDGE sen.)
4. *Phillipsia grandis* ETHERIDGE, jr., 1892*
5. *Phillipsia woodwardi* ETHERIDGE, jr., 1892*

6. *Phillipsia* sp. indet. (a), ETHERIDGE, jr., 1892
7. *Phillipsia* sp. indet. (b), ETHERIDGE, jr., 1892
8. *Griffithides dubius* ETHERIDGE, sen. 1872*
9. *Griffithides seminiferus* de KONINCK, 1877
10. *Griffithides seminiferus* var. *australasica* ETHERIDGE, jr., 1892
11. *Griffithides sweeti* ETHERIDGE, jr., 1894*
12. *Griffithides* sp. indet. ETHERIDGE, jr., 1892

Excluding specifically indterminable species, five marked with asterisks out of nine species are said to be worthy of recognitition. In adding many new species MITCHELL described in his monograph 23 species of Carboniferous trilobites of Australia. Among them *Phillipsia connolli* was a solitary western Australian trilobite occurring in the Gascoigne River area. All others were collected from Queensland and New South Wales. *Griffithides sweeti* was procured at Crow's Nest Creek, near Mount Morgan, Queensland from the trilobite beds of the Permo-Carboniferous Gymie Series whose exact age is unknown.

The remaining trilobites are Carboniferous and mostly Lower Carboniferous in age. None of them is, however, known definitely either Upper Carboniferous or Permian, although a few Permian ones were lately described from Australia and Tasmania.

Recently taxonomic comments and partly chronological ones were given by STUBBLEFIELD, OSMOLSKA, G. and R. HAHN and others on these species in the light of modern palaeontology as shown in the fossil list 8.

STUBBLEFIELD (1948) and OSMOLSKA (1970) suggested *Linguaphillipsia* and *Weberiphillipsia* respectively for the cranidium and pygidium of *Phillipsia collinsi.* According to her the pygidium is extremely similar to *Weberiphillipsia kirgisica.* She is of opinion that there is no true *Phillipsia* in Australia. According to G. and R. HAHN (1972), however, *Phillipsia rockhamptonensis* has the cephalon of *Phillipsia* and its pygidium looks like that of *Phillipsia* (*Elliptophillipsia*). Further taxonomic comments were added by her on a few species among which she emphasized that *Griffithides convexicaudara* should be assigned to *Richterella* as an approximate contemporary species to late Kinderhookian *Richterella snakedensis* HESSLER, 1965. G. and R. HAHN (1972) on the other hand considered it to be a close ally to *Cummingella.* Because *Phillipsia grandis* is thought to be a composite species, G. and R. HAHN proposed a new species, *Liguaphillipsia ? magna,* for ETHERIDGE's pygidium in fig. 5, pl. 21, 1892.

In 1924 MITCHELL described one more species, *Cordania gardneri* from the upper Burindi Series (Westphalian ?) in New South Wales.

Additional trilobites which the authors are aware are as follows:

1. *Linguaphillipsia divergens* CVANCARA, 1959, from the upper part of the lower Burindi Group (upper Tournaisian), New South Wales.

2. Recently ENGEL and MORRIS (1975) described four species of *Linguaphillipsia* with two subspecies in *L. elongata* from the Tournaisian through the Visean in New South Wales as below.

Linguaphillipsia raglanensis, nov. (up. Tournais.-low. Vise., Cu II_{α}).
L. cangonensis, nov. (late mid. Vise., Cu III_{α})
L. elongata elongata (MITCHELL, 1918) (late mid. Vise., Cu III_{α})
L. elongata rouchelensis (MITCHELL, 1918) (mid. Vise., Cu $IIII_{\alpha}$)
L. divergens CVANCARA, 1959 (up. Vise., Cu $III_{\beta-\gamma}$)

Fossil list 8. Carboniferous Trilobites of Australia (John MITCHELL, 1918 with comments by STUBBLEFIELD, OSMOLSKA and HAHN)

Taxonomic name	Age and Area	Comments
Phillipsia collinsi MITCHELL	N.S.W., Low.? (IV)	*Linguaphillipsia* ? (S), *Weberiphillipsia* (O)
Phillipsia coulteri MITCHELL	N.S.W., Low.	"*Phillipsia*"
Phillipsia breviceps MITCHELL	N.S.W., Carb.	*Proetus* (*Pudoproetus*) (H)
Phillipsia proxima MICHELL	N.S.W., Low.	*Paladin* (*Paladin*) (H)
Phillipsia ? *robusta* MITCHELL	N.S.W., Carb.	*Linguaphillipsia* ? *grandia* (H)
Phillipsia ? *stroudensis* MITCHELL	L.S.W., Low.?	*Conophillipsia* ? (H)
Phillipsia superba MITCHELL	N.S.W., (Carb.)	*Cummingella* ? (H)
Phillipsia ? *waterhousei* MITCHELL	N.S.W., Carb.	"*Phillipsia*"
Phillipsia elongata MICHELL	N.S.W., Carb.	*Linguaphillipsia* (H)
Phillipsia rockhamptonensis MITCHELL	Qu., Carb.	*Phillipsia* (*Phillipsia*) (H)
Phillipsia stanveliensis MITCHELL	Qu., Carb.	"*Phillipsia*"
Phillipsia grandis ETHERIDGE fil.	Qu., Carb. (uT)	*Linguaphillipsia* (O)
Phillipsia woodwardi ETHERID. fil.	Qu., L, M(uT)	*Conophillipsia* (O)
Phillipsia morganensis MITCHELL	Qu., Low.?	*Cyrtoproetus* (H)
Phillipsia connolli MITCHELL	W., Carb.	*Griffithidella* (*Griffithidella*) (H)
Phillpsia rouchelensis MITCHELL	N.S.W., (Carb.)	*Conophillipsia* ? (H)
Phillipsia dungogensis MITCHELL	N.S.W., Carb. (mV)	*Phillipsia* ? (*Phillipsia* ?) (H)
Griffithides convexiccudatus MITCHELL	N.S.W., Low. (uT-IV)	*Richterella* (O) *Cummingella* (H)
Griffithides sweeti ETHERIDGE fil.	Qu., P-C	*Cyrtoproetus* (H)
Griffithides dubius ETHERIDGE fil.	Qu., Carb.	*Cyrtoproetus* (H)
Brachymetopus strzeleckii MCCOY	N.S.W., Carb.	*Brachymetopus*
Brachymetopus dunstani MITCHELL	Qu., L, M	*Brachymetopus*
Brachymetopus sp. indet.	Qu., L, M	*Brachymetopus*

Abbreviations. N.S.W.: New South Wales, Qu.: Queensland, W.: Western Australia, Carb.: Carboniferous, Low.: Lower Carb., L, M: Lower or Middle Carb., P-C: Permo-Carboniferous, l, m, u: lower, middle, upper., T: Tournaisian, V: Visean, S: STUBBLEFIELD, 1948, O: OSMOLSKA, 1970, H: G. & R. HAHN, 1969, 1970, 1972.

3. *Conophillipsia brevicaudata* ROBERTS, 1963, from Bingleburra formation of the Burindi Group (upper Tournaisian), New South Wales.

4. *Weiania goldringi* CAMPBELL and ENGEL, 1963, from the Tulcumba sandstone, Kinderhookian or lower Tournaisian, N.S.W. This is the type species of *Weiania* in the Cyrtosymbolinae. This genus was accepted as a subgenus of *Archaegonus* by G. and R. HAHN (1969).

5. *Proetus* (*Megaproetus*) *cambrerus* JELL, 1977, from the upper Bridge member of Munduberra sandstone, Queensland.

As summarized above, the Carboniferous trilobites of Australia attain some 30 species. Assuming the taxonomic revision, they are distributed in the following 13 genera and some subgenera including a few of doubtful reference.

Brachymetopidae—*Brachymetopus, Australosutura*
Proetidae s. l.
Proetinae—*Cyrtoproetus, Proetus (Pudoproetus, Megaproetus)*
Phillipsiinae—*Phillipsia, (Phillipsia, Elliptophillipsia), Conophillipsia*
Linguaphillipsiinae—*Linguaphiilipsia, Weberiphillipsia*
Cummingellinae—*Cummingella, Richterella*
Griffithidinae—*Griffithidella (Griffithidella)*
Ditomopyginae—*Paladin (Paladin)*
Dechenellidae
Cyrtosymbolinae—*Weiania*

Among them *Proetus* (*Megaproetus*) is a sole endemic subgenus indigenous to Queensland where it is represented by its type-species. *Brachymetopus* and *Paladin* are on the other hand so widely distributed that they do not bear much importance for consideration of provincality and migration. It is, however, noteworthy that *Brachymetopus* (*Barchymetopella*) as well as *Paladin* (*Weberides*) are as yet unrepresented in Australia.

Australosutura, whose type species is *Cordania gardneri*, is an interesting genus distributed from Queensland and New South Wales to Oklahoma and Missouri through Argentina or the Andean route. *Richterella* and *Phillipsia* (*Elliptophillipsia*) are two other taxa known from the United States of America and possibly from eastern Aurstralia, but no intermediate link is as yet known between the two areas.

The occurrences of *Weiania*, *Conopphillisia* and *Weberiphillipsia* are recorded from eastern Australia on one side and from the Urals or/and Central Asia on the other. These two separate areas are connected by *Cyrtoproetus*, *Cummingella* and *Linguaphillipsia* which are widely distributed in Eurasia. The first genus is known from Europe to the Urals and Central Asia; the second genus from Europe to Central Asia and Yunnan ? and Japan; and the third genus from Europe to Japan through the Urals, ? Central Asia, Turkey and Southeast Asia. These six genera are, however, unknown from the Americas.

Proetus (*Pudoproetus*) and *Griffithidella* were originally instituted in the United States and recently they were found in Japan. The latter is known further from the Altais and South Urals and the former from the Altais to the western slope of the Urals through Central Asia where it is well represented. It may be represented also in Peninsular Thailand by REED's *Proetus* cf. *coddonensis* (G. and R. HAHN, 1969). At the same time it is noteworthy that *Conophillipsia* occurs in Japan, but as yet unknown in South Asia.

The faunal affinity indicated by the Carboniferous trilobites of Australia is, as in the case of those of Japan, closer to European or Eurasian ones than those of North America or the Americas. As pointed out already (KOBAYASHI and HAMADA, 1978), the affinities of the Southeast Asiatic trilobites to those of the Japanese and the Australian ones are about the same degrees.

There are so many genera common between the Australian and Eurasiatic faunas. However, broadly speaking, a half did not enter into Europe beyond the Urals. In view of the occurrence of *Linguaphillipsia* in Turkey and Southeast Asia the trans-Eurasiatic route of migration must have been the Tethyan sea, although no Lower Carboniferous trilobite was uncovered in the Himalayan mountains. Now it is certain that the route was trifurcated in Southeast Asia a branch of which was extending into Australia through the Burmese-Malayan geosyncline in the early Carboniferous period. It is further a remarkable fact that the trifurcate carination as seen in *Schizophillipsia* sporadically developed in the Visean species of *Linguaphillipsia* in Eastern Australia. The recent discovery of *Conophillipsia* on the other hand combined with the occurrence of *Griffithidella* in the Altai mountains suggests the Mongolian geosyncline as another trans-Asiatic route of migration for some genera.

20. Carboniferous Trilobites of the Mid-Continent of North America

Carboniferous trilobites are known to be distributed widely in the United States of America from Georgia to Northern California (WHEELER, 1935) through the Middle Continent as far as Upper Mississippi valley in the north. They had long been referred to *Brachymetopus, Proetus, Phillipsia* and *Griffithides* s. l. until WALTER (1924) and NEWELL (1931) proposed *Proetides* (low. Miss.) and *Ditomopyge* (Penn.-Low. Perm.) for *Phillipsia insignis* WINTCHELL, 1863 and *Phillipsia* (*Griffithides*) *scitula* MEEK and WORTHEN, 1865 respectively.

J. M. WELLER (1936) was the first to carry out extensive revision of Carboniferous trilobites of North America in the generic level. He distinguished five new genera as follows:

Exochops (l. M. Mississippian)
Kaskia (M. Miss.-L. Pennsylvanian)
Paladin (M. Miss.-L. Penn.)
Ameura (Penn.-L. Permian)
Sevillia (Penn.)

The above generic ranges added in brackets according to the citation in MOORE's Treatise (1959).

A further revison was made on the Mississippian trilobites by HESSLER (1962, 63, 65). As the result he added the following five new genera and a new subgenus beside the occurrence of *Phillibole conkini*, n. sp. in Kentucky and Tennessee.

Phillibole (l. Miss.: up. Tournais.-low. Vise. in Europe)
Proetus (*Pudoproetus*) (l. Kinderhook-l. Osage.; Tournais.)
Breviphillipsia (up. Kinderhook-l. Osage.)
Griffithidella (up. Kinderhook-l. Osage.)
Elliptophillipsia (up. Kinderhook)
Thirgiffides (up. Kinderhook)
Richterella (up. Kinderhook-l. Chester)

Recently G. and R. HAHN (1969, 70, 72, 75) attempted to allocate these genera in their scheme of classification in the following manner:

Proetidae
Proetinae
  Proetus (*Pudoproetus* HESSLER, 1963)
Cyrtosymbolinae
  Archaegonus (*Phillibole* R. & E. RICHTER, 1973)

Phillipsiinae
Phillipsia (*Elliptophillipsia* HESSLER, 1963)
Piltonia (*Piltonia* GOLDRING, 1955)
Piltonia (*Breviphillipsia* HESSLER, 1963)
Metaphillipsia REED, 1943
Cummingellinae
? *Ameura* WELLER, 1936
Richterella HESSLER, 1965
Griffithidinae
Griffithidella (*Griffithidella* HESSLER, 1965)
Griffithidella (*Thigriffides* HESSLER, 1965)
Sevillia WELLER, 1936
Griffithides (*Particeps* REED, 1943)
Exochops WELLER, 1936
Ditomopyginae
Ditomopyge NEWELL, 1931 (syn.: *Cyphinium* WEBER, 1933)
Paladin (*Paladin* WELLER, 1936)
Paladin (*Kaskia* WELLER, 1936)
Brachymetopidae
Australosutura AMOS, CAMPBELL & GOLDRING, 1960
Brachymetopus M'COY, 1847
Proetides WALTER, 1924

In the Mid-Continent Carboniferous trilobites flourished most in the early Mississipian and somewhat declined in the late Mississippian period. Among the above genera *Sevillia* is restricted to occur in the Pennsylvanian. While *Paladin* (*Paladin* and *Kaskia*) ranges from upper ? Mississippian to Pennsylvanian, *Ditomopyge* and *Ameura* range from upper Pennsylvanian to Lower Permian.

The range of *Brachymetopus* as a genus is from Upper Devonian to Upper Carboniferous, but its occurrences are limited to the Kinderhookian-Osagean rocks in North America. *Proetus* (*Pudoproetus*) has been known to be a Tournaisian-lower Mississipian genus, but as mentioned below, it survived in the Arctic Canada until Middle Pennsylvanian.

21. Carboniferous Trilobites of South America

AMOS, CAMPBELL and GOLDRING (1960) reported the occurrence of *Australosutura gardneri* (MITCHELL, 1922) in the Visean of Chubut Province, Argentina. Later G. and R. HAHN (1969) proposed *Australosutura argentinensis* for this form. It is nevertheless an important link in the generic distribution between Australia and North America, because *Australosutura gardneri* is known (1) from the upper Burindi Series, New South Wales and *A.* aff. *gardneri* from the Mississipian (Visean) of Oklahoma (ORMISTON, 1966) and further *A. georgiana* RICH, 1966 occurs in the Osagean, Goergia and *A. strattonporterae* (ROWLEY, 1907) in the lower Kinderhookian, Missouri.

Judging from these known records, the genus, *Australosutura*, appeared first in the Kinderhookian in Missouri, then most flourished in the Osagean-Visean times in Georgia and Oklahoma in North America and in Peninsular Argentina, South America. Finally if died out in the Westphalian (?) in New South Wales, Australia.

Ameura is another trilobite genus known from the Americas. Its type-species is *Ameura missouriensis* (SHUMARD, 1858) which is distributed in the Desmoinesian of

Oklahoma and Missouri and the Missourian of Illinois. The second species is *A. major* (SHUMARD, 1858) which is more wide spread in Colorado, Iowa, Kansas and Missouri in the age from early Desmoinesian to Wolfcampian.

Ameura occurs also in South America in the Amazon region in the Upper Carboniferous formation, as represented by the following three species.

Ameura tapajotensis (KATZER, 1903)
Ameura duartei (KEGEL, 1951)
Ameura plummeri (KEGEL, 1951)

22. Carboniferous Trilobites from Alaska and Arctic Canada

Recently CHAMBERLAIN (1977) described three species and four species of Carboniferous trilobites respectively from Alaska and Ellesmere Island as foffows:

1. Mississippian, probably Meramecian, Brooks Range, Alaska.
   Griffithides (Griffithides) megalops CHAMBERLAIN, 1977
   Griffithides (Metagriffithides) ? bufo (MEEK and WORTHEN, 1870)
2. Middle Pennsylvanian or Atokan, Alaska Range
   Griffithides (Griffithides) majus CHAMBERLAIN, 1977
3. Middle Pennsylvanian or Atokan, Ellesmere Island.
   Proetus (Pudoproetus) hahni CHAMBERLAIN, 1977
   Nipponaspis misosilus CHAMBERLAIN, 1977
   Ditomopyge granulata (WEBER, 1933)
   Ditomopyge sp.

CHAMBERLAIN is of opinion that *Griffithides* (*Metaphillipsia* and *Particeps*) are two connecting links of the Mississippian fauna of the Mid-Continent with the Lower Carboniferous fauna of Europe and Central Asia. *Griffithides (Metaphillipsia) bufo* is an Osagean species, but he questions the identification of the Alaskan form with the species.

According to CHAMBERLAIN *Ditomopyge* is a genus common between the Eurasian-Arctic and the Mid-Continent-Andean faunas in the Pennsylvanian and Permian periods, but the species of the genus belong to the *D. artinskiensis* group in the former fauna but the *D. scitula* group in the latter fauna.

Proeus (Pudoproetus) is widely distributed in the lower Mississippian as well as the Etroeungtian-Tournaisian rocks. Pennsylvanian *P.* (*P.*) *hahni* must be a relic form of the subgenus. Assuming that *Nipponaspis misosilus* together with *Gitarra leonensis* ROMANO 1971 from the lower Westphalian of Spain belong to an identical genus with *Nipponaspis takaizumii* KOIZUMI from the Upper Permian *Yabeina* zone of the Abukuma mountains, Japan the third species is a derivative from the Atokan-Westphalian stock.

Finally, *Metagriffithides* is known to be distributed in England and Ireland on one side and on the other side in the Mid-Continent of North America where *Griffithides (Metagriffithides) bufo* occurs. Because little is known of Carboniferous trilobites in the Arctic Siberia and because *Griffithides (Metagriffithides) seminiferus kuleschi* (IVANOV in WEBER, 1937) is described from the lower Visean of Irkutsk, it is probable that the Meramecian form of *Metagriffithides* in Alaska has migrated by way of the Mongolian geosyncline.

III. The Carboniferous Trilobite Provinces

23. The Major Divisions of the Carboniferous System

In North America the Carboniferous System (CONYBERRY, 1822) is splitted into the Mississippian Formation (A. WINCHELL, 1869) and Pennsylvanian Formation (H. S. WILLIAMS, 1891). The major part of the Namurian was correlated to the upper part of the Mississippian by the Mississippian Subcommittee (1948), but to the basal part of the Pennsylvanian by the Pennsylvanian Subcommittee (1960). The latter boundary agrees approximately with that of just about the standard bipartation of the Carboniferous System into the Dinantian and Silesian Series in Europe.

Table 4. Correlation between the Carboniferous Formations in Europe and North America

Europe		North America	
Silesian	Stephanian	Virgilian	Pennsylvanian
		Missourian	
	Westphalian	Des Moinsian	
		Atokan	
		Morrowan	
	Namurian	Springerian	
Dinantian	Visean	Chesterian	Mississippian
		Meramecian	
	Tournaisian	Osagean	
		Kinderhookian	

In the tripartation of the Carboniferous System in the European Russia and Central Asia the Namurian which is restricted to the lower part of the classical Namurian is located at the top of the Lower Carboniferous of European Russia. The Stephanian is the approximate correlative of the Upper Carconiferous in the tripartation.

The Lower Carboniferous in Central and Western Europe consists of the Culm facies and the Carboniferous Limestone facies, like the Rhenish and Hercynian facies in the Devonian stratigraphy of Europe. The Lower Carboniferous of the calcareous facies is the Dinantian or Avonian which is divided into the Tournaisian and Visean. The Etroeungtian is now located at the top of the Devonian System (BRINKMANN, 1966).

Table 5. Two divisions of the Carboniferous System in Europe

<table>
<tr><th colspan="2">West Europe</th><th colspan="2">Russia</th></tr>
<tr><td rowspan="5">Silesian</td><td>Stephanian</td><td>Orenburgian
Gzhelian
Kassimovian</td><td>Upper</td></tr>
<tr><td rowspan="2">Westphalian</td><td>Moscovian</td><td rowspan="3">Middle</td></tr>
<tr><td rowspan="2">Bashkirian</td></tr>
<tr><td rowspan="2">Namurian</td></tr>
<tr><td>Namurian</td><td rowspan="3">Lower</td></tr>
<tr><td rowspan="2">Dinantian</td><td>Visean</td><td>Visean</td></tr>
<tr><td>Tournaisian</td><td>Tournaisian</td></tr>
</table>

24. The Culm Trilobites

The Culm composed chiefly of terrigenous sediments such as mudstone and graywacke is a kind of Flysch in the Variscan geosyncline, best developed in Germany and her adjacence. As well clarified by R. and E. RICHTER and others, the Cyrtosymbolinae were the most flourished trilobite group in the Culm sea represented by various genera of the subfamily, accompanied by *Drevermannia.* The atrophy of the visual organ was the most significant trend of specialization. Such trilobites are rare in other continents or outside of the Culm facies, although cyrtosymbolids occur also in the mixed facies with the Kohlenkalk facies as well as in remote places.

Carbonocoryphe is known from the Ural mountains, *Waribole* from the Urals and Central Asia and *Liobole* from the Urals, Central Asia and Spain. *Weiania* is on the contrary an exception of the Cyrtosymbolinae distributed from New South Wales, Australia to the Urals and England probably through Turkestan and Kirghiz Steppe, but absent in the typical Culm facies of Central Europe.

Among the Culm cyrtosymbolids *Phillibole* was a sole genus of the trans-Atlantic migration as far as Kentucky and Tennessee where is lower Mississippian *Phillibole conkini* HESSLER, 1969.

In West Malaysia *Waribole kedahensis* (KOBAYASHI and HAMADA, 1966) occurs in association with *Diacoryphe* ? sp. in the upper part of the red beds of the Langgon facies. *Waribole ellipticus* (MANSUY, 1912) is known from the Lower Carboniferous of Yunnan. *Waribole lobatus* is found also in the Akiyoshi limestone in West Japan together with two new species of *Archaegonus* (*Angustibole*). *Phillibole arakii* is here described from the Hikoroichi Series, North Japan. *Carbonocoryphe* (*Winterbergia* ?) *orientalis* KOBAYASHI and HAMADA, 1958 from the Tournaisian Hina limestone, West

Japan is the first record of occurrence in Asia.

It is further noteworthy that *Cyrtosymbole* sp. (pygidium) by LAPPARENT and PILLET, 1969 from Afghanistan resembles *Archaegonus* (*Weiania* and *Belgibole*) according to F. and R. HAHN, 1969, would be a link between European and Eastern Asiatic cyrtosymbolids. It can hardly be overlooked that the above Malayan cyrtosymbolids are gregarious in the so-called Langgon red beds which indicate the regressive facies at the Devonian-Carboniferous transition on one hand and *Carbonocoryphe orientalis* and three new species in *Waribole* and *Archaegonus* (*Angustibole*) are contained in the Lower Carboniferous white Akiyoshi limestone on the other. Thus their occurrences are different from the Culm facies. As pointed out already, *Carbonocoryphe orientalis* may represent a new subgenus of *Carbonocoryphe*.

25. The Kohlenkalk and later Carboniferous Trilobite Province in Europe

The Kohlenkalk is chiefly composed of calcareous sediments accumulated on the epicontinental sea. Brachiopods and corals are its leading fossils. The trilobites comprising the Phillipsiinae, Cummingellinae and so forth vary to a great extent. This is the normal or the cosmopolitan type of the fauna. They are distributed widely in the British Isles, Belgium, and adjacence in West Europe and Poland and European Russia in East Europe in the rocks from Tournaisian to Namurian. *Phillibole* and *Particeps* are two examples of the trans-Atlantic distribution, but rare in North America.

Caused by the Variscan cycle of orogeny, particularly by the Sudetian phase of orogeny the palaeogeography of Europe was greatly changed between the Visean and Namurian epochs. Sea, however, persisted in the Russian platform and the Uralian geosyncline where Middle and Upper Carboniferous trilobites thrived. The Carnic Alps and Karawaken of the Eastern Alps are also important fossiliferous areas for the Upper Carboniferous trilobites.

26. The Eurasian Lower Carboniferous Trilobite Province

In their proposed Cummingellinae G. and R. HAHN (1967) combined two branches supposed to have been derived from the *Cornuproetus* stock. One branch comprised two American genera *Richterella* and *Ameura*. The other is the Eurasiatic branch represented by *Cummingella* in addition to *Moschoglossis* and *Liobolina* where *Moschoglossis* is restricted to the Carboniferous limestone facies and *Liobolina* to the Culm facies in Europe.

Cummingella is a large genus well represented by many species and subspecies in Europe and Central Asia beside two doubtful species in Southeast Asia and Australia. G. and R. HAHN (1972) suggested *Cummingella* with question mark for *Griffithides cognatus* REED, 1927, from Yunnan. For *Griffithides convexicaudatus* MITCHELL from New South Wales *Cummingella* was also suggested by them, but *Richterella* by OSMOLSKA (1970). Now, however, *Cummingella* is well represented in Japan by some species from the Omi and Akiyoshi limestones. Therefore it is a typical Eurasiatic genus.

Linguaphillipsia and its close ally, *Palaeophillipsia*, constitute another important Lower Carboniferous group of trilobites which was widely distributed from Europe to

Australia through Central and South Asia where in the last *Linguaphillipsia* is known from Turkestan, Turkey, Southeast Asia, and further it is found in Japan.

Beside them G. and R. HAHN (1975) included *Pseudowaribole* (*Pseudowaribole* and *Geigibole*), *Gitarra*, *Bitumulina*, *Weberiphillipsia*, *Nipponaspis* and Permian *Hildaphillipsia* in the Linguaphillipsiinae, but none of them occurs in the Americas except for Middle Pennsylvanian *Nipponaspis misosilus* CHAMERLAIN in Ellesmere Island. Therefore *Linguaphillipsia* and the Linguaphillipsiinae in the Carboniferous period are an Australian-Eurasiatic genus and subfamily.

OSMOLSKA (1970) restricted the domain of the Phillipsiinae to include *Phillipsia*, *Piltonia* and *Eocyphinium* where the first is limited to occur in Europe, but the two others are found also in North America. According to her HESSLER's three species of *Phillipsia* belong to *Piltonia* and *Breviphillipsia sampsoni* (VOGDES, 1888) is an *Eocyphinium*.

G. and R. HAHN (1975) classidfied the Phillipsiinae as below.

Phillipsia (*Phillipsia*)..................Eurasia, ? Australia
Phillipsia (*Elliptophillipsia*) ....North America
Piltonia (*Piltonia*) ....Europe
Piltonia (*Breviphillipsia*) ....North America
Eocyphinium ....Europe
Metaphillipsia ....Europe, Siberia, ? North America

Thus, according to them the North American species of *Phillipsia* and *Piltonia* are different from European ones in the subgeneric level. The occurrences of *Phillipsia* (*Phillipsia*) and *Metaphillipsia* respectively in Australia and North America are not warranted.

A few years before this classification, however, G. and R. HAHN (1970) accepted *Griffithides* (*Metaphillipsia*) including *Phillipsia* (*Griffithides*) *bufo* MEEK and WORTHEN, 1870 as a wide spread subgenus in Eurasia and North America. Following this opinion, CHAMBERLAIN (1977) emphasized the faunal connection between Europe and North America through the Urals by the find of *G.* (*M.*) ? *bufo* in Alaska. To investigate the migration of metagriffithids, however, the occurrence of *G.* (*M.*) *seminiferus kuleschi* IWANOW, 1937 at Irkutsk can hardly be overlooked.

Beside the above genera *Conophillipsia* was referred to the Crassiproetinae by OSMOLSKA (1970), but to the Phillipsiinae by G. and R. HAHN (1972). Now it is known to be a distinct genus within the Proetinae. Eliminating this genus it is a remarkable fact that the Phillipsiinae represent a short ranged subfamily in the age from Tournaisian to Namurian and rare or absent in Southern and Eastern Asia and Australia. The occurrence of *Phillipsia* in North Japan is rather exceptional. In other words it is a subfamily flourished on the Atlantic-European side, although the subgeneric endemism is recognizable between European and North American forms.

In summary it is noted that *Cummingella* is an Eurasiatic genus and *Linguaphillipsia* an Australian-Eurasitic genus. The Phillipsiinae fiourished in Europe, if two subgenera are excluded. As mentioned below, the Griffithidinae represent an Eurasiatic subfamily, if *Exochops* is eliminated.

Griffithides (*Griffithides*) ....Europe, Central Aisia
Griffithides (*Particeps*) ....Europe

Exochops..............................North America
Cyphinioides...........................Europe, the Urals, Kazakhstan

27. The Mid-Continent—South American Carboniferous Trilobite Province and the Andean Route of Migration

This province was characterized not only by the lack of *Cummingella* and *Linguaphillipsia*, but also by such indigenous genera as

Richterella of the Cumingellinae
Exochops of the Griffithidinae
Elliptophillipsia and *Breviphillipsia* of the Phillipsiinae

in the Mississipian fauna and

Ameura of ? the Cummingellinae
Sevillia of the Ditomopyginae

in the Pennsylvanian fauna.

Australosutura was wide spread in the Kinderhookian-Osagean of North America and the Westphalian (?) of Australia. *Australosutura argentinensis* G. and R. HAHN, 1969 from the Visean in Province Chubut, Argentina prooves the route of migration from North America to Australia through the Andean geosyncline. In the Pennsylvanian times *Ameura* migrated from the Mid-Continent as far as the Amazon basin, Brasil.

28. The North Pacific and Trans-Eurasiatic Routes of Migration

Pudoproetus was distributed from the Mid-Continent of North America to the Urals, the Kirghiz Steppe, Turkestan and Altai mountains through Japan. *Griffithidella* is another trans-North Pacific genus distributed from North America to the Altai and Ural mountains on one side and Australia on the other through Japan, instead of the Andean route. Combined with *Metaphillipsia* from Irkutsk, near the Lake Baikal these two genera suggest the Mongolian geosyncline was a trans-Asiatic route for the Carboniferous trilobites until the Visean age.

Among the Eurasiatic genera *Linguaphillipsia* on the other hand shows the Tethyan route of migration through Turkey and the Malayan peninsula where in the latter the route was trifurcated, leading to Japan to the east and to Australia to the south. *Waribole*, *Angustibole*, *Phillibole* and *Carbonocoryphe* may also spread to the Far East from Europe through the same route.

Beside these two routes there may have been the Arctic route of migration, but little is as yet known of the Carboniferous trilobites from Northern Siberia between the Ural mountains and the Alaskan peninsula.

29. The Middle and Upper Carboniferous Trilobites

In the Brachymetopidae *Brachymetopus* s. str. is a Carboniferous cosmopolitan genus particularly well flourished in the Lower Carboniferous in Europe, the Urals, Turkestan, the Altais and in Japan. Furthermore it occurs in Australia and the United States of

America to the east of New Mexico. *Brachymetopella* is a branch issued in the Tournaisian (?) from the *Brachymetopus* stock. It was spread in the Urals to Japan through the Kirghiz Steppe and died out in the Orenburgian in the Eastern Alps.

Appearing with *Paladin* in the middle (?) Tournaisian the Ditomopyginae flourished most in the Permo-Carboniferous period. *Paladin* (*Paladin* and *Kaskia*) and *Ditomopyge* were widely spread in Eurasia and North America. Beside them there were four endemic genera as follows:

Kulmiella, Visean-Namurian, Europe
Pseudophillipsia, Stephanian-Permian, Eurasia
Humilogriffithides, Moscovian, China and Japan
Sevillia, Pennsylvanian, North America.

Incidentally *Ditomopyge* occurs in Australia in the Permian.

Thaiaspis (*Thaiaspis* and *Thaiaspella*) of the Thaiaspidinae are known from the Upper Carboniferous, Thailand, besides certain resembling forms in North America.

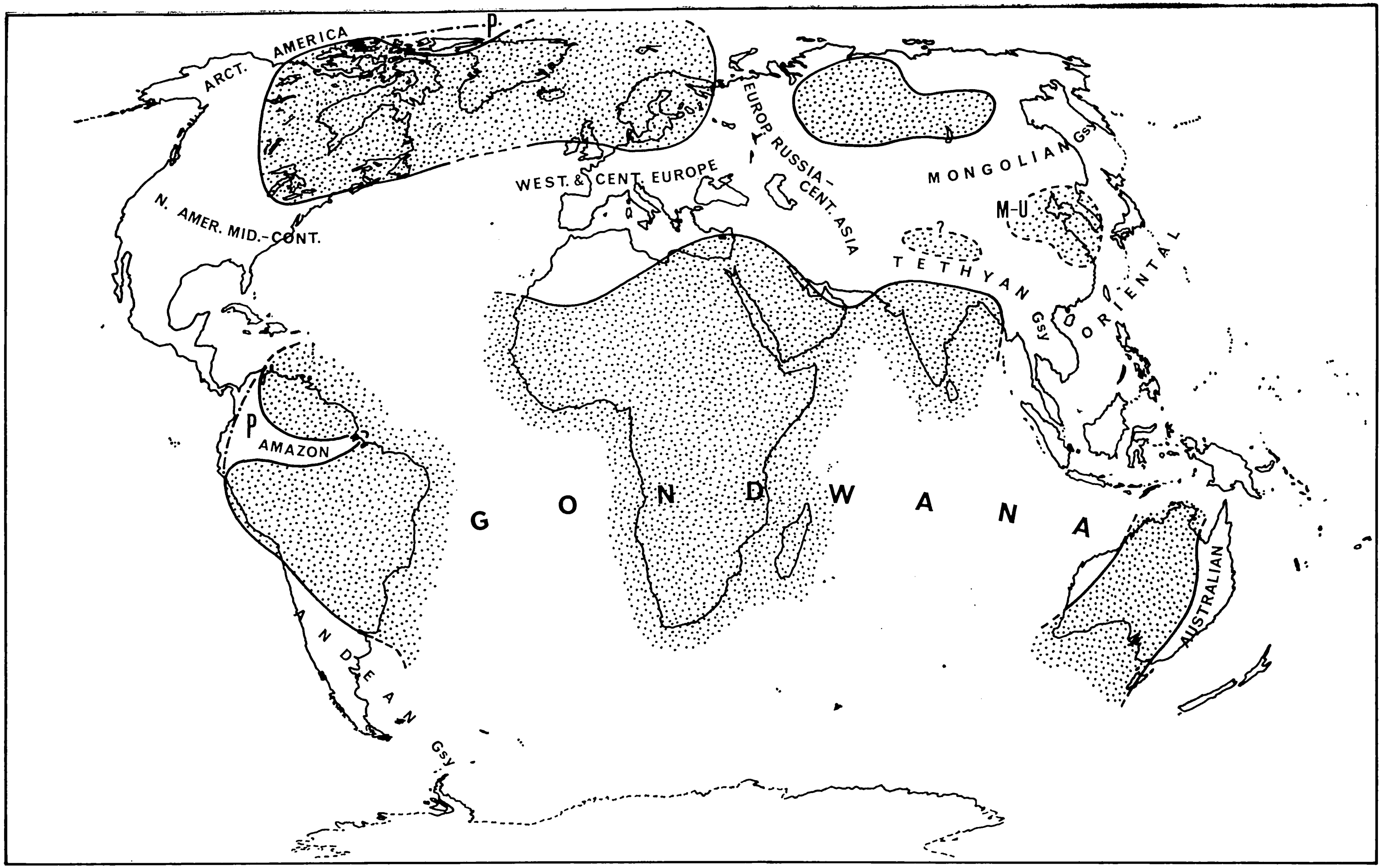
30. The Carboniferous Trilobite Provinciality

The Carboniferous trilobites of Eastern Asia were considerably clarified in recent years. Forty-one species are known at present from Japan, twelve or more species from China and about ten species from Southeast Asia, i. e. Laos, Viet-Nam, Thailand and Malaysia. The Oriental fauna constituted by them attains more than sixty species of trilobites in total. The Australian fauna comprises some thirty species of Carboniferous trilobites all distributed in Queensland and New South Wales except for *Griffithidella cannolli* (MITCHELL) from Western Australia.

Thus, our knowledge of Carboniferous trilobites in the western Pacific is now well advanced, although they are much less clarified in South Asia, Mongolia, South America and Arctic Siberia. As to the number of known species there is a considerable difference between the Dinantian-Mississippian and Silesian-Pennsylvanian periods. Although such a spatiotemporal unbalance exists in our knowledge, an attempt is made to elucidate the Carboniferous trilobite provinciality. As the result it is found that it is similar to that of the Devonian period detailed in the preceding monograph (1977), except for a the South African-Malvinian-West Antarctic subprovince of which little is known of the Carboniferous trilobite.

In the Carboniferous period there were the Old and New World Realms. The latter is best represented by a rich fauna in the Mid-Continent of North America. It is different from the former in the total absence of *Linguaphillipsia* and *Cummingella* and the presence of several endemic genera already noted. *Ameura* is one of them which migrated into the Amazon basin in the Pennsylvanian age, while the occurrence of *Australosutura* in Argentina reveals the faunal connection from the Mid-Continent to Eastern Australia through the Andean geosyncline in the Mississippian times. Because only a genus is so far known from the Amazon basin and another from the Andean geosyncline, they are accepted here two regions of the New World realm which were branched off from the North American Mid-Continent province.

The Old World realm comprises four provinces, namely, (1) the West-Central European province, (2) the European Russia-Central Asiatic province, (3) the Oriental pro-



Text-fig. 2. Palaeogeographic Map showing Early and Middle Carboniferous Trilobite Provinces.
P: submerged areas by the Pennsylvanian seas
M-U: submerged areas by the Moscovian and later Carboniferous seas

vince and (4) the Australian province which are well represented by rich trilobite faunas.

The first is the best known province where the Culm and Kohlenkalk faunas co-exist. In the second province the fauna of the first, but mosty of the Kohlenkalk is associated with the Oriental elements.

The fauna of the Oriental provience is related to the second and fourth faunas closely, and in a lessened degree to the North American one.

The Australian fauna is also closely allied to the Eurasiatic faunas, but *Australosutura* indicates its connection with the American faunas through the southeastern Pacific route.

Between the second and third provinces there were the Mongolian and Tethyan geosynclinal regions, of which Carboniferous trilobites, however, much remains for future investigation.

Finally, little is known of the trilobites in the Arctic North America. *Griffithides* (*Griffithides*) is characteristic of the Eurasiatic fauna in Europe-Central Asia, while *Pudoproetus* is wide spread from North America to the Urals and Australia through Japan. *Ditomopyge* is another wide spread genus in Eurasia and North America, but absent in the Carboniferous fauna of Australia. Of *Nipponaspis* Carboniferous records are isolated in Spain and Ellesmere Island, but the Alaskan form of *Metagriffithides* together with the Irkutsk form suggests the lower Visean-Meramecian faunal connection through the North Pacific route. In weighing the above facts the Arctic North American fauna may be closer to the Eurasiatic fauna than the Mid-Continent one.

In summary the Carboniferous trilobite sphere is tentatively classified into two realms, 5 provinces and 5 regions as below.

I. The Old World realm.
  A. The West-Central European province
  B. The European Russia-Central Asiatic province
    a. The Mongolian geosynclinal region
    b. The Tethyan geosynclinal region
  C. The Oriental province
  D. The Australian province
    c. The Arctic American region
II. The New World realm
  E. North American Mid-Continent province
    d. The Andean geosynclinal region
    e. The Amazon region

Palaeontology

Introduction and Summary

Before this project of research only the following five species of trilobites have been described from Japan in three articles by SUGIYAMA (1944), OKUBO (1951) and ENDO and MATSUMOTO (1962). Here some comments are added to them with fresh material.

Palaeophillipsia japonica SUGIYAMA and OKANO, 1944
Palaeophillipsia ? kitakamiensis SUGIYAMA and OKANO, 1944
Phillipsia ohmorensis OKUBO, 1951
Brachymetopus (Brachymetopina) japonica ENDO and MATSUMOTO, 1962
Humilogriffithides taniguchii ENDO and MATSUMOTO, 1962

Recently eight new species listed below were erected in preliminary reports by KOBAYASHI and HAMADA (1978a, b) and KOBAYASHI and TACHIBANA (1978). They are all redescribed here in further detail.

Proetus (Pudoproetus) obsoletus KOBAYASHI and HAMADA, 1978a
Carbonocoryphe (Winterbergia ?) orientalis KOBAYASHI and HAMADA, 1978a
Griffithidella nishikawai KOBAYASHI and HAMADA, 1978a
Thigriffides (?) hinensis KOBAYASHI and HAMADA, 1978a
Brachymetopus (Brachymetopella) akiyoshiensis KOBAYASHI and HAMADA, 1978b
Cummingella otai KOBAYASHI and HAMADA, 1978b
Paladin longispiniferus KOBAYASHI and HAMADA, 1978b
Conophillipsia decisegmenta KOBAYASHI and TACHIBANA, 1978

Since the authors had once listed new names of fifteen species in "Outline of the Carboniferous Trilobites of Japan", 1979, the Japanese fauna was further amplified with thirteen species marked by asterisks. Because *Paladin yukizawensis*, nom. nud. was found to be *Schizophillipsia yukisawensis*, gen. et sp. nov., new species proposed on this occasion total twenty-eight as follows:

Brachymetopus (Brachymetopus) omiensis,
Brachymetopus (Brachymetopus) gracilentus,*
Brachymetopus (Brachymetopella) kitagawai,*
Archaegonus (Angustibole) reliquius,
Archaegonus (Angustibole) impolitus,
Waribole lobata,
Phillibole arakii,
Phillipsia longiconica,*
Linguaphillipsia choanjiensis,
Linguaphillipsia higuchizawensis,
Linnguaphillipsia subconica,
Palaeophillipsia tenuis,
Dechenelloides asiaticus,*
Schizophillipsia yukisawensis,
*Schizophillipsia otsuboensis**
*Schizophillipsia ? platyrachis**
Cummingella subtrigonalis,
Cummingella mesops,

*Cummingella granulifera**
*Cummingella imamurai,**
Cummingella subovalis,
Cummingella (?) *euryrachis,*
*Bollandia pacifica,**
*Parvidumus densigranulatus,**
Thigriffides (?) *kibiensis,**
Paragriffithides japonicus,
*Paladin carinatus,**
*Paladin mizunoi.**

In addition three new formas are distinguished among them as follows:

Brachymetopus (*Brachymetopella*) *akiyoshiensis* forma *disjuncta*
Pudoproetus obsoletus forma *granulatus*
Phillipsia ohmorensis forma *multisegmenta*

Beside the forty-one species known in Japan at present there are *Liobole* ? sp. indet. and many others exactly indeterminable forms which suggest the greater wealth of Japanese trilobites.

The following three new genera and one new subgenus are founded on Japanese species as their type-species cited behind the genera.

Palaeophillipsia SUGIYAMA, 1944: *Palaeophillipsia japonica* SUGIYAMA and OKANO, 1944
Brachymetopus (*Brachynetopella*) KOBAYASHI and HAMADA, 1978: *Brachymetopus* (*Brachymetopella*) *akiyoshiensis* KOBAYASHI and HAMADA, 1978
Schizophillipsia, gen. nov.: *Schizophillipsia yukisawensis*, sp. nov.
Parvidumus, gen. nov.: *Parvidumus densigranulatus*, sp. nov.

In recent years Carboniferous trilobitology has been greatly advanced by OSMOLSKA, G. and R. HAHN and some others. The above cited Japanese species belong to twenty-one genera including five subgenera which are tentatively referred to two families and seven subfamilies in the Proetidae as below:

I. Brachymetopidae: *Brcchymetopus* (*Brachymetopus, Brachymetopella*)
II. Proetidae
   1. Proetinae: *Pudoproetus, Conophillipsia*
   2. Cyrtosymbolinae: *Archaegonus* (*Angustibole*), *Waribole, Phillibole, Liobole* ?, *Carbonocoryphe*
   3. Phillipsiinae: *Phillipsia*
   4. Linguaphillipsiinae: *Linguaphillipsia, Palaeophillipsia, Dechenelloides, Schizophillipsia*
   5. Cummingellinae: *Cummingella*
   6. Griffithidinae: *Bollandia, Parvidumus, Griffithidella, Thigriffides, Paragriffithides*
   7. Ditomopyginae: *Paladin* (*Paladin, Weberides*), *Humilogriffithides*

Some notes are given on *Brachymetopus* (*Brachymetopus, Brachymetopella*), *Conophillipsia, Carbonocoryphe, Linguaphillipsia, Dechenelloides, Bollandia, Paladin* (*Paladin, Weberides*) the Cyrtosymbolinae and Linguaphillipsiinae.

In summary the Carboniferous trilobites of Japan consist at present of forty-one species in twenty-one genera beside indeterminable ones which suggest a greater wealth of the fauna. The trilobites of the Kitakami biofacies are mostly deformed in various manners and different degrees. This state prevented the authors to make exact identification for part of the collection. The trilobites of the Akiyoshi biofacies are less deformed, but no complete dorsal shield has so far been obtained. Therefore isolate cephala and pygidia are tentatively combined in a species. There are in addition some isolate pygidia and other fragments which may be found in future to be a distinct species.

Family Brachymetopidae PRANTL and PŘIBYL, 1950

Genus *Brachymetopus* McCOY 1847

The subgeneric division of *Brachymetopus* on the basis of the presence or absence of the border spines on the pygidium and also the type-species of *Brachymetopus* (*Brachymetopus* and *Brachymetopina*) have long been a moot discussion among VOGDES, 1860, REED, 1903, RICHTERS, 1926, WEBER, 1937, GOLDRING and STUBBLEFIELD, 1957, SCHMIDT, 1958, GAURI and RAMOVŠ, 1964 and others. As the result of extensive and intensive revision on the European brachymetopids G. HAHN (1964 a-c) arrived at the conclusion that *Phillipsia maccoyi* PORTLOCK 1843 should be the type-species of *Brachymetopus* McCOY 1847 and the subgeneric distinction of *Brachymetopina* REED 1903 from *Brachymetopus* s. str. was ignored because it was found that marginal spines in the early post-larval stage disappeared in the grown stage in *Brachymetopus maccoyi spinosus* HAHN 1964.

The above spines in the 2 mm stage of pygidial length are no more than very short projections in *B. m. spinosus.* The spines are longer in the 2.3 mm stage of *B. maccoyi woodwardi* WHIDBORNNE, but the pleural ribs are all simple in these forms. Short but sharp spines are present in *B. moelleri thuringensis* HAHN and *B. senckenbergianus* HAHN respectively in the 3.3 mm and 5.6 mm stage of pygidium having double ribs.

In the Akiyoshi material two pygidia of 5 mm stage and one of 7 mm stage were collected at Shohoji with a cephalon measuring 4.5 mm in length exclusive of genal spines. Another cephalon of the same species collected at Iwanaga-dai of the same area is 6 mm long. Although the number of the specimens before hand is not great, all of them are in similar stages of growth and there is no reason to doubt their maturity.

Similar marginal spines are known of *B. vyssothkii* WEBER, 1937 in the 5 mm stage and a few others. *Brachymetopus spiniformis* WILLIAMS, 1947, has short spines or projections in the pygidium, 10 mm in length. Therefore it is undeniable that some brachymetopids maintained marginal pygidial spines until their full grown stages.

In *Brachymetopus maccoyi* (PORTLOCK, 1843) the glabella is short, truncate-conical, a pair of basal lobes are distinctly defined by posterior lateral furrows and facial sutures closed in the cephalon and nine pairs of pleural ribs simple, marginal spines present only in young stages of certain subspecies. These aspects commonly seen also in other European species, although the interpleural furrows are indistinct in *Brachymetopus moelleri thuringensis* HAHN, *B. uralicus* VERNEUIL and a few others. The outline of the cephalon and pygidium are mostly semicircular among the European species, although subtriangular cephala are met with uncommonly and subtriangular pygidia rarely.

To decipher the evolution of brachymetopi it may be wise to distinguish them in three or more species-groups with reference to not only the marginal spines in question but also some other biocharacters. Here the Brachimetopidae are splitted into *Brachymetopus* (*Brachymetopus* and *Brachymetopella*, nov.) and *Cheiropyge*.

Subgenus *Brachymetopus* McCOY, 1847

Brachymetopus (*Brachymetopus*) *omiensis* KOBAYASHI and HAMADA, sp. nov.

Plate I, Figures 1-7; Text-figure 3A

Description: Cephalon semicircular in outline strongly vaulted above crescentic depressed marginal border narrowing postero-laterally; glabella apparently elongate oval, very convex, highly elevated above cheeks which are also well convex; eyes fairly large, located far posteriorly and close to the glabella; frontal limb relatively short; marginal border nearly horizontal, composed of inner shallow smooth furrow and moderately convex granulate outer rim which is nearly as long as the furrow in the sagittal length; border furrow narrows postero-laterally and joins posterior border furrow into a diagonal furrow at genal angle and crosses the marginal rim; short genal spine present. Test with coarse granules except for furrows; granules along inner margin somewhat larger than others on the rim.

Pygium moderately convex, nearly semicircular; anterior margin broadly arcuate; axial lobe about one-third as wide as pygidium, conical, but abruptly rounded near posterior end; the lobe divided into more than 14 rings; posterior three or four on terminal pieces ill-defined, while others are clearly separated from one another by strong ring furrows; axial furrow deep; pleural lobe composed of six or seven ribs separated by pronounced pleural furrows; some of them divided into two unequal riblets by a shallow interpleural furrow which, however, dies out adaxially; anterior riblet evidently thicker than the other; interrupting the latter, the former bent backward near pygidial margin where it is suddenly thickened and rounded off shortly inside of the margin; neither distinct marginal furrow nor depressed border present, but pleural field is geniculated near the bent; a row of tubercles present on the top of axial ring as well as pleural riblet.

Observation:—A large cephalon and two pygidia of moderate size are from the Omi limestone. Because the posterior part of the glabella is destroyed, little is known of the occipital ring and basal lobes. The smaller one of these pygidia in fig. 2 is selected for the holotype of this species. In the exfoliated posterior part of this pygidium the axial lobe is seen to terminate just inside of the narrow doublure. The modes of the posterior bending and swelling of the anterior pleural riblet are visible on the two pygidia, particularly well on their exfoliated parts.

Comparison:—This pygidium is unusually paucisegmented. The last rib which is the sixth in the holotype and the seventh in the paratype pygidium is a short simple improminent rib parallel to the axis seen on the posterior-lateral side of the terminal piece of the axis. Another characteristic of this pygidium is the terminal bent of the anterior riblet by which the posterior one is embraced. A similar aspect is seen in *Brachymetopus senckenbergianus* G. HAHN, 1964, but in that species the anterior riblet is produced into a short spine. In this species on the other hand the margin of the pygidium is entire and the posterior bending of the riblet is incomparably emphasized. There the riblet is broadened in form of a mamelon and then rounded off just on the inner margin of the very narrow marginal rim.

Though the associate cephalon is imperfect, it is also quite distinctive. In most Eurasiatic species of *Brachymetopus* s. str. the glabella is subconical, straight laterally but rounded in front and its length is only a little longer than the sagittal length of the preglabellar area, but in this species the glabellar length occupies no more than two-third of the cephalic length. The glabella is oval at least in its anterior and median parts. In the outline and large size of the glabella it may be similar to *Brachymetopus lodiensis* MEEK, but the glabella is not so long, the preglabellar area distinctly differentiated into the frontal limb and border and the latter into a furrow and rim in this species.

Compared to *Brachymetopus japonicus* the glabella is broader and not parallel-sided, preglabellar field narrow and the marginal flanges well developed.

The small number of pleural segments and the mode of pleural ribbing of the pygidium are quite distinctive among various species of *Brachymetopus* (*Brachymetopus*).

Occurrence:—Omi limestone, SATO collect. *Pseudostaffella antiqua* zone of Akiyoshi limestone at Matuyama quarry. MIZUNO collect.

Brachymetopus (*Brachymetopus*) *gracilentus* KOBAYASHI and HAMADA, sp. nov.

Plate I, Figures 8-10; Text-figure 3B

Two cephala from Maruyama quarry differs from *Br. omiensis* in the longer and slender outline of the glabella like *Brachyymetopus* (*Brachymetopella*) *akiyoshiensis*, but it can be distinguished from *Br. akiyoshiensis* by the glabella slowly expanding backward and further by a pair of clear-cut small basal lobes.

A pygidium (I, 10) from the same locality differs from *Br. omiensis*' pygidium in the parabolic outline, slender axis and some median tubercles greater than those in rows of axial rings. Such tubercles are clearly seen on the third, fifth, seventh, ninth and eleventh rings on this pygidium. The depressed marginal border is more or less indented by shallow undulations corresponding to pleural furrows.

Occurrence:—*Pseudostaffella antiqua* zone of Akiyoshi limestone at Maruyama quarry.

Subgenus *Brachymetopella* KOBAYASHI and HAMADA, 1978

1978. *Brachymetopus* (*Brachymetopella*) KOBAYASHI and HAMADA, *Proc. Japan Acad. v. 54(B), no. 2*, p. 50.

Diagnosis:—Cephalon semicircular to broad subtriangular in outline; glabella long, subcylindrical or longiconic and unfurrowed; basal lobes obsolete; frontal limb short; marginal border and furrow well developed; eyes far posterior, fairly large, prominent, close to glabella; facial sutures widely divergent from eyes, if opened. Pygidium roundly triangular, well inflated and depressed near margin; axis multisegmented; pleural ribs in about seven pairs, prolonged beyond margin into sharp spines even in grown stages; these ribs generally double and the last pair may be united as a post-axial piece and median spine. Test granulate except for furrows.

Type-species:—Brachymetopus (Brachymetopella) akiyoshiensis KOBAYASHI and HAMADA, sp. nov.

Remarks:—The following species are most probably referable to this subgenus.

1. *Brachymetopus (Brachymetopus ?) pseudometopina* GAURI and RAMOVŠ 1964 from Upper Carboniferous (Orenburgian-Gshelian), Karawaken, Yugoslavia.
2. *Brachymetopus pseudometopina jesenicianus* G. & H. HAHN and RAMOVS 1977 from Upper Carboniferous (Gshelian), Karawaken, Yugoslavia.
3. *Brachymetopus strzelickii uralicus* WEBER 1937 from Visean, South Urals and Namurian, West Urals.
4. *Brachymetopus vyssotzkii* WEBER 1937 from Lower Carboniferous, Kirghiz steppe.
5. *Brachymetopus moelleri* WEBER, 1937 from Upper Carboniferous Fusulina limestone, Urals.

Like the type-species *B. pseudometopina* has a subtriangular pygidium with a large axis, double pleural ribs in 7 pairs ending at sharp marginal spines. Like *Loeipyge* large median tubercles appear on intermittent axial rings, but in that genus the pygidium lacks marginal spines and the depressed smooth marginal border is well developed. Its ogival cephalic outline looks similar to that of *Cheiropyge kansasensis.* The genal spine is absent in *B. pseudometopina pseudometopina,* but a short but broad spine is present in its subspecies *jesenianus.*

In *B. strzeleckii uralicus* the cephalon exclusive of genal spines is semicircular; glabella parallel-sided, rounded in front; basal lobes obscure; eyes large, prominent near neck ring; marginal border and furrow well pronounced; surface granules varing in size. Its pygidium has 13-15 axial rings and 6 pairs of double pleural ribs produced into short spines.

B. moelleri was founded on a subtriangular cephalon with round genal angles; glabella subcylindrical; basal lobes obscure; among granules a central glabellar one and a pair of preglabellar ones particularly large. Until its associate pygidium is found, its belonging to either this genus or *Cheiropyge* cannot be solved.

B. vyssotzkii is represented by a pygidium having 15 marginal spines; pleural ribs in seven pairs, anterior two being divided into two unequal bands; axis strongly convex, divided into 10-12 very prominent rings.

Beside these species LÖVENECK's pygidium of *Brachymetopus* from Tienshan having 12 marginal spines may be a member of this subgenus.

Distribution:—Carboniferous; the Urals, Central Asia and Japan.

Brachymetopus (Brachymetopella) akiyoshiensis KOBAYASHI and HAMADA, 1978

Plate II, Figures 1-2, 4 and 6; Text-figure 3C

1978. *Brachymetopus (Brachymetopella) akiyoshiensis* KOBAYASHI and HAMADA, *Proc. Japan Acad. v. 54(B). no. 21,* p. 51, figs. 1a-d and 2a-d.

Description:—Cephalon strongly vaulted toward glabellar centre, semicircular in outline, but having genal spines of moderate length. Glabella subcylindrical, one and half as long as broad, suddenly rounded in front, strongly convex, clearly outlined by profound dorsal furrows; lateral furrows obsolete; occipital furrow deep, straight, transversal; occipital ring thickened mesially; preglabellar limb short, steeply slant forward, separated from a little convex frontal border by broad profound smooth furrow. Cheeks very convex, rising toward eyes which are close-set to glabella in posterior to its centre and almost as high as the top of the glabella. Eyes reniform, prominent. Fixed cheek narrow; free cheek moderate in size, steeply inclined outward from eye. Marginal borders convex, thick and produced into stout genal spine, nearly as long as glabella; border furrows well developed, lateral and posterior ones of which become confluent to form a median furrow on genal angle. Facial sutures discernible in part; their anterior branches apparently a little convergent in front of eyes and cutting marginal border inside of eyes; their posterior branches diagonal on posterior cheek border as far as parallels through eyes. Surface of cephalon ornamented by coarse granules densely except for smooth furrows.

Pygidium roundly triangular, two-thirds as long as broad, strongly inflated and provided with six pairs of marginal spines; anterior margin somewhat arcuate. Axial lobe slightly broader than pleural field, breviconic, strongly elevated above the field, composed of more than twelve rings and a small terminal lobe; post-axial piece depressed and produced back into a spine; axial rings each decorated by a row of tubercles and separated from one another by profound ring furrows. Pleural lobes convex, composed of six pairs of double ribs, steeply declined in distal part, then depressed horizontally and ending at short spines; pleural furrows stronger than interpleural ones; each rib bearing a row of tubercles.

Observation:—In the cephalon from Iwanaga-dai (YANAGIDA collect.) the cranidium is so well anchylosed with the free cheek that no trace of the facial suture is visible. The anterior branch as well as the posterior one, however, can be seen in the other cephalon (II, 1) from Nakano Shohoji. While the left genal spine is well preserved in the later, the left spine is completely broken diagonally at the genal angle and the right one remains only partly in the former cephalon.

Between two pygidia from Shohoji the axial rings are all transversal in one (II, 6), but the middle ones are distinctly wavy in the other pygidium (II, 4). The latter shows the unpaired median spine clearly.

Comparison:—A small cephalon, 2 mm long, from the Tournaisian of Karaganda, Kirghiz steppe, which was called *Brachymetopus* sp. No. 1 by WEBER, 1937 looks very similar to the cephalon of this species in the general aspect, particularly in the cylindrical glabella and genal spines of moderate length, but in that species the glabella is more slender and its pygidium is unknown.

Occurrence:—A cephalon from the *Millerella* zone at Iwanaga-dai (IW-1), collected by YANAGIDA. Another cephalon (ASM 8003) and two pygidia (ASM 8010, 8007a) contained in medium and coarse calcarenite, partly oolitic calcarenite at loc. no. Ya-2, Nakano Shohoji, Kawahara, Isa-town, Mine city, in the lower part of the *Profusulinella beppensis* zone, collected by M. OTA, K. HASHIMOTO and KAGIOKA and kept in Akiyoshi Science Museum.

Barchymetopus (*Brachymetopella*) *akiyoshiensis* forma *disjuncta*
KOBAYASHI and HAMADA, forma nov.

Plate II, Figure 5

In a pygidium (ASM 8007b) the anterior four axial rings are persistent transversally, though wavy. The succeeding ten or more rings in the middle and posterior part of the lobe are on the other hand discrepant by a narrow smooth median zone. Otherwise this form agrees with the preceding two pygidia. It is noteworthy that the post-axial area which is produced into the median spine bears two pairs of tubercles suggesting that the seventh pair of pleural ribs are united therin.

Occurrence:—Nakano Shohoji (loc. Ya-2); collection of Akiyoshi Science Museum (ASM 8007b).

Brachymetopus (*Brachymetopella* ?) *japonica*
ENDO and MATSUMOTO, 1962

1962. *Brachymetopus* (*Byachymetopina*) *japonicus* ENDO and MATSUMOTO, *Sci. Rep. Scitama Univ. Ser. B, v. 4, no. 2*, p. 168, pl. 2, figs. 7a-c, non fig. 8.
1969. *Australosutura* ? *japonica* G. & R. HAHN, *Fossilium Catalogus I: Animalia, Pars 118*, p. 16.

Because two specimens were designated as two types by ENDO and MATSUMOTO and because the second type is an incomplete pygidium whose reference to this species or even the genus is not warranted, as discussed below, it is here eliminated out of this species.

The lectotype specimen is a strongly vaulted cephalon to which the first thoracic segment is attached. Its glabella is parallel sided and rounded in front; basal lobes obsolete; and test granulose. Insofar as the cephalon is concerned, this species is intimately related to *Brachymetopus* (*Brachymetopella*) *akiyoshiensis*, although they are specifically distinguishable by the somewhat smaller eyes, rather broad but less drooping preglabellar field and shorter genal spine in ENDO and MATSUMOTO's species. They noted further that "Lateral rim bears a row of rather large tubercles on the ridge."

The facial suture is indistinct, or fairly well anchylosed. G. and H. HAHN suggested *Australosutura* CAMPBELL and GOLDRING, 1960 for this species, but *Australosutura* typified by *A. gardneri* (MITCHELL, 1922) is quite distinct from this in the subtrigonal prominent basal lobes, deep posterior lateral furrows, lateral expansion of the glabella in posterior and pronounced constriction of the main glabella at its anterior glabellar furrows. The border furrow is pitted and the facial suture open in that genus.

Like *Brachymetopus* (*Brachymetopella*) *akiyoshiensis* this species has a cylindrical glabella whose basal lobes are obsolete. Compared to that species the glabella is narrow and the genal spines are short. The associate pygidium is quite different from that species.

ENDO and MATSUMOTO's pygidium in fig. 8 is said to have the axis more than one-third as wide as the pygidium anteriorly, but its outline is so obscure that all of the margins are imperfect. The axial rings and pleural ribs are incountable. Because the test is smooth, its belonging to an identical species with the cephalon is doubtful.

It is inconvincing even its being a brachymetopid's pygidium.

Occurrence:—Lower Moscovian *Fusulinelia* zone; Nishiyama quarry of the Denki-kagaku-Kogyo Co., Omi town, Nishikubiki County, Niigata Prefecture.

Brachymetopus (*Brachymetopella* ?) *kitagawai* KOBAYASHI and HAMADA, sp. nov.

Plate II, Figure 3

Description:—Small brachymetopid having strongly tuberculate test. Glabellar outline much expanded at triangular basal lobes; preglabellar area no more than one-third the sagittal length of cephalon; eyes large; marginal rim primonent; marginal furrow profound and confluent with posterior border furrow of cheek at genal angle wherefrom the furrow extends diagonally. Pygidium exclusive of marginal spines, nearly as long as wide; axial lobe occupying one-third the width, longiconic, but abruptly narrowing at terminus, composed of 10 or 11 rings, each decorated with a row of large tubercles beside three short median spines on the third and two other posterior rings; seven simple pleural ribs separated from one another by deep furrows and ending at short spines.

Observation and comparison:—On the pygidium the tubercles are close-set and countable 6 to 7 in anterior rings. On the pleural ribs 3 or 4 large tubercles alternate smaller ones. A few median spines are present as in *Brachymetopus maccoyi spinosus* G. HAHN, 1964. In the presence of marginal spines this pygidium is comparable with the pygidia of *Br. maccoyi woodwardi* WILDBORNE 1896, *Br.* (*Brachymetopella*) *vyssotzki* WEBER, 1937, *Br. senckenbergianus* G. HAHN, 1964, *Br.* (*Brachymetopella*) *pseudometopina* GAURI and RAMOVŠ, 1964 and *Br.* (*Brachymetopella*) *akiyoshiensis* KOBAYASHI and HAMADA, 1979 where in *Br.* (*Brachymetopus*) *senkenbergiana* and *Br.* (*Brachymeteopella*) *pseudometopina* the pleural ribs are distinctly divided into two bands. This pygidium is evidently longer and its axial lobe slender, if compared with those species except for *Br.* (*Brachymetopella*) *pseudometopina* whose pygidium is fairly long, axial lobe long conical and bearing some median tubercles.

The tuberculation is extraordinarily developed on the test of this species. The glabella is wholly covered by large tubercles. Its outline is unusually expanded at the basal lobes. The eyes are very large and located near the mid-width of the cheek. The diagonal marginal furrow crossing the genal angle suggests that the genal spine was present, but it is unpreserved at present. Like in *Br.* (*Brachymetopella*) *akiyoshiensis* the rudimentary suture appears to extend diagonally from the right lateral angle of the frontal glabellar lobe. Judging from the small size, the cephalon and pygidium are probably still in the early holaspid stage.

The glabella of this species is ornamented by greater tubercles more densely than that of the cranidium identified with *Brachymetopus spinosus* (HERRICK, 1889) by WILSON (1979, text-fig. C.)

In the cephalon the basal lobes are well defined and the eyes are fairly apart from the glabella. Therefore this species is not diagnostic of *Brachymetopella*.

Occurrence:—Choanji; KITAGAWA collect.

Family Proetidae SALTER, 1864

Subfamily Proetinae SALTER, 1864

Genus *Pudoproetus* HESSLER, 1963

Pudoproetus obsoletus KOBAYASHI and HAMADA, 1978

Plate III, Figures 1-3; Text-figure 3D

1978. *Proetus (Pudoproetus) obsoletus* KOBAYASHI and HAMADA, *Proc. Japan Acad. v. 54, ser. B*, p. 5, figs. 1a-b, 5a-b.

Description:—Glabella large, ovoid, nearly straight on lateral sides, regularly narrowing forward, well rounded in anterior, strongly vaulted, highest at a little anterior to its center; basal lobe of moderate size, roundly trigonal, narrower than a third of glabellar base, longer than broad, prominent, only slightly protruded laterally, limited on the other side by a nearly straight, deep oblique posterior lateral furrow; two or three anterior furrows very weak, and particularly so the most anterior one; occipital furrow deep; dorsal furrow very narrow, but deep; marginal border convex, fairly thick, separated from glabella by pronounced marginal furrow; fixed cheek narrow; eyes located in posterior; palpebral lobe steeply slanting inward; facial suture nearly straight, running forward from eye and a little laterally, but bent inward on marginal border; test smooth.

Pygidium well vaulted, nearly semicircular, about half as long as wide; axial lobe distinctly outlined by deep axial furrows, broader than a third of pygidial breadth, moderately convex, elevated above inner pleural platform, strongly arched down in posterior, slowly narrowing backward and well rounded at terminus, divided by profound transverse furrows into ten or more rings, a few posterior ones of which are, however, poorly segmented; pleural lobes horizontal in inner half, and gently declined in outer half, six-segmented by distinct interpleural furrows; pleurae flat-topped but each bisected by a pleural furrow; first anterior band distinctly facetted laterally; pleural and interpleural furrows die out on marginal border except for the first pleural and interpleural furrows which run into lateral border; border furrow shallow or absent; marginal border broad, equal in breadth between lateral and posterior sides and less inclined than outer pleural slope; test smooth.

A hypostoma tentatively referred to this species is moderately inflated, most convex in anterior part of central body; anterior margin arcuate and its curvature distinctly accentuated near lateral ends; central body conical in anterior, but gradually tapering back and well rounded in posterior; lunate posterior elevation separated from main central body by shallow oblique lateral notches or maculae at about one-fourth from posterior; anterior wings medium in size, confluent with each other in front of central body; their posterior margin straight; lateral marginal rim and furrow distinct; posterior margin well rounded.

Comparison:—The holotype cranidium whose occipital ring and postero-lateral part are imperfect belongs most probably to *Pudoproetus*, as it agrees nicely with the generic diagnosis in most observable biocharacters. Compared with the American species of the genus it differs in the weakness of anterior lateral furrows and the lack of granulation. However, the test is smooth and lateral furrows are all obsolete and even the basal ones rudimentary in *Proetus eminens* WEBER, 1937 from the lower Tournaisian of the Kirghiz Steppe which is referred to this genus by G. & R. HAHN (1969) and OSMOLSKA (1970).

The above pygidium agrees exactly with that of *Pudoproetus missouriensis* (SHUMARD, 1955) in outline, convexity and mode of ribbing, although the marginal border is somewhat broader in this species and the axial ring does not show such a prominent posterior crest as seen in that species. *Proetus* (*Megaproetus*) JELL, 1977 from the upper Visean of Queensland has a similar pygidium of gigantic size, but its axis has no more than eight rings.

Proetus (*Megaproetus*) *cambrertus* JELL, 1977 is said to have well defined maculae, but they are absent in three Hina hypostomata. This one can easily be distinguished from the hypostoma of *Cummingella* sp. indet. from Hina by the broad regularly arcuate anterior margin and more convex and longitudinally striated central body of that hypostoma, and from that of *Paragriffithides japonicus* by the roof-shaped anterior outline and triangular anterior wings of *P. japonicus*.

The hypostoma of *Pudoproetus sargaensis* (WEBER, 1937) from the Etroeungt beds on the western slope of the Urals closely resembles this hypostoma in general outline and convexity, although the anterior part of the *sargaensis*'s hypostoma is unpreserved. *Conophillipsia meisteri* (WEBER, 1937) from the Tournaisian Karaganda horizon, Kirghiz Steppe has also a similar hypostoma, but the central body appears shorter and elliptical in outline. *Conophillipsia* is unrepresented in the Hina fauna.

Occurrence:—Hina Limestone at Hina.

Pudoproetus obsoletus forma *granulatus* KOBAYASHI and HAMADA, forma nov.

Plate III, Figure 4

A large pygidium in the Hina limestone collection measures 23 mm in length and 42 mm in breadth. It looks a little broader and less inflated. The test is distinctly granulate, as clearly seen on some axial rings and pleural ribs. Nevertheless it is allied to the preceding so closely that the difference is no more than subspecific.

Occurrence:—Hina limestone at Hina.

Genus *Conophillipsia* ROBERT, 1963, em. KOBAYASHI and TACHIBANA 1978

Diagnosis:—Isopygous proetoids having subovoid or trapezoid glabella relatively broad and gently convex; two or three lateral furrows present; preglabellar field absent; eyes medium sized, close to glabella in posterior to middle of cephalon; facial sutures moderately divergent forward from eyes; interpleural furrows absent in thorax and pygidium; axial rings 13 to 20 and pleural ribs 9 to 15 in pygidium; its marginal border narrow and depressed; test generally granulose.

Type-species:—*Conophillipsia brevicaudata* ROBERTS, 1963, from upper Tournaisian, New South Wales, Australia.

Remarks:—Quite unexpected is that its thorax is composed of ten, instead of nine segments, because the genus has been located variously in the Phillipsiidae (ROBERTS, 1963), Crassiproetinae (OSMOLSKA, 1920), and the Phillipsiinae (G. and R. HANN, 1972). Now it is found to be one of the latest survivors of the Proetinae, although it is fairly well isolated from *Pudoproetus* in the multisegmented pygidium.

The type-species is represented by two cranidia and some free cheeks, thoracic segments and pygidia. In the holotype the glabella is oval, but trapezoidal in the other. Unfortunately little is known of the occipital lobes and fixed cheeks of the species. Because ROBERTS referred *Phillipsia woodwardi* ETHERIDGE, 1892 (Low. Carbon. Queensland), *P. kazakensis* WEBER, 1937 and *P. labrosa* WEBER, 1937 (Low. Tournais. and Passage beds, Turkestan and Kirghiz Steppe) to the genus, information may be available from them.

ETHERIDGE's species was revised by MITCHELL (1918) with additional material. According to the latter "Glabella subquadrate, wide and mildly rounded in front, —three pairs of glabellar furrows present, —basal pair (of lobes) subpiriform, —supplementary lobes present (on neck ring)," and "Facial sutures anteriorly directed outward at angle of 25°," and "genal angle apparently blunt."

WEBER (1937) proposed *Phillipsia labrosa* and *P. kazakensis* respectively for the cephalon and pygidium supposed to belong to single species. As they occur in abundance, he distinguished their varieties. In the cephalon the glabella is parabolic, separated from the striated frontal border by a deep furrow; basal lobes sharply bounded by posterior furrows; two anterior furrows weak; lateral lobes absent, but a median spine may be present on neck ring; anterior branches of facial sutures slightly divergent forward; genal spine long. *Proetus pila* which is now referred to *Pudoproetus* was its common associate closely allied to it, but the cephalon was highly convex, neck ring had triangular lobes at the ends and often a median tubercle; genal spine absent.

In comparison with *Proetus missouriensis* SHUMARD he combined this cephalon with the broad paucisegmented pygidium having double pleural ribs in his *Proetus pila*. As the result the longer and multisegmented pygidium having simple ribs in a greater number which was called *Phillipsia kazakensis* was supposed to be united with the cephalon of *P. lobrosa*.

The above species of *Conophillipsia* were all represented by dismembered carapaces. Therefore it is of great importance to find the complete dorsal shield of the genus. Remarkably enough, its thorax is composed of ten, instead of nine segments. This number combined with the short forwardly tapering glabella excludes the genus out of the Phillipsine. Insofar as the cephalon is concerned, it is undeniable that the nearest allay to this genus is *Pudoproetus* to which *P. pila* and *P. missouriensis* belong.

Pudoproetus and *Conophillipsia* are evidently two distinct genera, because the former is heteropygous whereas the latter is isopygous. If compared to the former, the pygidium is relatively long in the latter. It has 6 to 10 axial rings and 5 to 8 pleural ribs in *Pudoproetus* and 13 to 20 rings and 9 to 15 simple ribs in *Conophillipsia*. The marginal border is well developed in the former and narrow and ill-defined in the latter.

Though the dorsal shield is more inflated in *Pudoproetus* than *Conophillipsia*, both of them are decisegmented in thorax and their tests commonly granulate. Their cephala are similar to each other, but in *Pudoproetus*' cephalon the glabella is suboval, highly convex and overhanging the frontal border; lateral furrows in three to four pairs, instead of twe to three pairs in *Conophillipsia*; occiptal lobes ill-defined on neck ring; tropidial crest present in typical cheek; anterior branches of facial sutures less divergent than in *Conophillipsia*.

Conophillipsia resembles *Crassiproetus* STUMM, 1953 and *Monodechenella* STUMM, 1953, particularly in the pygidium, but the glabella is oval and strongly convex in them and the glabellar furrows are all obsolete in the former and so in *Monodechenella* except for the posterior pair. The occipital lobe is absent in *Crassiproetus*, but present in the latter. The pleural furrows are present in thorax in these two genera. Their resemblances indicate probably their subparallel specialization to *Conophillipsia*. *Cyrtoproetus* quite disagrees with this genus in the elongate and constricted glabella and other characteristics of the pygidium. *Conophillipsia* would be an aberrant off-shoot from the Proetinae stock near *Coniproetus* or *Bohemiproetus*.

Distribution:—Lower Carboniferous, Tournaisian to Etroeungtian; Australia (Queensland and New South Wales), Eastern and Central Asia (Japan, Kirghiz Steppe and Turkestan).

Additional species are *Proetus meisteri* WEBER, 1937, *P. antonovi* WEBER, 1937, and *Proetus cervicontinens* WEBER, 1937 (OSMOLSKA, 1970).

It is noteworthy that the find of this Tournaisian genus in Japan suggests the Mongolian geosyncline (KOBAYASHI, 1971) to be more probable than the Tethyan one for its trans-Asiatic route of migration, because it was thrived in Turkestan and the Kirghiz Steppe, but so far it is unknown from South Asia.

Conophillipsia decisegmenta KOBAYASHI and TACHIBANA, 1978

Plate III, Figures 5-10; Plate IV, Figures 1-5

1978. *Conophillipsia decisegmenta* KOBAYASHI and TACHIBANA, *Proc. Japan Accd, v. 54-B*, p. 264, figs. 1-4, (5).

Description:—Dorsal shield elliptical, moderately inflated. Cephalon nearly semicircular, surrounded by marginal border and furrow; genal spine short; glabella more or less trapezoidal, most expanded laterally through basal lobes; three pairs of lateral furrows distinct; posterior furrow diagonal, isolating basal lobes and issuing a short branch adaxially from midway; middle furrow less inclined; anterior one subhorizontal; unfurrowed median part broader than lateral lobe; frontal lobe a third as long as glabella; occipital furrow nearly straight; occipital ring depressed, provided with a pair of occipital lobes; eyes close-set to glabella in the extent from middle lateral lobe to posterior half of basal lobe; facial sutures divergent diagonally from eyes, but suddenly recurving on marginal border; the suture running also diagonally behind eye to cut posterior cheek border near its middle point; coarse granules distributed on cephalon particularly densely on glabella.

Thorax composed of ten segments; axial lobe slowly narrowing backward, but almost as wide as pleural lobe; pleural furrow very weak or obsolete. In pygidium axial lobe tapering back rather rapidly and rounded off at end, composed of 14 rings and terminal piece; pleural field divided into 11 to 12 ribs by deep furrows, arching down near margin; marginal border narrow and depressed; marginal furrow very weak or absent. Granulation of test more developed on axial than pleural lobe, obscure on marginal border and absent on various furrows.

Observation:—Because the specimens before hand are all deformed in different directions and various degrees, it is difficult to say any exact proportion in length among the cephalon, thorax and pygidium or in breadth between the axial and pleural lobes, but nevertheless it is certain that the thorax is nearly parallel-sided and the cephalon and pygidium are similar to each other in size and outline.

It is noteworthy that the glabella is neither longiconic nor pear-shaped. Because of the posterior expansion it looks somewhat oval, but the frontal lobe is so broad that the glabellar outline takes rather trapezoid. The eyes are medium in size. In a paratype cranidium (III, 7) the narrow and high frontal rim is separated from the glabella by a well developed trough.

In the holotype dorsal shield (III, 5-6) which is somewhat shortend secondarily in the sagittal trend, the cephalon and pygidium are semicircular. Two shields (IV, 1) which are a little laterally compressed, have pygidia parabolic in outline. A well preserved pygidium (III, 8) is similar to them. Its marginal border is comparatively broad. The axial lobe is composed of 14 rings and a depressed small subtriangular terminal piece and the pleural lobe is divided into 11 simple ribs beside the anterior band of the first segment by pleural furrows. The rings and ribs are each provided with a row of nodes along the posterior margin which are 12 or more in number on some anterior rings. The granulation is lessened on the thorax and pygidium than the cephalon and so on the pleural lobe than the axial lobe.

In a dorsal shield (IV, 2-3) strongly compressed laterally the glabella is crudely twisted. As the result it is invaded into the preglabellar furrow and rounded in front. Nevertheless, it belongs probably to this species, because the three lateral glabellar furrows, occipital lobes, size and position of eyes, ten thoracic segments, the segmentation of the pygidium and the granulate test are all diagnostic of this species. It shows the facial suture and genal spine clearly.

Occurrence:— All from clayslate of the Karaumedate formation at Minami-Iwairi, Higashiyama-cho, Higashi-iwairi and Nendōyama, Nagasaka district, Iwate Prefecture.

Subfamily Cyrtosymbolinae HUPÉ, 1953

This subfamily appeared first in the middle Devonian of Central Europe, developed in late Devonian and most flourished in early Carboniferous period, particularly in the Culm sea of Europe, but at the same time it spread widely from North America to Australia through Eurasia.

Archaegonus is a long-ranged genus from Upper Devonian through Dinantian, leaving a relic in the lower Namurian of the Urals and probably another in the Namurian of Afghanistan (G. & H. HAHN, 1969, 1975). According to G. and R. HAHN (1969), *Proetus* ?, *Phillipsia* ? sp. No. 4 WEBER, 1937 from the Kisil Series on the eastern slope of the Urals is referable to *Archaegonus* (*Angustibole*). Remarkably enough, the upper limit of the subgenus is now extended to the Bashkilian with *Archaegonus* (*Angustibole*) *reliquius* here described.

In Japan it is associated with *Waribole lobatus,* nov. in the Akiyoshi limestone. *Waribole* ranges from Upper Devonian to Lower Carboniferous and survived until Visean in Germany (Rheinisch Schifergebirge and Ober Harz). The Japanese species is the latest survivor, as its age is determined at Bashkirian by associated fusulinids and brachiopods (YANAGIDA's personal information). It was wide spread in the Carboniferous period from Europe, Western Asia (Kirghiz Steppe and Karatau) and Southeast Asia (Malaysia and ? Yunnan).

It is further noteworthy that *Phillibole arakii,* nov. is found in the Tournaisian at Choanji. *Macrobole kedahensis* KOBAYASHI and HAMADA, 1973 may be another oriental Tournaisian species, as *Macrobole* R. and E. RICHTER 1951 is a junior synonym of *Phillibole* R. and E. RICHTER, 1937, according to G. and R. HAHN (1969).

Genus *Archaegonus* BURMEISTER, 1843

Subgenus *Angustibole* G. HAHN, 1965

Archaegonus (*Angustibole*) *reliquius* KOBAYASHI and HAMADA, sp. nov.

Plate IV, Figures 6-11; Text-figure 4L

Description:—Glabella inclusive of neck ring fairly convex, elongate conical, twice as long as broad, well rounded at both ends, separated from narrow but prominent frontal rim by profound furrow equally narrow; three pairs of lateral furrows subparallel to one another, all not strong, progressively becoming shorter forward; posterior ones bent back, but scarcely reaching occipital furrow; basal lobe nearly as long as two other lateral lobes; frontal lobe half as long as glabella s. str.; occipital furrow deep and nearly straight; occipital ring distinctly narrowing laterally; occipital lobe present; palpebral lobe narrow, extending from anterior lateral furrow to the middle or basal lobe; anterior branch of facial sutures divergent forward as far as palpebral lobe; test smooth.

Observation:—In the holotype cranidium (IV, 7) the occipital lobe is clearly seen at the lateral terminus of the neck ring on the left side of the observer where the test is exfoliated. Whether or not, the median tubercle is present on the neck ring is indeterminable. The preoccipital furrow is seen to be bifurcated in the second cranidium (IV, 8). In the third cranidium (IV, 9) the frontal lobe of the glabella is relatively broad and less conical than those of the two other cranidia. This glabella is more or less constricted at its mid-length, like in *Archaegonus* (*Weiania*) CAMPBELL and ENGEL, 1963 and *Archaegonus* (*Phillibolina*) GANDL, 1968.

A right free cheek which may belong to this species is moderately arching down from eye (IV, 6) in posterior, fairly broad and bordered by a distinct marginal furrow and rim on the lateral and posterior sides. The genal angle is well rounded. There the rim is distinctly striated. The test is smooth.

A pygidium (IV, 11) provisionally referred to this species is subtrigonal in outline, moderately inflated and divided into three lobes of similar breadth by axial furrows;

axial lobe conical, composed of more than 13 rings; pleural lobe arching down gently from the axis without interruption and divided into seven or eight ribs by furrows. The first pleural furrow is strong. The convex first rib in front of the furrow is the anterior band of the first pleura. The succeeding ribs are flat-topped and anterior two or three of them are each divided into two equal bands by a weak interpleural furrow; pleural furrows become weak in posterior where the number of ribs are not exactly countable. There is no distinct marginal furrow. The border is simply indicated by the termination of ribbing at a short distance from the periphery.

Finally, a hypostoma (IV, 10) obtained from Maruyama quarry is quite distinct from the three kinds of hypostomata from Hina. In this hypostoma the central body is most convex in anterior and elliptical in outline, but it is truncated by a narrow frontal rim. Its surface is ornamented with fine longitudinal striae which, however, converge and meet on the posterior side. Behind the main part of the body there is a lunate platform. On the anterior side the body is arching down laterally and the frontal rim is twisted toward the posterior-lateral side so as to form a triangular smooth wing. The lateral rim of the hypostoma forms an inward concavity behind the wing and terminates with a casp. Therefrom the depressed relatively broad flat posterior border surrounds the platform.

Comparison:—This hypostoma resembles those of *Wagnerispina wagneri* GANDL, 1977 and *Archaegonus* (*Angustibole*) *barriensis* GANDL, 1977 and also *Mirabole kielanae* OSMOLSKA, 1962 and *Spinibole olgae* OSMOLSKA, 1966, although a pair of short spines issue from the posterior border in the latter two species. The spines appear not so distinct in the former two species and absent, if not unpreserved, in this species. All of them are similar to one another in the general aspect, particularly in the truncation of the elliptical central body by the anterior marginal rim and the presence of the depressed posterior border. This hypostoma looks similar to that of *Macrobole kedahensis* KOBAYASHI and HAMADA, 1973, although a pair of posterior spines are present in that species. Thus it is certain that this hypostoma belongs to the Cyrtosymbolinae. It is probable that it is this species' hypostoma.

Occurrence:—Maruyama quarry, Akiyoshi.

Archaegonus (*Angustibole*) *impolitus* KOBAYASHI and HAMADA, sp. nov.

Plate V, Figures 1 and 4

This species is closely allied to the preceding one in the outline of the glabella, possession of the occipital lobe, lack of the preglabellar area and the narrow fixed cheek. It is, however, easily distinguishable from that species by the much broader glabella and its very rough texture. This species has a median tubercle on the neck ring.

Occurrence:—Maruyama quarry, Akiyoshi.

Genus *Waribole* R. and E. RICHTER, 1926

Waribole lobatus KOBAYASHI and HAMADA, sp. nov.

Plate V, Figures 3 and 5-6; Text-figure 4K

Description:—Glabella large, gently convex, slowly tapering forward, rounded in front and provided with three pairs of weak lateral furrows; occipital furrow profound; occipital ring broader than glabellar base and bearing a median tubercle; a prominent occipital lobe marked on each side; preglabellar area of moderate size well concave and bent up toward a narrow frontal rim; palpebral lobe of medium size semicircular, set close to glabella with its centre at middle lateral lobe; eyes fairly large; cheek widely depressed inside of lateral rim; genal region unknown; facial sutures somewhat divergent forward from eyes and nearly diagonal posterior to them; test smooth.

Remarks:—In the glabellar outline, large eyes in posterior, concave submarginal border and narrow marginal rim this cephalon best fits in *Waribole*, but it is not quite diagnostic of the genus in the possession of the occipital lobes.

A pygidium provisionally referred to this species has a large conical axis one-third as wide as pygidium. It is composed of about 12 axial rings. The pleural field is divided into some 7 flat-topped ribs, but the ribbing becomes obsolete in posterior. The anterior two or three ribs on the contrary are each divided into two equal bands by a weak interpleural furrow. The first interpleural furrow is exceptionally strong. The smooth marginal border is in the same gentle slope with the ribbed part, but a shallow concavity separates them. In the prominence of the axial ring along its posterior margin this pygidium resembles that of *Cyrtosymbole* (*Waribole*) *abruptirhachis* (R. and E. RICHTER, 1919), although the ring furrows and also the lateral furrows of the glabella are not so strong as in that species.

Occurrence:—Maruyama quarry, Akiyoshi-dai.

Waribole sp. indet.

Plate V, Figures 2 and 7

A free cheek (V, 7) with a large prominent holochroal eye which is located a little posterior to mid-length of the cheek; inner part of the cheek gently arching down from the eye, then bent up to from a broad and deep trough inside of lateral margin. Posterior cheek border flat; its border furrow linear and joins with lateral furrow to cross genal angle diagonally. The lateral furrow, however, soon dies out near the junction. Antero-lateral margin of the cheek very gently arcuate, but somewnat stronger in posterior half. Anterior branch of facial suture semicircular; its posterior branch sigmoidal and apparently transversal along the posterior border furrow. Test smooth.

A pygidium (V, 2) from the same locality has a breviconic axis and a broad depressed marginal border. The axial lobe as broad as pleural lobe, rapidly narrowing backward, divided into seven rings and a terminal lobe which is rounded off behind. The pleural lobe gently convex divided into five or six flat-topped ribs by shallow pleural furrows; first furrow, however, exceptionally pronounded; first rib strongly facetted laterally. Marginal border fairly broad.

The above free cheek is more similar to *Archaegonus* (*Waribole*) *richteri* HAHN, 1967, than *Waribole lobatus,* although the eye is smaller than that of *W. richteri.* The associate pygidium of this species has a shorter and more stout axis than that of *W. lobatus.* Compared to *W. richteri* the outline of the pygidium looks more parabolic and its axis longer in this form.

Occurrence:—*Pseudostaffella antiqua* zone; Maruyama quarry, Akiyoshi-dai.

Waribole (?) sp. indet.

Plate XIX, Figure 10

A pygidium semicircular in outline; axial lobe one-third as wide as pygidium, moderately elevated above slightly inflated pleural lobes, divided into about 8 rings, rounded off at a short distance from posterior border; pleural lobe with 5 or more ribs, divided by narrow furrows anterior ones of which are subdivided into two bands by a weak furrow; marginal border fairly broad, somewhat broadened behind axial lobe; test smooth.

This pygidium resembles *Archaegonus* (*Waribole*) *richteri* HAHN, 1967 from the middle Dinantian *Pericyclus* Stufe) of Harz in outline and other aspects, but it is broader and slightly less segmented.

Occurrence:—Hina limestone; Hina.

Genud *Phillibole* R. and E. RICHTER, 1937

Phillibole arakii KOBAYASHI and HAMADA, sp. nov.

Plate V, Figure 8

Description:—Glabella large, moderately convex, subconical, tapering forward more or less regularly, but more slowly in anterior than posterior, forming weak constriction between two parts and rounded in front; basal lobes large, longer than one-third the glabella, limited by deep arcuate furrow extending from axial furrow to occipital furrow; median part between paired basal lobes wider than one third the glabellar breadth; a pair of lateral furrows in from of preoccipital one distinct and curving in parallel to the preoccipital furrow; occipital furrow deep; occipital ring relatively short; its lateral lobe clearly isolated behind basal lobe by extention of preoccipital furrow. Frontal rim very narrow, convex, separated from glabella by deep narrow marginal furrow. Fixed cheek very narrow; palpebral lobe of medium length, narrow, located a little posterior to the centre of glabella; anterior branch of facial suture extending a little laterally from parallel to the glabellar axis; posterior branch shorter than anterior one, running in parallel to axial furrow leaving a very narrow space for fixed cheek and crossing short posterior cheek rim diagonally.

Observation:—An internal mould of a cranidium at hand is slightly compressed diagonally. The left lateral furrow is traceable in the whole elength, but the right one very faint. Because the neck ring is imperfect, whether a median tubercle is present or not is indeterminable. The surface of the mould is smooth.

Comparison:—Like *Cyrtoproetns* this species has the clean-cut basal glabellar lobes and lateral occipital lobes, but the eyes are not so large as in that genus. The narrow fixed cheek and the course of the facial suture, particularly its post-ocular branch show that it is a cytosymbolid having the lateral lobes, but no preglabellar area like in certain species of *Phillibole*. Compared to *Phillibole nitida annosa* OSMOLSKA, 1973 and *Archaegonus* (*Phillibole*) *aprathensis richteri* OSMOLSKA, 1968 it differs not only in the outline of the glabella but also in the size of the basal lobe and the glabella and the prominence of the lateral lobes of the neck ring.

Occurrence:—Choanji; ARAKI collect.

Genus *Liobole* R. et E. RICHTER, 1949

Liobole (?) sp. indet.

Plate XVII, Figure 8

An internal mould of a pygidium sagittally depressed is lenticular in outline. But less arcuate on the anterior than the other side; axial lobe about a third as wide as pygidium, breviconic, rounded shortly inside doublure and divided into 9 rings; seven narrow ribs separated by broad depressed furrows, truncated by doublure except for the first rib.

Two pygidia of *Phillipsia* cf. *ohmorensis* from Otsubo-zawa which are also deformed by sagittal compression are similar to this in outline, but the axial lobe is comparatively narrow and the axial and pleural lobes have more numerous ribs. This short pygidium looks very similar to *Liobole glabroides* (R. et E. RICHTER, 1949) from the lower Visean of Germany.

Occurrence:—Sakamoto-zawa; MIZUNO collect.

Genus *Carbonocoryphe* R. and E. RICHTER, 1950

This genus was instituted by R. and E. RICHTER on *Carbonocoryphe bindemanni* R. & E. RICHTER, 1950. It has thrived in the middle and upper Dinantian (C II-III), but a relic species survived till the beginning of the Namurian. Its forerunner probably appeared in the lower Dinantian. HAHN and BRAUCKMANN (1975) splitted the genus into four subgenera, viz. *Carbonocoryphe*, *Phillibolina*, *Aprathia* and *Winterbergia*. Putting aside *Corbonocaryphe* ? *granulineata* (BALASHOVA, 1956) from the lower Tournaisian of the Mugodzhar mountains, Kazakstan, the authors referred ten species of *Carbonocoryphe* to these subgenera. They are distributed from Spain to the Urals through North and Central Europe (England, West Germany and Mähren), particularly well developed in the Culm facies. This is the first record of an isolate occurrence outside the restricted domain of dispersal.

Subgenus *Winterbergia* HAHN and BRAUCKMANN, 1975

Carbonocoryphe (*Winterbergia* ?) *orientalis* KOBAYASHI and HAMADA, 1978

Plate V, Figure 9

1978. *Carbonocoryphe* (*Winterbergia* ?) *orientalis* KOBAYASHI and HAMADA, *Proc. Japan Acad. v. 54—B,* p. 6, fig. 4.

Description:—Pygidium nearly semicircular, though its anterior margin is broadly arcuate, almost twice broader than long. Axial lobe nearly one-third as wide as pygidium, conically outlined by narrow axial furrows, highly elevated above pleural fields, suddenly rounded shortly inside posterior margin, wherefrom a short post-axial ridge issues, composed of ten rings beside articulating half-ring; most rings each divided into a main part and a pair of lateral buttons. Pleural field only slightly convex, depressed very near periphery, composed of eight or nine pleurae, anterior ones of which are each divided into two bands by a pleural furrow; two bands subequal in anterior, but anterior band becomes weaker backward and completely disappears in a few posterior pleurae. Marginal rim very narrow but distinct. Test smooth.

Comparison:—This pygidium resembles *Carbonocoryphe* (*Aprathia*) *emanueli* R. & E. RICHTER, but the marginal border is broader in that species. The pleural ribs extend as far as the margin of the pygidium in *C.* (*Carbonocoryphe*) *bindemanni*, while this pygidium has a narrow marginal rim like *C.* (*Winterbergia*) *hercynica* C. HAHN, though it is narrower than that of *C. hercynica*. The axial lobe is narrow in nearly all of the European species. In regard to the broad axis this species is comparable to *C. hercynica*, but the pygidium of that species is less segmented and the axial lobe evidently much shorter, if compared to this pygidium. Thus it fits in none of these four subgenera exactly, but this species appears to be nearest to *Winterbergia* among the existing subgenera.

Occurrence:—Hina limestone; Hina.

Subfamily Phillipsiinae OEHLERT, 1986

Genus *Phillipsia* PORTLOCK, 1843

Phillipsia ohmorensis OKUBO, 1951

Plate VI, Figures 1-10; Plate VII, Figures 10 and (?) 11; Text-figure 3H

1951. *Phillipsia ohmorensis* OKUBO, *Chikyukagaku, no. 4,* p. 25, pl. 1, figs. 1-4.
1962. *Phillipsia ohmorensis* ENDO and MATSUMOTO, *Sci. Rep. Saitama Univ. ser. B., v. 4, no. 2,* p. 164, ? pl. 1, figs. 8 & 7a-b.
1968. *Phillipsia ohmorensis* ARAKI and KOIZUMI, *Chigaku-Kenkyu, vol. 19, no. 8,* p. 211, pl. 2, fig. 15.
1973. *Linguaphillipsia ohmorensis* G. & R. HAHN, *Senckenber. Leth. vol. 53, no. 6,* p. 487, text-fig. 1-d.

Description:—Cephalon semicircular in outline, fringed by narrow, flat marginal border which is prolonged into a short genal spine and increasing its breadth on the antero-axial side. Glabella large, subcylindrical, clearly outlined laterally by nearly straight subparallel axial furrows and provided with four lateral furrows; frontal lobe protruded halfway or a little less into anterior border and rounded in front; first lateral furrow rudimentary; second and third furrows distinct and longer and stronger; fourth lateral furrow very pronounced, diagonal, extending toward centre of neck ring, but terminating near deep transversal occipital furrow; neck ring uniform in thickness. Eyes reniform, located posteriorly; palpebral lobe semicircular; fixed cheek narrow; free cheek wider than fixed cheek and inflated; lateral border narrow to moderate in breadth and depressed. Facial suture cuts frontal margin approximately the limit of palpebral lobe; behind eye the suture subparallel to axial furrow for a short distance, bent laterally, then diagonally and cutting posterior margin of the cheek at about median point. Test apparently smooth.

Thorax composed of 9 segments of similar size, provided with a row of tubercles; axial ring as wide as pleura; pleural furrow present; pleural end abruptly truncated.

Pygidium parabolic in outline, bordered by narrow inflated marginal flange; axial lobe a little narrower than pleural lobe, conical, composed of about 18 rings, terminating on posterior marginal furrow; post-axial furrow faintly discernible; pleural lobes divided into 13 ribs by furrows which extend through marginal border; a row of tubercles aligned on axial ring and pleural rib.

Observation:—The original description of this species is a little emended by fresh observations on OKUBO's specimens and others below mentioned. OKUBO described this species with four specimens from Higuchi-zawa and added a restored dorsal shield. The holotype and two other OKUBO's specimens were lost. There are, however, two specimens in his collection one of which is an external mould of the same individual whose internal mould was illustrated in his figure 3. Another internal mould not illustrated in his paper clearly shows many characteristics of the cephalon.

In the last mentioned specimen (VI, 1, PA 8003) two anterior lateral furrows are subparallel, diagonal and running antero-mesially. The third one is a little longer and transversal. The preoccipital one is diagonal and become shallower near the occipital furrow. These furrows agree better with these of the holotype photograph than his restoration in which all of the four lateral furrows are subparallel to one another. The glabella invades halfway into the frontal border which is broad there, but somewhat narrower in the middle and posterior parts. The median tubercles is present on the neck ring. The eyes are just like those in the holotype in size, outline, position and prominence. This cephalon agrees with the holotype also in the distinct pleural furrows in the thorax. The pygidium is absent on this specimen, but it is seen on his paratype specimen (VI, 2, PA 8004). Its axial lobe is narrow, conical and composed of more than 15 rings or probably 17 or 18 rings in total; pleural ribs and furrows, 12 or 13 in number, run into the very narrow depressed marginal border. The axial rings and pleural ribs each carries a row of tubercles. Now it is certain that these internal moulds belong to an identical species with the lost holotype.

Further observations on the glabellar outline, facial sutures and so forth can be made on some cephala collected by SASAKI, FURUHASHI and others at Higuchi-zawa.

Two complete dorsal shields were collected by HACHIYA from Higuchi-zawa and by SATO from Choanji. In one of them whose right cheek and pleural part are invisible, clearly shows the general outline of the trilobite, proportional size of cephalon, thorax and pygidium, number of thoracic segments and so forth, although they are a little deformed. The cylindrical glabella and its slight projection on the frontal border can be seen not only in them but also in a cephalon collected from Higuchi-zawa by HAMADA and YOSHIDA. The greater projection in OKUBO's specimens depends partly upon the expansion of the lateral border toward the frontal border. On the other hand the expanding part is not well preserved in these specimens. In the specimen collected by HAMADA it is seen that the lateral and posterior marginal furrows join at the genal angle and the united median furrow crosses the angle toward the genal spine, as shown by OKUBO in his restoration.

Ten new pygidia fom Higuchi-zawa reveal some variation in outline by secondary deformation and also in tuberculation by preservation. A pygidium collected from Higuchi-zawa by YOSHIDA, for example, is elongate trigonal. Although a row of tubercles is restricted to the axial ring in the thoracic segments in OKUBO's restoration, it can be seen clearly on the thoracic pleurae in the dorsal shield in fig. 2, pl. VI in this paper as well as in OKUBO's holotype illustration in fig. 1b.

Comparison:—OKUBO pointed out the lack of the preglabellar field as its most important generic distinction from *Palaeophillpsia* and four pairs of lateral glabellar furrows, tuberculation of the test and the posterior projection of the axial lobe on the marginal border as the specific distinction from *Phillipsia gemmulifera, P. glabra* and other similar trilobites.

ENDO and MATSUMOTO presumed that this species may be a synonym of *Palaeophillipsia japonica* and intended to discard *Palaeophillipsia*, doubting the presence of the preglabellar field in *P. japonica*.

Recently G. and R. HAHN referred these two species to *Linguaphillipsia*. This species, however, must be excluded from *Linguaphillipsia* as well as *Palaeophillipsia* by the lack of the glabellar constriction and also of the preglabellar field.

The glabella is cylindrical in ENDO and MATSUMOTO's shield in fig. 8, pl. 6, but it is constricted at the mid-length and expanded in posterior in the other shield in figs. 7a-b, pl. 6, as they stated that "glabella—widest at the basal lobes." The latter specimen is probably a *Linguaphillipsia*. Because it is said that "glabella—overhanging the flat marginal band," it is quite different from *Phillipsia ohmorensis*.

As commonly seen in *Phillipsia* the very narrow marginal border of the pygidium and the extention of the pleural furrow or/and ribs into the border to some length are quite distinctive or this species among the Lower Carboniferous trilobites in Japan. This species may be added to the group of *Phillipsia kellyi* PORTLOCK, 1843, by OSMOLSKA, 1970 whose cephalon is scarcely ornamented.

Occurrence:—Hikoroichi formation; early Carboniferous, OKUBO collection from a mountain slope northeastward of Ohmori village. Specimens described by ENDO and MATSUMOTO came from Choanji, Hikoroichi-town. New specimens dealt here with were collected by HAGA HAMADA, SATO and YOSHIDA mostly at Higuchi-zawa and partly at Choanji. All of these localities are within Ofunato city.

Phillipsia ohmorensis forma *multisegmenta*, forma nov.

Plate VII, Figures 3-7

In the dorsal shield of this species the axial rings and pleural ribs number 15 to 16 and 13 to 14 respectively, while 20 to 21 rings and 16 to 18 ribs are countable in some isolate pygidia which are distinguished as *multisegmenta*. It appears to be a tendency for such a multisegmented form that the tuberculation is commonly strengthened particularly on the axial rings. On the other hand, there are intermeidate forms in the number of segmentation among the pygidia. In other werds the distinction between the pauci- and multi-segmented forms is not quite sharp.

Occurrence:—Hikoroichi formation at Higuchi-zawa, collected by HACHIYA, HAGA, SASAKI and YOSHIDA. A pygidium from Choanji in KOBAYASHI's old collection.

Phillipsia cf. *ohmorensis* OKUBO

Plate VII, Figure 8-9

An external mould of a pygidium (VII, 9) is strongly deformed by sagittal compression. The axial lobe is truncated by a relatively broad doublure near the posterior extremity, but it is presumably composed of about 20 axial rings as 16 rings are actually countable. Likewise the pleural ribs number probably 13 or so in total as 12 of them are countable on the specimen. On the left side of the observer the ribbing is impressed on the depressed border almost as far as the lateral margin. It is seen on some axial rings and pleural ribs that they are tuberculated along their posterior margin.

The posterior prolongation of the axial lobe, the numbers of axial rings and pleural ribs and the extention of the ribs into the marginal depression show the best agreement of this pygidium with the *Phillipsia ohmorensis* among the Kitakami trilobites. Thus, the pygidium suggests that the species or its close ally has survived until the Arisuan age.

In another pygidium diagonally deformed (VII, 8) has the tuberculate axial rings also and pleural ribs in number similar to the preceding. It is seen in this second specimen that the ribs run into the depressed lateral border like in *Phillipsia ohmorensis*, but the border is broader, if compared to that species.

Occurrence:—Arisu formation at Otsubo-zawa, MURATA collect.

Phillipsia longiconica KOBAYASHI and HAMADA, sp. nov.

Plate VII, Figures 12-14

Description:—This species is represented by an imperfect dorsal shield, two cephala and two pygidia, all deformed. The shield consists of nine thoracic segments, multisegmented pygidium and part of the cephalon. Its glabella is conical and densely granulate. In the thorax the pleura is a little broader than the axial ring which bears a row of tubercles along the posterior margin. The pleural furrow is transversal.

An isolate cephalon is laterally compressed with the result that its breadth is reduced and its convexity emphasized. Its entire outline looks parabolic or even subtriangular in the present state. It is surrounded by marginal borders and furrows. The lateral and posterior borders are moderately convex and join at the genal angle wherefrom a short spine issues. In comparison with these borders and cheeks the convexity of the glabella and frontal border are very strong. They are separated by a profound anterior marginal furrow.

The holochroal eye is prominent, relatively short, reniform, close-set to the glabella. It extends from the anterior lateral furrow to the middle of the basal lobe of the glabella. The facial suture anterior to the eye is regularly arcuate as far as the limit of the eye. In the posterior to the eye it is more or less diagonal, then transversal and becomes diagonal again to cut the posterior cheek border at its median point. The cheek is a little broader than the glabella at the present state. This cephalon preserves its posterior part poorly.

An isolate cranidium, also laterally compressed, clearly shows its long conical outline well rounded in front. There it is separated from the convex frontal border by a marginal furrow. In the posterior half of the glabella there are three pairs of lateral furrows and an occipital one. These three laterals are disposed divergent inwardly the posterior one of which is well pronounced.

This cranidium is found associated with a pygidium in the same slab. This and another pygidium in another slab are both compressed in the sagittal direction but in different digrees. The axial lobe is nearly as wide as the pleural one. It narrows back regularly but near the terminus where it is suddenly rounded off. It is composed of 17 to 18 axial rings. The pleural ribs countable about 14 to 15, are extending as far as the periphery, but shortly before the margin they are depressed and the posterior ones are commonly discrepant at the geniculation. These ribs are narrower than the pleural furrows. The pleural rib and axial ring bear a row of small and numerous tubercles on the top. The cephalon appears non-tuberculate.

Comparison:—This species is distinguishable from *Phillipsia ohmorensis* primarily by the outline of the glabella which tapers forward and well rounded in front and secondarily by its separation from the convex frontal border by a distinct marginal furrow. The glabella is more quadrate in outline and a little encroaches into the depressed frontal border in that species. The glabella is typically granulose in this but smooth in that species. In the pygidium the axial rings and pleural ribs are respectively about 17 to 18 and 14 to 15 in this species whereas the rings and ribs are about 18 and 13 in that species. The axial lobe terminates very suddenly in the two pygidia of this species.

Occurrence:—Collected by FURUHASHI and YOSHIDA at Sakamoto-zawa.

Subfamily Linguaphillipsiinae G. and R. HAHN, 1972

Palaeophillipsia and *Linguaphillipsia* were instituted respectively by SUGIYAMA and OKANO, 1944 and STUBBLEFIELD, 1948. These two genera have been accepted both valid by WELLER (1959), G. HAHN (1967), OSMOLSKA (1970) and G. and R. HAHN (1972). While G. HAHN referred them to the Phillipsiinae and GANDL (1968) did so for *Linguaphillipsia*, OSMOLSKA (1970) considered *Linguaphillipsia* and possibly *Palaeophillipsia* were two genera of the Dechenellinae. Subsequently G. and R. HAHN proposed the Linguaphillipsiinae, nov. to include them in addition to *Bitumulina* OSMOLSKA, 1970, *Weberiphillipsia* OSMOLSKA, 1970 and *Hildaphillipsia* G. and R. HAHN, 1972.

Prior to this OKUBO (1951) described *Phillipsia ohmorensis*, sp. nov. from the Lower Carboniferous or Etroeungtian Hikoroichi Series at Ohmori, Ofunato City (formerly Hikoroichi village, Kesen-gun), Iwate Prefecture and pointed out its distinction from *Palaeophillipsia japonica* from the upper part of the Ohmori Series at Choanji, Hikoroichi village. This series was considered Upper Devonian at that time, but later the *japonica* horizon was found to be located in the lowest Carboniferous by OKUBO (1951) and MINATO (1953).

It was unfortunate that the holotype specimen of *P. japonica* was lost during the World War II and the original illustration of the species was poor. Therefore ENDO and MATSUMOTO (1962) considered that *Palaeophillipsia japonica* may be a synonym of *Phillipsia ohmorensis*, suspecting the presence of the preglabellar field which OKUBO pointed out an important distinction of the former from the latter. From such a consideration ENDO and MATSUMOTO intended to surpress the genus *Palaeophillipsia*. On the other hand G. and R. HAHN (1973) referred recently *Phillipsia ohmorensis* to *Linguaphillipsia*.

In the study on the evolution of *Linguaphillipsia* G. and R. HAHN (1973) distinguished the following four species-groups in the genus.

terapaiensis-Gruppe
matthewi-Gruppe
longicornuta-Gruppe
strabonis-Gruppe

According to them these groups were divergent from the late Devonian *Archaegonus*-Gruppe of the Cyrtosymbolinae already at the beginning of the Carboniferous period. "*Palaeophillipsia*" *japonica* and *Linguaphillipsia ohmorensis* are two lower Tournaisian species respectively of the *terapaiensis*-group and the *matthewi*-group.

In 1975 they referred the following genera and subgenera to the subfamily.

Linguaphillipsia STUBBLEFIELD, 1948 (incl. *Palaeophillipsia* SUGIYAMA and OKUBO, 1944)
Pseudowaribole G. and R. HAHN, 1967
(*Pseudowaribole*)
(*Geigibole* GANDL, 1968)
Bitumulina OSMOLSKA, 1968
Weberiphillipsia OSMOLSKA, 1970
Hildaphillipsia G. and R. HAHN, 1972
Nipponaspis KOIZUMI, 1972

Thus the subfamily was expanded and its range extended to the Upper Devonian with *Pseudowaribole* (*Pseudowaribole*). At the same time the genus *Linguaphillipsia* became very comprehensive. ENGEL and MORRIS (1973) stated that " both the *matthewi*- and *strabonis*-groups have diverged considerably from the *terapaiensis* group to the point where their relationship with *Linguaphillipsia* becomes open to question."

In 1977 GANDL transferred *Gitarra* GANDL, 1968 to the Linguaphillipsiinae from the Griffithidinae in which G. and R. HAHN (1970) has located it. Likewise, BRAUCKMANN (1978) removed *Dechenelloides* GANDL, 1968 to the Linguaphillipsiinae from the Dechenellinae of the Proetidae in which GANDL has originally instituted it.

As the result of the present study we reached the following conclusions.

1. *Phillipsia ohmorensis* is not a *Linguaphillipsia* but a *Phillipsia* probably of the *Phillipsia kellyi* group as detailed in its description.
2. *Palaeophillipsia japonica* does not belong to either an identical species or the same genus with *Phillipisa ohmorensis* as discussed in this article. Although no topotype diagnostic of the species is not yet available, a new species, *Palaeophillipsia tenuis* having a comparatively large preglabellar field was obtained in the Hikoroichi district.
3. At the same time three new species of *Linguaphillipsia* were found in the Hikoroichi district. They are

   Linguaphillipsia choanjiensis, sp. nov.
   Linguaphillipsia higuchizawensis, sp. nov.
   Linguaphillipsia subconica, sp. nov.

   These species are all Tournaisian in age.
4. In addition to them *Dechenelloides asiaticus*, nov. is found in the Torunaisian of the same district.
5. As detailed later, *Schizophillipsia yukisawensis*, gen. et sp. nov. is proposed for a Visean species of *Linguaphillipsia* in the same region (ARAKI and KOIZUMI, 1968), and *Schizophillipsia otsuboensis* sp. nov. from the Tournaisian of Otsubo in the district is added to it.
6. Finally it is noted that a pygidium of *Linguaphillipsia* sp. nov. from the Omi limestone is allied to that of *Linguaphillipsia strabonis* (FRECH, 1917) from the Tournaisian of Turkey.

Genus *Linguaphillipsia* STUBBLEFIELD, 1948

This genus was instituted by STUBBLEFIELD with *Linguaphillipsia terapaiensis* sp. nov. as its genotype. According to him it is a phillipsid proetid with cephalon having flat or gently convex marginal border in front of glabella, short preglabellar field which is usually but a marginal furrow, wider marginal border on free cheek. Glabella longer than wide, not expanded anteriorly; sides subparallel as far as furrows lying third from occipital furrow; thence forming a crescentic curve towards the occipital furrow; widest at the basal lobes; basal furrows strongly curved towards but not necessarily reaching occipital furrow. Palpebral lobes relatively small. Thorax and pygidium imperfectly known of the type-species.

The cephalon in fig. 3, pl. XIII, SUBBLEFIELD 1948 reveals that the frontal border is half as wide as the lateral border. In other words the glabella invades there halfway of the marginal border on the lateral sides. As the result the marginal furrow is bent forward on the lateral sides of the frontal lobe. This bending is shown on the cranidium in fig. 1 by a diagonal depression on the fixed cheek. The palpebral lobe is narrow but almost half as long as the glabella exclusive of neck ring. It is certain that its posterior end reaches or almost reaches the posterior border furrow of the cheek.

Linguaphillipsia choanjiensis, sp. nov.

Plate VIII, Figures 1-3; Text-figure 3K

1962. *Phillipsia ohmorensis*, ENDO and MATSUMOTO, *Sci. Rep. Saitama Univ. Ser. B, vol. 4, no. 2*, pl. 8, fig. 7a.

Description:—Dorsal shield long, subelliptical, roughly twice as long as wide and moderately inflated.

Cephalon semicircular, provided with long genal spines. Glabella fairly well inflated, long, gently contracted at mid-length, a little broader in posterior than anterior, protruded into a half of frontal border, provided with three pairs of lateral furrows; anterior and middle laterals weak; posterior lateral furrow isolating preoccipital lobe from median part; occipital furrow very pronounced and bent forward in middle part where occipital ring is a little expanded; median tubercle absent; dorsal furrow narrow but distinct. Eyes fairly large, opposed in posterior half of the glabella; palpebral lobe crescentic. Cheek broader than glabella; lateral border very broad, prolonged into a genal spine as far as seventh thoracic segment. Facial suture arcuate in anterior to eye and cutting posterior margin of the cheek at middle point.

Thorax almost as long as cephalon, composed of nine segments; axial lobe slightly narrower than pleural lobe, gently tapering backward; pleuron truncated at lateral end; pleural furrow diagonal in two-thirds from axis.

Pygidium a little longer than cephalon, more or less parabolic in outline, axial lobe long, conical, composed of 14 to 15 rings; pleural lobe slightly inflated, divided into 9 to 10 ribs by pleural furrows; interpleural furrow discernible; marginal border very broad, smooth, clearly limited inside by a shallow marginal furrow.

Test smooth.

Comparison:—This species disagrees with *Palaeophillipsia japonica* SUGIYAMA and OKANO primarily in the absence of the preglabellar field. The cephalon is more triangular and the glabella is more expanded in that species. The axial rings of the pygidium are more numerous in this species, assuming that only 10 to 11 rings are present in that species.

Like *Linguaphillipsia terapaiensis* STUBBLEFIELD the glabella is encroached on the frontal border in this species, but it differs from that species in the outline of the glabella. Furthermore, the lateral furrows appear to be more pronounced in that species, though it is represented by internal casts.

The pygidium of this species resembles that of *Linguaphillipsia paczoltovicensis* (JAROVZ, 1913) in OSMOLSKA, 1930 in the general outline and segmentation, but it is more triangular, the axial lobe broader, axial rings are geniculate and interpleural furrows stronger in that species.

Like *Phillipsia ohmorensis* OKUBO this species has the glabella protruded halfway into the frontal border, but it is quite distinct from that species in the glabellar outline lacking the lateral constriction, much broader and flat or slightly inflated marginal border on the cephalon and pygidium, smaller number of segmentation of the pygidium and absence of tuberculation on the test.

Finally, ENDO and MATSUMOTO's *Phillipsia ohmorensis* from Choanji in their fig.

7a, pl. I is most probably an internal mould of this species.

Occurrence:—Near the gate of Temple Choanji; formerly, Choanji Series, now referred to the Hikoroichi Series. KOBAYASHI and SASAKI collections.

Linguaphillipsia higuchizawensis, sp. nov.

Plate VIII, Figures 5-9; Text-figure 31

This is a close ally to *Linguaphillipsia terapiensis* and *L. silesiaca* as seen in the glabellar outline, disposition of lateral lobes and furrows, size, shape and posterior position of the eyes and palpebral lobes and the aspects of free cheek and facial suture. The holotype is an internal mould of a cephalon on which no trace of granulation is recognizable, while granules are dense on the surface in *Linguaphillipsia silesiaca*. Compared to *L. silesiaca* the glabella, particularly its frontal lobe, is broader and the genal spine shorter in this species.

The cephalon is semicircular in outline and well inflated. Eyes are in the same level with the glabellar top. The posterior part of the glabella is remarkably expanded between the eyes. In the outline of the glabella it is nearer to *L. terapaiensis*, but the preglabellar space is shorter. In this species the frontal rim is incomparably narrow and more prominent than in these species. The marginal furrow there is also narrow and depressed, forming a forwardly declined narrow concave band which is separated from the frontal slope of the glabella by a very narrow furrow. This boundary shows the projection of the glabella into the frontal border for a short distance in comparison with the lateral borders.

One can see a pair of antennal (?) tubercles on the axial furrows at mid-length of the frontal lobe. An obtuse ridge on the free cheek extending postero-laterally from the tubercle suggests the inner margin of the doublure.

An internal mould of a complete pygidium referred to this species is broader than one and a half of its length; posterior and lateral margins are very gently arcuate; axial lobe as wide as or a little broader than the pleural lobe, conical, but rounded at posterior terminus, composed of about 14 rings; pleural lobe divided into some 12 ribs by pleural furrows which are as wide as or even broader than the ribs; marginal border narrow and depressed; test apparently smooth.

This pygidium is quite distinct from other Kitakami pygidia in the very narrow marginal border. It resembles *Griffithides* ? *ambiguus* REED, 1942, from the Carboniferous limestone, Isle of Man, although the lateral and posterior margins are regularly rounded and comparatively longer and more inflated in the latter. The convexity is secondarily reduced in the Japanese specimen.

Occurrence:—Higuchi-zawa, Ofunato city, Iwate Prefecture.

Linguaphillipsia aff. *higuchizawensis*

Plate VIII, Figure 10

A fairly large imperfect pygidium represented by an internal and external mould is parabolic or roundly triangular in outline. The axial lobe, a little narrower than the pleural lobe, is composed of about 16 rings, judging from the thirteen rings in the preserved part. The pleural ribs, all simple, may be 12 or 13 in number, if complete; interpleural furrow narrow and deep. The ribs are distinctly bent forward and backward respectively near the inner and outer end. The marginal border is smooth, very narrow and strongly depressed. The test is smooth.

Like *Phillipsia* the marginal border is narrow as seen on the left side, but it is smooth. It is generally broader in *Linguaphillipsia*. The combination of the above characteristics does not fit in either the Phillipsiinae or the Linguaphillipsiinae, but it is more distinct from *Phillipsia*. Among the Kitakami trilobites the nearest ally may be the pygidium of *L. higuchizawensis*.

Occurrence:—Ohmori; KOBAYASHI collect.

Linguaphillipsia subconica KOBAYASHI and HAMADA, sp. nov.

Plate IX, Figures 1-7; Plate X, Figures 1-10; Plate XI, Figures 1-3; Text-figure 3E

Description:—Dorsal shield elongate oval in outline, a little shorter than twice the breadth; thorax slightly shorter than pygidium, nearly as long as cephalon exclusive of genal spines.

Cephalon subtrigonal, rounded in front and prolonged into a pair of genal spines as far as the fourth thoracic segment. Glabella densely granulated, invading into frontal border for a short distance, subconical, but contracted at about mid-length, provided with four pairs of lateral furrows, but the first pair of the furrows are rudimentary; preoccipital furrow best developed, diagonal, then longitudinal and meeting with occipital furrow; dorsal and occipital furrows deep; occipital ring carrying a median tubercle, narrowing laterally behind the basal lobes and decorated by minute tubercles. Eyes large, semicircular, embracing the posterior expansion of glabella from lateral sides. Cheek a little broader than occipital ring, provided with thick lateral border which broadened toward the frontal lobe of glabella and protruded posteriorly into paired genal spines; marginal furrows narrow but deep and become confluent with each other at genal angle and extending onto genal spine as a median furrow. Anterior branch of facial suture describing an arc shortly inside of parallels through eyes; its posterior branch extending postero-laterally from eye beyond the parallels. Hypostoma having strongly arcuate anterior margin, bearing a pair of anterior wings; main body and depressed marginal border both expanded laterally behind the wings and subangulated at mid-length; maculate furrow diagonally cutting into posterior part of the body.

Thorax composed of nine segments; its lateral margin gently arcuate; axial ring bearing a row of small tubercles along posterior margin; thoracic pleura a little broader than axial ring, rectangularly truncated at lateral end and divided into two unequal bands by pleural furrow which, however, dies out at about mid-breadth of the pleura; anterior band narrow and facetted at about one-third of pleural breadth from axial ring.

Pygidium parabolic, slightly broader than long; axial lobe conical, but terminating back at blunt end, divided into 15 to 18 rings; pleural lobe divided into 11 to 13 ribs anterior ones of which are subdivided into a narrow low anterior band and a prominent posterior band; the latter as well as axial rings bearing a row of tubercles on top; pleural ribs extending as far as near margin, but interrupted by narrow but distinct marginal furrow; extension of pleural ribs, however, often represented by tubercles only.

Observation:—This species is well represented by many specimens including several in which the cephalon, thorax and/or pygidium are still anchylosed. The holotype dorsal shield (IX, 1a-b), whose external and internal moulds are before hand, clearly shows the characteristics of the cephalon and pygidium. Not only in this, but also in some other specimens it is seen that four pairs of lateral furrows are generally better impressed on the internal mould of the glabella, but the first laterals are commonly obsolete on the external mould. When the cephalon or the cranidium is compressed in the sagittal direction as in two SASAKI's specimens, the invasion of the glabella is somewhat obscure, although it can hardly be overlooked that the glabella encroaches onto the frontal furrow.

The Choanji collection contains two hypostomata both of which are attached to the cephala. One of them (X, 4a-c) is a paratype. This hypostoma is separated from the doublure by a narrow space where the arcuate rostral plate has existed.

Another paratype (IX, 6a-b) is a dorsal shield whose cephalon and thorax are unpreserved on their left anterior side, but it enables one to restore a complete trilobite except for the glabella which can be supplemented with the two other type specimens.

There are many pygidia which suggest that the second paratype is a little compressed laterally. It is understood also with them that the marginal furrow is strongly emphasized in some pygidia by the duplication of the doublure. In a pygidium (SASAKI collect.) the first pleural rib is scarcely interrupted by the furrow.

Occurrence:—Very common at Choanji; collected by FURUHASHI, MIZUNO, SASAKI and TAKAHASHI. A pygidium from Higuchi-zawa may be referred to this species.

Linguaphillipsia sp. nov.

Plate XIII, Figure 15

Pygidium parabolic in outline; axis subcylindrical in anterior, but slowly tapering in middle and posterior and rounded off at terminus, composed of 16 or 17 axial rings; pleural field low, slightly convex divided by deep furrows into about nine flat-topped ribs which do not extend into marginal border, except for the first rib and furrow; second to fourth or fifth ribs divided again into two similar bands by a weak interpleural furrow; marginal border less inclined than ribbed part, but marginal furrow absent at the boundary; test smooth.

Observation:—The first pleural rib is preserved on the right side, though imperfectly and the first furrow can be seen there to extend shortly into the lateral border. Behind this part the test is exfoliated as wide as the doublure. The left pleural lobe is shifted forward by faulting along the left axial furrow. In this part it is seen that the marginal furrow is absent and the ribbing does not extend into the lateral border.

Comparison:—This pygidium resembles that of *Bitumulina bitumulina* (WEBER, 1932) in outline, but the axial lobe is narrowing back regularly and the pleural ribs are more numerous. In the regular bipartation of the pleural ribs it agrees with

Linguaphillipsia tulensis (IVANOV in WEBER, 1937), but these bands are tuberculated along their posterior margins in that species and many other aspects of the pygidium are different between the two species. Incidentally, G. and R. HAHN (1972) are of opinion that *L. tulensis* is synonymous with *Linguaphillipsia silesiaca* (SCUPIN, 1900). This species may be more allied to *Linguaphillipsia strabonis* (FRECH, 1917) from the Kohlenkalk, Tournaisian, of the High Taurus, Eastern Turkey in general aspects, but the axial lobe is more conical and its lateral parts are differentiated from the main median part. In this pygidium the lobe has one or two more axial rings, while one rib appears less in the pleural lobe. The test is smooth but tuberculated in that species.

Occurrence:—Omi limestone; KOBAYASHI collect.

Linguaphillipsia 2 spp. indet. (A and B)

Plate XIII, Figure 14; Plate XVII, Figure 11

A small imperfect cranidium (A, XII, 14) whose granulate glabella is nearly parallel-sided and well rounded in front. It is separated from the thick frontal border by a profound furrow. The glabella appears to be expanded laterally in the posterior part where three lateral furrows are parallel to one another; eyes extending from the anterior ones postero-laterally.

These are about all which one can see. It looks like *Linguaphillipsia subconica*, but the glabella is slender and the marginal furrow very pronounced. If the posterior lateral furrow is the pre-occipital one, the basal lobe is unusually small. Nevertheless this could be an immature cranidium of *Linguaphillipsia* allied to *L. subconica*.

Another cranidium (B, XVII, 11) larger than the preceding has a glabella unusually quadrate in anterior. It is not constricted in the middle, but more or less expanded in the posterior part. Thus the outline disagrees with that of *L. subconica*, but otherwise *L. subconica* is the nearest to this form.

Occurrence:—A small cranidium from up-stream of Higuchi-zawa, KITAGAWA collect. A larger cranidium from Higuchi-zawa; MIZUNO collect.

Linguaphillipsia (?) sp. indet.

Plate VII, Figure 15

The third cranidium is similar to the second one in the outline of the glabella, but the test is not granulated as the preceding two cranidia. Compared to *L. choanjiensis* the frontal border is narrower and more convex. It is more allied to *L. higuchizawensis*. The associate pygidium in the same slab is, however, triangular in outline.

Occurrence:—Sakamoto-zawa, YOSHIDA collect.

Genus *Palaeophillipsia* SUGIYAMA and OKANO, 1944

Palaeophillipsia japonica SUGIYAMA and OKANO, 1944

Plate XIV, Figure 1

1944. *Palaeophillipsia japonica* SUGIYAMA and OKANO, in SUGIYAMA, *Study Rep. Geol. Min.*

Inst. Tokyo Bunrika Univ. No. 1, p. 26, pl. 1, fig. 1.
1973. *Linguaphillipsia japonica* G. & R. HAHN, *Senckenberg. Leth. Bd. 53,* pp. 481-489.

Occurrence:—Choanji, Hikoroichi village, Kesen County, Iwate Prefecture.

Fossil horizon:—Upper part of Omori Series (Kesen Group).

Repository:—Reg. No. 8202, Institute of Geology and Mineralogy, Tokyo Bunrika University. [Translated from the original text in Japanese]

Dorsal shield elliptical, though somewhat twisted, composed of cephalon, thorax and pygidium, although part of pygidium and left free cheek of cephalon are unpreserved. The shield, if restored, 17 mm in length, about 14 mm at the maximum breadth at the junction between thorax and pygidium; cephalon, thorax and pygidium nearly same in length.

Cephalon semicircular, but more or less triangular. Glabella fairly large 5 mm long, 4 mm wide, rounded in front, nearly parallel-sided, but rather abruptly tapering forward near the front and slowly expanding backward in posterior part. Relatively large preglabellar field separating glabella from anterior border. Two pairs of lateral glabellar lobes and one pair of (pre-)occipital lobes present in posterior of glabella, but not clean-cut; anterior lateral lobes smaller, shorter and narrower than posterior ones, only one-fourth as wide as glabella and none of them reaching glabellar axis; (pre-)occipital lobes generally not very prominent; lateral glabellar furrows not much pronounced, narrower than lateral lobes or as wide as the lobes; anterior lateral furrows narrower than posterior ones; (pre-)occipital lobes rounded, about 1 mm in diameter. Facial suture starting from near median part of anterior border, describing a large arc, passing inside of eye, then becoming strongly concave and terminating at posterior border. Though these sutures are running gradually outward behind eyes, they terminate near neck ring and therefore fixed cheek is very narrow. Free cheek on the contrary particularly broad in posterior, trapezoidal in general outline. Anterior border very narrow; lateral border broadened as wide as about 1 mm. Boundary between anterior border and free cheek not very sharp, but rather gradually merging. Eye moderate in size, located in posterior of cephalon, renifrom, about 2.2 mm long and 1 mm or so at the broadest part; its posterior part and the posterior part of (pre-)occipital lobe nearly in same level. Occipital ring distinct, almost uniform in breadth. Genal spines long, produced backward; their ends reaching as far back as the third thoracic segment and sharply pointed, but broadened toward root and transmit into lateral borders.

Thorax: As thorax and pygidium are disconnected in the specimen, the number of axial rings and pleurae are not countable, but as they are undoubtedly nine in the same group of trilobites, 6 rings and 6 pleurae are present and 3 thoracic segments must be unpreserved. Axial rings are so poorly preserved that their details are unknown. However, the surface is not smooth, but seemingly striated (?) laterally. Whether it is granulate or not is indeterminable. Its median part is arcuate forward, but lateral terminals are nearly horizontal. Ring furrows rather broad. Pleural lobes reveal similar aspect as axial rings, but they are nearly horizontal in the vicinity of axial rings and gradually bent backward laterally.

Pygidium: Outline semicircular. Like thorax axial and pleural parts distinctly separated from each other by deep axial furrows. Axial rings and pleurae are same in number, but only 8 are countable in the specimen. If complete, they may be 10 to 11, but 2 to 3 of them are unrepresented. As in thorax axial rings and pleurae are prominent, their surface is probably smooth, more or less rounded with weak backward convexity, so that the pygidium is separated from the thorax distinctly. The difference between median and lateral parts of axial ring as seen in thorax indiscernible in pygidium. Pleural lobe extending as far as thorax laterally.

The original description of the holotype specimen is translated above from Japanese into English. SUGIYAMA pointed out the following six items as generic characteristics.

1. Presence of narrow preglabellar field
2. Parallel lateral sides of glabella
3. Facial suture turning laterally to describe an arc in posterior of cephalon.
4. Small eyes far in posterior
5. Thorax composed of 9 segments whose axial rings differentiate into a median and two lateral terminal parts.
6. Pygidium composed of 10 to 11 segments whose pleurae extend to periphery without smooth marginal border.

Among them he emphasized items 1, 3 and 4 for especially important distinctions from *Phillipsia* and he noted that items 1 and 3 reveal affinities to Devonian proetids.

It is noteworthy that his diagrammatic drawing of cephalon of *Palaeophillipsia japonica* shows that the glabella is not parallel-sided but distinctly constricted at mid-length and that the posterior part is broader than the anterior as typical of *Linguaphillipsia*. This glabellar outline can be confirmed by the illustration of the type specimen. Judging from the illustration (fig. 1), eyes are not small, but moderate or rather large; facial sutures describe large arcs in front of eyes. Behind the eyes they extend laterally, then posteriorly and cut the posterior margin of the cephalon just about the limits of eyes. Pygidium looks roundly triangular in outline and marginal border of moderate size probably depressed; pleural ribbing extending as far as the margin.

OKUBO (1951) distinguished *Phillipsia ohmorensis* from *Palaeophillipsia* by the presence of the preglabellar field and pointed out that the age of *Palaeophillipsia japonica* was lowest Carboniferous, instead of uppermost Devonian. Subsequently ENDO and MATSUMOTO (1962) suggested that *Palaeophillipsia japonica* might be a synonym of *Phillipsia ohmorensis* OKUBO. They noted further that the holotype specimen of this species was lost during the World War II. But it is undeniable that in future any diagnostic specimen may be found out of the bed of the type locality. Recently G. and R. HAHN (1973) referred *Paleophillipsia japonica* to *Linguaphillipsia*.

As mentioned above, *Palaeophillipsia* is intimately related to *Linguaphillipsia*, but at the same time the former with the preglabellar field can be distinguished from the latter without it. Furthermore a new species bearing the diagnostic preglabellar field was found in the same restricted area. It is named here *Palaeophillipsia tenuis*. By these reasons the two genera are here accepted both valid.

Palaeophillipsia tenuis KOBAYASHI and HAMADA, sp. nov.

Plate VIII, Figure 4; Plate XIII, Figure 16; Plate XIV, Figures 2-4 and 6; Text-figure 3J

This is a *Paleiophillipsia* having a slender glabella provided with a pair of subtrigonal basal lobes and three pairs of lateral lobes; preglabellar area relatively large, concave and distinctly depressed below glabella and narrow frontal rim; median tubercle present on neck ring; eye moderate in size, set close to posterior of glabella; granules present.

The holotype cranidium (XIV, 2) from an upstream of Higuchi-zawa is an internal mould. It agrees with *Palaeophillipsia japonica* in the possession of a relatively long depressed area in front of the glabella but just behind the narrow marginal rim. The length of this preglabellar area plus the frontal rim corresponds to 0.125 of the length of the cranidium whereas it is 0.127 in the holotype cranidium of *P. japonica.*

Compared to the type cranidium this glabella is slender, and its middle contraction and posterior expansion are lessened in degree, but evidently the posterior lobe is broader than the anterior one. The neck ring is narrowing laterally and carries a median tubercle near the posterior margin like in *Linguaphillipsia terapaiensis.*

Four pairs of lateral lobes are distinctly separated by three pairs of pronounced lateral furrows. The posterior furrow runs from the lateral margin of the glabella more or less diagonally and then turns backward forming an obtuse angle at the bent. The basal lobe defined by the furrow is subtriangular, nearly as wide as one-third the glabella. The middle lateral furrow is broadened adaxially, but somewhat shorter. The anterior lateral furrow is shortest and almost rectangular to the glabellar margin. The three lobes anterior to the basal one are reduced the breadth and prominence anteriorly. The median lobe between these paired lobes terminates with a narrow transversal elevation or probably an incipient median preglabellar lobe. The occipital furrow is most expanded behind the ridge. Coarse but sparce granules are seen in front of the ridge and also on the lateral lobes near the median lobe.

The palpebral lobe is extending from the anterior lateral furrow as far as the basal lobe in accordance with the lateral expansion of the glabellar posterior half. The facial suture takes a slightly arcuate course from the palpebral lobe to the frontal margin. There the fixed cheek is very narrow. The glabella is sparcely granulate.

Beside the holotype there are internal moulds of four cranidia, all deformed in different manner, but they are sufficient to warrant their specific identification.

Broadly speaking, the cranidium, glabella and palpebral lobe are all relatively narrow, if compared to those of *P. japonica.* Because this is an internal mould, the internal relief may be somewhat emphasized than the external one of the carapace. Nevertheless it agrees with *P. japonica* in the presence of the relatively large preglabellar area. This is the nearest to the species in the trilobite collection at hand.

This cranidium resembles the young one of *Phillipsia ornata belgica* (OSMOLSKA, 1970, fig. 1, pl. XI), but the preglabellar field is shorter and less concave, the frontal border broader and rounded on the top, the frontal lobe of the glabella cylindrical and well rounded in front and the preglabellar furrow less developed and the eyes are smaller in that species. It is more or less similar to *Archaegonus* and *Cyrtodechenella* in the preglabellar aspects, but it is quite different in the glabellar outline, size and position of the palpebral lobe and the absence of the occipital lobe.

Occurrence:—The holotype collected by KITAGAWA from upper stream of the Higuchi-zawa. Four other cranidia were collected by from Higuchi-zawa and Choanji by MIZUNO and SASAKI. An internal mould of a dorsal shield from Choanji (pl. 8, fig. 4, SASAKI collect.) consists of a cephalon, thorax and part of a pygidium.

Palaeophillipsia (?) *kitakamiensis* SUGIYAMA and OKANO, 1944

1944. *Palaeophillipsia* ? *kitakamiensis* SUGIYAMA and OKANO, *Study Rep. Geol. Min. Insi. Tokyo Bunrika Univ. No. 1*, p. 29, pl. 1, figs. 2a-c.

This specific name was proposed for a *Palaeophillipsia*-like pygidium whose length and breadth being in proportion of 4 to 3. It is segmented 14 to 15 in number and has granulate test. Its illustration shows that the pygidium is parabolic, instead of semicircular. Not only this outline, but also the granulation and multisegmentation show that it is not identical with *Phillipsia ohmorensis*. It is represented by three pygidia but the illustration and description are insufficient to warrant the generic identity.

Occurrence:—Choanji, Hikoroichi village, Kesen-county, Iwate Prefecture. Reg. no. 8204, Tokyo Bunrika University collection. Unfortunately, the type specimen was lost.

Genus *Dechenelloides* GANDL, 1968

This genus was instituted by GANDL on *Proetus angustigenatus* LEYH, 1897 in the Dechenellinae PŘIBYL, 1946, of the Proetidae. Later BRAUCKMANN (1978) transferred it to the Linguaphillipsiinae by the reason that the posterior lateral furrow (S1) is not bifurcated, the pygidium relatively paucisegmented and the long time-gap exists between the genus and the Devonian Dechenellinae.

Compared with the type-species the outline of the glabella is slender and its lateral furrows are obsolete, but otherwise the Japanese species agrees with this better than any other genus.

Dechenelloides asiaticus KOBAYASHI and HAMADA, sp. nov.

Plate VII, Figures 1 and 2; Plate XIX, Figure 11; Text-figure 4E

The glabella is pear-shaped, or conical but well rounded in front, somewhat contracted at about mid-length and laterally expanded in posterior, although the outline is slender, if compared with the type-species. The basal lobe and preoccipital furrow are distinct, but other lateral furrows obscure. The dorsal and occipital furrows are profound. The median tubercle is absent and the occipital lobe obsolete on the neck ring. The eyes are large, semicircular and opposed at the posterior portion of the glabella. The preglabellar field is fairly large. The marginal rim is narrow. The cheek is nearly as wide as the glabella. The genal spine is moderate in length. The anterior branches of the facial sutures are divergent from the eyes as far as their parallels and suddenly recurved on the rim. The posterior branch extends laterally from the end of the eye and nearly diagonal through the posterior cheek border.

The thorax of the paratype shield appears to have ten segments. The associated pygidium on the same slab is as long as broad. The axial lobe is prominent, narrow, longiconical and composed of 13 or 14 rings. The pleural lobe is fairly broad, gently convex, and divided into some ten ribs anterior one of which are subdivided into two bands. The marginal border is well defined, narrow and depressed. The test is smooth.

Occurrence:—Higuchi-zawa, HACHIYA and SHIMIZU collect.

Genus *Schizophillipsia* KOBAYASHI and HAMADA, gen. nov.

Diagnosis:—Linguaphillipsiids having trifurcate carinae on free cheeks, nine to eleven segments in thorax; pleural ribbing extending to narrow marginal rim in pygidium.

Type-species:—Schizophillipsia yukisawensis KOBAYASHI and HAMADA, sp. nov.

Remarks:—The trifurcate carination of the cheek similar to that of *Schizoproetus* in the dechenellids is very uncommon to see among the phillipsiids (s. l.). Therefore it is a remarkable fact that such a carination is well represented in Australia by three Visean species as follows:

1. *Phillipsia elongata* MITCHELL, 1818
2. *Linguaphillipsia divergens* CVANCARA, 1958
3. *Linguaphillipsia cangonensis* ENGEL and MORRIS, 1975

They, however, have the pygidia much more segmented. The thorax is composed of nine segments in *L. elongata elongata.* The hypostoma of *L. divergens* is quite distinct from the associate hypostomata with *S. yukisawensis.*

Distribution:—Visean; Japan.

Schizophillipsia yukisawensis KOBAYASHI and HAMADA, gen. et sp. nov.

Plate XI, Figure 4; Plate XII, Figure 1-14; Plate XIII, Figures 3-13; Text-figure 3F

1968. *Linguaphillipsia* sp. ARAKI and KOIZUMI, p. 157, pl. I, figs. 9-13, pl. II, fig. 12.
1979. *Paladin yukizawensis* (nom. nud.) KOBAYASHI and HAMADA, p. 104.

Description:—Dorsal shield more or less ovate in outline. Cephalon large, semicircular except for long genal spines; glabella protruded halfway into frontal border, contracted in middle part, more expanded in posterior than anterior; three short lateral furrows divergent inward from the contraction; basal lobe large, well defined by preoccipital furrow; median tubercle present on neck ring; occipital and dorsal furrows strong; eyes large, semicircular; fixed cheek narrow; free cheek moderate in size and convexity and provided with trifurcate carina; lateral border mesially ridged; genal spine nearly as long as a half of thorax; lateral and posterior border furrows join at genal angle and thence continuing to median furrow on the spine; facial sutures divergent forward from eyes and recurved on the marginal border; their posterior branches cutting posterior cheek margin a little inside of the mid-point. Associate hypostoma fairly long, not much inflatted, having a pair of anterior wings and raised lateral borders.

Thorax nearly as long as cephalon, composed of ten segments; axial lobe nearly as wide as pleural lobe. Pygidium shorter than thorax, semicircular; axial lobe a little narrower than one-third of pygidium, composed of about 10 rings and a terminal lobe; pleural lobe gently arching down in outer part, divided into 8 or more ribs by narrow furrows, all simple except for the first which is double; these ribs extending almost to very narrow marginal rim.

Test smooth.

Observation:—The Yuki-sawa trilobites are all deformed in various ways and degrees. Caused by the deformation it is difficult to grasp the original form, particularly of the glabella. It is generally contracted at the mid-length and more expanded in posterior than the other and provided with two or three pairs of short lateral furrows beside the long preoccipital pair which are usually distinct. It is a general tendency for the short furrows and the lateral glabellar expansion to be emphasized by the sagittal compression. When laterally compressed, the lateral furrows become obsolete and the lateral expansion of the glabella modified in different manners so much that the modification puzzles the observer for their identification. The two cranidia which were previously made two paratypes of *Paladin* (*Weberides*) *longispiniferus* are known now to be sagittally depressed ones of this species.

The trifurcate carination on the free cheek is very distinct in the paratypes A, B (XII, 5, 12) and C. In the latter two the lateral border is distinctly ridged in the middle. In the paratype C (XI, 4) a left free cheek with a long genal spine is contained in the same slab with the pygidium and ten thoracic segments still anchylosed.

In the holotype dorsal shield the thorax is definitely composed of ten segments. The paratype D (XII, 8) consists of six thoracic anchylosed segments. Its first axial ring clearly shows that the annulus of the ring behind the articulating furrow is divided into pre- and post-annuli by an intra-annular furrow.

The pygidium of this species generally possesses ten axial rings plus a terminal lobe and eight to nine pleural ribs which the latter are separated from on another by narrow pleural furrows as seen in the paratype E (XIII, 6). These furrows are broader than the pleural ribs in some pygidia. The ribbing extends almost to the very narrow marginal rim. In the internal mould the ribs are very narrow and the furrows very broad. Looking through the pygidia in various states of preservation it is understood that the doublure is fairly broad. Its breadth corresponds approximately to the marginal slope of the pleural field and the axial lobe terminates shortly inside of the slope.

Hypostoma:—Two isolate hypostomata from Yuki-sawa belong to the same kind, but a little different from each other. They are not strongly inflated and have nearly straight anterior margin. There are a pair of trigonal flat anterior wings. These wings are evidently larger in A form than B form. The main part behind the wings are long, subelliptical and surrounded by raised marginal rim on the lateral and posterior sides. The outline of the part is more expanded in anterior in A form (XII, 9) and more or less parallel-sided and rounded in posterior in B form (XII, 10). In both of them unusually narrow parallel furrows are running along the lateral rim. In addition a pair of such furrows are present on the two sides of the median ridge in A form whereas in B form the main body forms a low median arch.

Thus they are considered to belong possibly to two distinct species and either one of them to this species. They reveal a new form of hypostoma quite distinct from those of *Paladin* (*Paladin*) *helmisensis* (WHITTINGTON, 1954) and other proetoids.

Immature pygidium:—A small pygidium, 2.8 mm. long (XIII, 13) agrees with the adult pygidium of this species in segmentation and inflation, namely the axial and pleural lobes are segmented respectively into 10 to 11 and 8 to 9 and the pleural lobe is gently arching down in the outer part. The axial lobe is, however, narrower and less conical and the marginal border broader and distinctly pointed behind the axial lobe. The outline of the pygidium looks comparatively long.

In the outline of the pygidium, particularly in the presence of the posterior projection it is allied to *Paladin* (*Weberides*) *longispiniferus*, but the outline is not so trigonal as the pygidium of that species. In the number of pleural ribs it agrees with that species, but 13 to 14 axial rings are countable in that pygidium.

In *Paladin mucronatus mucronatus* (MCCOY) the posterior margin of the pygidium is primarily entire and an incipient mucro appears in a certain stage of growth (OSMOLSKA, 1970).

This pygidium is found in association with the grown one of this species in the same slab, but the association cannot warrant its reference to this species. It is placed here very provisionally, until more will be learn of linking forms.

Occurrence:—Most common in the Onimaru Series at Yuki-sawa, Rikuzen Takada city, ARAKI and MIZUNO collect.

Schizophillipsia otsuboensis KOBAYASHI and HAMADA, sp. nov.

Plate XIII, Figure 17; Plate XXI, Figures 8-11;; Text-figure 3G

Description:—Cephalon with a pair of fairly long genal spines. Glabella roundly quadrate in anterior half, well expanded laterally in posterior and more or less constricted between two parts; two pairs of lateral furrows divergent from the constriction; preoccipital furrow restricting basal lobe confluent with profound occipital furrow; neck ring provided with a median tubercle, narrowing behind the lobe; dorsal furrow deep; frontal border convex, separated from glabella by marginal furrow. Eyes opposed at posterior half of glabella; palpebral lobe lunate; trifurcate carination distinct on free cheek; genal spine as long as glabella. Facial sutures running forward from eyes, but a little laterally and taking arcuate course; sutures more or less diagonal shortly behind eyes, then extending almost laterally and finally cutting posterior cheek borders at their middle points.

Thorax composed of nine or more segments. Pygidium parabolic in outline; pleural lobe broader than axial one; pleural ribs 9 or so in number, nearly flat, separated by narrow furrows and extending as far as narrow marginal rim.

Test smooth.

Observation:—The holotype (XXI, 10) is composed of a cranidium and a right cheek with a long genal spine. It shows most of the cephalic aspects, although the glabella is uncommonly narrowing forward in its anterior half. In a paratype cranidium sagittally depressed to some extent the glabella is distinctly constricted at the mid-length and the frontal, lateral glabellar and occipital furrows are all deep. In a cranidium laterally compressed, on the contrary, these furrows are all weakened and the anterior marginal furrow looks particularly broad.

In a dorsal shield the cephalon and nine thoracic segments are still anchylosed, but the part behind the ninth segment is unpreserved. The trifurcate carination on the free cheek can clearly be seen on the holotype cephalon as well as this shields. Another shield (Pl. XIII, fig. 17) diagonally deformed is composed of nine thoracic segments and a pygidium which the latter has 9 pleural ribs. Its outline is well rounded laterally and posteriorly and its rim narrow. The axial lobe is unfortunately crashed in this pygidium. The pleural ribbing extends as far as the narrow marginal rim.

Occurrence:—Otsubo-zawa.

Schizophillipsia (?) *platyrachis* KOBAYASHI and HAMADA, sp. nov.

Plate XIII, Figures 1 and 2

A dorsal shield resembles *Schizophillipsia yukizawensis* in the outline of the glabella, large eyes and particularly in the mode of pleural ribbing. The lateral furrows are, however, very weak on the glabella. The occipital ring carries a median tubercle. The thorax is composed of eleven segments, instead of ten in that species and its axial lobe is quite broad (XIII, 1).

In a cephalon from the same locality the lateral furrows are almost completely obsolete on the glabella. The trifurcate elevation is apparently present, but not sharp. The narrow pleural ribs on the pygidium extending as far as the peripheral slope are typical of *Schizophillipsia*.

Occurrence:—Uncommon at Yuki-sawa.

Linguaphillipsid, gen. et sp. indet.

Plate XI, Figure 5

An internal mould of a dorsal shield strongly deformed by lateral compression. As the result its axial lobe is strongly warped up. Glabella very broad, strongly constricted at mid-length; its anterior part as wide as posterior part, encroching frontal border; two lateral furrows distinctly impressed beside well developed preoccipital one; schizochroal eyes large, close-set to posterior half of glabella; cheek narrower than glabella, remarkably depressed; lateral and posterior borders of cheek narrow, clearly limited by marginal furrows. Axial rings of thorax each divided into two bands, beside articulating half-ring.

The outline of the glabella and its lateral furrows are typical of the Linguaphillipsiinae. This cephalon resembles *Schizophillipsia yukisawensis*, ex. its paratype A, but the glabellar furrows are not obsolete and the trifurcate carination is recognizable on the cheek in that paratype, but indiscernible in this specimen. In this dorsal shield nine segments are countable in its thorax and its pygidium may be less segmented than the pygidium of *S. yukisawensis*.

Occurrence:—Yuki-sawa; ARAKI collect.

Subfamily Cummingellinae G. & R. HAHN, 1967

Genus *Cummingella* REED, 1942

Cummingella otai KOBAYASHI and HAMADA, 1978

Plate XIV, Figures 7-9, 11 and 13

1978. *Cummingella otai* KOBAYASHI and HAMADA, *Proc. Japan Acad. v. 54, no. 2,* p. 53, figs. 3-c.

Description:—Cephalon strongly inflated, suboval in outline; glabella highest in anterior, more expanded there than in posterior and contracted in mid-length; anterior lobe gibbous, overhanging frontal border, gently inclined backward and ornamented by irregular transversal striae; posterior lateral furrow shallow; other laterals obsolete; basal lobe long, subtrigonal; occipital furrow straight, transversal; neck ring nearly uniform in thickness, but abruptly narrowing at lateral ends; fixed cheek narrow; eyes very large, reniform, prominent, opposed at posterior of glabella; palpebral lobe narrow; free cheek steeply inclined outward from eye, mesially carinate and ornamented by irregular subparallel striae, limited by smooth grooves from eye and lateral border; the border convex, stout and ornamented with subparallel striae; facial suture apparently running forward from eye along the glabella maintaining short distance as far as marginal border.

Pygidium semicircular, well inflated; axial lobe nearly one-third as wide as pygidium, narrowing rather slowly, broadly rounded at terminus, composed of ten or more rings; pleural field horizontal in inner half and gently inclined in the other, divided into about 7 ribs, each subdivided into two subequal bands by an interpleural furrow; marginal border limited inside by shallow furrow and gently sloping outward.

Observation:—The holotype (XIV, 7) is a cephalon 6.1 mm long (ASM 8002) whose genal part is unpreserved. In the frontal view the marginal border lies concealed beneath the glabella. The border and intermediate carina of the free cheek extend from the glabella laterally.

Comparison:—This massive cephalon having hourglass shaped glabella, very large eyes and narrow free cheek agree with *Cummingella*, particularly *C. jonensi* (PORTLOCK), but the glabellar furrows are obsolete except for the basal ones. The mesial carina bounded by a deep furrow on each side is most distinctive characteristic from the known species of *Cummingella*. This should be a highly specialized terminal species.

The pygidium (XIV, 13) referred to this species from the *Millerella yowarensis* zone at Iwanaga-dai (IW-1) has a stout axis composed of 10 or more rings and about 7 pleural ribs divided into two subequal bands as usual in *Cummingella*. Another pygidium (XIV, 8) from the *Profusulinella beppensis* zone at Nakano Shohoji, Akiyoshi-dai is so similar to the preceding pygidium that it is difficult to isolate from this species.

A nearly complete pygidium (XIV, 9) from the Omi limestone is tentatively referred to this species. It resembles *Cummingella jonesi* as well as *C. brevicauda* (GOLDRING, 1958) in the outlines of the pygidium and axial lobe, but it is much fewer segmented. Like *Cummingella brevicauda* axial rings and pleural ribs are flattopped and the latter clearly divided into two subequal bands by a linear interpleural furrow and ring and pleural furrows are narrow and shallow. *C. brevicauda* has 12-13 rings and 9 ribs, and *C. jonesi* does 13 rings and 9-10 ribs, both convex (OSMOLSKA, 1970). In this form the axis is composed of 7-8 rings and a terminal lobe and only 6-7 pleural ribs are countable. Minute granules are sparcely seen on the test.

Occurrence:—A solitary cephalon was collected by YANAGIDA, M. OTA and N. OTA at a point (loc. R-41) 257 m east-south-east from Ryuga-ho triangulation, Akiyoshi-dai in medium to coarse calcarenite of the *Millerella* sp. zone. The pygidium was obtained later at Ikusei-Bokujo, Iwanaga-dai in the *Millerella yowarensis* zone. A pygidium (ASM 8005) from the *Profusulinella beppensis* zone at Nakano Shohoji, Akiyoshi-dai is also referable to this species. A pygidium collected by IMAMURA from Omi limestone.

Cummingella cf. *otai* KOBAYASHI and HAMADA

Plate XIV, Figures 10 and 12

Two of three pygidia from the *Profusulinella beppensis* zone at Nakano Shohoji, Akiyoshi-dai are compared to *C. otai* somewhat longer and the axis more breviconic (ASM 8009) or more stout (ASM 8006), but the differences may be no more than subspecific, or mutational (by WAAGEN, 1868).

Cummingella subtrigonalis KOBAYASHI and HAMADA, sp. nov.

Plate XV, Figures 1-5; Plate XVII, Figure 4(?) ; Text-figure 4C

Description:—Cephalon massive, subtriangular and strongly inflated. Glabella transversely striated in anterior, broad, strongly expanded in anterior to constriction where it is gibbous, becoming highest near center and overhanging frontal border; basal lobes large, long and triangular; preoccipital furrow diagonal, deep, but not reaching deep occipital furrow; additional furrow shorter than the preceding, extending from lateral constriction also diagonally; neck ring somewhat thickened mesially; median tubercle present on the ring. Fixed cheek very narrow; eye large and prominent, but below the sagittal profile of glabella; palpebral lobe crescentic, narrow and simply inclined inward; free cheek striated, a little inflated and regularly sloping toward marginal furrow and border; lateral and posterior marginal furrows profound and join at genal angle; lateral and posterior borders stout and the former striated; genal spine absent. Facial sutures running forward from eyes in parallel and close to axial furrows; their posterior branches short and diagonal.

Observation:—YANAGIDA's collection from Maruyama contains a specimen (XV, 3) composed of a cephalon and three thoracic segments. The glabella and cheek are distinctly striated. The cephalon is subtrigonal, although its anterior part is broken off. Two lateral furrows are seen on the glabella; eyes are large and prominent the genal angle is well preserved. In the thorax the axial ring is broader than the pleuron. The latter is divided into two bands.

Another specimen (XV, 5) consists of five thoracic segments. The anterior band, somewhat narrower than the other band is distinctly facetted. In some axial rings annulus is clearly bipartated by an intra-annular furrow.

The third specimen (XV, 4) is an imperfect cranidium to which two thoracic segments are attached. It looks similar to the first specimen.

The fourth specimen (XVII, 4) is a pygidium similar to that of *Cummingella otai*, but its outline appears broader. The axial lobe is more rapidly narrowing back and the marginal border strongly thickened posteriorly.

Comparison:—Like *Cummingella otai* this species has the striated glabella and cheeks, but the free cheek is only slightly convex, instead of carinate in that species. Additional distinctions are in the more triangular outline and the stronger inflation of the cephalon, presence of a pair of short but distinct oblique furrow on the glabella beside the preoccipital ones, and the weaker furrows along the peripheries of the eye and marginal border, particularly the former which is extraordinarily well developed in that species.

Occurrence:—Omi limestone (HACHIYA collect.); Akiyoshi limestone at Maruyama. (YANAGIDA collect.).

Cummingella mesops KOBAYASHI and HAMADA, sp. nov.

Plate XV, Figures 6-7; Plate XVI, Figures 1-4 and ? 5; Plate XVII, Figure 1-3; Text-figure 4A

Description:—Cephalon massive, parabolic in outline, strongly convex, most elevating in anterior of glabella; genal spine absent. Glabella large, broad, subcylindrical in posterior to constriction, but expanded in anterior where it is bulbous, overhanging to frontal border; basal lobe of moderate size, triangular, isolated by diagonal furrow; other lateral furrows obsolete, but one may be discernible by cross light as a shallow and short depression near constriction; occipital furrow narrow, but distinct; median tubercle present on neck ring; in sagittal profile the ring evidently below the glabella which is gradually ascending forward in posterior portion, but abruptly sloping down in anterior in describing a semicircle and overhanging to frontal border; doublure below the frontal lobe narrow. Fixed cheek very narrow; eye medium in size, moderate in prominence and a little lower than glabella; palpebral lobe small and narrow. Free cheek relatively large, gently slanting outward, but divided by an obtuse median ridge into a broad outer slope and a narrow and shallow depression inside the ridge; marginal furrow profound; lateral border having sharp crest and its outer side commonly striated; posterior cheek border stout, round-topped and non-striated; genal angle well rounded. Facial suture running in parallel and close to axial furrow in anterior, but in posterior a little laterally behind eye and then diagonally as far as median point of posterior cheek border.

Pygidium semicircular with well arcuate anterior margin. Axial lobe outlined by axial furrows, conical but having blunt terminus, elevated above pleural fields, having low regularly convex top, composed of about ten rings. Pleural lobes subhorizontal near axis, gradually arching down to margin, but a little incised along marginal furrow, composed of seven segments which are each divided into two equal bands, although the division becomes obscure in posterior segments; the first pleural rib narrow and prominent and the first pleural furrow profound, both extending into lateral border.

Marginal border smooth on exfloriated part, but often striated on the remaining test.

Observation and comparison:—The holotype is a complete cephalon (XVI, 1). Insofar as can be seen on its left cheek, the test is smooth except for the outer side of the lateral border. Weak striation is, however, seen on the test and also on the exfoliated part of the right free cheek. The glabella is also striated in its overhanging part, but more faintly.

Another cephalon (Omi, XVI, 2) is nearly complete, but the test is largely exfoliated. Compared to the preceding, the striation is observable more clearly on the frontal lobe. These two cephala agree with each other in the outline and convexity of the cephalon, location of the glabella, size and position of the eyes, the relatively large free cheek and its bipartation by an obtuse carination.

The carination is quite developed in the cheek of *Cummingella otai*. The cephalon is more triangular in *Cummingella subtrigonalis*. The eyes are much larger and the free cheeks more strongly striated in those two species.

The pygidium (XVII, 2) in SATO collection which is provisionally referred to this species is nearly complete, but its test is largely exfoliated. Two cranidia and a free cheek from Matuyama quarry, Akiyoshi-dai may be referable to this species. One of the cranidia (XVI, 3) best agrees with the holotype. Its eyes are evidently smaller for *Cummingella subtrigonalis*. In another cranidium (XVI, 5) the pre-occipital furrow is relatively strong, but otherwise it is not essentially different from this species. The free cheek from the quarry (XVI, 4) is only striated on the outer slope of the lateral border.

Another pygidium from Omi (XVII, 3) looks somewhat parabolic in outline. It is evidently shorter than *Cummingella subovalis* and *C. imamurai* and disagrees with them in the relative size of the axial lobe to the pygidium.

Like this species *Cummingella gaveei* (WEBER, 1933) has comparatively small eyes, but it differs in outline and lobation of the glabella and other characteristics, particularly the frontal border which clearly visible in the dorsal view. The pygidium resembles that of *C. brevicauda* (GOLDRING, 1958), but not so multisegmented.

Occurrence:—Omi limestone (SATO and SHIMIZU collect.); Omi, Niigata Prefecture; Akiyoshi limestone, Maruyama quarry, Yamaguchi Prefecture.

Cummingella granulifera KOBAYASHI and HAMADA, sp. nov.

Plate XIX, Figures 12-14, 17a-b; Text-figure 4B

Description:—Glabella strongly convex, its main part flask-shaped, remarkably expanded in anterior where it looks globular, gradually narrowing back between a pair of basal lobes which are completely isolated by pronounced diagonal preoccipital furrows; one or two lateral furrows short; occipital furrow straight and deep; neck ring narrower than glabella, provided with a median tubercle; eyes almost half as long as glabella, located far posteriorly. Free cheek unknown. Hypostoma provided with a pair of large anterior wings; main body oblong, convex, longitudinally striated; maculae short or insignificant; marginal border narrow, inclined inward, subangulate between lateral and posterior parts.

In thorax axial ring somewhat broader than pleuron, convex, very stout; pleuron geniculate at about midway, divided into two ribs by broad transversal furrow.

Pygidium semicircular, well inflated; axial lobe broader than pleural lobe, breviconic, abruptly rounded near posterior end, composed of about 9 rings; ring furrows narrow; pleural lobe divided by pleural and interpleural furrows into 13-14 ribs, thicker and thinner ones alternating; first pleural furrow as strong as that of thoracic pleuron. Marginal border comparatively broad, convex, densely striated and clearly separated from ribbed part by a furrow.

Test granulate.

Observation:—Although the granulate test is largely exfoliated, the granulation is still preserved at different parts of the cranidium, thorax and pygidium. The granules are seen only on the left basal lobe in the holotype (XIX, 12). Because the glabella is strongly convex, the lateral furrows are seen in the three cranidia only in the lateral view. A paratype (XIX, 14) consists of three thoracic segments and a pygidium. On the right pleural lobe of this pygidium are seen the facetted first rib and the pronounced pleural furrow just behind it.

Comparison:—Compared to the other species in Japan the nearest cranidium is that of *Cummingella mesops* in which the basal lobes are completely cut off and the median tubercle present on the occipital ring. The main lobe of the glabella is, however, more vaulted, the preoccipital furrow much stronger and the eyes are larger and located more posteriorly in this species.

The associate pygidium resembles that of *C. otai* most closely in the broad outline and double ribs, but in this species the pygidium is more or less broader and more inflated, its axial lobe relatively broader, the pleural rib divided into two unequal bands more distinctly and the marginal border very stout and striated wholly.

The hypostoma (XIX, 13) looks similar to that of *Cummingella* sp. indet. from the Hina limestone in outline, auriculation and longitudinal striation. The maculae, however, appear more pronounced in that hypostoma.

The granulate test distinguishes this species from all other Japanese species.

Cummingella gapeevi (WEBER, 1933) from the lower Namurian of the Donetz basin (OSMOLSKA, 1970) has also such a strong preoccipital furrow, but it is quite different from this species in most other characteristics.

Occurrence:—At the Northeast of Nakano Shohoji (La-134; 71-136) and Iwanagadai in the Moscovian *Fusulinella biconica* zone of the Akiyoshi limestone.

Cummingella imamurai KOBAYASHI and HAMADA, sp. nov.

Plate XVII, Figure 7

Pygidium parabolic in outline, relatively long for *Cummingella*; axial lobe longiconic, divided into 10 or more rings by distinct furrows; pleural furrows very weak, about seven in number; interpleural furrows seen only one or two anterior ribs on the outer side; marginal border in moderate breadth in posterior, but narrowing antero-laterally.

Like *Cummingella carringtonensis* (ETHERIDGE in WOODWARD, 1883-1884) the axial rings separated from one another by wide ring furrows look somewhat scale-like and posterior ones bear granules. The two species are similar to each other in the elongate outline of the pygidium. The numbers of axial rings and pleural ribs are, however, quite smaller in this species as that species has 12-13 rings and 8-9 ribs. In this species the pleural segmentation is obsolete and the axial lobe is more rapidly tapering backward, if compared with that species.

This species is denominated in favour of Emeritus Professor Sotoji IMAMURA of the Hiroshima University who has discovered trilobites in the Omi limestone some fourty years ago.

Occurrence:—Omi limestone collected by IMAMURA.

Cummingella subovalis KOBAYASHI and HAMADA, sp. nov.

Plate XVIII, Figure 5

Description:—Pygidium suboval, one and half as long as broad, well vaulted and strongly arched down in posterior; axis occupying two-fifths the pygidial width, conical, rounded at hind, gently convex, divided into about eleven rings by shallow furrows; pleural lobe divided into 6 or 7 ribs; first rib and furrow most pronounced; succeeding ribs broader, flat-topped, each divided into two subequal bands by an interpleural furrow which is weaker than pleural one; ribbing, however, tending to be obsolete posteriorly; marginal border of moderate breadth somewhat depressed; test smooth.

Comparison:—This pygidium is longer and its axial lobe longiconic, if compared with *Cummingella mesops*. It is closely allied to *Cummingella polonica* (WEBER) from lower Visean in the Urals (in OSMOLSKA, 1970), although the axial lobe is more conical and broader, the pleural ribbing much weaker and one segment lessened in the axial as well as pleural segmentation. The abrupt arching down of the axis and its two sides in posterior are also very distinctive of this species.

Occurrence:—*Millerella* zone; Iwanaga-dai, 130 m to the south of the stream, Akiyoshi Museum, (IW).

Cummingella, sp. nov.

Plate XVII, Figure 5

A cephalon in a boulder obtained at Osobudani, Fukuji belongs to the genus *Cummingella*. Specifically, it is allied to *C. subtrigonalis* on one side and to *C. mesops* on the other. It agrees better with the former in the outlines of the cephalon and glabella and the possession of large eyes, but the test is quite smooth like the latter. The fine striation characteristic of the former is absent.

A few short lateral furrows are present in front of the strong preoccipital furrow. Two of them are fairly distinct, but the anterior one is very faint.

Occurrence:—Osobu-dani, Fukuji, Gifu Prefecture is a new Carboniferous trilobite locality in Japan. The specimen was obtained by MIZUNO.

Cummingella (?) *eurypyge* KOBAYASHI and HAMADA, sp. nov.

Plate XVII, Figure 6; Text-figure 4D

A large pygidium, 17 mm long and 26.5 mm wide; axial lobe, 14 mm long and 11.5 mm wide. It resembles the pygidia of *C. otai* and *C.* cf. *otai,* but the pygidium and particularly its axial lobe are very broad and paucisegmented. The axis is broader than a half of the pygidium and abruptly tapering back to a blunt tip, divided into six or seven rings by weak furrows; pleural lobe flat on axial side regularly sloping down to the smooth marginal border without any boundary furrow, divided into five flat ribs beside rather prominent first rib and a deep furrow behind it.

This pygidium looks similar to *Cummingella shartymensis* (WEBER, 1937) from the Namurian of the Urals in the weak segmentation and the great width but different in the lessened segmentation, because that species has 9 axial rings and 6 pleural ribs. *Cummingella auge* G. & R. HAHN, 1968, has a longer pygidium and a narrower axial lobe, if compared with them.

This pygidium resembles *Paraphillipsia* TOUMANSKY, 1935 no less than *Cummingella,* but its identification with the Middle Permian genus is hesitated until its cephalon will be found.

Occurrence:—Profulinella beppensis zone; Nakano Shohoji, Akiyoshi-dai (ASM 8004).

Cummingella (?) sp. indet.

Plate XVIII, Figures 1-4

Cranidium strongly inflated; glabella a little broader in posterior than anterior to the constriction at mid-length; lateral furrows all effaced; occipital furrow strong, well pronounced to form shallow depressions on neck ring near its lateral ends; palpebral lobe flat, crescentic and located on lateral side of glabellar posterior portion.

This imperfect cranidium has the glabella more expanded in posterior like in *Cummingella* sp. 2 by OSMOLSKA, 1970. It becomes vertical in front and the glabellar furrows are quite obsolete as in *Cummingella jaroszi insulae* OSMOLSKA, 1970.

A narrow left cheek of Hina having a large prominent eye in posterior; lateral and posterior borders thick, distinctly limited by deep furrows; genal spine apparently absent. Among the Hina fauna this free cheek belongs more probably to this species than any other trilobite.

A hypostoma probably of this species which is provided with a pair of large anterior wings is strongly inflated. It is as long as wide. The anterior margin is broadly arcuate; central body large, about twice as long as broad, very prominent, highest in anterior conical part, divided into two unequal parts by lateral shallow depression or maculae at about one-third from posterior; these depressions shallow, separating lunate posterior elevation from the main anterior-median part; wings on the antero-lateral side flat, depressed, steeply slanting laterally, and confluent with each other in front of the central body; anterior rim very narrow; marginal rim and furrow well developed on lateral sides and subangulated at the junction with the posterior rim. The central body is striated longitudinally. Because the posterior part is broken, it is indeterminable whether it has a pair of posterior spines like the hypostoma of *Cummungella brevicauda* (GOLDRING), but it closely resembles that hypostoma.

A pygidium from Hina, resembling that of *C.* ? *jaroszi insulae*, is tentatively referred to this species. Compared to that pygidium its axial lobe is evidently narrower and the pleural segmentation more obsolete. The marginal border appears nearly as broad as in that pygidium, but the marginal furrow is almost completely effaced in this pygidium.

Occurrence:—Hina limestone, Hina; NISHIKAWA collect.

Subfamily Griffithidinae HUPÉ, 1953

Genus *Bollandia* REED, 1943

In 1943 REED instituted many new genera and subgenera of British Carboniferous trilobites among which were the following three:

Metaphillipsia REED, 1943.	*Asaphus seminifera* PHILLIPS, 1836
Griffithides (*Particeps* REED, 1943).	*Gr.* (*Particeps scoticus* REED, 1943)
Permoproetus (*Bollandia*) REED, 1943).	*Asaphus globiceps* PHILLIPS, 1836

Their type-species are each cited behind the generic or subgeneric names. Incidentally *Permoproetus* was primarily a Permian genus by TOUMANSKY (1935). G. HAHN (1967) made *Bollandia* a subgenus of *Griffithides* PORTLOOK, 1843 with the contention that the former is ancestral to *Permoproetus* and a few other Permian griffithids. G. and R. HAHN (1971) divided *Griffithides* into four subgenera, namely *Griffithides* s. str., *Bollandia*, *Metaphillipsia* and *Particeps*. Subsequently in 1975, however, they transferred *Metaphillipsia* to the Phillipsiinae OEHLERT, 1886 on one hand, but on the other they added *Reediella* OSMOLSKA as an additional subgenus of *Griffithides*.

Prior to this OSMOLSKA (1970) accepted *Bollandia* as an independent genus of the Proetinae. At the same time she founded *Reediella* in the same subfamily whose type species was *Reediella reedi* OSMOLSKA, 1970.

Thus, there is some disagreement among the authors with regard to the taxonomy of *Bollandia* and its allies. As summarized by G. and R. HAHN (1970), the known distribution of *Bollandia* is in western, middle and eastern Europe and western Asia, i. e. Turkestan, Kirghiz Steppe, Karatau mountains and ? Turkey in the rocks from high Tournaisian and Visean. Therefore it is quite unexpected to find a new species of *Bollandia* in the Kitakami mountains, North Japan. *Bollandia pacifica* is proposed for it. As described in detail, it reveals morphic resemblances with *Bollandia* as well as *Particeps*, but phylogenetically it is considered to be a developed form of *Bollandia*, instead of *Particeps*.

Because *B. pacifica*, as it is in the type-species of *Bollandia*, has nine segments, instead of ten in thorax, *Bollandia* is better to eliminate from the Proetinae, but its subgeneric reference to *Griffithides* cannot be warranted. The pygidium of *Bollandia* is most paucisegmented among four subgenera which G. and R. HAHN referred to *Griffithides*, as seen below.

Trilobites	axial rings	pleural ribs
Griffithides s. str.	13-15	9-10
Particeps	12-15	9-11
Reediella	10-12 or 13	7- 9
Bollandia	10-11	6- 8

Bollandia pacifica having 12 axial rings and 8 or 9 pleural ribs agrees best with *Reediella* and nearer to *Particeps* than *Bollandia* in the number of segmentation. The pygidium of *Particeps* is, however, quite different from that of *Bollandia* in the longer outline and lacking well marked border. The pygidium of *Reedella* is on the other hand comparatively broad and strongly granulated.

In the cephalon oƒ *Reediella* the glabella is nearly parallel sided like in *Bollandia*, but slowly tapering forward, instead of expanded somewhat in anterior in *Bollandia*. The expansion is fairly strong in *B. pacifica* in comparison with other species of *Bollandia*. In *Particeps* the glabella is generally broadest across the frontal lobe, but parallel-sided in posterior. The cephalon, particularly the glabella of this species is most similar to *Particeps*.

The geological range of *Reediella* and *Particeps* is respectively lower Tournaisian-? lower Visean and from Visean to Namurian. Not only morphologically but also from the life range it is quite improbable that *Reediella* is closely related to *Bollandia*. The age of *B. pacifica* is Visean, if not late Tournaisian. Therefore it must be a highly developed form of *Bollandia*. In view of the pygidium it may be a terminal form of the genus, not linking with *Particeps*.

The close alliance of *B. pacifica* to *Thaiaspis euryrachis* from the Moscovian of Thailand suggests that *Thaiaspis* was derived from *Bollandia*.

Distribution:—From Tournaisian to Visean; Eurasia.

Bollandia pacifica KOBAYASHI and HAMADA, sp. nov.

Plate XVIII, Figures 6-9; Plate XIX, Figures 1-4; Text-figure 4G

Description:—Dorsal shield elliptical, strongly inflated, particularly near peripheries. Cephalon semicircular, broader than thorax, arched up toward the axis. Glabella subquadrate, but somewhat expanded laterally in anterior half, broadly arcuate in anterior, highly convex, becoming subvertical and overhanging to frontal border. Basal lobe triangular, longer than broad, no more than a quarter of occipital breadth; preoccipital furrow strong, nearly diagonal and straight; other lateral furrows obsolete. Occipital furrow profound; median tubercle present on neck ring. Cheek as wide as glabella along posterior margin. Eyes not large, close set to basal lobes. Free cheek arching down from eye to lateral margin; marginal furrow weak, but posterior border furrow is well pronounced. Facial sutures slightly divergent forward from eyes and posteriorly cutting a little inside the median point of posterior margin.

Thorax slightly shorter than cephalon, composed of nine segments; axial lobe strongly convex, broader than pleural one; pleuron sloping down in lateral half, divided into a narrow depressed anterior band and a well developed posterior one by a transversal pleural furrow.

Pygidium shorter than thorax, very broad. Axial lobe broader than a third of pygidium, regularly tapering back, and terminally rounded off, composed of 12 rings whose lateral termini are all depressed and isolated by para-axial furrow. Pleural ribs 8 or 9 in number, anterior ones of which are divided into two bands like thoracic pleuron. Marginal border smooth, strongly slanting; marginal furrow weak or absent. Test smooth.

Observation:—Two nearly complete dorsal shields from 808 m point are similar to each other in size. The holotype (XVIII, 8) which consists of an external and internal moulds reveals the convexity of the shield, although it is modified to some degrees by secondary deformation. The paratype (XVIII, 9) is an external mould of a flattened dorsal shield by vertical depression.

The internal mould of the holotype shows the forward projection and drooping of the glabella and the prominence of the right eye clearly. The median occipital tubercle is obscure on the holotype, but it is well preserved in the paratype. The genal part is not well preserved in these specimens, but a short spine may be present.

It is seen on the right side of the holotype that the thoracic pleurae are rounded at the lateral ends.

Five additional specimens (2 shields, 1 cranidium, 1 thorax-pygidium and 1 pygidium) were collected from Odaira-yama. The glabella of the isolate cranidium is strongly convex, steeply slanting in anterior. In the other specimens which are secondarily depressed the convexity of the cephalon is greatly reduced.

A pygidium from Odaira-yama is longer than others, but otherwise it is not essentially different. This pygidium clearly shows the bipartation of a pleural rib into a very narrow low anterior band and a stout posterior band. Such a division is, however, obscure in most other pygidia.

A trilobite shield contained with *Paladin carinatus* in the same slab from an unknown locality in the Hikoroichi-Setamai district may be referable to this species. The glabella of this trilobite reaches the frontal margin of the cephalon. Its cheek is strongly convex and non-carinate, the lateral border poorly defined and the genal spine absent. Its pygidium is very unlike that of *Paladin* and resembles that of *Bollandia pacificus* in the outline, convexity and segmentation.

Comparison:—The glabella is said typically parallel-sided in *Bollandia*, but somewhat contracted in the middle and more expanded in anterior than the other even in *Bollandia globiceps* (PHILLIPS) and *B. claviceps* (BURMEISTER). In this species the eyes are relatively small. They are located more posteriorly, if compared to those of *B. globiceps*.

The pygidium of *Bollandia claviceps* has 12 axial rings and 7-8 pleural ribs, whereas this pygidium possesses 12 rings and 8-9 ribs. The trisection of the axial ring occurs commonly in this genus. It is quite pronounced in this species.

Occurrence:—Near 808 m point; collected by Koji NAKAMURA. Odaira-yama. From an unknown locality in the Hikoroichi-Setamai district (Hokkaido University collect.).

Genus *Parvidumus* KOBAYASHI and HAMADA, gen. nov.

Diagnosis:—Strongly granulate griffithides with forwardly expanding glabella which is encroaching frontal border; a pair of preoccipital lobes rather small and subtriangular; eyes large, located in posterior; thorax composed of nine segments; pygidium with 9-11 axial rings and 7-8 pleural ribs; granules on them typically spinose.

Type species:—*Parvidumus densigranulatus* KOBAYASHI and HAMADA, sp. nov.

Comparison:—This genus resembles *Bollandia* as well as *Reediella* in outline and segmentation of the pygidium. The glabella is, however, tapering forward in *Reediella*. In *Bollandia* the pygidium is more convex and non-granulate and its rib is generally double. The cephalon is strongly vaulted and lacks genal spines and the frontal border and the frontal lobe of the glabella are vertical.

The pygidium of *Particeps* is also strongly vaulted, without marked border. The pygidium may be granulated, but not the cephalon. The preoccipital furrow is short and somewhat pitted in *Particeps*.

In the granulation and mode of ribbing this pygidium resembles *Eocyphinium*'s and also *Piltonia*'s, but the outline of the pygidium is longer, more triangular or parabolic. The marginal border is narrower. In cephalon one or two lateral furrows are commonly discernible in front of the preoccipital furrow in *Eocyphinium*. The pygidium has 14 to 17 axial rings and 9-10 pleural ribs in *Eocyphinium*.

Distribution:—Lower Carboniferous; Eastern Asia.

Parvidumus densigranulatus KOBAYASHI and HAMADA, sp. nov.

Plate XX, Figures 1-15; Text-figure 4F

Description:—Cephalon semicircular with short genal spines; glabella more or less expanding forward and encroaching frontal border; preoccipital lobe small; other lateral furrows obsolete; eyes fairly large and in posterior. Nine segments in thorax; axial lobe broader than pleural one. Pygidium semicircular or parabolic and moderate in convexity, but depressed near periphery; axis composed of 9-11 rings and pleural lobe of 7-8 ribs, each decorated by a row of granules produced into short spines; marginal border depressed. Test granulate densely.

Observation:—This species is represented by six dorsal shields, four cephala and five pygidia, all deformed in different ways. The general aspect of the trilobite is best shown by the dorsal shield in fig. 8. It is, however, difficult to grasp the complete concept of the cephalon by any one specimen. It is noteworthy that none of them has either a median preoccipital lobe or lateral glabellar furrows anterior to the preoccipital one.

In a cephalon in (XX, 1), strongly compressed in the sagittal direction the frontal border is seen in front of the glabella, but in others the glabella encroaches the border. In that cephalon it is seen that three rows of granules extend laterally from the glabella between the striated lateral border and the eye.

In the pygidia in figs. 14 and 15 about seven spines are countable on the axial rings as well as pleural ribs in anterior.

Occurrence—Yuki-sawa and Odaira-yama; MIZUNO and ARAKI collect.

Genus *Griffithidella* HESSLER, 1965

Griffithidella nishikawai (KOBAYASHI and HAMADA, 1978)

Plate XX, Figure 16; Text-figure 4I

1978. *Griffithides nishikawai* KOBAYASHI and HAMADA, *Proc. Japan Acad. vol. 54—B*, p. 6, figs. 3a-b.

Description:—Glabella gently convex, long, subquadrate, but well rounded in front, broadly contracted in mid-length, and less expanded in posterior than anterior; basal lobe as wide as one third the glabella, isolated from median portion by narrow but distinct posterior lateral furrow; two middle laterals at contraction weak, short and subparallel to the preceding; their interval about half as long as basal lobe; anterior lateral rudimentary; frontal lobe large and well rounded; occipital furrow very pronounced; occipital ring convex, only a little thickened mesially; median tubercle present at the centre of convex axial ring; fixed cheek narrow, not wider than frontal border in anterior but expanded laterally at palpebral lobe which is fairly large, flat and located far posteriorly; frontal border narrow flat and depressed; test finely granulate.

Comparison:—This cranidium is similar to *Griffithidella doris* (HALL, 1860) as well as *Thigriffides roundyi* (GIRTY, 1926) in the outline and convexity of the cranidium and glabella and narrow frontal border and fixed cheeks. The lateral furrows on its glabella is evidently weaker than those of *G. doris* and somewhat stronger than those of *T. roundyi.* Compared to these allies the palpebral expansion of the fixed cheek appears narrower in this species. On this account it resembles *Griffithidella welleri* (BRANSON and ANDREWS, 1938). With an imperfect cranidium it is difficult to determine its exact generic position, but it belongs most probably to the genus *Griffithidella*.

Occurrence:—Hina limestone, Hina; NISHIKAWA collect.

Genus *Thigriffides* HESSLER, 1965

Thigriffides hinensis KOBAYASHI and HAMADA, 1978

Plate XX, Figure 17; Plate XXI, Figures 1-3 and ? 4; Text-figure 4M

1978. *Thigriffides ? hinensis* KOBAYASHI and HAMADA, *Proc. Japan Acad., vol. 54, ser. B*, p. 7, figs. 1a-b, 5a-b.

Description:—Cranidium moderately inflated; glabella subquadrate in anterior half, a little expanded laterally in posterior half, very slightly narrowing between these two parts, gently arching up in sagittal profile, but more abruptly slanting in anterior third than the other; lateral furrows obsolete, but a long curving lateral furrow in posterior and two short laterals in the middle part emergent under cross light; occipital furrow deep; median tubercle present on neck ring; narrow flat frontal rim seen in front of the glabella; palpebral lobe separated from the expanded posterior part of glabella by shallow furrow and extended horizontally in lunate form; test smooth.

Pygidium provisionally referred to this species more or less subtriangular, but rounded; its axial lobe highly elevated above the inner pleural platform, composed of about 9 rings; pleural ribs countable seven, flat-toped; the first rib prominent, facetted antero-laterally and the first pleural furrow well pronounced, both running into lateral border; pleural furrows perceptible on a few succeeding ribs; marginal furrow indistinct; unfurrowed marginal border in same slope with the outer part of the pleural ribs.

Observation:—The holotype is the cranidium in fig. 17, pl. XX. The paratype pygidium in fig. 2, pl. XXI and a cranidium of this species are contained in a limestone block. Because this cranidium is laterally compressed, the convexity of the glabella and palpebral lobe is pronounced, lateral furrows are obliterated and the anterior border flat narrow, fixed cheeks anterior to the eye are strongly depressed. A left free cheek provisionally referred to this species reveals weak convexo-concavity from the eye to the lateral margin where the border edge is distinctly striated like that of the frontal border of the holotype cranidium.

Comparison:—As noted already, this cranidium differs from *Griffithidella nishikawai* in the more quadrate glabella. In the less rounded outline and more gentle convexity of the anterior glabellar lobe and obsolete lateral furrows it agrees better with *Thigriffides* than *Griffithidella*. Compared to this species, however, the glabella is more strongly constricted and its anterior part more rounded in *Thigriffides roundyi* (GIRTY, 1926). Like this species the palpebral lobe issues horizontally from the posterior part of the glabella, but the dorsal furrow at their boundary is strongly curved in that species. Thus this species is not quite diagnostic of *Thigriffides*. It is, however, noteworthy that a pygidium closely resembling *T. roundyi* is contained in the Hina collection.

Another resembling trilobites are certain subgenera of *Archaegonus* whose glabellae are not much tapering forward, the frontal limbs greatly reduced and large palpebral lobes located far back. *Weania* and *Angustibole*, for example, reveal such aspects, but their glabella are more conical.

Occurrence:—Hina limestone, Hina; NISHIKAWA collect.

Thigriffides aff. *hinensis* KOBAYASHI and HAMADA

Plate XVII, Figure 9, Plate XXI, Figure 4

Pygidium broad, semicircular, moderately inflated; axial lobe nearly as wide as a pleural lobe, conical, composed of about 8 rings; pleural lobe gently convex, divided into 6 rings, beside the first rib, by pronounced pleural furrows; a few anterior ribs divided again into two bands by a weak interpleural furrow; marginal border narrow and depressed.

Among the pygidia of Japanese Carboniferous trilobites the nearest to this is the one of the preceding species, although minor differences are perceptible between them in outline and convexity of the pygidium and its segmentation.

Occurrence:—The *Marginatia toriyamai* zone of the Akiyoshi limestone on the road to limestone quarry of Sumitomo Cement Company; OTA collect.

Thigriffides (?) *kibiensis* KOBAYASHI and HAMADA, sp. nov.

Plate XXI, Figures 5-7; Text-fignre 4J

A large smooth cranidium resembles the preceding species, but less convex. The glabella is nearly parallel-sided and broadly rounded in front; basal lobes more or less rhombic in outline, bounded by shallow posterior lateral furrows; two short lateral furrows discernible in front of the basal ones; occipital furrow relatively weak; occipital ring depressed; median tubercle present on the ring; frontal border and fixed cheeks very narrow; palpebral lobe of moderate size located in posterior.

This cranidium represents a distinct species near *Thigriffides hinensis.*

Two pygidia very similar to the pygidium of *Thigriffides hinensis* are tentatively combined with the cranidium in this species. They are somewhat broader and the segmentation is more obsolete, if compared to the pygidium of that species. In these pygidia pleural furrows are obliterated except for the first one and the marginal border is mesially subangulated by the sudden increase of inclination in its outer half.

Occurrence:--Hina limestone, Hina; NISHIKAWA collect.

Genus *Paragriffithides* REED, 1943

Paragriffithides japonicus KOBAYASHI and HAMADA, sp. nov.

Plate XXII, Figures 15-16; Text-figure 4H

Description:—Pygidium semi-oval, well inflated, two-thirds as long as wide. Axis conical, nearly as wide as a third of pygidium, abruptly narrowing near terminus, more or less trigonal in cross section, longitudinally sloping gradually, but abruptly in posterior and its crest becomes subvertical in terminal part, composed of 14 or 15 axial rings which are separated from one another by deeply excavated furrows; each ring ornamented by a row of tubercles of which the median one is particularly prominent; a pair of medium ones at middle points of lateral slopes. Pleural lobe horizontal on axial side, but well slanting on the other side, composed of 7 segments; each segment consists of two ribs divided by a pronounced pleural furrow; posterior rib usually stronger than anterior rib and close-set with the succeeding anterior rib with a weak interpleural furrow between them; the first anterior rib, however, fairly strong and facetted; the last anterior rib effaced and the seventh posterior rib is indicated simply by a median tubercle; each pleural rib bearing a row of tubercles of which one on median geniculation is most prominent; anterior rib commonly terminating at a large tubercle on concave or somewhat depressed marginal border which is sloping in much lessened degree than pleural rib; marginal furrow absent; pleural and interpleural furrows somewhat pitted at the ends shortly inside of the margin.

Associate hypostoma provided with a pair of large triangular anterior wings. Its anterior margin is roof-shaped, but its outline behind the wings slowly narrowing backward and well rounded along the posterior margin; marginal rim and furrow distinct in middle and posterior parts; posterior margin entire; median body gently convex and non-striated, though the test is rough; lateral furrows short, shallow and very oblique.

Observation and comparison:—A hypostoma found on the anterior side of the type pygidium is gently arcuate in sagittal section, but strongly inflated by lateral arching down and a pair of triangular anterior wings in the extension of the same inclination; anterior margin of the wing straight or slightly concave and forming an obtuse angle with its counter; main body divided into a large anterior and a very small posterior part by paired shallow oblique lateral notches or maculae; lateral and posterior furrows and rims simple; lateral rim more or less angulated near the incision. The posterior rim is not expanded in form of tongue as seen in the hypostomata of *Phillipsia ornata belgica* (REED), *Eocyphinium castletonensis* OSMOLSKA and *Phaladin eichwaldi parlis* (REED) all illustrated by OSMOLSKA (1970).

Not only the association of the hypostoma with the pygidium in the same block, but their size also suggest that they belong probably to the same individual. The hypostoma resembles that of *Paladin* (*Paladin*) *helmsensis* WHITTINGTON, 1954, but the roof-shaped anterior margin and well rounded posterior outline are quite distinctive of this hypostoma.

Judging from REED's diagnosis of *Paragriffithides* (1945) and WOODWORD's description and illustration of *Phillipsia carinata* SALTER (1884 MS) it is certain that this species is congeneric with that species. Its specific characteristics are in the number of axial rings, unequal division of the pleural segment and longitudinal rows of prominent tubercles on the axial and pleural lobes of the pygidium.

Occurrence:—Hina limestone at Hina; NISHIKAWA collect.

Subfamily Ditomopyginae HUPÉ, 1953

Genus *Paladin* J. N. WELLER, 1936

Paladin carinatus KOBAYASHI and HAMADA, sp. nov.

Plate XXII, Figure 1; Text-figure 4N

Description:—Cephalon parabolic (?) with genal spines a little longer than its sagittal length; glabella nearly cylindrical, but slightly contracted at mid-length, narrower than a third of cephalic breadth and its rounded anterior end shortly encroaching frontal border; basal lobes about two-fifths as long as glabella; median tubercle present on occipital ring; eyes large, opposed in posterior half of glabella; free cheek narrow with trifurcate carination; marginal border relatively broad, roof-shaped; lateral and posterior marginal furrows combined into median furrow on genal spine; anterior branch of facial suture well arcuate, but not so far extended laterally as the eye; test smooth.

Observation:—Because the cephalon is secondarily compressed transversally, its outline must have been much broader. The crest on the marginal border is traceable from the lateral to the anterior side. In comparison to the border the cheek is quite narrow. The trifurcate carination is seen on the two free cheeks. The basal lobes are relatively small, whereas the eyes are very large.

Comparison:—Such a long genal spine is seen in *Paladin mucronatus* (MCCOY, 1884), its subspecies, *russicus* OSMOLSKA, 1970, *Paladin maillieuxi* (DESMANET, 1933), and so forth. The marginal border is carinated in *Paladin mucronatus mucronatus*. The bicarination of the border and the cheek is the characteristic of this species.

Occurrence:—Hikoroichi-Setamai district of the Kitakami mountains, exact locality unknown; Hokkaido University collection.

Paladin (?) *mizunoi* KOBAYASHI and HAMADA, sp. nov.

Plate XXI, Figures 12-18; Plate XXII, Figure 14 ?

Description:—Cephalon characterized by its parabolic or even subtrigonal outline and broad marginal border; glabella scarcely invading into the frontal border, contracted near mid-length, its main lobe exclusive of basal lobes pear-shaped; basal lobe clearly outlined, as long as a third of the glabella; occipital ring thick; median tubercle apparently absent; eyes lunate, half as long as glabella.

This cephalon is an external mould whose genal part is broken. The anterior branch of the facial suture is arcuate, but does not reach the parallels through the eyes' limits. The lateral border is very broad and gently convex.

A dorsal shield and six pygidia collected from the same locality are at hand. The shield is composed of nine thoracic segments and a pygidium; its thoracic pleuron divided into two bands on the axial side and truncated at the other end. The pygidium is parabolic in outline; axial lobe composed of 16 to 18 rings and pleural lobe of 8 to 10 ribs; ring and pleural furrows narrow and deep; marginal border narrow and depressed. In some axial lobes the rings are crenulated at lateral ends. A few anterior pleural ribs may be divided into two riblets. Four of the six pygidia are more or less trigonal, but two others are fairly well rounded laterally and posteriorly. The difference is, however, chiefly due to secondary deformation, because they agree with one another in the segmentation and the narrowness of the marginal border.

Occurrence:—Otsubo-zawa; SASAKI collect.; Choanji; KITAGAWA collect.

Paladin sp. indet.

Plate XXII, Figures 2-5

Four cranidia which are all deformed internal moulds, belong most probably to an identical species. Glabella moderately convex, subquadrate, about twice longer than broad, arcuate or well rounded in anterior, more or less narrowing in middle part; basal lobes not large, completely separated by preoccipital furrows; two pairs of rudimentary lateral furrows discernible in front of the lobes; occipital and dorsal furrows profound; neck ring bearing a median tubercle; frontal border strongly convex; palpebral lobe large, opposed in posterior; fixed cheek narrow; anterior facial sutures nearly straight, a little divergent forward from eyes; posterior ones apparently diagonal; test probably smooth.

Because the coexistence of a separate cranidium and pygidium on the same slab cited in the succeeding page, does not warrant their derivation from a trilobite, it is not the less probable that this kind of cranidia belong to *Paladin* (*Weberides*) *longispiniferus*, particularly in considering the frequency of occurrences of the pygidium as well as the cranidium.

Occurrence:—Yuki-sawa; SASAKI collect.

Subgenus *Weberides* REED, 1942

Weberides was founded by REED in 1942 on *Phillipsia mucronata* McCOY, 1844, and his establishment of this genus was fully justified by PŘIBYL, 1950. Subsequently in 1954 WHITTINGTON pointed out the duplication of REED's *Weberides* with *Paladin* WELLER, 1936 in their generic domains, although he hesitated to warrant that the former is a synonym of the latter. While WELLER (1959) and MAXIMOVA (1960) recognized *Weberides* as a valid genus, its synonymy with *Paladin* was accepted by HAHN (1970) and OSMOLSKA (1970). The last author, however, divided *Paladin* into three groups on the basis of pygidia as follows:

I-group including most of North American species beside a few European ones, with pygidium wide, subsemicircular and broadly rounded posteriorly.
II-group including *Paladin mucronata* and ? *P. ailinensis*, having mucronate pygidium.
III-group including most of European species beside three North American ones with pygidium narrow, elongate, sometimes bluntly pointed posteriorly.

Such a grouping by means of pygidium morphology would bear palaeontological value, because it is related to the difference in centre of distribution within Eur-America. The second group i. e. *mucronata* group must be *Weberides*, although OSMOLSKA igonores "subgenus" in her taxonomy. Here a new species is instituted from Japan. It is an extreme form along the trend of mucronate specialization at the same time with reduction in segmentation of the pygidium. Because *Paladin* is one of the most comprehensive genera having wide distribution in the Carboniferous or Permo-Carboniferous period, its subgeneric division is a step to clarify its intrageneric evolution.

Paladin (*Weberides*) *longispiniferus* KOBAYASHI and HAMADA, 1978

Plate XXII, Figures 6-13; Text-figure 40

1968. *Weberides* ? sp. ARAKI and KOIZUMI, *Chigakn-kenkyu, v. 19*, p. 158, pl. 2, figs. 3-4, 14.
1978. *Paladin longigpiniferus* KOBAYASHI and HAMADA, *Proc. Japan Acad. v. 54-B*, no. 2, p. 53, figs. 4a-b, non 4c,

Description:—Pygidium subtriangular except for long spine; axial lobe a little narrower than one-third of pygidium, divided into 13 to 14 axial rings; pleural ribs 8 to 9 in number, all simple and ridged with long anterior slope; first rib extending into lateral border, all others terminating just inside of the border; marginal border narrow, constant in breadth and depressed; caudal spine issuing from the border as far as the main pygidium. Test smooth.

Observation:—The holotype pygidium is trigonal except for a prolonged caudal spine; lateral margins almost straight; anterior margin broadly arcuate. The axial lobe is a little narrower than a third of the pygidium, composed of 13 to 14 rings; 8 to 9 ribs are countable on the pleural field, the first one of which extends into the lateral border. These ribs are all inclined gently forward but steeply backward, forming a distinct crest between the two slopes. The lateral border is narrow. The caudal spine which issues from it is extending as far as the length of the pygidial shield. In the paratype pygidium the spine is only partly preserved, but its outline is less deformed than the holotype pygidium.

There are some additional pygidia having the same outline and segmentation, but the spine is shorter or broken off. One of them is contained in a slab with a cranidium typical of *Paladin*, although it is laterally compressed. Its glabella is cylindrical and rounded at both ends; a pair of triangular basal lobes clearly marked; occipital ring more rounded on posterior than anterior side; preglabellar area moderate in size; frontal rim narrow and well rounded; palpebral lobe opposed in posterior half of the glabella; anterior branchs of facial sutures slightly divergent from the eyes.

The two cephalic remains (Figs. 4c & d on Pl. XXII) which were referred to this species in the previous paper may be better to eliminate out of this species, because the glabella is distinctly constricted at mid-length and two or three rudimentary lateral furrows are impressed. In view of the trifurcate ridge on the left cheek (Fig. 4c) it is more likely to belong to *Schizophillipsia yukisawensis.*

Comparison:—The pygidium of this species shows its belonging to the *mucronata* group of *Paladin.* According to REED *Weberides* has 15-18 axial rings and 10-12 pleural ribs, but this species has only 13-14 rings and 8-9 ribs. The first 2-3 ribs may invade the marginal border and bifurcate at their ends in his *Weberides,* but in this species the invasion is recognizable only of the first rib and its terminal bifuraction inrecognizable. It is quite isolated from the known species of *Paladin* in its trigonal outline and extraordinarily elongate caudal spine.

Occurrence:—Common in the Onimaru Series at Yuki-sawa.

Genus *Humilogriffithides* INAI, 1936

1936. *Humilogriffithides* INAI, *Proc. Imp. Acad. v. 12,* no. 2, p. 299.

INAI denominated this genus in describing *Humilogriffithides divinopleurus,* new species, from the Moscovian Penchi Series in Penhsihu district, Liaoning, Northeast China. The dorsal shield of the type-species is oblong; cephalon and pygidium semi-elliptical and subequal in size. Glabella moderately convex, more expanded in anterior and overhanging; one or two lateral furrows discernible in the middle narrow part; basal lobe longer than broad, distinctly limited by preoccipital furrow; neck ring very narrow; eyes fairly large, located far back; fixed cheek narrow; free cheek broad, pointed at genal angle; marginal border very narrow. Pygidium with about 13 axial rings and 8 pairs of pleural ribs, each divided by a furrow into two bands which are decorated by a row of tubercles on each band; marginal furrow absent.

Compared to *Griffithides* and *Neogriffithides* the eyes are much larger and located more posteriorly in this species. It is nearer to *Paladin,* but the frontal lobe invades into the frontal border completely; fixed cheeks are narrower and free cheeks broader; general spines absent. In the pygidium the axial lobe is regularly tapering back.

ENDO described another new species, *Humilogriffithides someyai,* from the same series at Paotachiang, Liaoning. Its glabella is considerably expanded and protruded in anterior; the preoccipital lobe trisected like *Cyphinioides.*

Distribution:—Middle Carboniferous; Northeast China and Japan.

Humilogriffithides taniguchii ENDO and MATSUMOTO, 1962

1962. *Humilogriffithides taniguchii* ENDO and MATSUMOTO, *Sci. Rep. Saitama Univ. Ser. B, Vol. 4, No. 2,* p. 160, pl. 3, figs. 1a-3b.

This species can easily be distinguished from the type-species of *Humilogriffithides* by the more strongly convex cephalon, obsolete lateral glabellar furrows, larger basal lobes, very broad occipital ring and stout lateral and posterior borders of the cheeks; axial ring broader than pleuron in thorax; pygidium strongly convex, wholly granulate.

Occurrence:—Lower Moscovian *Fusulinella* zone at Nishi-yama quarry, Omi-town, Niigata Prefecture.

Free cheek and pygidium, gen. et sp. indet.

Plate XIX, Figures 8 and 9

A massive pygidium whose test is exfoliated is very poorly segmented, although some ten axial rings and about eight pleural ribs are discernible. Axial lobe is very large, stout, rounded off near posterior terminus; pleural field horizontal in inner part but arching down in the outer part in the same inclination with marginal border; only first rib and deep furrow behind it running into relatively narrow marginal border.

A free cheek from the same quarry having large prominent eye and convex striated lateral border which is separated from the cheek slope by a pronounced lateral furrow.

The pygidium looks similar to *Cummingella* cf. *otai* in outline and convexity, although the marginal border is somewhat broader and better defined in the latter. As the associate free cheek is also *Cummingella*-like, it is probable that the cheek and pygidium belong to an identical species of *Cummingella.*

Occurrence:—*Pseudostaffella antiqua* zone; Maruyama quarry, Akiyoshi-dai.

Pygidia, gen. et sp. indet.

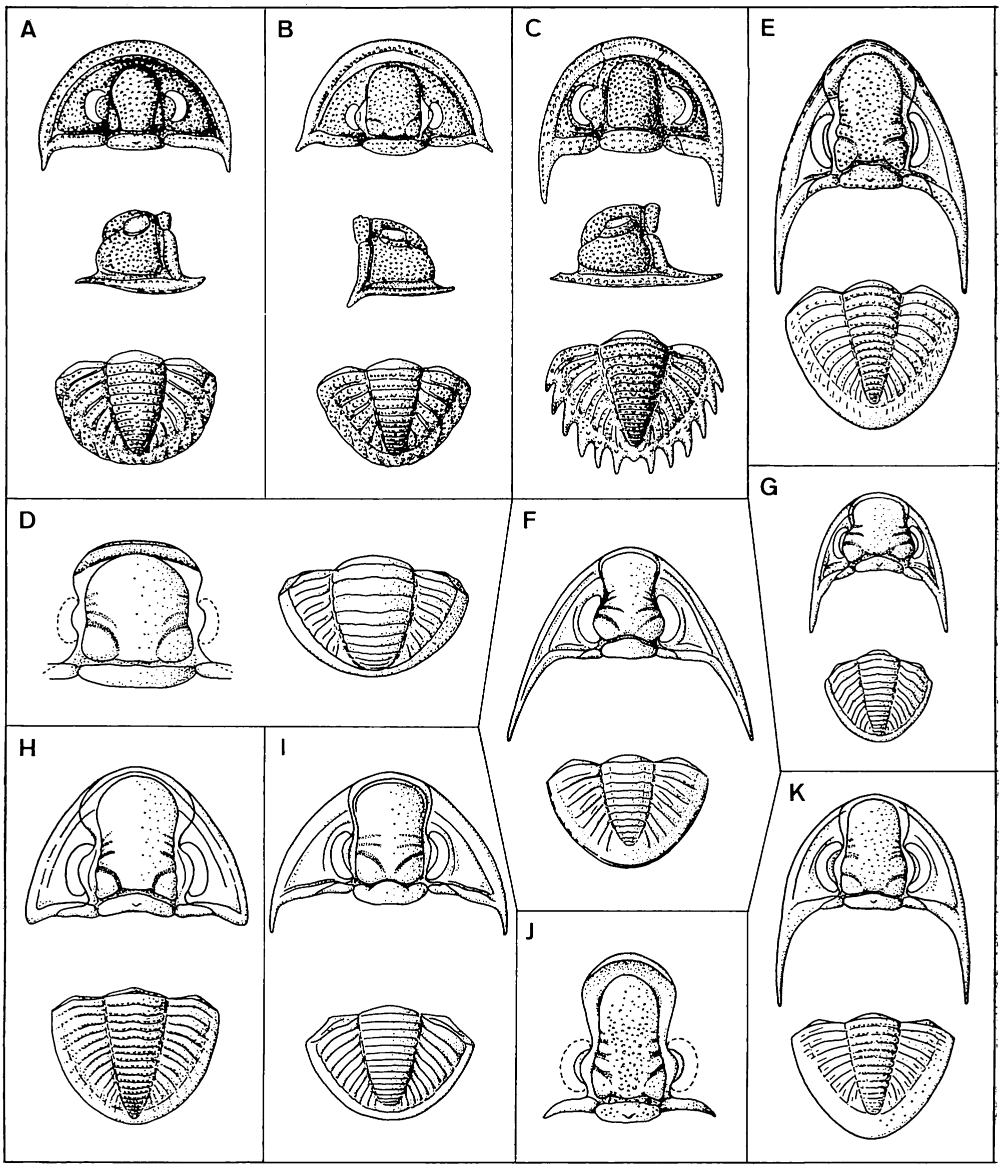
Plate XVII, Figure 10; Plate XIX, Figures 5-7

A form (XIX, 5) is represented by a broad, moderately inflated pygidium whose test is exfoliated and its doublure exposed; first pleural furrow very strong in comparison with the succeedings. The nearest pygidium to this may be *Cummingella* ? *eurypyge,* although its specific identification cannot be warranted.

Another pygidium collected at Ikusei Pasture, Iwanaga-dai (XVII, 10) resembles the preceding pygidium, but it is distinct from that form at least specifically, because it is evidently broader in outline, its anterior margin not so arcuate, axial lobe comparatively narrow and more slowly tapering back as far as the posterior border where the lobe is suddenly rounded off and the pleural lobe is wider and less inflatted in this form than in that form. This broad pygidium is more or less allied to *Thigriffides hinensis,* although the axial lobe is not conical and the segmentation quite obsolete.

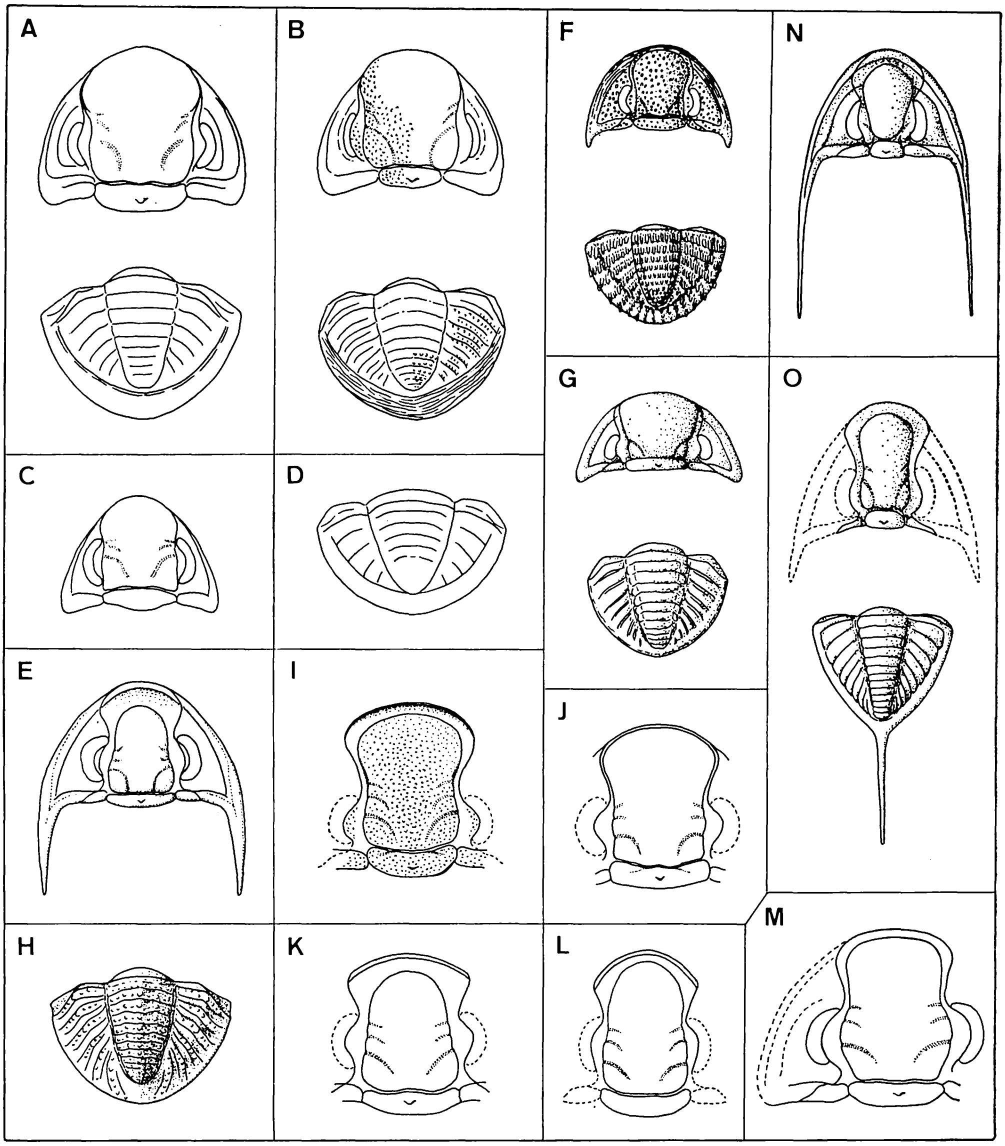
Two other pygidia (XIX, 6, 7) are longer than the preceeding, but not so long as *Cnmmingella subovalis* and *C. imamurai.* In outline they are nearer to *Cummingella* *otai* and *C. mesops.* The axial lobe of this form is, evidently broader than those of *C. otai* and *C. mesops.* This form looks not the less similar to *Waribole lobatus,* but its pleural lobes are arched up, while they are simply slanting in *W. lobatus.*

Occurrence:—Akiyoshi limestone.



Text-fig. 3. Restoration of some Japanese Carboniferous Trilobites—1.

A. *Brachymetopus* (*B.*) *omiensis*, sp. nov. ×2.
B. *B.* (*B.*) *gracilentus*, sp. nov. ×2.5.
C. *B.* (*Brachymetopella*) *akiyoshiensis* ×3.
D. *Pudoproetus obsoletus* ×1.
E. *Linguaphillipsia subconica*, sp. nov. ×1.5.
F. *Schizophillipsia yukisawensis*, sp. nov. ×4.
G. *Schizophillipsia otsuboensis*, sp. nov. ×3.
H. *Phillipsia ohmorensis* ×2.
I. *Linguaphillipsia higuchizawensis*, sp. nov. ×1.5.
J. *Palaeophillipsia tenuis*, sp. nov. ×2.5.
K. *Linguaphillipsia choanjiensis*, sp. nov. ×1.5.



Text-fig. 4. Restoration of some Japanese Carboniferous Trilobites—2.

A. *Cummingella mesops*, sp. nov. ×2.
B. *C. granulifera*, sp. nov. ×3.
C. *C. subtrigonalis*, sp. nov. ×2.
D. *C.* (?) *eurypyge*, sp. nov. ×2.
E. *Dechenelloides asiaticus*, sp. nov. ×3.
F. *Parvidumus densigranulatus*, sp. nov. ×2.
G. *Bollandia pacifica*, sp. nov. ×1.5.
H. *Paragriffithides japonicus*, sp. nov. ×1.5.
I. *Griffithidella nishikawai* ×3.
J. *Thigriffides* (?) *kibiensis* ×1.5.
K. *Waribole lobatus*, sp. nov. ×2.5.
L. *Archaegonus* (*Angustibole*) *reliquius*, sp. nov. ×3.
M. *Thigriffides hinensis* ×2.5.
N. *Paladin carinatus*, sp. nov. ×2.
O. *P.* (*Weberides*) *longispiniferus* ×3.

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Place Names in China

Ceshui, Tsechuei	測水
Dushan, Tushan	独山
Fangshenpu, Fanshenbao	房身堡
Guangxi, Kwangsi	広西
Guizhou, Kweichou	貴州
Guomen, Kuomen	果門
Hejiagou, Hechiakou	賀家溝
Hunan	湖南
Kansu, Gansu	甘粛
Kiangsu, Jiangsu	江蘇
Kirin, Chilin, Jilin	吉林
Kuomen, Guomen	果門
Kwangsi, Guangxi	広西
Lantschou-fu, Lanzhou-fu	蘭州府
Laokuantzekou, Laoguanzigou	老灌子溝
Liaoning	遼寧
Liaoyang-hsien, Lioyang-xian	遼陽県
Linchiang, Linjiang	臨江
Liujiang-xian, Liouchiang-hsien	柳江県
Liuzhou, Liouchou	柳州
Loping, Leping	楽平
Kilien-shan, Qilian-shan	祈連山
Maping	馬平
Nei Mongol, Inner Mongolia	内蒙古
Nanshan	南山
Opo, Ebo	俄博
Paitzuyai, Baiziai	百子隘
Pataochaing, Badaojiang	八道江
Penhsihu, Benxihu	本渓湖
Pozhai, Pêchai	坡寨
Shantan, Shandan	山丹
Shantung, Shangong	山東
Shixiagou, Shihhsiakou	石峡溝
Szechuan, Sichuan	四川
Taiyuan	太原
Taning-hsien, Taning-xian	大寧県
Tatang	大塘
Tsinan, Jinan	済南
Wushan	巫山
Xiasi, Hsiaszu	下司
Xintian-xian, Hsientien-hsien	新田県
Yanguan, Yenkuan	岩関
Yentai, Yantai	煙台
Yiliang	宜良
Yunnan-fu	雲南府
Yushuwan, Yüshuwan	楡樹湾
Zhungenningqi, Chunkening-chi	准格爾旗

Postscript

According to Hisayoshi Igo and Hisaharu Igo's recent study on conodonts from the lower part of the Akiyoshi limestone, Akiyoshi-dai, the geologidal age of the part is younger than that obtained by fusulinids, brachiopods and other fossils. Namely, the *Marginatia toriyamai*-bearing limestone is late Visean and the *Millerella yowarensis* zone latest Visean. H. and H. Igo (1979), Additional note on the Carboniferous conodont biostratigraphy of the lowest part of the Akiyoshi Limestone Group, southwestern part of Japan. *Annual Report of the Institute of Geoscience, the University of Tsukuba*, No. 5, p. 47-50.

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Brackets bounding a page number indicate a provisional identification with cf., aff. or the like.

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Plate I

Explanation of Plate I

Brachymetopus (*Brachymetopus*) *omiensis* KOBAYASHI and HAMADA, sp. nov. ....p. 54

Figs. 1a, b. A paratype cephalon showing surface granulation. Omi limestone at Higashi-yama quarry, Omi, Niigata Prefecture, SATO coll., PAt* 7528, ×3.6.

Figs. 2a-d. The holotype pygidium showing rounded marginal border without any spines. Loc. ditto, SATO coll. PAt 5729, ×3.9.

Figs. 3a, b. Rubber replica of another pygidium showing surface granulation. Loc. ditto, SATO coll., PAt 5730, ×3.0.

Figs. 4a-c. A small cephalon from the Akiyoshi limestone (*Pseudostaffella antiqua* zone) at Maruyama quarry, Akiyoshi, Yamaguchi Prefecture, MIZUNO coll. PAt 5731, ×5.2.

Figs. 5-7. Three pygidia of the species from the Akiyoshi limestone. Loc. ditto, ONO coll., ASM 8043** (=PAt 5824), ×2.6, PAt 5732, ×2.4, PAt 5733, ×3.7.

Brachymetopus (*Brachymetopus*) *gracilentus* KOBAYASHI and HAMADA, sp. nov. ......p. 55

Figs. 8a, b. The holotype cephalon from the Akiyoshi limestone at Maruyama quarry. MIZUNO coll. PAt 5734, ×1.8.

Fig. 9. Another cephalon Loc. ditto, MIZUNO coll., ASM 8044 (=PAt 5825), ×3.3.

Figs. 10a-c. A paratype pygidium showing nodulous marginal border and the much larger and more distinct row of the central granulation on the axial lobe than the preceding species. Loc. ditto, MIZUNO coll., PAt 5735, ×5.7.

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* PAt is an abbreviation of catalogue section for Palaeozoic Arthropoda in the Tokyo University Museum repository.

** ASM stands for Akiyoshi Science Museum.

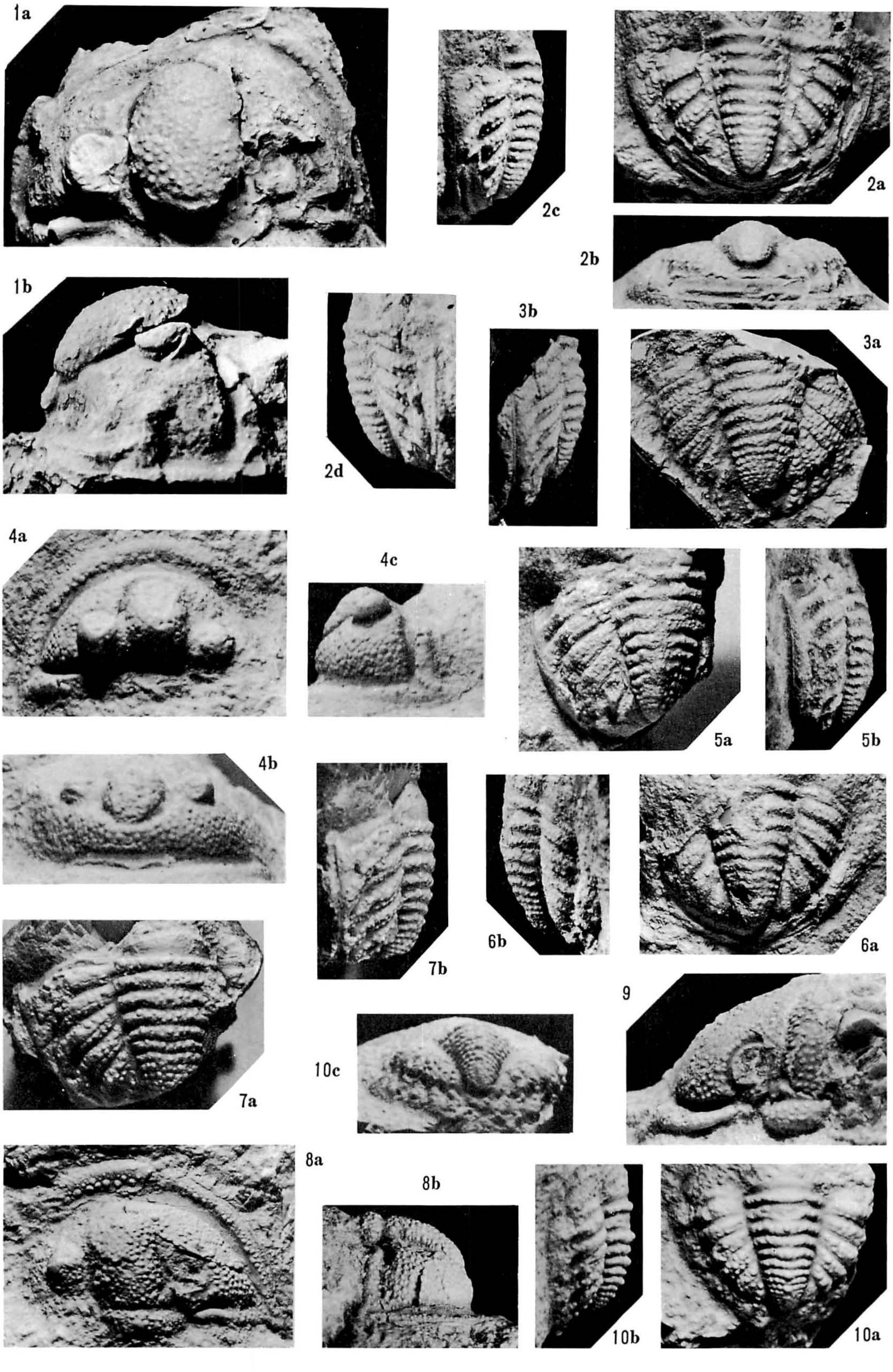
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Plate II

Explanation of Plate II

Brachymetopus (*Brachymetopella*) *akiyoshiensis* KOBAYASHI and HAMADA, 1978 ....p. 56

Figs. 1a-e. The holotype cephalon having larger genal spines than those of *Brachymetopus* (*Brachymetopus*) *omiensis* and *B.* (*B.*) *gracilentus*. *Profusulinella beppensis* zone of the Akiyoshi limestone. OTA coll., ASM 8003 (=PAt 5736), ×6.0.

Figs. 2, 4, 6. Another cephalon (2) and two pygidia (4, 6). The latter two show spinose marginal border. Loc. ditto, OTA coll., 2, PAt 5737, ×5.7, 4, paratype ASM 8007a (=PAt 5738), ×5.5, 6, ASM 8010 (=PAt 5826), ×6.1.

Brachymetopus (*Brachymetopella*) *akiyoshiensis* forma *disjuncta*, KOBAYASHI and HAMADA, forma nov. ....p. 58

Figs. 5a, b. An imperfect pygidium showing the disjunct axial segmentation. *Profusulinella beppensis* zone of the Akiyoshi limestone at Nakano Shohoji, Yamaguchi Prefecture, OTA coll. AM 8007b (PAt 5739), ×6.3.

Brachymetopus (*Brachymetopella* ?) *kitagawai* KOBAYASHI and HAMADA, sp. nov. ....p. 59

Figs. 3a, b. Internal mold of a small imperfect cephalon (a) showing somewhat coarse granulation, ×8.4, and the holotype pygidium (b) with spinose marginal border and a few but strong dorsal projection along the axial lobe, ×6.1. Hikoroichi Series at Choanji, Ofunato city, Iwate Prefecture, KITAGAWA coll. PAt 5740, 5741.

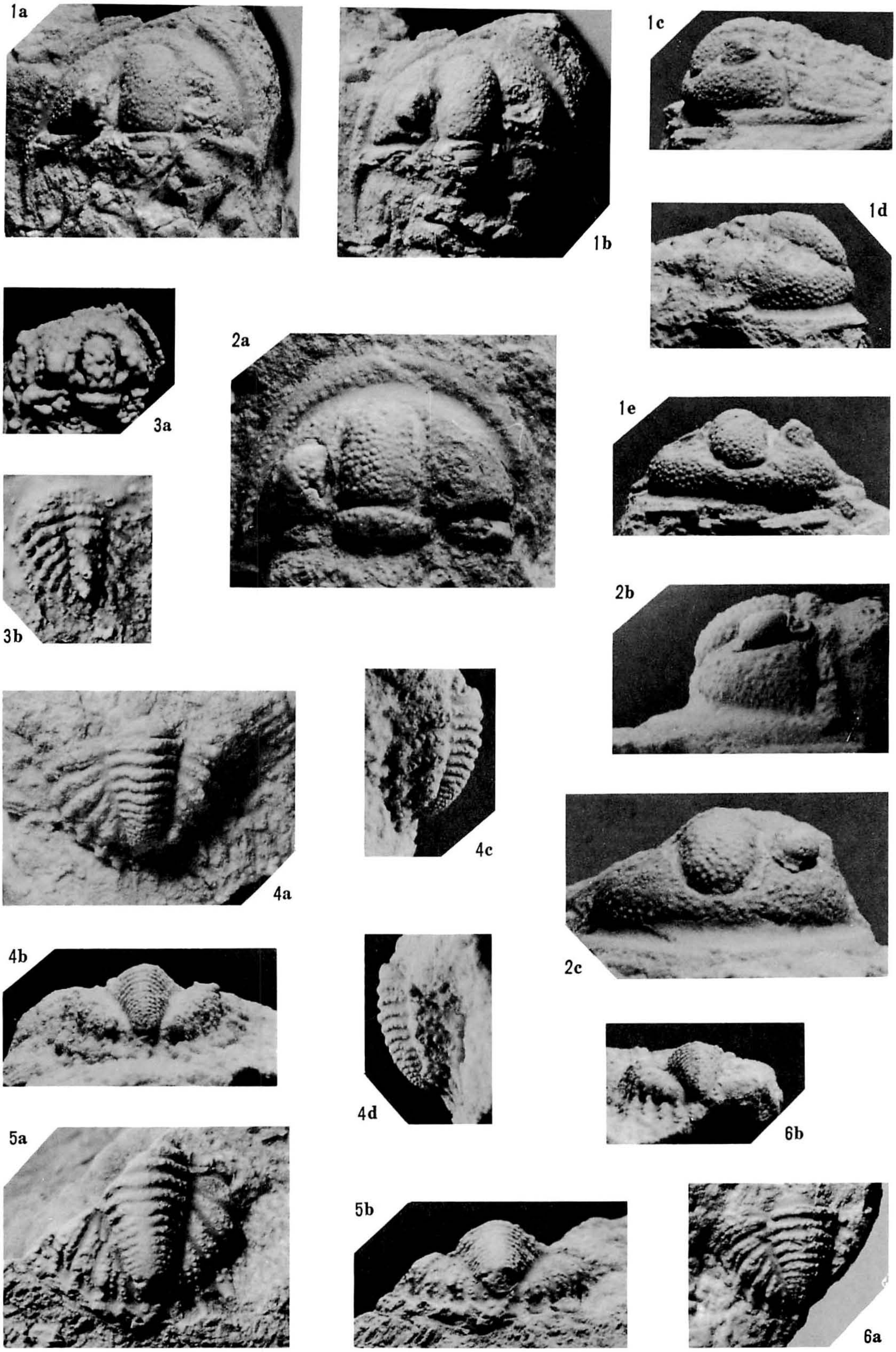
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Plate III

Explanation of Plate III

Pudoproetus obsoletus KOBAYASHI and HAMADA, 1978 ....p. 60

Fig. 1. The holotype cranidium showing short and rounded anterior of the glabella. Hina limestone at Hina, Okayama Prefecture, NISHIKAWA coll. PAt 5742, ×2.5.

Figs. 2a, b. Ventral and lateral views of a hypostome. Loc. ditto, NISHIKAWA coll. PAt 5743, ×2.8.

Fig. 3a-c. An imperfect paratype pygidium showing broad axis and smooth test. Loc. ditto, NISHIKAWA coll. PAt 5744, ×1.5.

Pudoproetus obsoletus forma *granulatus* KOBAYASHI and HAMADA, forma nov. ....p. 61

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Conophillipsia decisegmenta KOBAYASHI and TACHIBANA, 1978 ....p. 65

Figs. 5-8. The holotype specimen and other specimens showing general features of the carapace. Note Fig. 5 with ten thoracic segments. 5, holotype, ×1.3, 6, ×1.3. The paratype specimen (Fig. 7) showing the surface granulation and the position of glabellar furrows, ×3.0. A rubber mould of the pygidial external (Fig. 8) showing somewhat coarse granulation on axial and pleural segments, ×2.0. Lower Karaumedate Series, Minami-Iwairi, Nagasaka area, Iwate Prefecture, TACHIBANA coll.*

Conophillipsia cf. *decisegmenta* KOBAYASHI and TACHIBANA, 1978 ....p. 63

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* All reposited at the Tsukuba University.

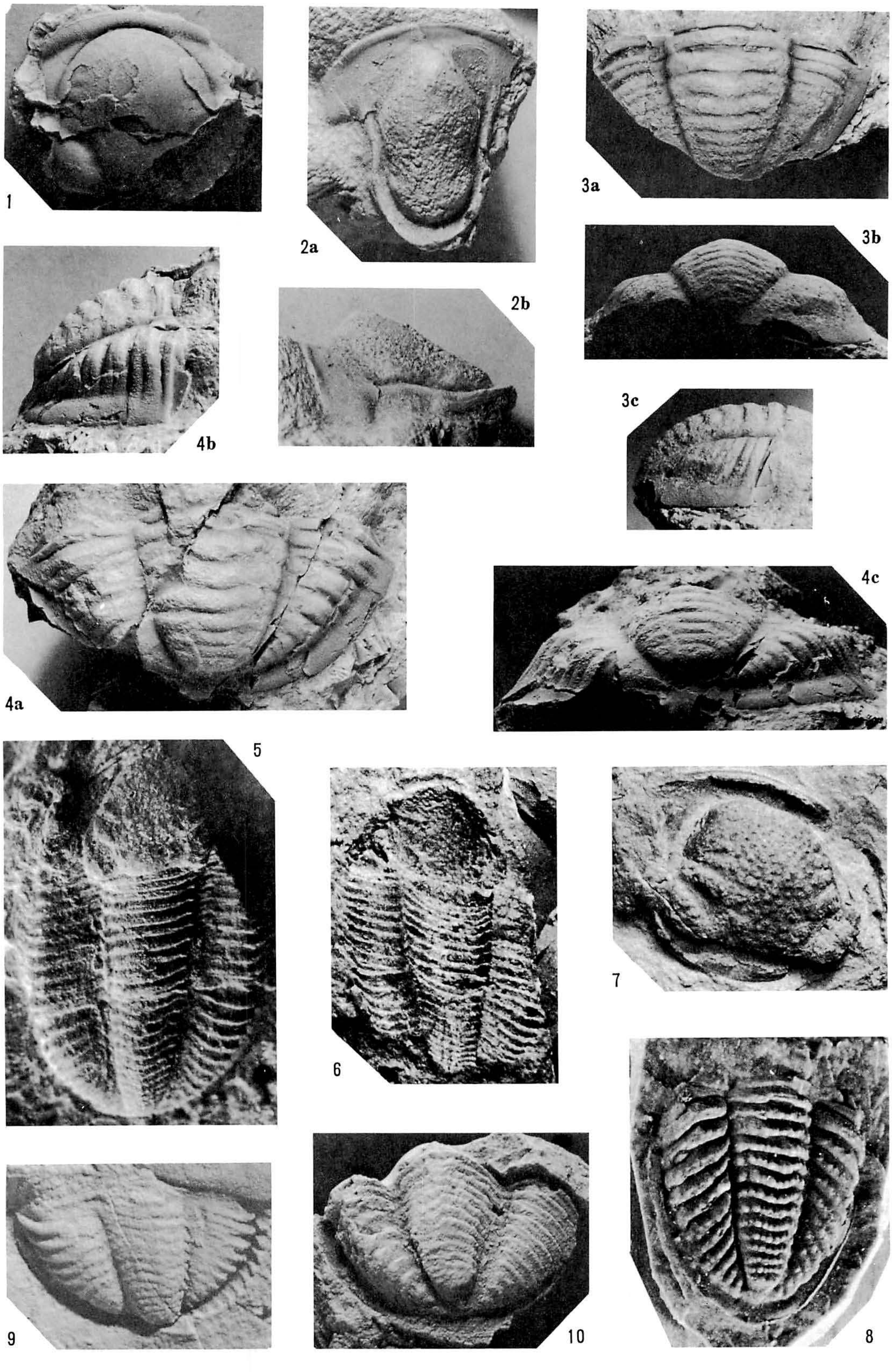
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Plate IV

Explanation of Plate IV

Conophillipsia decisegmenta KOBAYASHI and TACHIBANA, 1978 ....p. 63

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Conophillipsia cf. *decisegmenta* KOBAYASHI and TACHIBANA, 1978 ....p. 64

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Archaegonus (*Angustibole*) *reliquius* KOBAYASHI and HAMADA, sp. nov. ....p. 65

Fig. 6. An imperfect free cheek with a broad genal angle. *Pseudostaffella antiqua* zone of the Akiyoshi limestone at Maruyama quarry, Mine city, Yamaguchi Prefecture, MIZUNO coll. PAt 5750, ×5.2.

Figs. 7a, b. The holotype cranidium showing faint glabellar furrows. Loc. ditto, MIZUNO coll. PAt 5751, ×5.4.

Figs. 8, 9. Two other cranidia from the same locality, MIZUNO coll. PAt 5752, ×4.5, PAt 5753, ×4.1.

Figs. 10a, b. Ventral and lateral views of a hypostome. Loc. ditto, MIZUNO coll. PAt 5754, ×4.5.

Figs. 11a-c. A pygidium showing the triangular outline. Loc. ditto, MIZUNO coll. PAt 5755, ×3.5.

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* All reposited at the Tsukuba University, Ibaragi Prefecture.

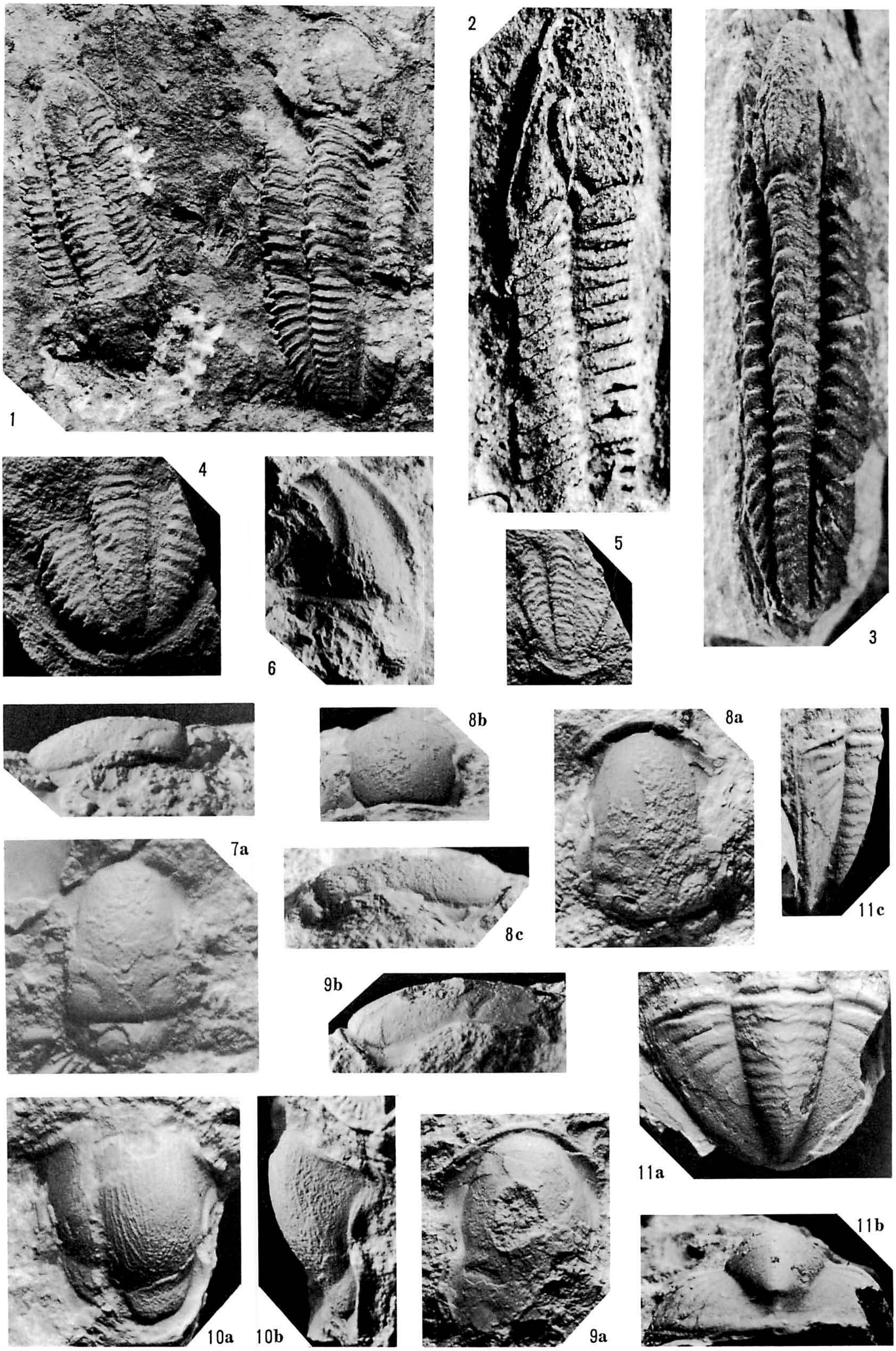
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Plate V

Explanation of Plate V

Archaegonus (*Angustibole*) *impolitus* KOBAYASHI and HAMADA, sp. nov. ....p. 66

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Fig. 4. Another cranidium showing shallow glabellar furrows and a median tubercle on the neck ring. Loc. ditto, MIZUNO coll. PAt 5757, ×6.4.

Waribole lobatus KOBAYASHI and HAMADA, sp. nov. ....p. 67

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Waribole sp. indet...p. 67

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Phillibole arakii KOBAYASHI and HAMADA, sp. nov. ....p. 68

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Carbonocoryphe (*Winterbergia* ?) *orientalis* KOBAYASHI and HAMADA, 1978 ....p. 70

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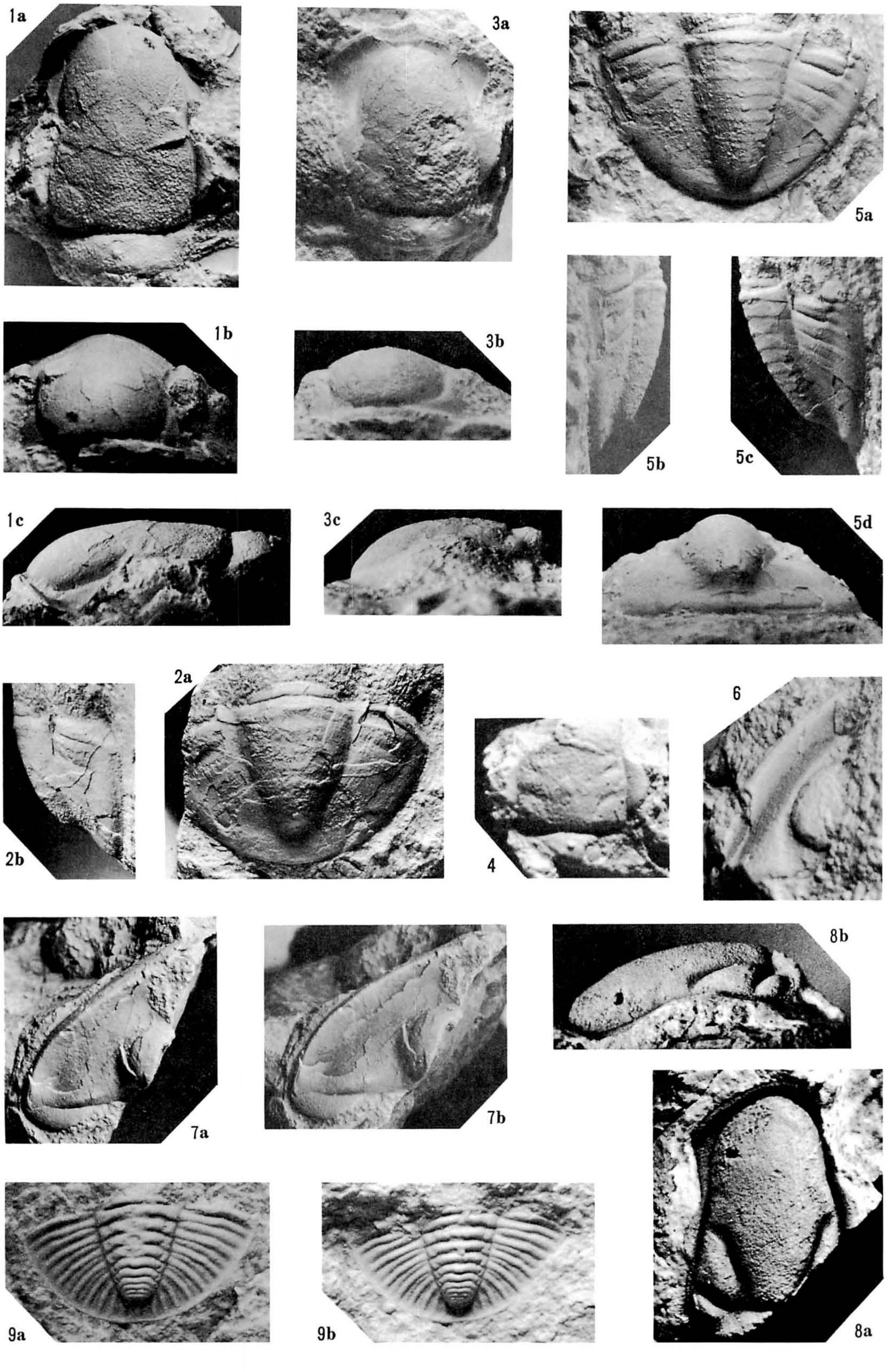
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Plate VI

Explanation of Plate VI

Phillipsia ohmorensis OKUBO, 1951 .... p. 70

Fig. 1. A rubber replica of OKUBO specimen showing general features of the cephalon and thorax of the species. Hikoroichi Series at Ohmori (OKUBO's loc. no. 29-3), Ofunato city, Iwate Prefecture, OKUBO coll. PA 8003 (OKUBO's figure on his pl. 1, fig. 2 is an internal mold of this specimen), ×3.1.

Figs. 2a, b. An internal cast (a) and a rubber replica of the external of an obliquely compressed specimen. Hikoroichi Series at Higuchi-zawa, Ofunato city, OKUBO coll. PA 8004 (a), ×4.0, (b), ×2.2.

Fig. 3. A flattened specimen from the Hikoroichi Series at Choanji, Ofunato city, SATO coll. (750801) PAt 5765, ×2.5.

Fig. 4. An obliquely deformed dorsal shield from Higuchi-zawa, HAGA coll. PAt 5766, ×3.0.

Figs. 5-7. Four cephala of this species from Higuchi-zawa (H_2). 5, HAMADA coll. PAt 5767, ×2.2, 6, FURUHASHI coll. PAt 5768, ×2.4, 7a, b, SASAKI coll., b, external rubber mold PAt 5769, ×2.3.

Figs. 8-10. Two pygidia from Higuchi-zawa. 8, HAGA coll. (PAt 5827), ×1.8, 9, HACHIYA coll. (H_2) PAt 5771, ×2.3, and 10, a pygidium from Omori-zawa, Ofunato city, Tokyo Univ. old coll. (no. 29), PAt 5772, ×1.9.

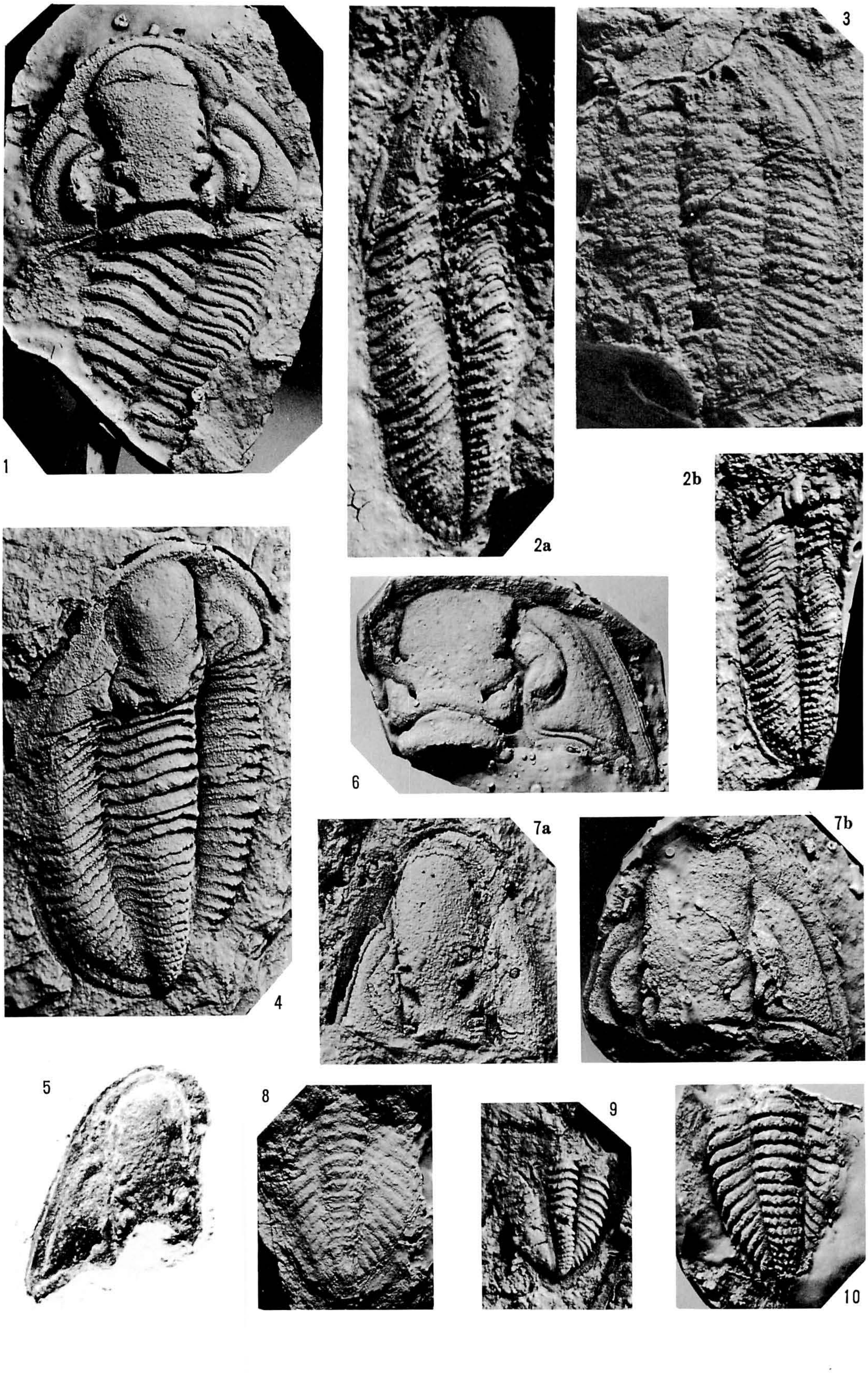
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Plate VII

Explanation of Plate VII

Dechenelloides asiatica KOBAYASHI and HAMADA, sp. nov. ....p. 85

Fig. 1. The holotype cephalon showing the large eyes and broad and long genal spines. Hikoroichi Series at Higuchi-zawa (H_2), Ofunato city, SHIMIZU coll. PAt 5773, ×3.4.

Fig. 2. The paratype specimen with an external cast of a small pygidium of which the rubber replica is shown on pl. 19, fig. 11. Higuchi-zawa (H_2), HACHIYA coll. (770321) (cephalon and thorax) PAt 5774, PAt 5775 (pygidium), ×3.6.

Phillipsia ohmorensis forma *multisegmentata* KOBAYASHI and HAMADA, forma nov. ...p. 73

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Phillipsis cf. *ohmorensis* OKUBO, 1951..p. 73

Figs. 8, 9. Strongly depressed pygidium collected from Otsubo-zawa, Rikuzen-Takada city, Iwate Prefecture, HACHIYA coll. PAt 5780, ×3.4, MURATA coll. PAt 5781, ×1.9.

Phillipsia ohmorensis (?) OKUBO, 1951

Figs. 10, 11. Strongly deformed two cephala from Higuchi-zawa (H_3), YOSHIDA coll. 10, PAt 5782, ×2.3, 11, PAt 5783, ×3.9.

Phillipsia longiconica KOBAYASHI and HAMADA, sp. nov. ....p. 73

Figs. 12-14. Obliquely deformed three specimens from Sakamoto-zawa, Ofunato city. 12, paratype FURUHASHI coll. PAt 5784, ×3.1, 13a, b, holotype, 14, YOSHIDA coll. PAt 5785a, b, ×2.8, PAt 5786, ×2.8.

Linguaphillipsia (?) sp. indet. ....p. 81

Fig. 15. A strongly deformed cranidium from Sakamoto-zawa, YOSHIDA coll. PAt 5787, ×3.3.

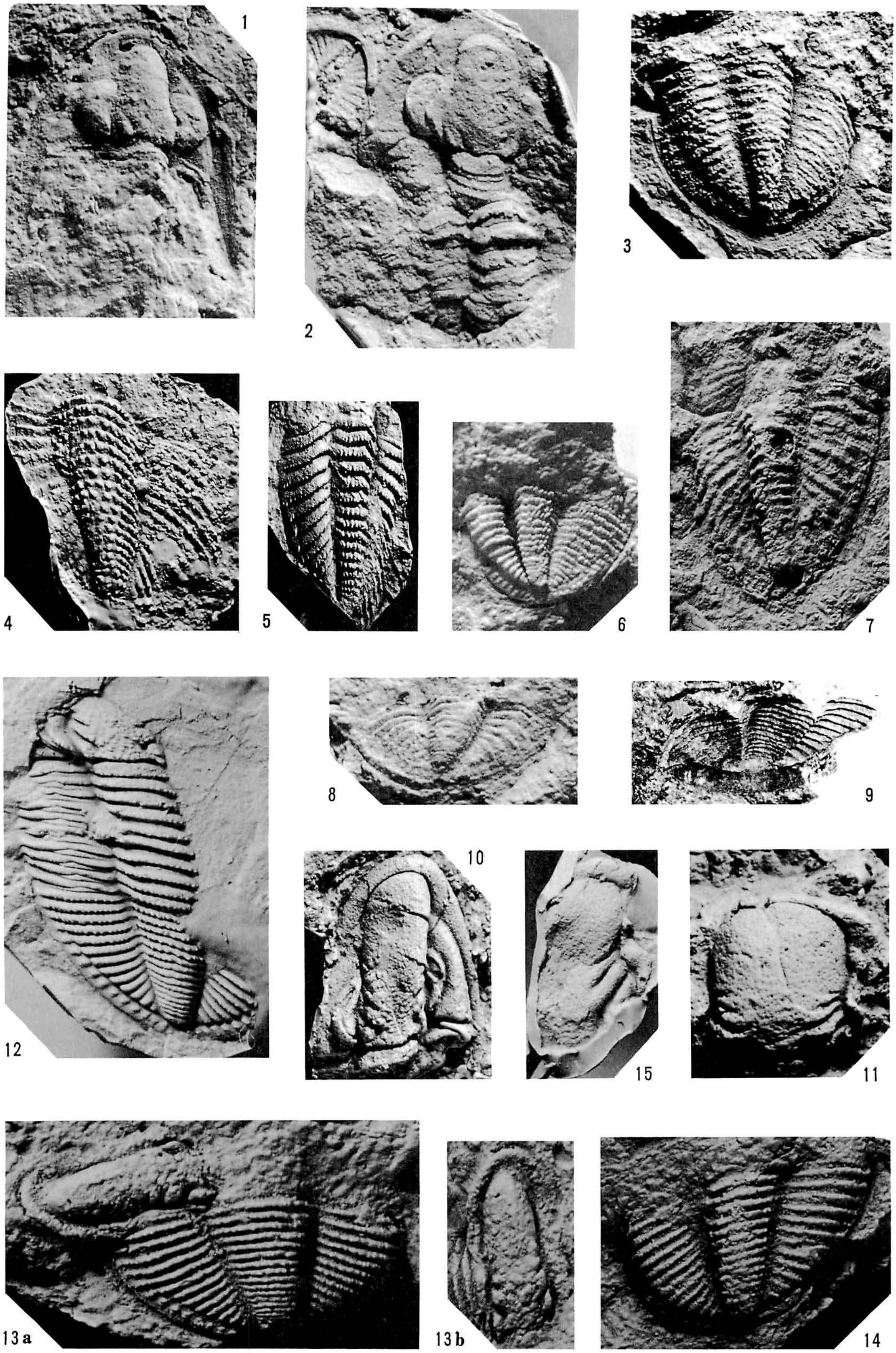
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Plate VIII

Explanation of Plate VIII

Linguaphillipsia choanjiensis KOBAYASHI and HAMADA, sp. nov. ....p. 77

Fig. 1. An internal mold of almost complete dorsal shield illustrated as *Phillipsia ohmonensis* by ENDO and MATSUMOTO, 1962, pl. 8, fig. 7a. ×3.0.

Fig. 2. The holotype specimen (an external rubber model) showing smooth surface of the dorsal shield. Hikoroichi Series at Choanji, Ofunato city, Iwate Prefecture. Tokyo Univ. coll. PAt 5788, ×3.9.

Fig. 3. Another rubber replica of the species. SASAKI coll. PAt 5789, ×2.5.

Palaeophillipsia cf. *tenuis* KOBAYASHI and HAMADA, sp. nov. ....p. 85

Fig. 4. An incomplete specimen (internal mold) from Choanji. SASAKI coll. PAt 5790, ×3.0.

Linguaphillipsia higuchizawensis KOBAYASHI and HAMADA, sp. nov. ....p. 78

Figs. 5a-c. The holotype cephalon (internal mold) showing somewhat wide glabella and other features. Hikoroichi Series at Higuchi-zawa, Ofunato city. FURUHASHI coll. PAt 5791, ×2.5.

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Fig. 8. A part of a large dorsal shield from Higuchi-zawa (H_2). HACHIYA coll. (770320), PAt 5794, ×1.0.

Fig. 9. A paratype specimen from Higuchi-zawa (H_2), HACHIYA coll. (770321) PAt 5795, ×1.2.

Linguaphillipsia aff. *higuchizawensis* KOBAYASHI and HAMADA, sp. nov. ....p. 78

Fig. 10. An external clay mold showing smooth surface of the pygidium from Omori, Ofunato city. Tokyo Univ. coll. PAt 5796, ×1.6.

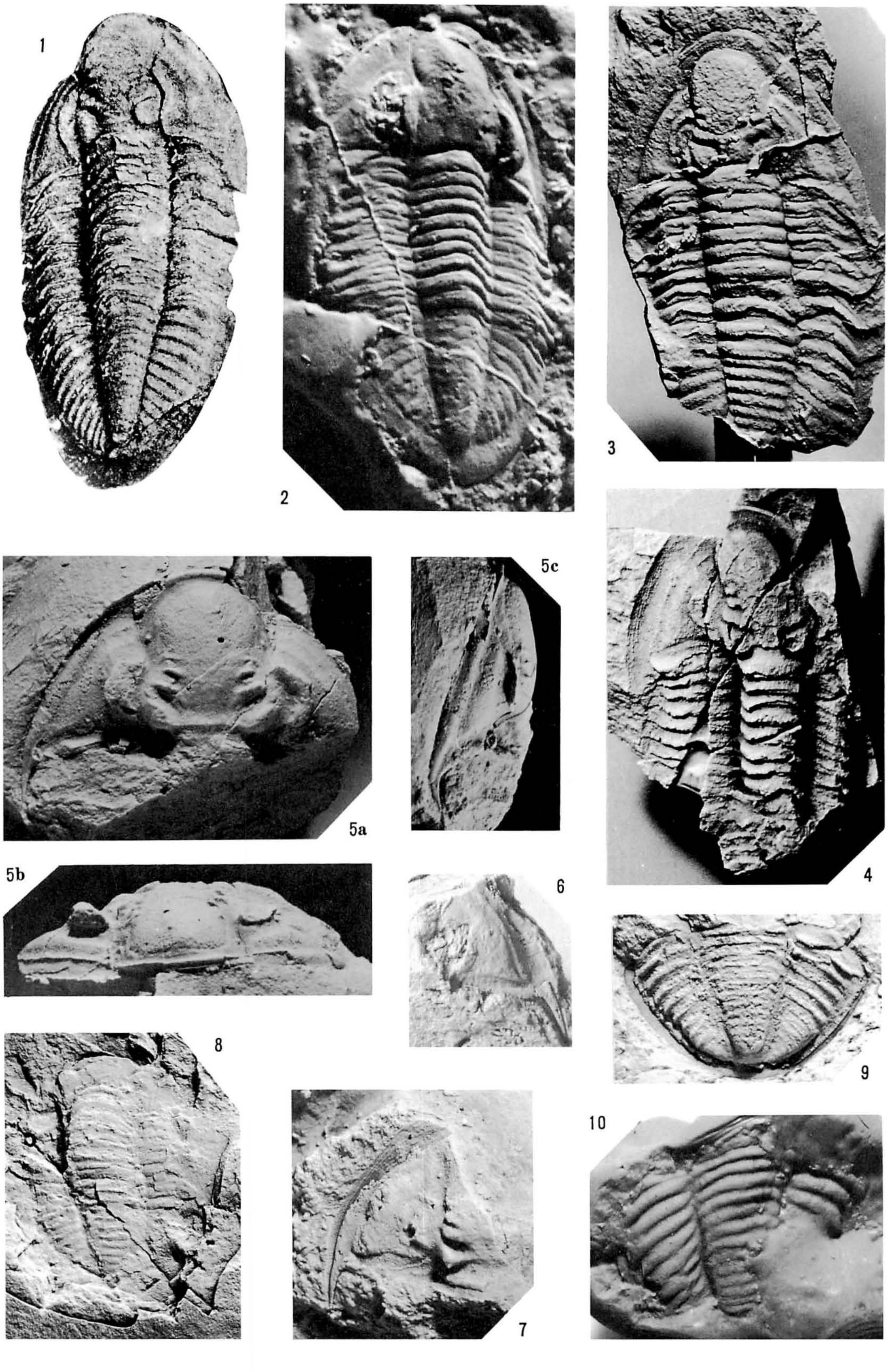
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Plate IX

Explanation of Plate IX

Linguaphillipsia subconica KOBAYASHI and HAMADA, sp. nov. .... p. 79

Figs. 1a-c. The holotype specimen showing the external (a) and internal (b) features of the dismembered dorsal shield from Choanji, Ofunato city, Iwate Prefecture. MIZUNO coll. (1885) PAt 5797, a ×3.5, b ×3.2, c ×3.2.

Figs. 2, 3. External rubber replica of strongly deformed cranidia showing coarse glabellar granulation. Choanji, SASAKI coll. PAt 5798, ×3.8, Pat 5799, ×2.9.

Fig. 4. A dismembered cephalon and a pygidium from Choanji. SASAKI coll. PAt 5800, ×3.3.

Figs. 5a, b. Internal (a) and external (b) features of a paratype from Choanji. SASAKI coll. PAt 5801, ×3.1.

Figs. 6, 7. An internal (7) and external (8) molds of pygidia showing distinct granulation on the axial rings and a border with a few granulation. Choanji, SASAKI coll. PAt 5802, ×2.2, PAt 5803, ×3.1.

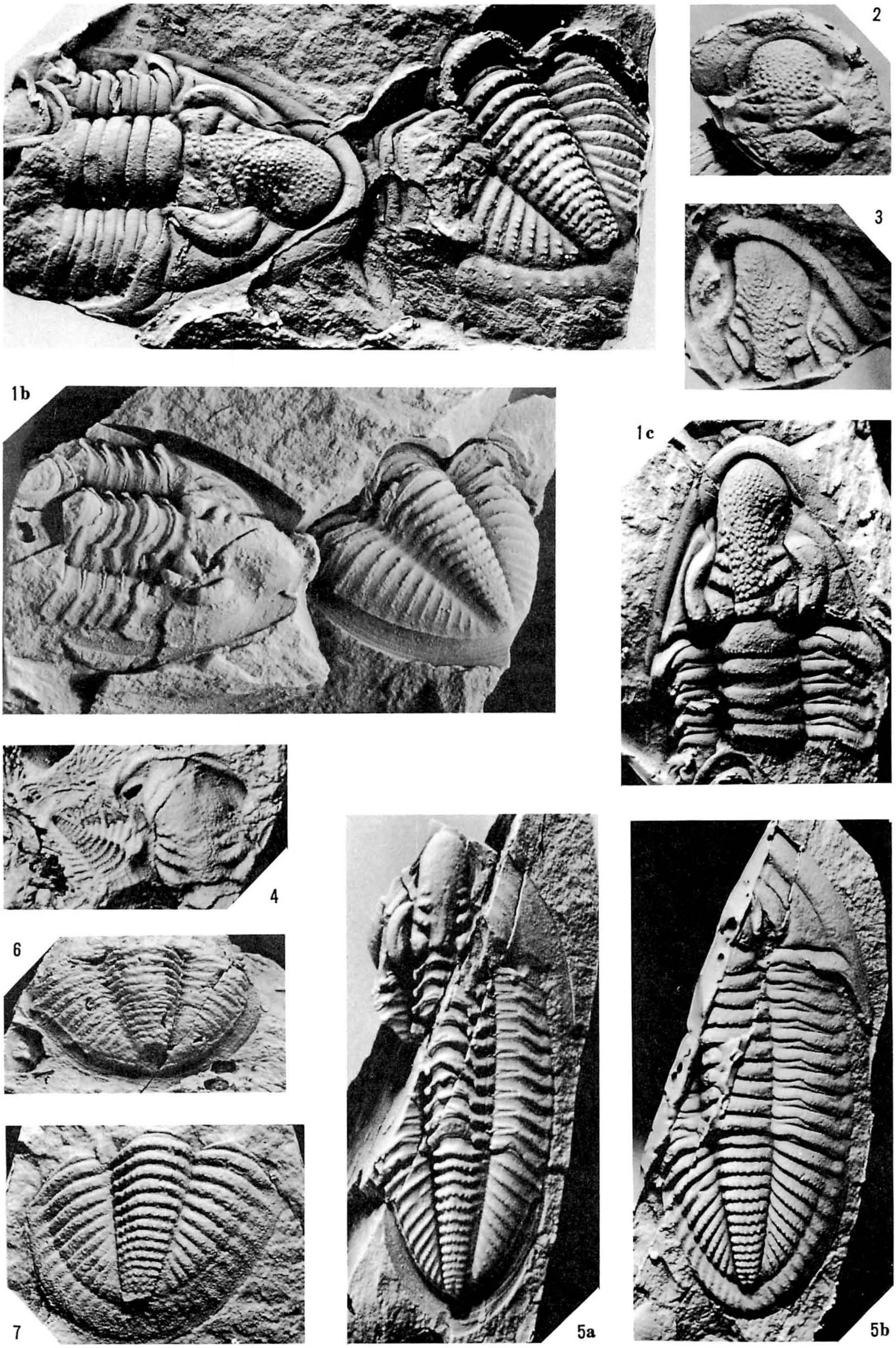
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Plate X

Explanation of Plate X

Linguaphillipsia subconica KOBAYASHI and HAMADA, sp. nov. ....p. 79

Figs. 1a, b. Internal and external features of an incomplete dorsal shield from Choanji, Ofunato city, Iwate Prefecture. SASAKI coll. PAt 5804, a ×4.7, b ×3.0.

Fig. 2. An external rubber replica of a cephalon. Loc. ditto, MIZUNO coll. PAt 5805a, ×2.9.

Fig. 3. An internal mold of a small cranidium. Loc. ditto, KITAGAWA coll. PAt 5806, ×3.9.

Figs. 4a-c. Internal and external replicas of two dismembered dorsal shields and a hypostome. Paratype. Loc. ditto, MIZUNO coll. PAt 5807, ×3.0.

Fig. 5. Internal mold of a laterally compressed cranidium. Loc. ditto, FURUHASHI coll. PAt 5808, ×3.7.

Figs. 6a, b. Internal and external molds of a pygidium. Loc. ditto, SASAKI coll. PAt 5809, ×2.2.

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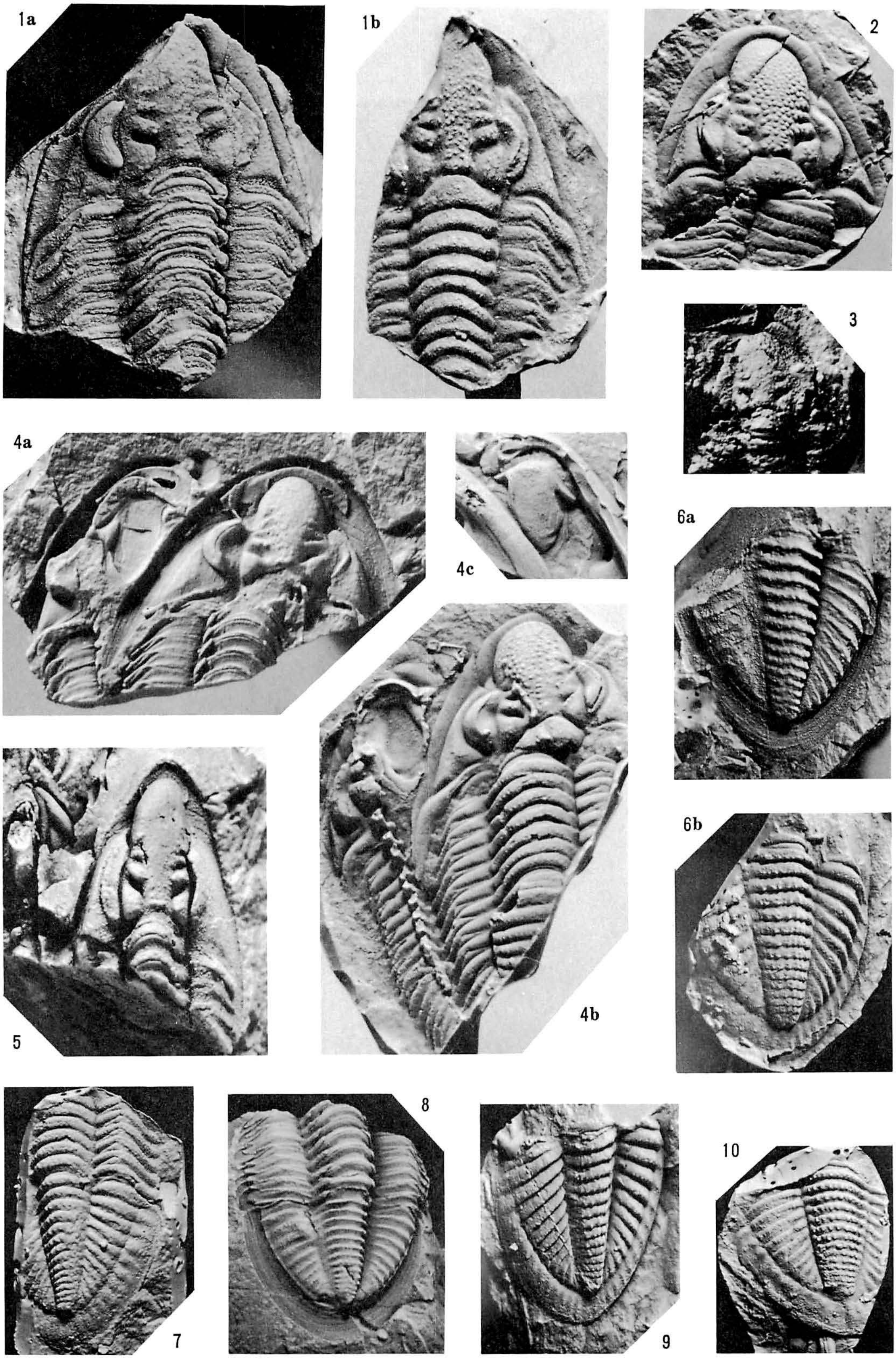
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Plate XI

Explanation of Plate XI

Linguaphillipsia subconica KOBAYASHI and HAMADA, sp. nov. ....p. 79

Fig. 1. Two dorsal shield on a slab from the Hikoroichi Series at Choanji, Ofunato city. A rubber replica on Pl. 10, fig. 2 (PAt 5805a) is taken from the right external cast. MIZUNO coll. PAt 5805b (left), ×2.8.

Figs. 2, 3. Two external replicas of pygidia. 2. FURUHASHI coll. from Choanji. PAt 5947, ×3.6, 3, MIZUNO coll. from Higuchi-zawa (H_2), Ofunato city. PAt 5948, ×2.5.

Schizophillipsia yukisawensis KOBAYASHI and HAMADA, sp. nov. ....p. 86

Figs. 4a-c. An external cast (a) and its rubber mold (b, c) from Yuki-sawa, Rikuzen-Takada city, Iwate Prefecture. A paratype specimen C, ARAKI coll. PAt 5814, a ×5.0, b, c. ×4.4.

Linguaphillipsiid, gen. et sp. indet. ....p. 89

Figs. 5a, b. Dorsal and right lateral views of an internal mold of a deformed dorsal shield from Yuki-sawa. ARAKI coll. PAt 5815, ×7.8.

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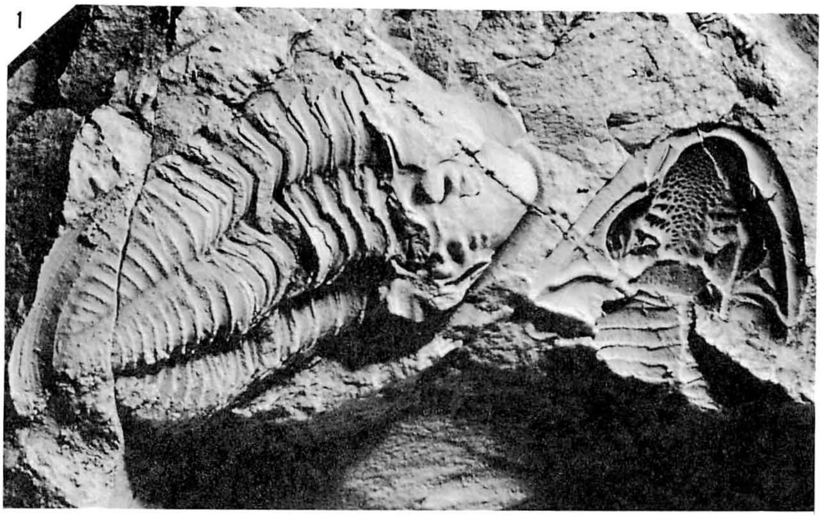

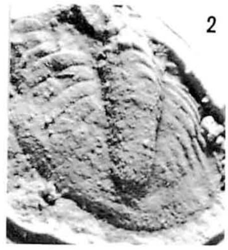

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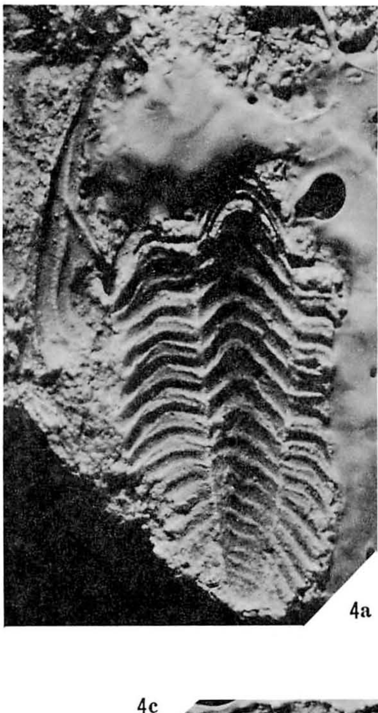

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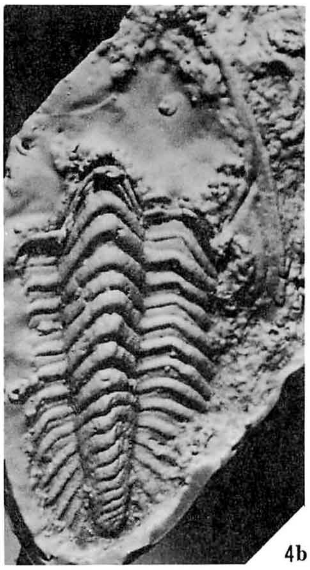

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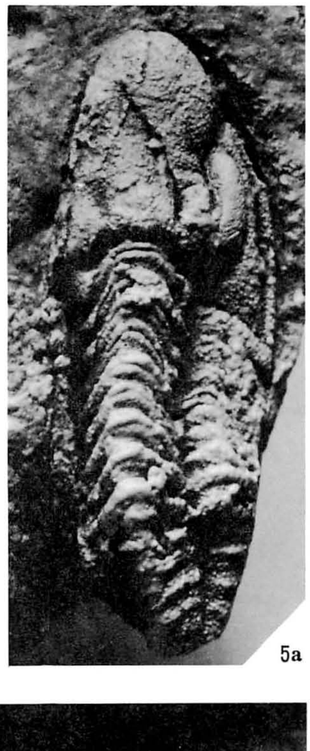

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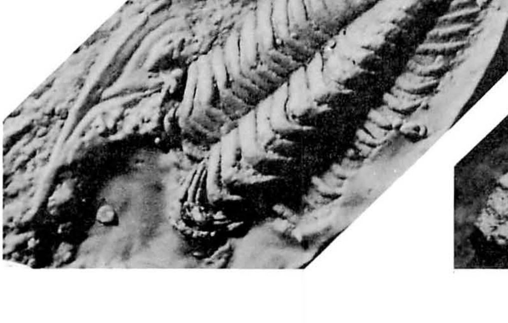

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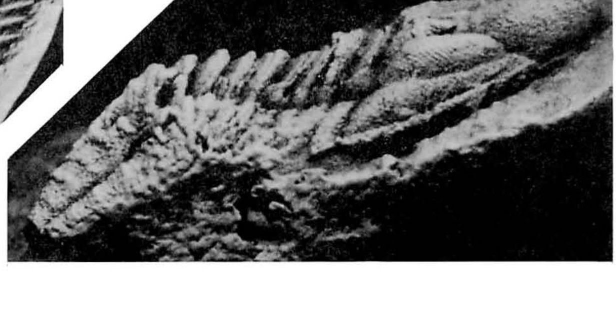

Plate XII

Explanation of Plate XII

Schizophillipsia yukisawensis KOBAYASHI and HAMADA, sp. nov. ....p. 86

Fig. 1. A slab with two incomplete dorsal shield from Yukisawa, Rikuzen-Takada city, Iwate Prefecture. ARAKI coll. PAt 5816a, b, ×4.0.

Fig. 2. Almost complete but deformed internal mold from the same locality as the preceding specimen. ARAKI coll. PAt 5817, ×3.9.

Figs. 3-6. Four internal molds of cranidia showing general features. Loc. ditto, Araki coll. 3, PAt 5818, ×4.3, 4, PAt 5819, ×4.3, 5, paratype A, MIZUNO coll. (740506) PAt 5820, on the same slab as PAt 5837, ×4.7, 6, Araki coll. PAt 5821, ×2.8.

Fig. 7. The holotype specimen, largely exfoliated dorsal shield, showing 10 thoracic segments, ARAKI coll. from Yuki-sawa. PAt 5822, ×2.8.

Fig. 8. Thoracic segments, (paratype D). Loc. ditto. ARAKI coll. PAt 5823, ×2.0.

Fig. 9. Rubber molds of a deformed cephalon and pygidium. Note a weak granulation on an axial part of the glabella. ARAKI coll. from Yuki-sawa. PAt 5829, ×4.0.

Fig. 10. Another cephalon showing a weak granulation, an eye and glabellar furrows. Loc. ditto, ARAKI coll. PAt 5830, ×5.1.

Figs. 11, 12. Rubber replicas of three cephala showing sharply edged lateral border and genal spines. Loc. ditto, ARAKI coll. 11, PAt 5831, ×3.1, 12, paratype B, PAt 5832, ×5.3.

Figs. 13, 14. Two deformed hypostomata from Yuki-sawa. ARAKI coll. 13, PAt 5833, ×7.9, 14, PAt 5834, ×9.2.

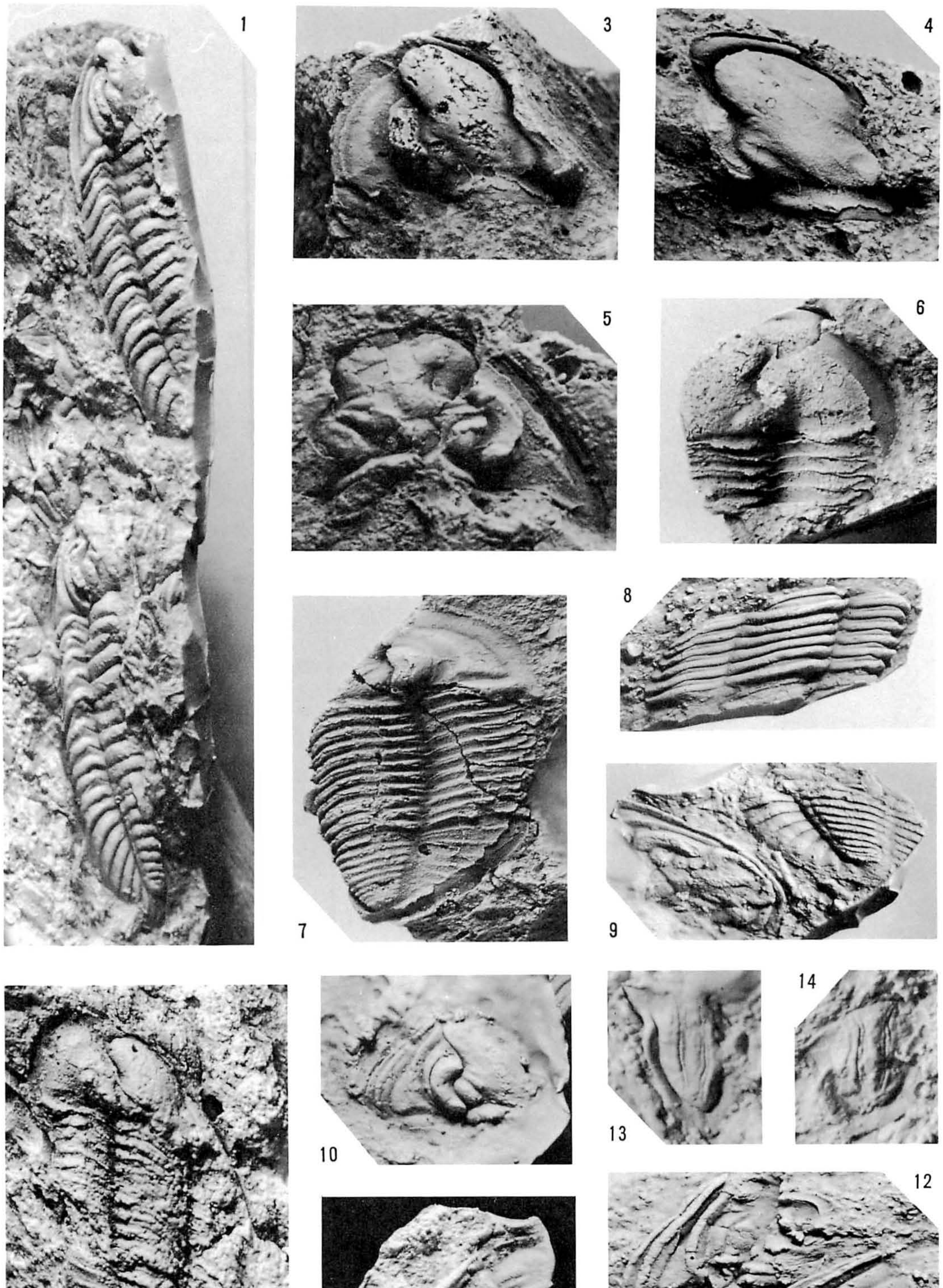
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Plate XIII

Explanation of Plate XIII

Schizophillipsia (?) *platyrachis* KOBAYASHI and HAMADA, sp. nov. ....p. 89

Fig. 1. An incomplete dorsal shield (rubber replica) of the holotype from Yuki-sawa, Rikuzen-Takada city. ARAKI coll. PAt 5835, ×3.8.

Fig. 2. A deformed cephalon from the same locality as above. MIZUNO coll. PAt 5836, ×2.5.

Schizophillipsia yukisawensis KOBAYASHI and HAMADA, sp. nov. ....p. 86

Fig. 3. An internal mold of a cranidium from Yuki-sawa. MIZUNO coll. PAt 5837, on the same slab as PAt 5820, ×5.0.

Figs. 4-11. Seven pygidia showing various outlines owing to tectonic deformation. 4, ARAKI coll. from Yuki-sawa, PAt 5838, ×4.9, 5, MIZUNO coll. from the same locality, PAt 5839, ×3.6, 6, paratype E coll. by ARAKI, PAt 5340, ×3.3, 7, ARAKI coll. PAt 5841, ×3.4, 8, MIZUNO coll. (770502) PAt 5842, ×3.3, 9, ARAKI coll. (occurs in association with large "*Posidonomya*") PAt 5843, ×3.0, 10, MIZUNO coll. PAt 5844, ×3.6, 11, ARAKI coll. PAt 5845, ×5.0.

Fig. 12. An internal mold of a pygidium jointed with thoracic segments, paratype, ARAKI coll. from Yuki-sawa. PAt 5846, ×5.8.

Fig. 13. An immature pygidium of the species. Loc. ditto, MIZUNO coll. PAt 5847, ×4.3. (A pygidium on Pl. 13, fig. 7 is on the same slab).

Linguaphillipsia sp. indet. A ....p. 81

Fig. 14. A small cranidium showing distinct granulation on an elongate glabella. KITAGAWA coll. from Higuchi-zawa, Ofunato city in association with *Palaeophillipsia tenuis*. PAt 5848, ×4.3.

Linguaphillipsia (?) sp. nov. ....p. 81

Figs. 15a, b. An incomplete pygidium from the Omi limestone, Omi, Niigata Prefecture. KOBAYASHI coll. PAt 5849, ×2.5.

Palaeophillipsia tenuis KOBAYASHI and HAMADA, sp. nov. ....p. 84

Fig. 16. A small glabella from Choanji. MIZUNO coll. (720813) PAt 5850, ×3.4.

Schizophillipsia otsuboensis KOBAYASHI and HAMADA, sp. nov. ....p. 88

Fig. 17. An incomplete dorsal shield, paratype, from Otsubo-zawa, Rikuzen-Takada city. SASAKI coll. PAt 5851, ×3.6.

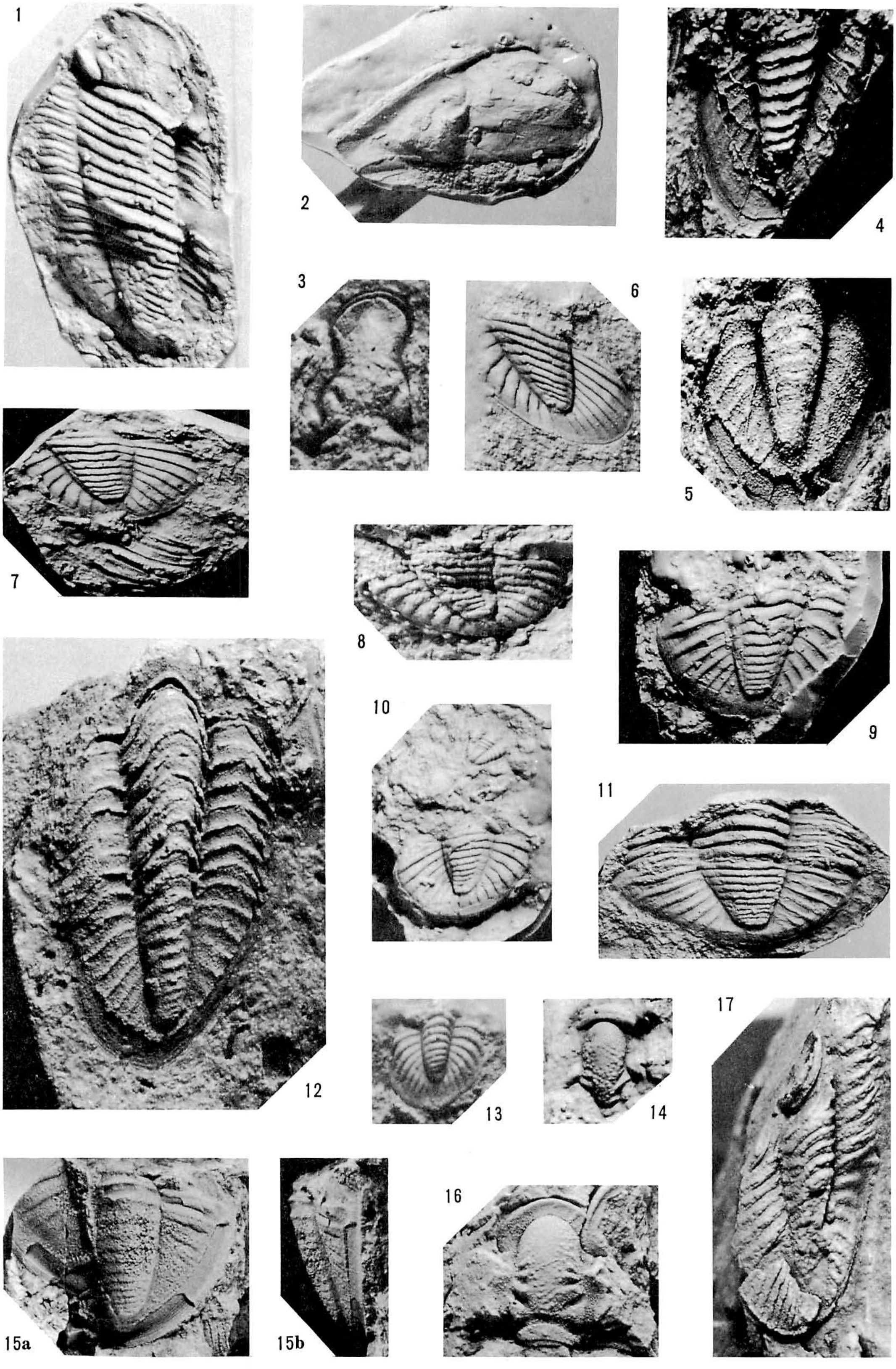
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Plate XIV

Explanation of Plate XIV

Palaeophillipsia japonica SUGIYAMA and OKANO, 1944................................p. 81

Fig. 1. The holotype specimen (the figure reproduced from SUGIYAMA and OKANO, 1944), ×3.0.

Palaeophillipsia tenuis KOBAYASHI and HAMADA, sp. nov. ....p. 84

Figs. 2-4, 6. Four glabella showing general features of the genus. 2, the holotype specimen, from Higuchi-zawa (H_1), Ofunato city, KITAGAWA coll. (internal mold) PAt 5852, ×3.8, 3, MIZUNO coll. from H_1, PAt 5853, ×3.2, 4, SASAKI coll. from Choanji, Ofunato city, PAt 5854, ×2.7, 6, MIZUNO coll. from H_1, PAt 5855, ×3.4.

Palaeophillipsia ? sp. indet.

Fig. 5. A rubber replica of an external mold of free cheek from Higuchi-zawa (H_1), MIZUNO coll. PAt 5856, ×5.3.

Cummingella otai KOBAYASHI and HAMADA, 1978....................................p. 90

Figs. 7a-c. The holotype cephalon from the *Millerella* zone of the Akiyoshi limestone at Ryugaho, Akiyoshi-dai, Yamaguchi Prefecture. ASM 8002 (=PAt 5949), ×5.3.

Figs. 8, 9, 11, 13. Four pygidia. 8, from the *Profusulinella beppensis* zone of the Akiyoshi limestone at Nakano Shohoji, Akiyoshi-dai, ASM 8005 (=PAt 5950), ×2.9, 9, Omi limestone at Higashi-yama quarry, Omi, Niigata Prefecture, Tokyo Univ. coll. PAt 5857, ×3.5, 11, an incomplete specimen from Akiyoshi-dai, YANAGIDA coll. PAt 5858, ×2.6, 13, a paratype specimen from the *Millerella* zone of the Akiyoshi limestone at Ikusei meadow, Iwanaga-dai, Yamaguchi Prefecture, OTA coll. PAt 5858, ×2.9.

Cummingella cf. *otai* KOBAYASHI and HAMADA, 1978................................p. 91

Figs. 10, 12. Two pygidia from the Akiyoshi limestone. 10, ASM 8009 (=PAt 5951), ×3.6, 12, PAt 5860 (IW), ×3.3.

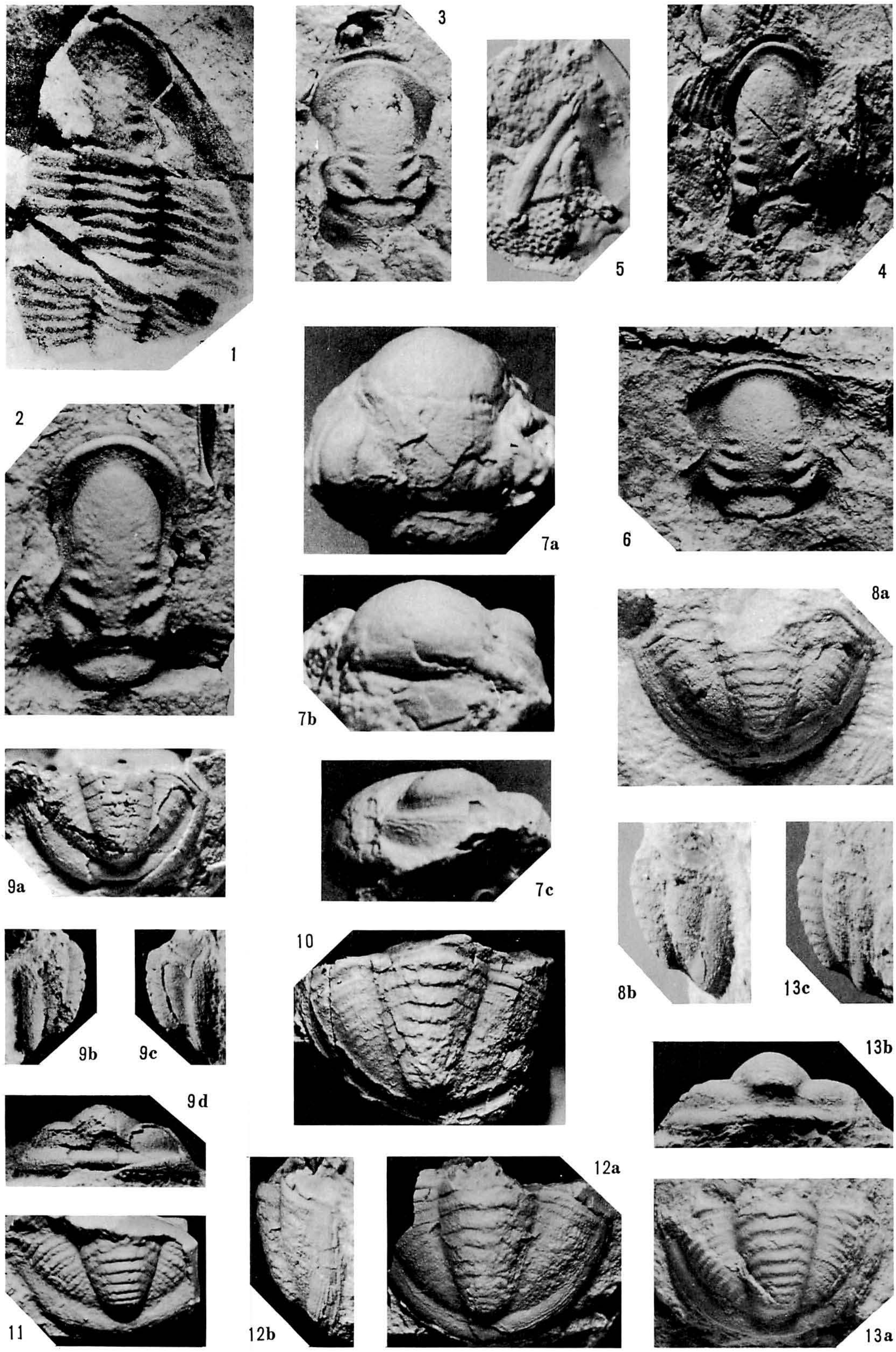
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Plate XV

Explanation of Plate XV

Cummingella subtrigonalis KOBAYASHI and HAMADA, sp. nov. ....p. 91

Figs. 1, 2. Two complete cephala from the Omi limestone at Higashi-yama quarry, Omi, Niigata Prefecture showing the general features of the species. 1, ISHIGURO coll. PAt 5861, ×3.5, 2, the holotype specimen, HACHIYA coll. PAt 5862, ×3.6.

Figs. 3-5. Three specimens collected from the Akiyoshi limestone. YANAGIDA coll. 3, an exfoliated cephalon and thorax, ASM 8045 (=PAt 5952), ×2.9, 4, another specimen, PAt 5863, ×4.8, 5, thoracic segments, PAt 5864, ×3.4.

Cummingella mesops KOBAYASHI and HAMADA, sp. nov. ....p. 92

Fig. 6. A free cheek from the Omi limestone at Higashi-yama quarry, Omi, Niigata Prefecture. SATO coll. (ST6) PAt 5865, ×3.2.

Fig. 7. A large glabella collected by SATO from the same locality (ST4). PAt 5866, ×2.0.

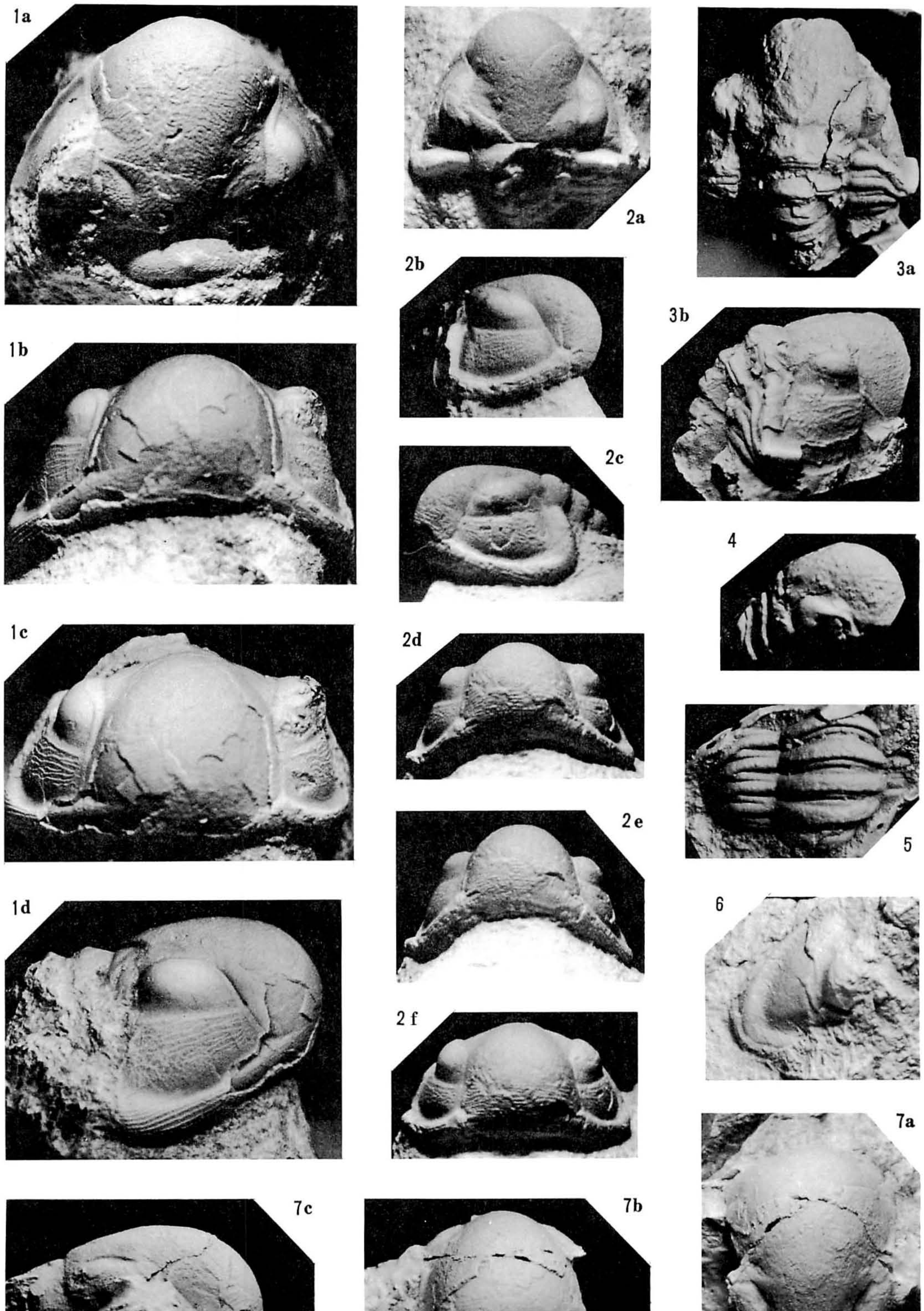
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Plate XVI

Explanation of Plate XVI

Cummingella mesops KOBAYASHI and HAMADA, sp. nov. ....p. 92

Figs. 1, 2. Two cephala from the Omi limestone at Higashi-yama quarry, Omi, Niigata Prefecture. 1, the holotype specimen, SATO coll. (760805) PAt 5867, ×2.9, 2, another specimen, SATO coll. PAt 5868, ×2.8.

Figs. 3, 4. Specimens from the Akiyoshi limestone (*Pseudostaffella antiqua* zone) at Maruyama quarry, Akiyoshi, Yamaguchi Prefecture. 3, an incomplete cranidium, MIZUNO coll. (55), PAt 5869, ×3.0, 4, a free cheek coll. by MIZUNO (21), PAt 5870, ×3.9.

Cummingella cf. *mesops* KOBAYASHI and HAMADA, sp. nov.

Figs. 5a-d. A small cranidium collected from the *Pseudostaffella antiqua* zone of the Akiyoshi limestone at Maruyama quarry, Yamaguchi Prefecture. MIZUNO coll. (59) PAt 5871, ×6.4.

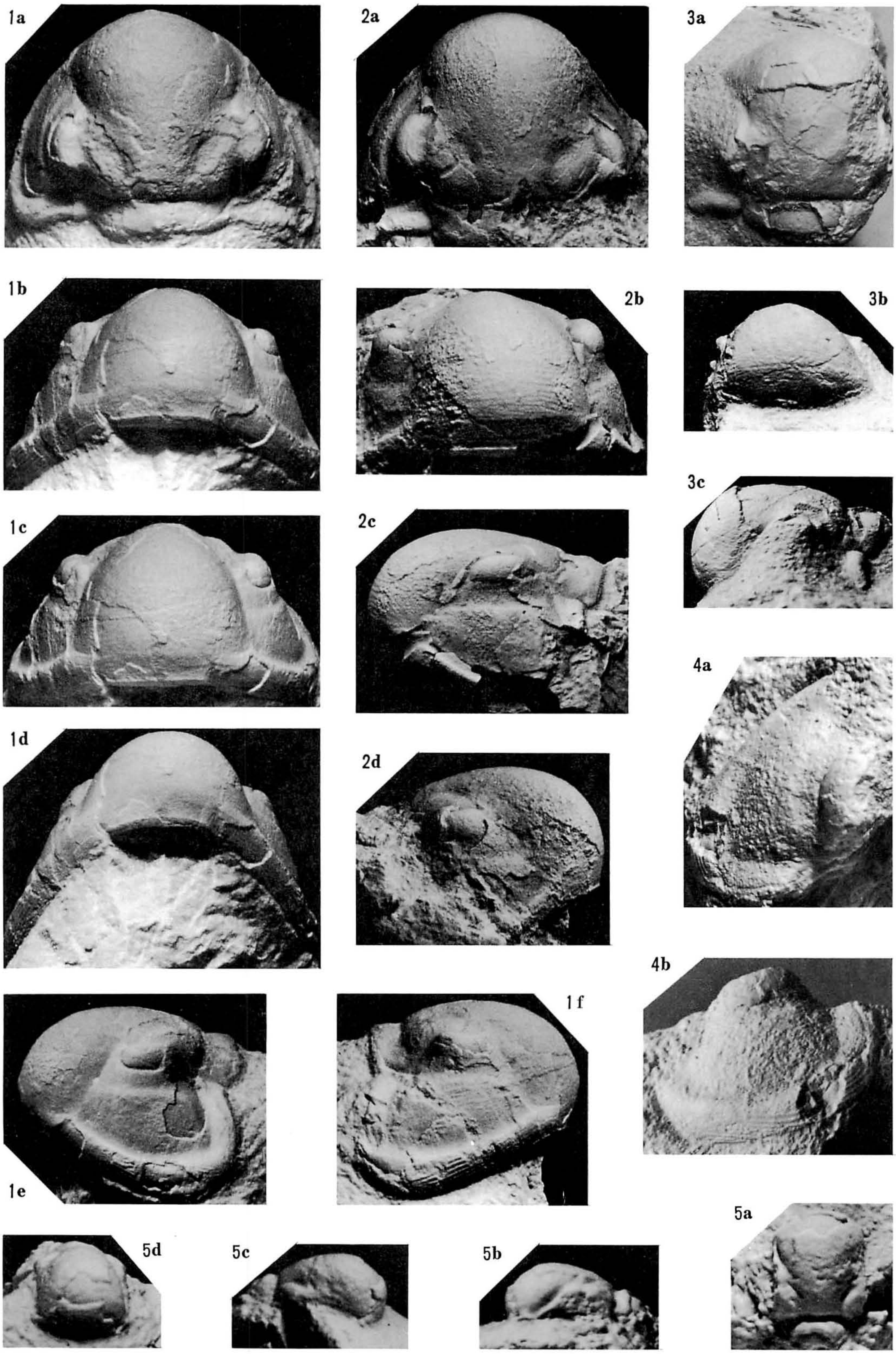
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Plate XVII

Explanation of Plate XVII

Cummingella mesops KOBAYASHI and HAMADA, sp. nov. ....p. 92

Figs. 1-3. Three specimens from the Omi limestone. 1, a large cranidium coll. by SATO, PAt 5872, ×2.5, 2, an incomplete pygidium coll. by SATO, PAt 5873, ×2.5, 3, SHIMIZU coll. (760605), PAt 5874, ×2.5.

Cummingella cf. *subtrigonalis* KOBAYASHI and HAMADA, sp. nov.

Figs. 4a, b. A pygidium collected by SATO, PAt 5875, ×4.8.

Cummingella, sp. nov. ....p. 95

Fig. 5. An imperfect cephalon from a likestone boulder in Osobu valley, near Fukuji, Gifu Prefecture. MIZUNO coll. PAt 5876, ×3.5.

Cummingella (?) *eurypyge* KOBAYASHI and HAMADA, sp. nov. ....p. 96

Figs. 6a-c. The holotype pygidium from the Akiyoshi limestone at shohoji. PAt 5877, ×2.5.

Cummingella imamurai KOBAYASHI and HAMADA, sp. nov. ....p. 94

Figs. 7a-d. The holotype pygidium from the Omi limestone. Collected by Imamura, Tokyo Univ. coll., PAt 5878, ×3.0.

Liobole ? sp. indet. ....p. 96

Fig. 8. An internal mold of a strongly deformed pygidium from Sakamoto-zawa, Ofunato city, Iwate Prefecture. MIZUNO coll. (770502) PAt 5961, ×3.4.

Thigriffides aff. *hinensis* KOBAYASHI and HAMADA, 1978.............................p. 102

Figs. 9a, b. An incomplete pygidium from the *Marginatia toriyamai* zone of the Akiyoshi limestone on the road to limestone quarry of Sumitomo Cement Co., Akiyoshi. Coll. by OTA, ASM 8046 (=PAt 5879), ×3.1.

Pygidium, gen. et sp. indet. ....p. 110

Fig. 10. A pygidium from the *Millerella yowarensis* zone of the Akiyoshi limestone at Ikusei meadow, Iwanaga-dai. ASM 8047 (=PAt 5953), ×2.1.

Linguaphillipsia sp. indet. (B) ....p. 81

Fig. 11. An incomplete cranidium from the Hikoroichi Series at Higuchi-zawa (H_I). MIZUNO coll. (770503). PAt 5880, ×2.9.

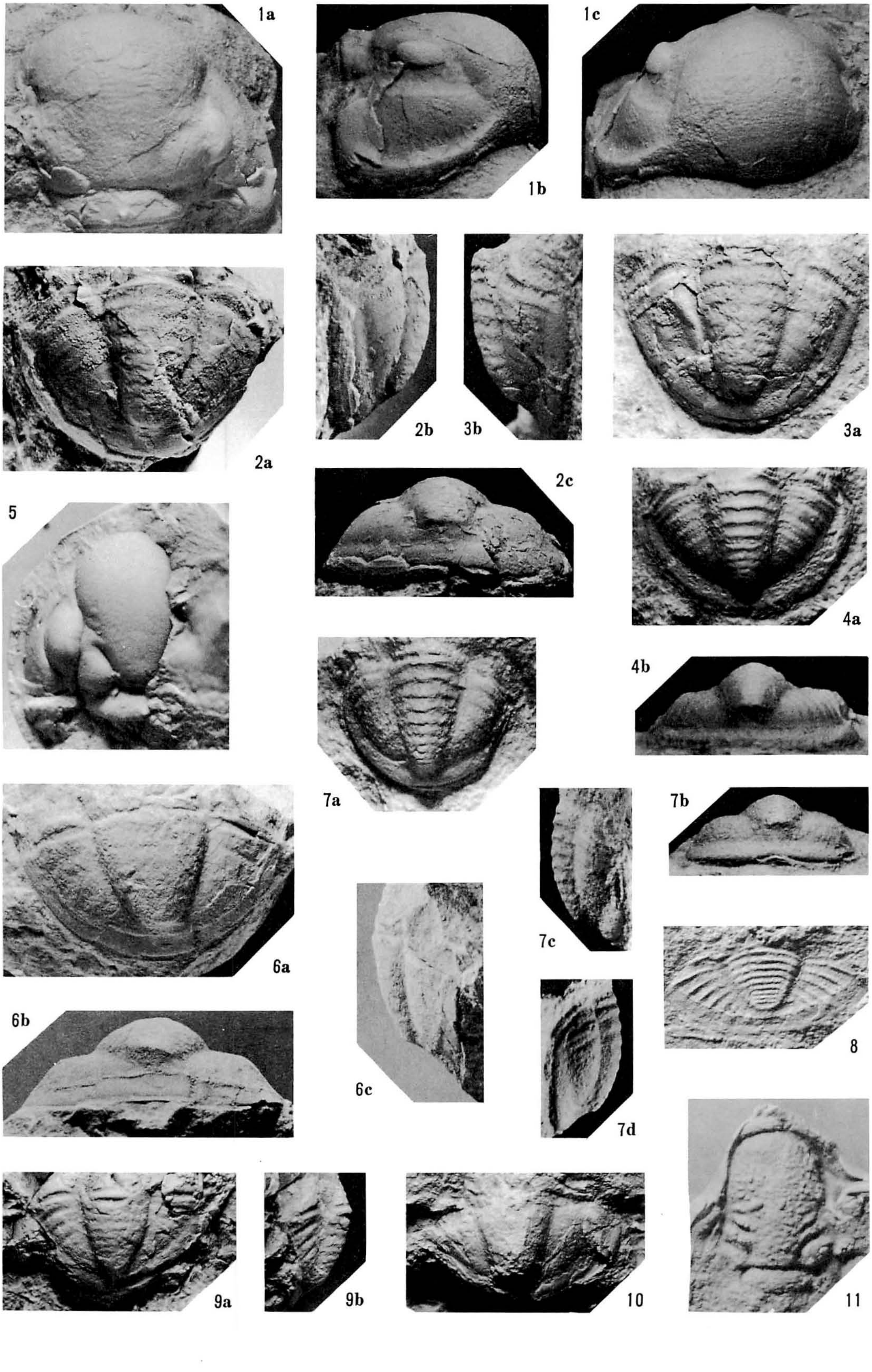
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Plate XVIII

Explanation of Plate XVIII

Cummingella (?) sp. indet. ....p. 96

Figs. 1a, b. An imperfect cranidium showing faint glabellar furrows. Hina limestone, Okayama Prefecture. NISHIKAWA coll. PAt 5881, ×2.6.

Figs. 2a-c. Three views of a hypostome from the Hina limestone. NISHIKAWA coll. PAt 5882, ×3.8.

Fig. 3. A free cheek with a large eye. Hina limestone. NISHIKAWA coll. PAt 5883, ×3.9.

Fig. 4. A pygidium from the Hina limestone. NISHIKAWA coll. PAt 5884, ×2.0.

Cummingella subovalis KOBAYASHI and HAMADA, sp. nov. ....p. 95

Fig. 5. The holotype pygidium from the Akiyoshi limestone, south of the Akiyoshi Science Museum (IW). ASM 8048 (=PAt 5954), ×2.8.

Bollandia pacifica KOBAYASHI and HAMADA, sp. nov. ....p. 98

Fig. 6. An internal mold of a deformed cranidium from Odaira-yama, Rikuzen-Takada city, Iwate Prefecture. ARAKI coll. PAt 5885, ×2.7.

Fig. 7. A compressed dorsal shield. Hokkaido Univ. coll. from the Kitakami mountain (precise locality unknown). UHR 30424B (=PAt 5955) on the same slab with PAt 5960, ×2.9.

Figs. 8, 9. Two dorsal shields. 8, the holotype specimen (rubber replica) from near 808 m alt. highland, Iwate Prefecture. UHR 30425 (=PAt 5956), ×4.7, 9, the paratype specimen coll. by NAKAMURA. UHR 30426 (=PAt 5957), ×4.2.

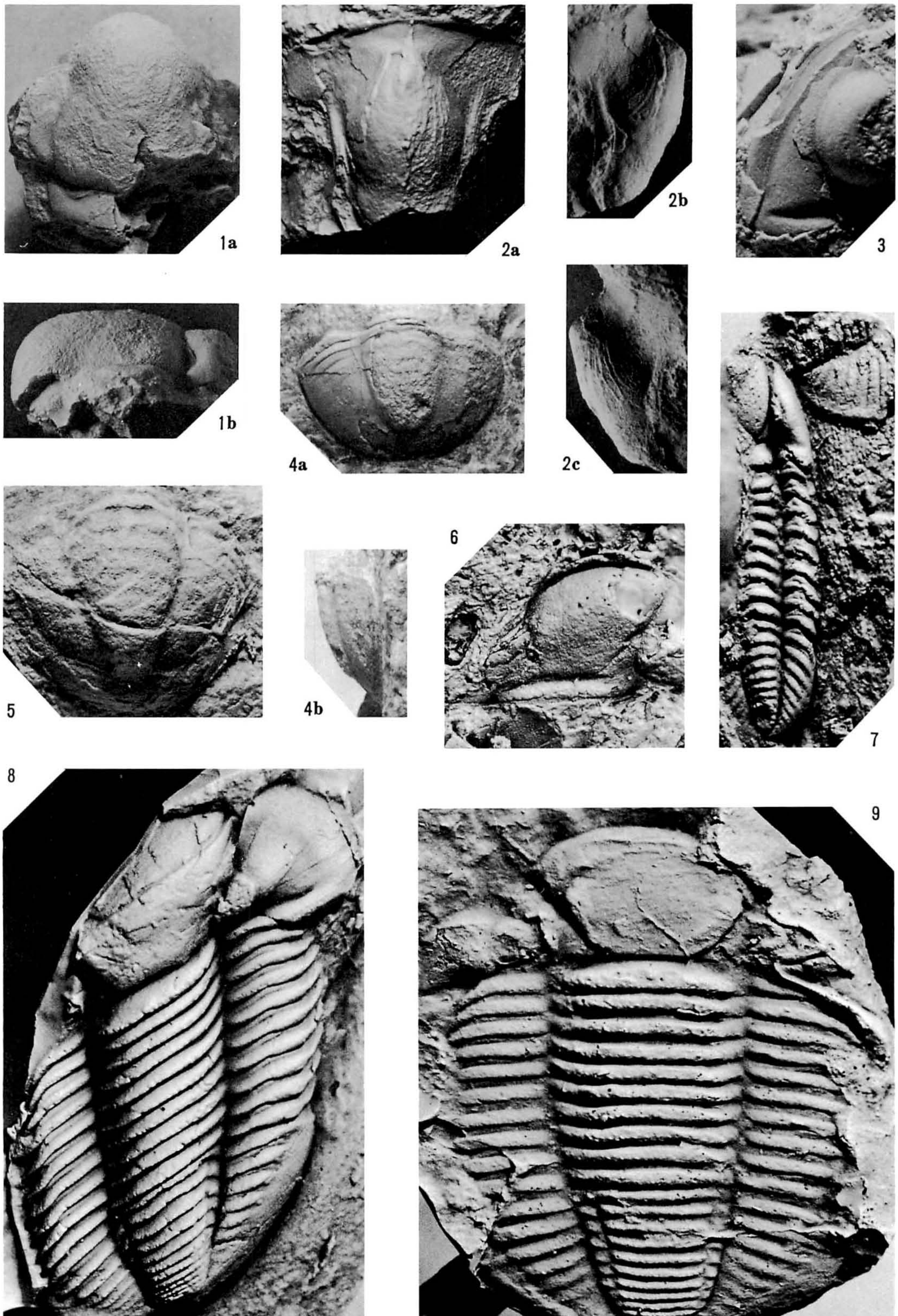
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Plate XIX

Explanation of Plate XIX

Bollandia pacifica KOBAYASHI and HAMADA, sp. nov. ....p. 98

Figs. 1-4. Variously deformed specimens from Odaira-yama, north of Otsubo-zawa, Rikuzen-Takada city, Iwate Prefecture. ARAKI coll. PAt 5886, ×2.1, PAt 5887, ×1.6, PAt 5888, ×2.0, PAt 5889, ×3.5.

Pygidium, gen. et sp. indet. (A) ....p. 110

Figs. 5a, b. An exfoliated specimen (IQ 01). Akiyoshi limestone, ASM 8049 (=PAt 5958), ×3.2.

Pygidium, gen. et sp. indet. (B)..p. 110

Figs. 6a-c. Partly exfoliated pygidium (IQ 04). Akiyoshi limestone, PAt 5890, ×3.5.

Fig. 7. Another pygidium (IQ 04). Akiyoshi limestone, ASM 8009 (=PAt 5959), ×3.4.

Pygidium, gen. et sp. indet. ....p. 110

Figs. 8a, b. A large pygidium from the Akiyoshi limestone (*Pseudostaffella antiqua* zone) at Maruyama quarry, Akiyoshi. MIZUNO coll. (42). PAt 5891, ×2.3.

Free cheek, gen. et sp. indet. (5) ....p. 110

Fig. 9. Collected from Maruyama quarry. MIZUNO coll. PAt 5892, ×3.0.

Waribole (?) sp. indet...p. 68

Fig. 10. Slightly broken pygidium from the Hina limestone at Hina, Okayama Prefecture. NISHIKAWA coll. PAt 5893, ×3.2.

Dechenelloides asiaticus KOBAYASHI and HAMADA, sp. nov. ....p. 85

Fig. 11. A small immature pygidium (paratype) from Higuchi-zawa (H_2), Ofunato city. HACHIYA coll. (770321) PAt 5775, ×6.0.

Cummingella granulifera KOBAYASHI and HAMADA, sp. nov. ....p. 93

Figs. 12a, b. The holotype cranidium showing somewhat rough test surface with granules. Akiyoshi limestone (*Fusulinella biconica* zone), OTA coll. PAt 5894, ×5.9.

Fig. 13. A hypostoma showing its general feature. Loc. ditto. OTA coll. PAt 5898, ×3.0.

Figs. 14a-c. Three views of the paratype pygidium with some thoracic segments. Loc. ditto, OTA coll. PAt 5896, ×3.5.

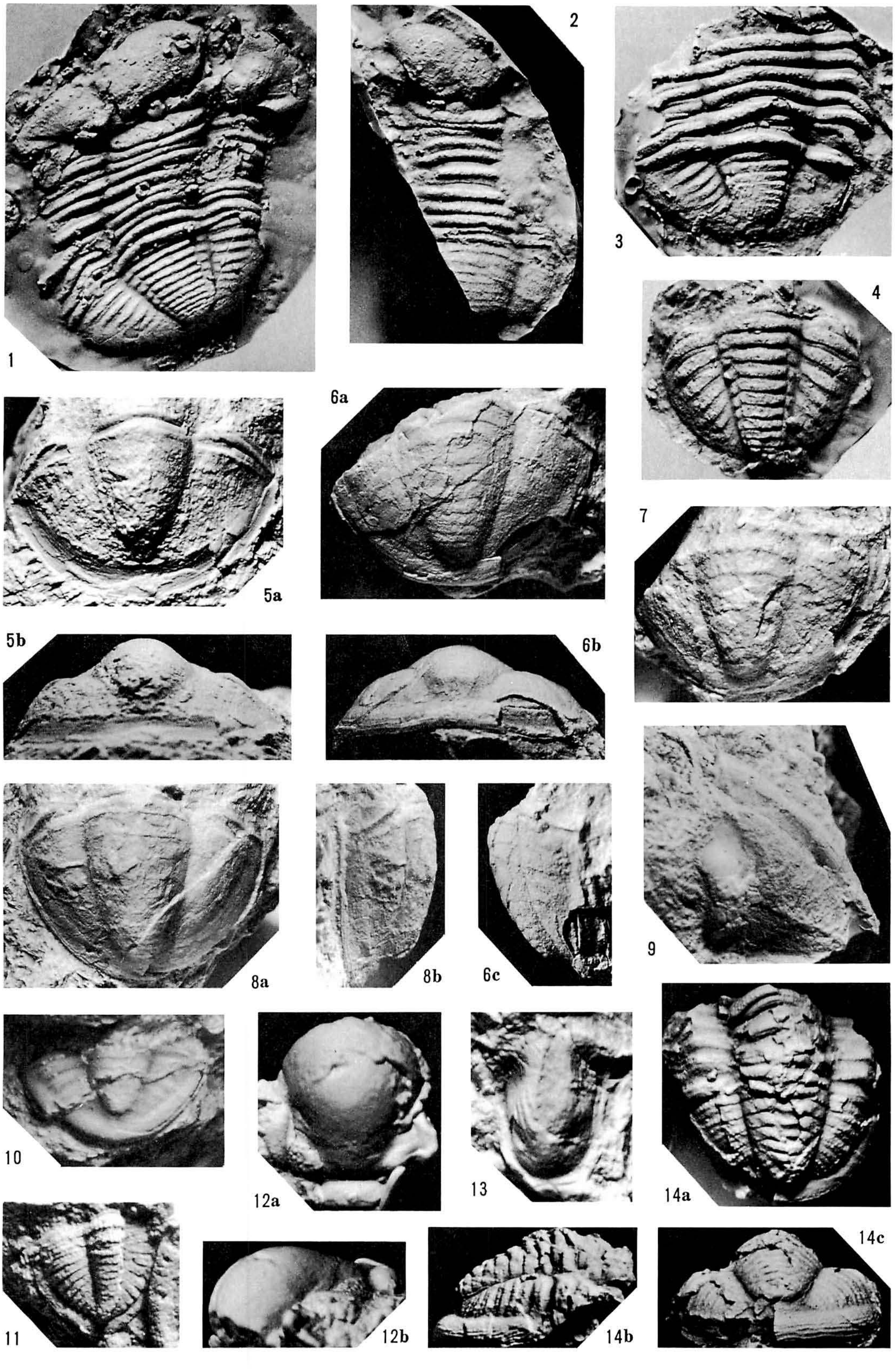
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Plate XX

Explanation of Plate XX

Parvidumus densigranulatus KOBAYASHI and HAMADA, gen. et sp. nov. ....p. 100

Figs. 1-3. Three deformed cephala showing surface granulation. 1, a paratype specimen from Odaira-yama, Rikuzen-Takada city, Iwate Prefecture. ARAKI coll. PAt 5897, ×3.5, 2, specimen from Yuki-sawa, Rikuzen-Takada city. MIZUNO coll. (740506), PAt 5898, ×3.0, 3, another specimen from Odaira-yama, ARAKI coll. PAt 5899, ×5.0.

Figs. 4-9. Variously deformed dorsal shields from Odaira-yama. ARAKI coll. 4, PAt 5900, ×3.5, 5, PAt 5901, ×4.1, 6, PAt 5902 and 5903 (free cheek), ×3.8, 7, PAt 5904, ×3.4, 8, a paratype specimen (internal mold), PAt 5905, ×3.9, 9, PAt 5906, ×4.5.

Fig. 10. A compressed pygidium showing surface ornamentation. Odaira-yama, ARAKI coll. PAt 5907 on the same slab as PAt 5897, 5901, ×4.3.

Fig. 11. A compressed cranidium showing somewhat coarse granulation. Yuki-sawa, ARAKI coll. PAt 5908, ×4.1.

Figs. 12-15. Two internal molds (12, 13) and two external molds (14, 15) of pygidia from Yuki-sawa. ARAKI coll. 12, PAt 5909, ×4.5, 13, PAt 5910, ×3.7, 14, a paratype, PAt 5911, ×4.1, 15, the holotype specimen, PAt 5912, ×4.2.

Griffithidella nishikawai (KOBAYASHI and HAMADA, 1978) ....p. 101

Figs. 16a, b. The holotype cranidium from the Hina limestone at Hina, Okayama Prefecture. NISHIKAWA coll. PAt 5913, ×4.0.

Thigriffides hinensis KOBAYASHI and HAMADA, 1978 ....p. 101

Figs. 17a, b. The holotype cranidium from the Hina limestone. NISHIKAWA coll. PAt 5914, ×4.4.

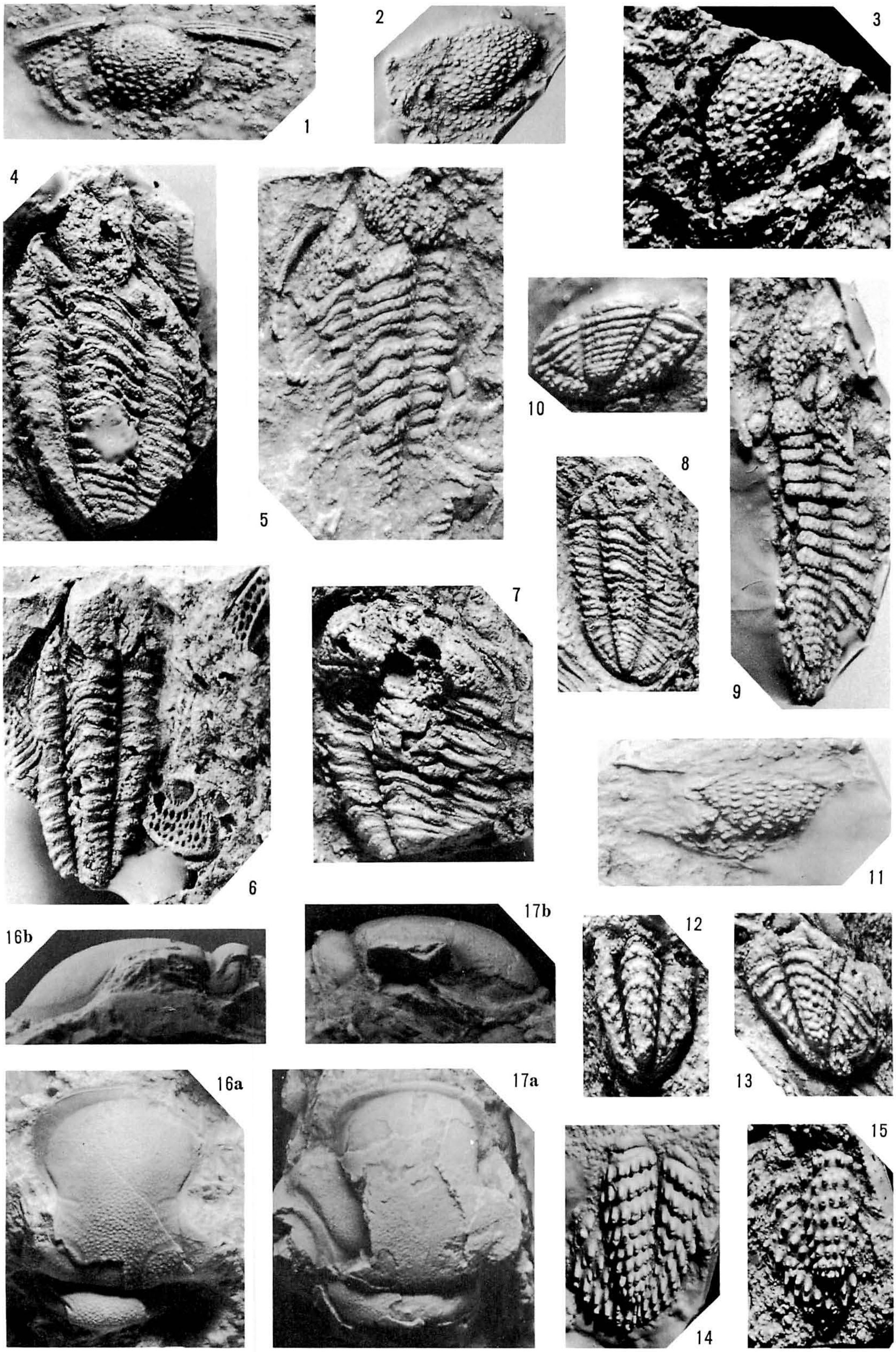
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Plate XXI

Explanation of Plate XXI

Thigriffides hinensis KOBAYASHI and HAMADA, 1978 ....p. 101

Fig. 1. A free cheek showing a large eye. Hina limestone, NISHIKAWA coll. PAt 5915, ×3.8.

Figs. 2, 3. Two pygidia from the same locality. 2, a paratype specimen, NISHIKAWA coll. PAt 5916, ×2.5, 3, another pygidium, NISHIKAWA coll. PAt 5917, ×1.7.

Thigriffides aff. *hinensis* KOBAYASHI and HAMADA, 1978.............................p. 102

Fig. 4. An imperfect cranidium from the Hina limestone. NISHIKAWA coll. PAt 5918, ×3.0.

Thigriffides (?) *kibiensis* KOBAYASHI and HAMADA, 1978 ....p. 103

Fig. 5. The holotype cranidium showing somewhat flattened shield. Hina limestone, NISHIKAWA coll. PAt 5919, ×2.2.

Figs. 6, 7. Two pygidia. NISHIKAWA coll. PAt 5920, ×2.8, PAt 5921, ×4.0.

Schizophillipsia otsuboensis KOBAYASHI and HAMADA, sp. nov. ....p. 88

Figs. 8-11. Four cephalic shields from Otsubo-zawa, Rikuzen-Takada city, Iwate Prefecture. ARAKI coll. 8, a paratype specimen, PAt 5922, ×2.7, 9, PAt 5923, ×2.0, 10, the holotype specimen, PAt 5924, ×4.6, 11, PAt 5925, ×3.7.

Paladin mizunoi KOBAYASHI and HAMADA, sp. nov. ....p. 105

Fig. 12. The holotype cephalon from Otsubo-zawa, SASAKI coll. PAt 5926, ×5.5.

Figs. 13-16. Variously deformed four pygidia from the same locality. ARAKI coll. 13, PAt 5927, ×2.9, 14, PAt 5928, ×3.0, 15, PAt 5929, ×2.7, 16, PAt 5930, ×3.9.

Fig. 17. A pygidium with attached thoracic segments. SASAKI coll. from Otsubo-zawa. PAt 5931, ×3.1.

Fig. 18. Slightly deformed pygidium from the Hikoroichi Series at Choanji, Ofunato city, Iwate Prefecture. KITAGAWA coll. PAt 5932, ×5.9.

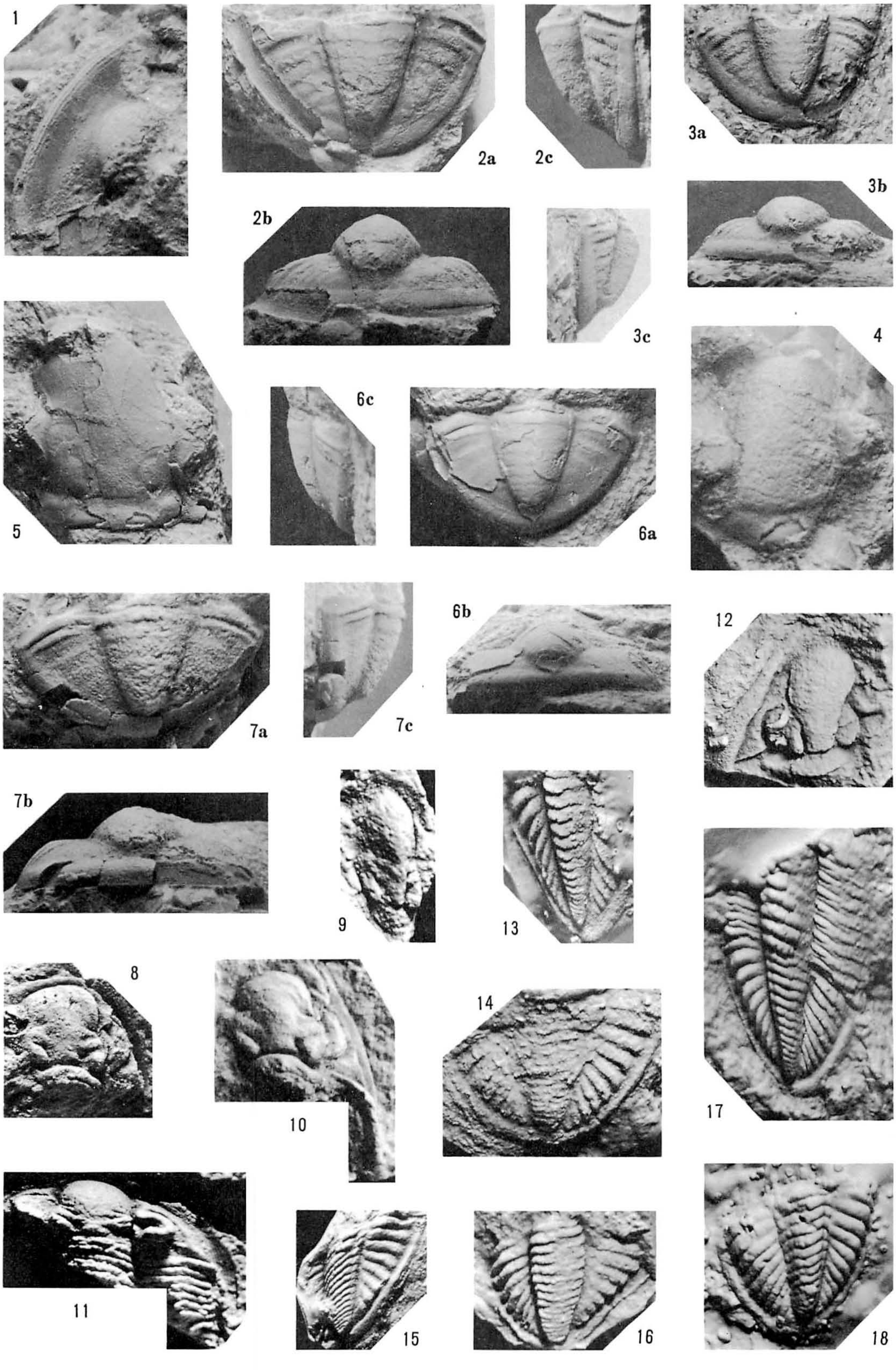
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Plate XXII

Explanation of Plate XXII

Paladin carinatus KOBAYASHI and HAMADA, sp. nov. ....p. 104

Fig. 1. A slightly compressed cephalon showing a large and long genal spine. Holotype Hokkaido Univ. coll. UHR 30424A (=PAt 5960) from the Kitakami mountains (precise locality unknown) on the same slab as PAt 5955, ×2.9.

Paladin sp. indet. ....p. 105

Figs. 2-5. Variously preserved four cranidia from Yuki-sawa, Rikuzen-Takada city, Iwate Prefecture. ARAKI coll. 2, PAt 5933, ×2.9, 3, PAt 5934, ×4.1, 4, PAt 5935, ×4.0, 5, PAt 5936, ×2.6.

Paladin (*Weberides*) *longispiniferus* KOBAYASHI and HAMADA, 1978 ....p. 106

Fig. 6. A poorly preserved cranidium from Yuki-sawa. ARAKI coll. PAt 5937 on the same slab as PAt 5939, ×4.2.

Figs. 7-13. Variously preserved seven pygidia showing the general features and a long caudal spine. ARAKI coll. from Yuki-sawa. 7, PAt 5938, ×3.3, 8, PAt 5939, ×4.0, 9, PAt 5940, ×4.3, 10, PAt 5941, ×3.9, 11, PAt 5942, ×4.6, 12, a paratype specimen, PAt 5943, ×4.6, 13, the holotype specimen, PAt 5944, ×4.0.

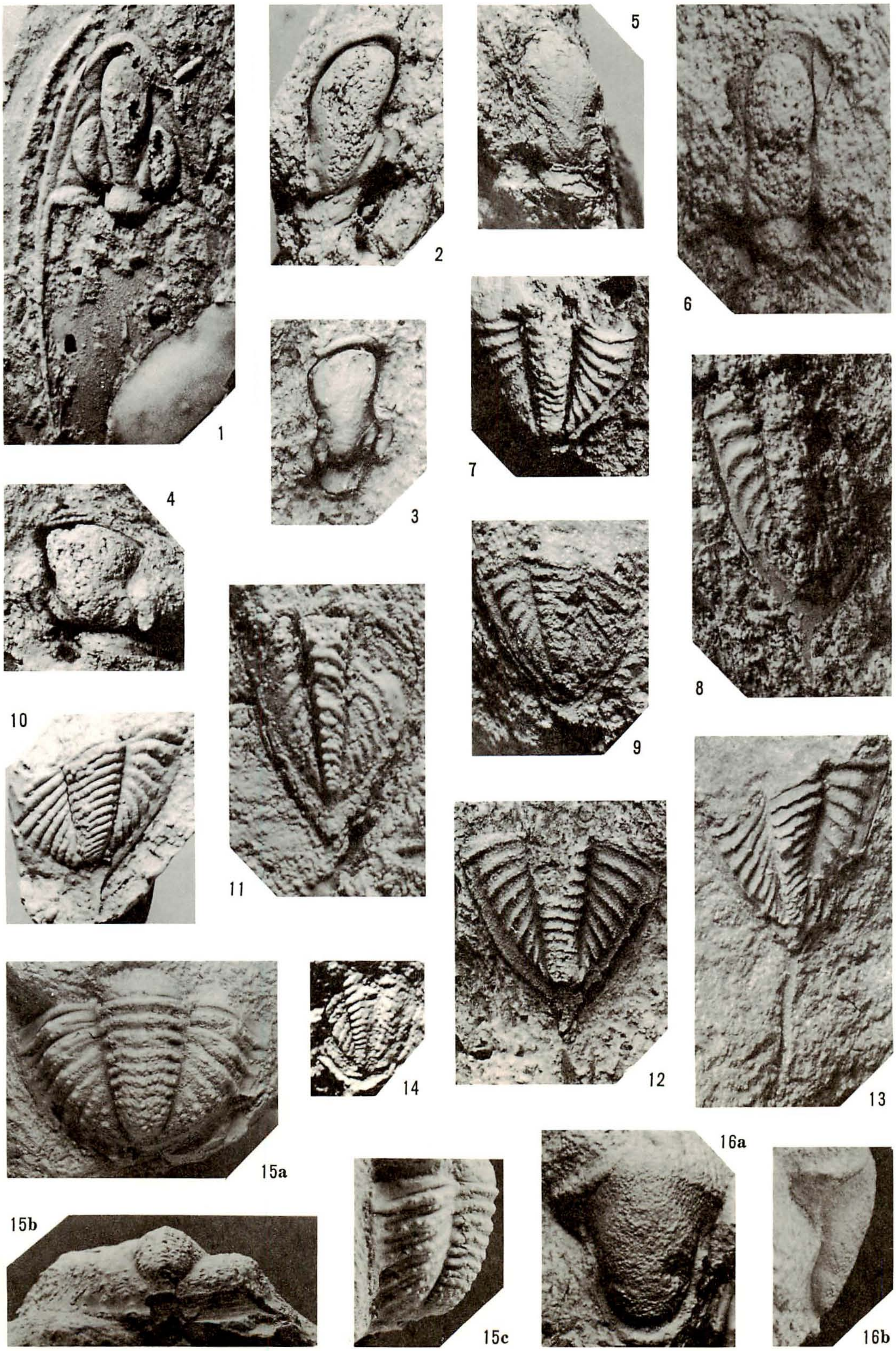
Paladin cf. *mizunoi* KOBAYASHI and HAMADA, sp. nov. ....p. 105

Fig. 14. A small pygidium from Otsubo-zawa. ARAKI coll. PAt 5945, ×5.2.

Paragriffithides japonicus KOBAYASHI and HAMADA, 1978 ....p. 103

Figs. 15a-c. Three views of the holotype pygidium from the Hina limestone, Hina, Okayama Prefecture. NISHIKAWA coll. PAt 5946a, ×2.7.

Figs. 16a, b. Two views of a hypostome associated with the holotype pygidium. NISHIKAWA coll. PAt 5946b, ×3.5.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Palaeontological Society of Japan, Special Papers No. 23

Carboniferous Trilobites of Japan

1980年12月10日 印刷
1980年12月15日 発行

定価 5,000円

編集者 首藤次男
発行者 日本古生物学会
東京都文京区弥生2-4-16
日本学会事務センター内
印刷者 学術図書印刷株式会社
富田 潔
東京都練馬区豊玉北2/13