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

By

Teiichi KOBAYASHI and Takashi HAMADA

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

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Abstract

Kobayashi, T. and Hamada, T. (1984): Permian Trilobites of Japan in Comparison with Asian, Pacific and other Faunas. *Palaeont. Soc. Japan, Sp. Pap.*, No. 26, pp. 92, pls. 14.

The Permian triobites of Japan, 22 species in 11 genera in total, are all described and illustrated in this monograph. The high specialization shortly before the annihilation of the Trilobita is exemplified by five indigenous genera, particularly *Pseudophillipsia* (*Nodiphillipsia*). Combined with recent advancements in China and Thailand the Oriental trilobites are now immensely clarified. Here the Permian trilobite world is divided into two realms in addition to two provinces and two regions as shown in a palaeogeographical map.

Preface

In Japan phillipsiid pygidia were first found in the Kitakami mountains in 1888. Later trilobite localities were increased from various areas, but little has been done on their palaeontology until very recent. In this monograph twenty-two Japanese species of Permian trilobites are all described. They belong to eleven genera in the Brachymetopidae and the Phillipsiidae. Like Carboniferous trilobites Permian ones are contained in limestone in the inner and outer zones whereas they are mostly in non-calcareous rocks in the Kitakami and Abukuma mountains in the median zone. Geologically they are in a range from early Permian to late Permian and most flourished in the middle Permian period.

It is certain that these trilobites belong to the Eurasiatic realm, but six endemic genera and subgenera indicate local colours of the Japanese fauna. Together with the neighbouring ones this fauna distinguishes the oriental province from the occidental province. The Permian trilobite sphere is divisible into the Tethyan and American realms and the former into two provinces and one region. Another region is added to the latter. The faunas of the two realms were commingled through the northern Pacific Ocean.

* Studies on Japanese Trilobites and Associated Fossils-XXXIV.

It was about 1973 that the two authors commenced a study on the Silurian trilobites of Japan. Subsequently they intended to describe other trilobites from the three younger Palaeozoic Systems. Then, incorporated with Professor M. Murata of Kumamoto University, Professor S. Sakagami of Chiba University, formerly of Ehime University, Professor J. Yanagida of Kyushu University and Professor T. Nishida of Saga University, the authors extended the plan to include some other megafossils. This project on *Studies on Japanese Trilobites and Associated Fossils* (JTAF Project) was renewed to take up with a subsidy for the Japan Academy Members in 1975. The result of the present authors' studies were successively published through Special Papers of the Palaeontological Society of Japan mostly by the financial support of the Ministry of Education, Science and Culture as follows:

1. Silurian Trilobites of Japan in Comparison with Asian, Pacific and other Faunas. *Pal. Soc. Japan, Sp. Pap.,* No. 18, 153 pp. 12 pls. 1974.
2. Devonian Trilobites of Japan in Comparison with Asian, Pacific and other Faunas. *Ibid.,* No. 20, 202 pp. 13 pls. 1977.
3. Carboniferous Trilobites of Japan in Comparison with Asian, Pacific and other Faunas. *Ibid.,* No. 23, 132 pp. 22 pls. 1980.
4. Permian Trilobites of Japan in Comparison with Asian, Pacific and other Faunas. *Ibid.,* No. 26, 92 pp. 14 pls. 1984.

In addition, *Sphaerexochus* (*Onukia*) *sugiyamai* was described in a short paper in 1976. As the result, the Silurian, Devonian and Carboniferous trilobites number at present 33, 18 and 41 species respectively. Now the Permian and older Palaeozoic trilobites of Japan total 111 species. It is indeed a great addition to the trilobitology from this little known area. As the result not only the palaeontological field, but also the world picture through these Palaeozoic periods are considerably illuminated, as discussed in the section of biostratigraphy. Some notes are given on two families, Brachymetopidae and Phillipsiidae in the palaeontological section.

For the publication of this monograph of the Permian trilobites the authors are much indebted also to Professors T. Hanai, Y. Takayanagi and T. Shuto and Drs. I. Fujiyama and J. Yanagida of the Palaeontological Society. A considerable part of trilobite specimens was collected by Professor S. Akagi, Professor K. Tachibana, Dr. Y. Okazaki, Dr. T. Ohno, and Messrs. H. Araki, T. Asami, M. Furuhashi, K. Hachiya H. Hayano, S. Hayashi, T. Hirano, M. Hori T. Imamura, T. Inaba, J. Inoue, E. Kaneko, Y. Kasahara, K. Kitagawa, H. Koizumi, F. Kojima, Y. Ishiguro, Y. Mizuno, S. Nakajima, I. Nishikawa, Y. Okada, M. Ohkura, T. Ono, K. Sasaki, H. Sato, K. Shimizu, J. Sugawara, T. Suzuki, Y. Tanaka and T. Tashiro and the manuscript was type-written by Mrs. Y. Tsuchida. Prof. M. Tamura of the Kumamoto University and Dr. N. Kambe of the Geological Survey of Japan assisted the authors in providing some copies of references. Here the authors express their warmest thanks to all of these persons and organizations.

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I. Permian Trilobites in Japan

1. The Distribution of the Permian Trilobites in Japan

The occurrence of "Schwanzfragmente eines *Phillipsia*-ähnlichen Trilobiten in Japan" was first announced by Harada in his "Die japanischen Inseln" (1890, S. 70). This discovery of trilobite pygidia was made by Kotora Jimbo (1888) in the limestone of Kobama in Naburi and in the clayslate of Nemari in Maiya where in the latter the trilobite-bearing clayslate was underlain by a fusuline limestone. Later in 1924 Hayasaka described *Phillipsia* sp. indet. illustrating three pygidia from a Permian clayslate at Imo, Yahagi Village, Kesennuma, Province of Rikuzen (Miyagi Prefecture).

While these Permian trilobite localities are all in the southern part of the Kitakami Mountains, Nagao (1931) found two pygidia of *Phillipsia* in the northern Abukuma Mountains at Kami-Mano Village, Sōma County, Fukushima Prefecture. This trilobite locality is, however, known at present to be in the Carboniferous Mano Formation (Sato, 1956). Then Mabuchi (1935) distinguished two trilobite horizons, namely the *Richthofenia* Zone and the *Yabeina* Zone in the Iwaizaki Limestone Formation at Iwaizaki, Kamihashi Village, Motoyoshi County, Miyagi Prefecture and Shiida (1940) added a few other trilobite localities.

According to Inai (1939) the Iwaizaki Limestone and the Toyoma clayslate overlying it are not monoclinal, but the stratigraphic sequence is complicated by isoclinal folding. Morikawa (1960), however, recognized three successive fusuline zones in the main part of the Iwaizaki Limestone. At any rate the trilobites occur in the *Richthofenia japonica* zone in the alternation of claysltate and black limestone at the top of the Iwaizaki Limestone whence Endo and Matsumoto (1962) described *Pseudophillipsia obtusicauda* (Kayser).

One year before Endo and Matsumoto's report Araki (1961) collected numerous specimens including cephala at many localities in Kesennuma district in the upper clayslate beds of the Kamiyatsuse Formation or the Middle Permian Kanokura Series and referred the trilobites to *Pseudophillipsia*. Then S. Jimbo (1966) collected better specimens at Mt. Kurosawa, Kesennuma district and identified them with *Pseudophillipsia obtusicauda.* Koizumi (1964), on the other hand, divided the *Richthofenia japonica* Zone of Iwaizaki into two parts where only *Pseudophillipsia obtusicauda* was found in a lower horizon, and this species was associated with *Paladin yanagisawai* Endo and Matsumoto (i.e. *Jimbokranion subovalis*, sp. nov. p. 74) in an upper horizon.

The trilobite fauna of the Kesennuma district was further enriched by Araki and Koizumi (1968) and Koizumi and Sasaki (1978). The latter found six species at Omote-Matsukawa and Myôgasawa in the district as follows:

Trilobites	Kanokura Series	
	Lower	Upper
Cheiropyge aff. *himalayensis*		×
Pseudophillipsia aff. *obtusicauda*	×	
Pseudophillipsia aff. *sumatrensis*	×	
Pseudophillipsia aff. *anshuensis*	×	×
Ditomopyge (*Paragriffithides*) sp.		×
Thaiaspidinae indet., (i.e., *Paladin* sp. Araki & Koizumi, 1968)	×	×

According to them the lower Kanokura Series in the table is approximately correlated to the Kattizawa Stage with the *Parafusulina* Zone. The upper Kanokura Series is the Iwaizaki Stage possibly inclusive of the top of the Kattizawa Stage. The lower and upper part of the Iwaizaki Stage corresponds to the *Neoschwagerina* Zone and the *Yabeina* Zone respectively.

In the Maiya district in the southern Kitakami Mountains Onuki *et al.* (1960) and Onuki (1969) distinguished two trilobite horizons, namely *Phillipsia* sp., *Pseudophillipsia* sp. and *Anisopyge* sp. in the Nishikori Formation (*Pseudoschwagerina* Zone) i.e. in the lower part of the Sakamotozawa Series and *Pseudophillipsia obtusicauda* and *Phillipsia* sp. in the Tenjinnoki Formation (*Neoschwagerina* Zone), i.e. the lower part of the Kanokura Series. There the upper part of the Kanokura Series is indicated by the Yamazaki Conglomerate Formation (*Yabeina* Zone).

In summarizing these reports there are probably four trilobite horizons in the Permian System of the Kitakami Mountains. Namely, the Nishikori trilobites in the *Pseudoschwagerina* Zone, the Kattizawa trilobites in the *Parafusulina-Neoschwagerina* Zone and those of the Tenjinnoki Formation and the upper part of the Iwaizaki Limestone in the *Yabeina* Zone. These four trilobite zones in ascending order would be approximately Sakmarian or Wolfcampian, Artinskian or Leonardian, Socian or lower Guadalupian (Wordian) and Basleoan or upper Guadalupian (Capitanian) in age respectively.

In the southern Abukuma Mountains Kobiyama (1956) and Yanagisawa (1958) discovered *Griffithides* cf. *brevicauda* and a new phillipsiid at Takakura-yama, 7 km to the west of Yotsukura, Fukushima Prefecture. Yanagisawa and Nemoto (1961) dated the trilobite-bearing Kashiwadaira Clayslate at Middle Permian. Endo and Matsumoto (1962) erected a new species, *Paladin yanagisawai* for the phillipsid. Later Takaizumi (1971) found a complete dorsal shield of a new trilobite in association with *Paladin yanagisawai* in the Kashiwadaira Clayslate and Koizumi (1972) proposed a new generic name, *Endops* for *Paladin yanagisawai* and *Nipponaspis takaizumii* gen. et sp. nov. for the other trilobite.

In the Ashikaga Mountains in the northern part of the Kwanto region Fujimoto (1961) first announced a trilobite occurrence at Kuzuu. Hayashi and others (1976) reported *Pseudophillipsia* from Tsukura, Kiriu City, Gunma Prefecture. Recently Koizumi, Yoshino and Kojima (1979) described and illustrated a pygidium of *Pseudophillipsia* (*Pseudophillipsia*) sp. from the Yamasuge Limestone (*Parafusulina* Zone) of the Nabeyama Formation at Yamasuge, Kuzuu Town, Tochigi Prefecture.

Compared with Northwest Japan less has been known of Permian trilobites in Southwest Japan, particularly in its outer zone. Nakazawa (1958) was the first to report two pygidia of trilobites from Katsura-dani (Kato Village), Hirohata, Ohé Town, Kasa County, Kyoto Prefecture. Okubo provisionally compared them with *Pseudophillipsia* sp. from the top part of the Iwaizaki Limestone. Associate brachiopods are allied to the Middle Permian Kanokura fauna.

The second locality in the inner zone is Mihara-noro, Tojo Town, Hiba County, Hiroshima Prefecture where the Permian limestone contains a copious macrofossils including three species of trilobites (Hayasaka and Nishikawa, 1963). Endo and Matsumoto (1960) reported the occurrence of a pygidium of phillipsiid indet, from the lowest Permian *Triticites nishikawai* Subzone of the *Pseudoschwagerina* Zone. Recently *Griffithides* sp. and *Paladin* sp. were described by Akagi (1971) from the Lower Permian *Pseudoschwagerina* Zone of the Mihara-noro Formation on the hillside of Mirahara-noro, Tojo Town.

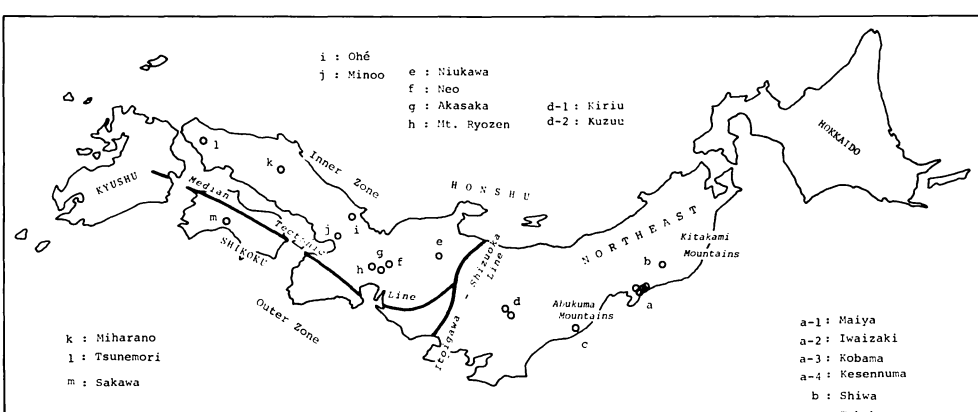
In the Outer Zone of Southwest Japan Imamura (1966) discovered in the Shimoyama Limestone in the Sakawa basin, Kochi Prefecture, Shikoku Island a trilobite pygidium, or *Neoproetus* sp. by Hamada's preliminary determination. This limestone contains an exotic faunule for the Chichibu Group of Shikoku which is profused in corals and sponges, but fusulines are rare. They are *Waagenophyllum indicum, Amblysiphonella shikokuensis, A. mabuchii* and *Rhabdactina columnaria* besides *Staffella sphaerica* and *"Glomospira"* sp. and their age was considered early? Permian by Yabe and Sugiyama (1934). Later it was considered as late as late Permian (*Yabeina* Zone). As the result of the present study, the trilobite in question is determined to be a *Paraphillipsia* and its age is probably late Middle Permian, as this trilobite genus was most flourished in the Middle Permian.

As shown in Text-figure 1, Permian Trilobites are widely distributed in Northeast and Southwest Japan as well as in the Inner and Outer Zones. In two advanced papers (1980, a, b) the authors have described four new species as follows:

1. *Paraphillipsia levigata* from the Shimoyama Limestone, Sakawa basin, Shikoku Island.
2. *Neogriffithides imbricatus* from the Middle Permian limestone, Mt. Ryozen, Kinki region.
3. *Pseudophillipsia intermedia* from the Middle Permian limestone, Neo, Gifu Prefecture.
4. *Pseudophillipsia spatulifera* from the Kanokura Formation, Kesennuma City, Miyagi Prefecture.

Recently trilobites were found by Kojima and others (1984) in the Akasaka Limestone from the *Parafusulina* (or *Pseudodoliolina*) Zone, *Neoschwagerina* Zone, *Yabeina globosa* Zone and the *Codonofusiella-Reichelina* Zone, and now three distinct species of *Pseudophillipsia* (*Pseudophillipsia* and *Nodiphillipsia*) were distinguishable among them.

Fresh materials together with part of these previous collections are dealt with in the project of this study and the results thus obtained will follow.



Text-fig. 1. Localities of Permian trilobites in Japan.

2. Permian Trilobites in Japan

a. The Kesennuma-Iwaizaki District in the Kitakami Mountains

The Kesennuma-Iwaizaki district in the southern Kitakami Mountains is most prolific among the trilobite localities in Japan. There the Permian System is represented by the Sakamotozawa, Kanokura and Toyoma Formations in ascending order. In the Kesennuma district the Kattizawa Stage in the lower part of the Kanokura Formation is particularly rich in brachiopoda and bivalves including *Leptodus richthofeni.* Omote-matsukawa of Tsukitate has been known as the type locality of *Monodiexodina matsubaishi* (Fujimoto).

Trilobites dealt with in this study were collected at Myogasawa, Anabuchi, quarries of Omote-Matsukawa and some other localites mostly from the Kattizawa Stage, but part of the collection obtained from Anabuchi (II) and quarries of Omote-Matsukawa (II, III) may be derived from the Iwaizaki Stage.

The followings were determined in the Kesennuma trilobite collection.

Trilobites \ Localities	1	2	3	4	5	6
Cheiropyge (*Suturikephalion*) *koizumii* Kobayashi and Hamada			X	X		
Ditomopyge densigranulata, sp. nov.				X		
Pseudophillipsia (*Nodiphillipsia*) *spatulifera* Kobayashi and Hamada			X		X	
Pseudophillipsia (*Nodiphillipsia*) *sasakii*, sp. nov.			X			
Pseudophillipsia (*Nodiphillipsia*?) *simplex*, sp. nov.			X			
Pseudophillipsia aff. *simplex*				X		
Pseudophillipsia (*Nodiphillipsia*?) *binodosa*, sp. nov.			X			
Pseudophillipsia aff. *binodosa*				X		
Ampulliglabella kojimai, sp. nov.	X		X			
Ampulliglabella rotunda, sp. nov.		X	X	X		
Jimbokranion subovalis, sp. nov.						X

1: Myoga-sawa
2: Hokyoji
3: Anabuchi
4: Quarries of Omote Matsukawa
5: Kamiyatsuse
6: Hosoo-zawa, Kamiyatsuse

Suturikephalion is a subgenus of *Cheiropyge* having semianchylosed facial sutures. *Ampulliglabella* is a new genus resembling *Acropyge brevica*, but the preoccipital lobe is obsolete. Its cephalon is also similar to *Thaiaspis*, but it has the depressed marginal border on the cephalon and its pygidium is not mucronate. *Jimbokranion* is another new genus resembling *Thaiaspis.* These two genera and one subgenus are all indigenous. *Ditomopyge* as a genus is cosmopolitan. *D. densigranulata* is, however, an aberrant species in which granulation is developed.

Pseudophillipsia (*Nodiphillipsia*) is the leading subgenus in the Kesennuma trilobite assemblage as represented by more than four species. This subgenus is wide spread in the late Permian of Asia as far as Caucasus. *Pseudophillipsia* (*Nodiphillipsia*) *spatulifera* is such a unique species showing high specialization in the spatulate genal spines.

Beside them a poorly preserved pygidium was collected from Upper (?) Permian exposure at Zenchaya, Shishiori Village of the district.

In the Iwaizaki area adjacently to the south of Kesennuma City, there is the Iwaizaki Limestone Formation, about 200 m thick which is very rich in brachiopods, corals and various other macrofossils. By means of fusulinids three zones are distinguished, namely the *Monodiexodina matsubaishi* Zone, the *Pseudofusulina paramotohashii* Zone and the *Lepidolina multiseptata* Zone in ascending order. The last zone is the correlative to the *Lepidolina-Yabeina* Zone and the two others are considered near the *Neoschwagerina* and *Parafusulina* Zones. Therefore the main lower part of the Iwaizaki Limestone belongs to the Kattizawa Stage and the upper part represents the Iwaizaki Stage.

Koizumi (1964) reported the occurrence of *Paladin yanagisawai* and *Pseudophillipsia obtusicauda* from the alternation of limestone with black clayslate and schalstein in the upper Iwaizaki Limestone Formation. The former is quite different from *Endops yanagisawai.* It is here named *Jimbokranion subovalis,* gen. et sp. nov. The latter is a deformed pygidium whose segmentation is obscure. Hence no comment can be given here.

The Kesennuma trilobites are mostly Guadalupian and the Iwaizaki trilobites are probably Kazanian-Capitanian.

b. Shiwa near Morioka, Iwate Prefecture

In association with *Leptodus* and other Permian brachiopods a few trilobite remains were reported by Sato (1971) to occur at Hiraguri, Sahinai, Shiwa town on the western margin of the central Kitakami Mountains. This is the northern-most locality of the Japanese trilobites.

The senior author examined a better preserved pygidium among them. It is parabolic in outline. A narrow marginal border is imperfectly preserved (Pl. I, fig. 15). The axial lobe is high, flat-topped, steeply slanting laterally and composed of 20 or more rings; pleural ribs tuberculate, countable more than 16 of which anterior ones are divided into two riblets by an interpleural furrow. This pygidium belongs evidently to *Pseudophillipsia*. It resembles *Pseudophillipsia spatulifera* closely.

c. The Takakura-yama Area, Abukuma Mountains

The Permian rocks of the area are classified into three formations in ascending order as follows:

The Iriishikura Slate Formation, about 100 m thick.

The Motomura Sandstone Formation, 150 to 300 m thick.

The Kashiwadaira Formation, about 400 m thick, composed of black shale and fine sandstone.

The last formation yields *Lepidolina multiseptata, Leptodus richthofeni* and other brachiopods, cephalopods and other fossils including two species of trilobites, namely

Nipponaspis takaizumii Koizumi

Endops yanagisawai (Endo and Matsumoto).

The age of the fauna is upper Guadalupian and nearly contemporaneous with the Iwaizaki fauna.

d. The Kuzuu and Kiriu Areas in the North Kwanto Region

In the Ashio Mountains the Nabeyama Formation consists mainly of limestone and dolomite and overlies the Izuru Volcanic Formation. It contains fusulinids and brachiopods abundantly. Its lower division called Yamasuge Limestone contains *Parafusulina kaerimizensis*, *Helicoprion* and brachiopods and its age is nearly Artinskian.

Trilobites collected from the areas are as follows:

From Tsukuhara, Kiriu area, Gunma Prefecture:

Pseudophillipsia (*Pseudophillipsia*) *kiriuensis*, Kobayashi and Hamada, 1984

Pseudophillipsia kiriuensis subtrigonalis, subsp. nov.

From Yamasuge, Kuzuu, Tochigi Prefecture:

Pseudophillipsia (*Pseudophillipsia* ?) *kuzuensis*, sp. nov.

e. Niukawa, Gifu Prefecture

A fragmentary free cheek of a trilobite illustrated by Okazaki (1982) was collected from the Permian formation at Hiomo, Niukawa near Takayama.

f. Neo, Gifu Prefecture

From Neo, Gifu Prefecture, the Middle Permian limestone (*Parafusulina-Neoschwagerina* Zone) yields *Pseudophillipsia* (*Carniphillipsia* ?) *intermedia* Kobayashi and Hamada.

g. The Akasaka Area, Gifu Prefecture

Akasaka is a classical locality for the palaeontology of Japan. *Fusulina japonica* Gümbel, 1874 therefrom is the oldest Linnéan name founded on a Japanese fossil (Kobayashi, 1980). Later the Akasaka Limestone was studied by Schwager (1883) and many others. Wakimizu (1902) classified the limestone into nine units lithologically the ninth of which called Sarasa overlying the others unconformably. Ozawa (1927) distinguished four *Neoschwagerina* zones and 12 subzones of fusulinids in the limestone formation. Various fossils have been described from the Akasaka Limestone, but no trilobite was found there until recent years (1973). As the result of the subsequent fossil hunting by Kojima and others many trilobites were collected from different horizons from the upper *Parafusulina* (or *Pseudodoliolina*) Zone to the *Codonofusiella-Reichelina* Zone. In their collection they distinguished three species of *Pseudophillipsia* (1984). The present authors described later five species from four zones as follows:

1. Upper *Parafusulina* Zone (or *Pseudodoliolina* Zone) —*P.* (*Pseudophillipsia*) *kiriuensis* Kobayashi and Hamada
2. *Neoschwagerina* Zone — { *P.* (*Pseudophillipsia*) *catena* Kobayashi and Hamada; *P.* (*Pseudophillipsia*) *akasakensis* Kobayashi and Hamada }
3. *Yabeina globosa* Zone — *P.* (*Nodiphillipsia*) *ozawai* Kobayashi and Hamada
4. *Reichelina changhsingensis* Zone — *Pseudophillipsia* (*Nodiphillipsia*) *hanaokensis* Kobayashi and Hamada

As stated above, *P. kiriuensis* occurs in the Yamasuge Formation and its age is evidently Nabeyaman or early Middle Permian, whereas *P.* (*Nodiphillipsia*) *hanaokensis* is undoubtely Upper Permian.

h. Mt. Ryozen, Suzuka Range, Shiga Prefecture

Neogriffithides imbricatus Kobayashi and Hamada was collected from the Permian limestone of Mt. Ryozen, in the Suzuka range which yields *Pseudofusulina, Pseudoschwagerina* and *Paraschwagerina.*

i. The Ohé Area, Kyoto Prefecture

Nakazawa (1958) found two pygidia of trilobites at Katsura-dani, Hirohata, Ohe Town, Kyoto Prefecture in sandy shale containing *Lyttonia* cf. *nobilis* and other brachiopods suggesting the relation to the Kanokura fauna. Okubo referred the trilobites to *Pseudophillipsia,* because it resembles the trilobite in the bryozoan bed at the top of the Iwaizaki Limestone. This trilobite horizon is presumed to be Middle Permian or late Middle Permian in age.

j. Minoo Waterfall, Osaka Prefecture

An imperfect pygidium of a trilobite (Pl. I, Fig. 14) found in the Tamba Group near Minoo waterfall in Osaka Prefecture, West Japan belongs probably to a griffithid whose age is Permian, if not Carboniferous.

k. Mihara-noro, near Tojo, Hiroshima Prefecture

Endo and Matsumoto (1962) described Phillipsiidae gen. et sp. indet. from the *Triticites nishikawai* Subzone of the *Pseudoschwagerina* Zone at Kue-Mihara-noro, Tojo Town, Hiba district, Hiroshima Prefecture. Subsequently Akagi (1971) determined his trilobites also from the *Pseudoschwagerina* Zone of Miharano as *Griffithides* sp. and *Paladin* sp.

As the result of the restudy on Akagi's trilobites, the cranidium and associate pygidium of *Griffithides* sp. is found to be a new trilobite allied to *Neoproetus.* Because the specimens are imperfect, this form is here denominated "*Neoproetus*" *akagii,* sp. nov. Akagi's *Paladin* sp. and probably Endo and Matsumoto's indeterminable trilobite from the same limestone may be two pygidia of this new species. This is an earliest Permian or Asselian species.

l. The Tsunemori Area, near Akiyoshi Plateau, Yamaguchi Prefecture

A trilobite pygidium was found in the Tsunemori Formation at Hinaga, Omine Town, Mine City, Yamaguchi Prefecture. Insofar as can be seen in Okafuji's illustration (1971), it is a long subtrigonal multisegmented pygidium with a relatively narrow flat-topped axis. It belongs most probably to *Pseudophillipsia,* as the junior author has previously suggested *Pseudophillipsia obtusicauda* for it (in Okafuji, 1971, p. 40).

Another pygidium was obtained from the same locality. Okafuji's illustration shows that it is an internal mould of a less segmented, ill-preserved pygidium to which the junior author has tentatively given the name "*Paladin*" *yanagisawai* with a question mark.

In West Japan this is a sole exception that the Permian trilobite is contained in shales.

m. Shimoyama, Sakawa Basin, Kochi Prefecture, Shikoku Island

Paraphillipsia levigata Kobayashi and Hamada from the Shimoyama Limestone in the Sakawa basin, Shikoku Island is the solitary trilobite in the outer zone of Southwest Japan. The age of the Shimoyama Limestone has been disputed for years, but now it can be determined at late Middle Permian because of the wide distribution of *Paraphillipsia* from Crimea to the Far East in the age. This conclusion is in support of the fact that the Shimoyama fauna is similer to the Iwaizaki fauna in association of *Amblysiphonella* and other fossils.

Fossil List 1. Permian trilobites of Japan

Trilobites \ Localities	Shiwa	Kesennuma	Iwaizaki	Takakura-yama	Kuzuu	Kiriu	Neo	Akasaka	Mt. Ryozen	Ohé	Minoo	Miharano	Tsunemori	Sakawa
Cheiropyge (*Suturikephalion*) *koizumii*		X												
Nipponaspis takaizumii				X										
Paraphillipsia levigata														X
"Neoproetus" akagii, n. sp.												X		
Paladin (?) *iwaizakiensis*, n. sp.			X											
Endops yanagisawai				X									?	
Neogriffithides imbricatus									X					
Ditomopyge densigranulata, n. sp.		X												
Pseudophillipsia (*Pseudophillipsia*) *kiriuensis*,						X		X						
Pseudophillipsia (*Pseudophillipsia*) *kiriuensis* forma *subtrigonalis*, n. f.						X								
Pseudophillipsia (*Pseudophillipsia* ?) *kuzuensis*, n. sp.					X									
Pseudophillipsia (*Pseudophillipsia*) *akasakensis*								X						
Pseudophillipsia (*Pseudophillipsia*) *catena*								X						
Pseudophillipsia (*Carniphillipsia* ?) *intermedia*						X								
Pseudophillipsia (*Nodiphillipsia*) *spatulifera*		X												
Pseudophillipsia (*Nodiphillipsia*) *sasakii*, n. sp.		X												
Pseudophillipsia (*Nodiphillipsia* ?) *simplex*, n. sp.		X												
Pseudophillipsia (*Nodiphillipsia* ?) aff. *P.* (*N.* ?) *simplex*		X												
Pseudophillipsia (*Nodiphillipsia* ?) *binodosa*, n. sp.		X												
Pseudophillipsia (*Nodiphillipsia* ?) aff. *P.* (*P.* ?) *binodosa*		X												
Pseudophillipsia (*Nodiphillipsia*) *ozawai*								X						
Pseudophillipsia (*Nodiphillipsia*) *hanaokensis*								X						
Pseudophillipsia sp. indet.	X	X								X			X	
Ampulliglabella kojimai, n. sp.		X												
Ampulliglabella rotunda, n. sp.		X												
Jimbokranion subovalis, n. sp.		X												
Griffithid, gen. et sp. indet.											X			

3. The Sequence of the Permian Trilobite Horizons in Japan

The Permian System is generally divided into two or three parts, each comprising one or more formations as commonly adopted in biostratigraphy in Eurasia, North America and other areas. The limitation and correlation of these parts and formations, however, often disagree in some details. Therefore, in weighing various opinions, such units are correlated tentatively as shown in Table I, in considering their para-synchronism.

Table 1. Division of the Permian System.

<table>
<tr><th>Biparti-tion</th><th colspan="2">German Basin</th><th>Tripar-tition</th><th colspan="2">Eur-Asia</th><th colspan="2">North America</th><th>Biparti-tion</th></tr>
<tr><td>Upper</td><td colspan="2">Zechstein (Thuringian)</td><td>Upper</td><td colspan="2">Tatarian, (Dzhulfian) Chideruan</td><td colspan="2">Ochoan</td><td rowspan="3">Upper</td></tr>
<tr><td rowspan="5">Lower</td><td rowspan="5">Rotliegend</td><td rowspan="2">Saxonian</td><td rowspan="3">Middle</td><td rowspan="2">Kazanian /Ufimian</td><td>Basleoan</td><td>Capitanian</td><td rowspan="2">Guada-lupian</td></tr>
<tr><td>Socian</td><td>Wordian</td></tr>
<tr><td rowspan="3">Autunian</td><td>Kungurian /Artinskian</td><td>Artinskian, s.l.</td><td colspan="2">Leonardian</td><td rowspan="3">Lower</td></tr>
<tr><td rowspan="2">Lower</td><td>Sakmarian</td><td rowspan="2">Sakmarian, s.l.</td><td colspan="2" rowspan="2">Wolfcampian</td></tr>
<tr><td>Asselian</td></tr>
</table>

In Japan the Permian strata are generally classified into five formations or series with special reference to fusuline zones, but details of the zonation and correlation are not yet settled. For instance, important questions are attached to the Nabeyaman Series as an lower Middle Permian unit of the Japanese Permian and also on the *Yabeina-Lepidolina* Zone or *Yabeina globosa* Zone as to its reference to either the upper Middle or the lower Upper Permian. A further intensive investigation is required to complete correlation of the uppermost part of the Permian sequence. Nevertheless the tripartition of the system which is a little different from the foreign ones is generally accepted. Under this circumstance the international correlation of these divisions as well as five series to the foreign classifications in Table 2 is inevitably tentative.

Table 2. Division of the Permian System in Japan.

<table>
<tr><th>Series</th><th>Stage</th><th>Fusulinacean Zone</th><th>Conodont Zone</th></tr>
<tr><td rowspan="2">Upper</td><td>Mitaian</td><td>Palaeofusulina</td><td rowspan="3"></td></tr>
<tr><td>Kuman</td><td rowspan="2">Lepidolina – Yabeina</td></tr>
<tr><td rowspan="2">Middle</td><td>Akasakan</td></tr>
<tr><td>Nabeyaman</td><td>Neoschwagerina</td><td>Diplognathodus lanceolatus-D. nodosus</td></tr>
<tr><td rowspan="3">Lower</td><td rowspan="3">Sakamotozawan</td><td>Parafusulina</td><td>D. oertlii-Neostreptognathodus pequopensis</td></tr>
<tr><td rowspan="2">Pseudoschwagerina</td><td>Neogondolella bisselli-Sweetognathodus whitei</td></tr>
<tr><td>Streptognathodus elongatus</td></tr>
</table>

It is noteworthy that the trilobites from West Japan and the Ashikaga Mountains in the eastern extension of the Inner Zone of West Japan are contained in limestones, while the mother rocks of the trilobites from Takakura-yama and the Iwaizaki-Kesennuma district in North Japan which are geotectonically located in the Median Zone are mostly non-calcareous rocks.

The oldest of them is *"Neoproetus" akagii* from the lowest Permian of Mihara-noro. Judging from its morphology it indicates an early off-shoot probably of the *Neoproetus* stock, instead of the progenitor of *Neoproetus* and its allies by itself.

The next oldest may be *Neogriffithides imbricatus* from Mt. Ryozen. In Europe *Neogriffithides* ranges from Sakmarian to early Artinskian. The Ryozen Limestone yields *Pseudoschwagerina,* but *Pseudofusulina* also occurs in the Suzuka Range. The imbrication of the salient median crests of the axial rings reveals its specialization. The age of this species is either late Sakmarian or early Artinskian.

The third horizon is indicated by the Nabeyaman trilobites from the Yamasuge Limestone which is pene-contemporaneous with the Wordian, but its lower part extends probably into the upper part of the Leonardian or Artinskian. These trilobites are *Pseudophillipsia (Pseudophillipsia) kiriuensis* and probably *Pseudophillipsia (Pseudophillipsia ?) kuzuensis.*

Another Nabeyaman horizon is represented by *Pseudophillipsia (Carniphillipsia) intermedia* from the limestone of the *Parafusulina-Neoschwagerina* Zone at Neo in the northwestern part of Gifu Prefecture.

The Akasaka Limestone ranges from Nabeyaman to Mitaian. From the viewpoint of trilobite evolution two horizons of *Pseudophillipsia (Nodiphillipsia)* are suitable to include in Upper Permian, but it is still a question whether the *Yabeina globosa* Zone is lower Upper Permian or it is better placed at the top of the Middle Permian.

The Kesennuma trilobites were collected from some different horizons of the Kanokura Formation which ranges from upper Nabeyaman to basal Kuman. Judging from Koizumi and Sasaki's report (1978) *Pseudophillipsia* is more flourished in the lower part called the Kattizawa Stage, but the geneirc variation is greater in upper part called the Iwaizaki Stage.

In the collection dealt with in this monograph, Myoga-sawa, Hokyoji and Kamiyatsuse (1, 2, 5) and Hosoo-zawa, Kamiyatsuse (6) yield each only a single species, while all of the species occur in Anabuchi or/and quarries of Omote-Matsukawa (3, 4). There are probably two or more horizons at the latter two localities. It is a remarkable fact that in this district *Pseudophillipsia* is best represented in the Anabuchi collection. *Pseudophillipsia (Nodiphillipsia) spatulifera* is one of the most specilized species of the genus.

The Kattizawa trilobites are mostly late Nabeyaman to Akasakan in age. In adding three species of *Pseudophillipsia* from Kuzuu, Kiriu and Neo, the genus has flourished in Japan in the Nabeyaman-Mitaian age, when the generic variation was advanced. In the upper Middle-lower Upper Permian fauna the two Takakura-yama trilobites, *Nipponaspis* and *Endops,* are endemic. Likewise, *Ampulliglabella, Jimbokranion* and *Cheiropyge (Suturikephalion)* of the Kesennuma area are other two endemic genera and one endemic subgenus.

An exact correlation of the Iwaizaki sequence to the fusuline zones of West Japan is difficult, but *Paladin* (?) *iwaizakiensis* from the upper part of the Iwaizaki Stage may be the latest survivor of *Paladin.*

It is noted that *Waagenophyllum indicum* (Waagen and Wentzel) and *Amblysiphonella* occur in the *Yabeina* Zone of the Iwaizaki area as well as the Shimoyama Limestone of the Sakawa basin. Therefore the latter containing *Paraphillipsia levigata* is probably the correlative of the *Yabeina* Zone of Iwazaki. The extensive distribution of *Paraphillipsia* from Crimea to the Far East through the Himalaya and Southeast Asia suggests the Middle Permian age of the

Shimoyama Limestone. It is, however, still a question that the *Yabeina-Lepidolina* Zone is either upper Middle Permian or lower Upper Permian.

The trilobite horizons are fairly succesive in Japan from Sakamotozawan to Mitaian as follows:

Early Sakamotozawan: – "*Neoproetus*" *akagii*

Late Sakamotozawan-early Nabeyaman: – *Neogriffithides imbricatus*

Nabeyaman:– Trilobites from Kuzuu, Kiriu and Neo

Akasakan partly Nabeyaman:– Kattizawa trilobites

Late Akasakan: – *Nipponaspis, Endops, Jimbokranion, Paraphillipsia levigata*

Late Akasakan-early Kuman: – *Paladin* (?) *iwaizakiensis*

Akasakan to Mitaian: – *Pseudophillipsia* (*Nodiphillipsia*)

The trilobites were most flourished in Japan in the middle Permian or the *Parafusulina-Neoschwagerina* age, when they occur in calcareous as well as non-calcareous rocks and in Southwest Japan and Northeast Japan. *Pseudophillipsia* attained its acmic prominence of development and maintained its flourishment into the *Yabeina* zone and died out with *Pseudophillipsia* (*Nodiphillipsia*) *hanaokensis* in late Permian age. Thus the Middle Permian or the Guadalupian trilobites occupy the major part of the Japanese Permian trilobites among which such endemic genera and a subgenus as *Brachymetopus* (*Suturikephalion*), *Endops, Ampulliglabella,* and *Jimbokranion* and some aberrant or highly specialized species like *Nipponaspis takaizumii, Paraphillipsia levigata, Ditomopyge densigranulata* and *Pseudophillipsia* (*Nodiphillipsia*) *spatulifera* have been included. *Pseudophillipsia* is the most common and wide-spread genus in the Permian age, but unknown from the Lower Permian or the Sakamotozawan Stage, Among the Japanese trilobites *Pseudophillipsia* (*Nodiphillipsia*) is the latest surviving subgenus which appeared probably in the Akasakan age.

II. Permian Trilobites in Asia and other Areas

1. East and Southeast Asia

During the Permian period Korea and North China have been land and the Mongolian geosyncline has already turned out an embayment opening its mouth in the maritime province of the Soviet Union. In the later part of the period Mongolia and Northeast China i.e. the former Manchuria emerged extensively. The late Permian sea was, however, lingering upon around the southern part of the maritime province of U.S.S.R.

a. Far East of the Soviet Union

Pseudophillipsia (*Anisopyge*) *suchanica* Weber, 1944, was described from Senkina Shapka in the Suchan river area, Primoria. It is indicated by a pygidium of *Anisopyge* and accompanied by *Paraphillipsia* sp. indet. The age of these trilobites is late Permian or the *Lepidolina* and *Misellina lepida* Zone (Verschagin and Krasnyi, 1958).

b. China

Phillipsia obtusicauda Kayser, 1885, from Loping, Kiangsi was referred to *Griffithides* by French (1911) and *Pseudophillipsia* by Endo and Matsumoto (1962) and G. and R. Hahn (1970). As the result of the type-revision G. Hahn and Brauckmann (1975) determined that it belongs to *Pseudophillipsia* (*Pseudophillipsia*). Its age is Lopingian or late Permian, instead of late Carboniferous as primarily considered. Incidentally, Endo and Matsumoto's *Pseudophillipsia obtusicauda* from Japan is specifically distinct from Kayser's species and belongs to *Pseudophillipsia* (*Nodiphillipsia*) *spatulifera.*

Recently *Pseudophillipsia chongqingensis,* nov. was described from the Upper Permian of Chongqing, Sichuan by Lu Yen-hao (1974). In this monograph *Pseudophillipsia lui,* nov. is proposed for *Pseudophillipsia obtusicauda* described by Lu from this locality. The occurrence of *Griffithides* sp. from Lower Permian Zhesi suite in Abahanaerqi district, Inner Mongolia, is reported by Nan Run-shan (1976).

Qian Yiyuan (1977) further amplified the Chinese trilobites with the following Upper Permian species.

Pseudophillipsia qinglongensis, nov., *P. pyriformis,* nov. and *Acropyge multisegmenta* gen. et sp. nov. from the upper Lopingian Dalong suite at Zhongying, Qinglung, Guizhou (Kweichou),

Pseudophillipsia anshuensis, nov. and *P. subcircularis,* nov. from the lower Lopingian, Longtan suite, at Jaiozishan, Anshun, Guizhou, and

Pseudophillipsia heshanensis, nov. a close ally to *P. qinglongensis,* found in the Upper Permian at Heshan, Guangxi (Kwangsi).

In the same year Zhou Tian-mei (1977) reported the occurrences of *Paladin* sp. from the Lower Permian Maokou Series in Hubei and *Pseudophillipsia obtusicauda* (Kayser) from the Upper Permian Changhsing Series in Guangdong.

Next Year Yin Gong-zheng (1978) added to them the following two species from Guizhou.

Pseudophillipsia huishuiensis, nov. from Lower Permian Chihsia suite at Chenfanquan, Guishui, and

Acropyge brevica, nov. from Upper Permian Dalong suite at Tianshengqiao, Nayong.

In 1981 Qian Yiyuan described the following Permian trilobites from Xizang (Tibet):

Pseudophillipsia cf. *chongqingensis* Lu, 1974, from the Lower Permian Xiongencuo Formation in the Baxoi district.

Ditomopyge sp. 2 from the Lower Permian Urulung Formation in the Lhünzhub district.

Pseudophillipsia raggyorcakaensis Qian, 1981, from the Upper Permian Raggyorcaka Formation in Shunanghu region.

They total 10 species of *Pseudophillipsia* and 2 of *Acropyge* besides *Griffithides* sp., *Ditomopyge* spp. and *Paladin* sp. *Ditomopyge yunchuangensis* Wang, 1937 from Yungchang, Kansu is here excluded, because it is known to be an Upper Carboniferous trilobite, while it was considered Permian.

Incidentally, the lower boundary of the Permian System in South China has been drawn traditionally between the *Pseudochwagerina* Zone of Maping Formation and the *Schwagerina tschernyschewi* Zone of the Qixia (Chihsia) Formation, but lately it was proposed to take the base of the *Pseudofusulina moelleri* or *Propopanoceras* Zone of the Longyin Formation as the boundary (Chinese Academy of Geological Science, 1979, p. 29). This change may transfer a few species of various fossils to the Permian fauna from the Carboniferous fauna.

c. Laos, Viet-Nam and Cambodia

Permian trilobites are known from Indochina as follows:

Pseudophillipsia acuminata Mansuy, 1912, from Middle Permian graywacke with *Lyttonia* cf. *tenuis* at Luang Prabang (Ban-Pak-Luang and Xieng Men), Laos.

Ditomopyge ? *proetoides* Mansuy, 1913, and *Phillipsia* sp. ? from the Lower Permian *Productus* Limestone with *Schwagerina princeps* respectively at Khan-Khent and Ban Saotai (Yan-yen sheet), North Viet-Nam. Their age may be late Carboniferous. Weber (1937) compared a pygidium of *Griffithides* sp. from the Upper Carboniferous of Timan with *Ditomopyge*? *proetoides.*

Anisopyge ? sp. Mansuy, 1913, from the Upper Permian at Ban Na Hai, Laos.

Phillipsia ? sp. Mansuy, 1914, from Takreen Phom Nien Ka near Sisophon, western Cambodia, in association with various Permian fossils.

In short, one species of *Pseudophillipsia* besides doubtful *Anisopyge* and a phillipsiid are all so far known from this part of Southeast Asia.

d. Thailand and Malaysia

Lower Permian trilobites are well represented in the Rat Buri Limestone at Tham Nam Maholan near Wang Saphung, Loei district, East-Central Thailand among which the following species were determined by the authors (1979).

Loeipyge spinifer Kobayashi and Hamada
Ditomopyge amorni Kobayashi and Hamada
Neoproetus (*Triproetus*) *subovalis* Kobayashi and Hamada
Paraphillipsia inflata Kobayashi and Hamada
Paraphillipsia cf. *inflata* Kobayashi and Hamada

They were contained in limestone boulders of the cliff-making limestone. Therefore some of them were derived from others in slightly different horizons. Nevertheless, the age of the limestone at the cliff is determined at Lower Permian or Asselian with brachiopods by Yanagida (1967) and with fusulines by Igo (1972).

In West Malaysia trilobites are known to be contained in shales of North Pahang which bear Middle and Upper Permian brachiopods and other fossils. The trilobites examined were poorly preserved, but *Ditomopyge* sp. indet. and *Neoproetus* aff. *subovalis* were discriminated among them.

e. Indonesia

Trilobite remains were collected in Timor from red and brown Trichites limestone by Reinwardt, 1821, Macklot, 1829 and Schneide, 1880. *Phillipsia* ? *parvula* Beyrich, 1865 named for a form from neighbourhood of Koepong, Timor may be the oldest among Linnean names of Oriental trilobites, if not all Asiatic trilobites. It was once said to be probably a juvenalium of *Neoproetus indicus* (Tesch, 1923, Gheyselinck, 1937, G. & R. Hahn, 1970), but now it is determined to be *Microphillipsia* ? *parvula* by Hahn and Brauckmann's type revision. Its age would be Kazanian or late Middle Permian.

Beyrich's denomination was followed by *Phillipsia sumatrensis* Roemer, 1880, from Padang, Sumatra. Later Gemmellaro (1892) made it the type-species of his genus *Pseudophillipsia.* This species was primarily considered Upper Carboniferous, but now known to be also Kazanian.

In 1923 Tesch described some Permian trilobites from Timor and Letti, including *Proetus (Neoproetus) indicus,* subgen. et sp. nov. The Timorian fauna was later greatly enriched by Gheyselinck (1937). They were obtained from the Basleo beds, whose age is Kazanian. G. R. Hahn erected two new genera, namely *Timoraspis,* 1967 for *Griffithides breviceps* and *Hildaphillipsia* for *Griffithides hildae.* At present some fifteen species of trilobites are known from Sumatra, Timor and Letti, namely one species of *Hildaphillipsia,* six species of *Neoproetus,* 2 species of *Timoraspis,* one species of *Microphillipsia* and three species of *Pseudophillipsia,* besides a few dubious ones.

Finally, in New Guinea Martin (1911) procured limestone floats in Noord river, West Irian, which contained many imperfect pygidia of small trilobites, probably *Phillipsia,* s. l.

Fossil List 2. Permian trilobites of Indonesia.

Trilobites (original identification)	Padang, Sumatra	Timor	Letti	Revised by G. & R. Hahn, 1970, 1972 and Hahn & Brauckmann, 1975
Phillipsia ? pervula Beyrich, 1865		X		*Microphillipsia ?*
Phillipsia sumatrensis Roemer, 1880	X			*Pseudophillipsia*
Phillipsia sp. Boehm, 1907		X		*Neoproetus ?*
Neoproetus indicus Tesch, 1923		X		*Neoproetus*
Phillipsia aff. *obtusicauda* Tesch, 1923		X		*Pseudophillipsia*
Phillipsia sp. indet. Tesch, 1923			X	?
Phillipsia hildae Gheyselinck, 1937		X		*Hildaphillipsia*
Griffithides trigonoceps Gheys., 1937		X		*Neoproetus*
Griffithides gerthi Gheys., 1937		X		*Neoproetus*
Griffithides baungensis Gheys., 1937		X		*Neoproetus*
Griffithides breviceps Gheys., 1937		X		*Timoraspis*
G. breviceps axistriata Gheys., 1937		X		*Timoraspis*
Griffithides brevicauda Gheys., 1937		X		*Neoproetus*
G. (Pseudophillipsia) timorensis Gheys., 1937			X	*Pseudophillipsia*
Griffithides teschi Gheys., 1937		X		*Neoproetus*

2. Permian Trilobites of the Oriental Province

In the area from Japan to Indonesia through China are known at present more than forty species of trilobites in 17 genera as follows:

Brachymetopidae: *Cheiropyge* (*Suturikephalion**)

Phillipsiidae

Linguaphillipsiinae: *Nipponaspis**, *Hildaphillipsia**
Cummingellinae: *Paraphillipsia*
Griffithidinae: *Anisopyge*, *Neoproetus*
Ditomopyginae: *Paladin*, *Endops**, *Neogriffithides*, *Timoraspis**, *Microphillipsia*, *Ditomopyge*, *Pseudophillipsia* (*Pseudophillipsia* *Carniphillipsia* ?, *Nodiphillipsia*), *Acropyge*
Subfamily Uncertain: *Ampulliglabella** *Jimbokranion**, *Loeipyge**

Among them eight genera and subgenera marked with asterisks are endemic. *Paladin* and *Ditomopyge* are two cosmopolitans of which the former appeared already in the Tournaisian and the latter in the Upper Carboniferous. *Acropyge* is an Asiatic genus known from China and Iran.

Fossil List 3. The Permian trilobite assmblages of the Oriental province.

Trilobite Genera \ Area	Primoria	NE Japan	SW Japan		China	Indochina	Thailand, Malaysia	Indonesia
			Inner Zone	Outer Zone				
Cheiropyge (*Sturikephalion*)		X						
Nipponaspis		X						
Hildaphillipsia								X
Paraphillipsia				X			X	
Anisopyge	X							
Neoproetus			X				X	X
Paladin		X			X			
Endops		X						
Neogriffithides			X					
Timoraspis								X
Microphillipsia								?
Ditomopyge		X			X	?	X	
Pseudophillipsia		X	X		X	X		X
(*Carniphillipsia*)			(X)					
(*Pseudophillipsia*)		(X)						
(*Nodiphillipsia*)		(X)	(X)		X			
Acropyge					X			
Ampulliglabella		X						
Loeipyge							X	
Jimbokranion		X						

Paraphillipsia, *Neoproetus*, *Neogriffithides*, *Pseudophillipsia* and *Microphillipsia* are Eurasiatic genera. Thus the fauna is definitely Eurasiatic, but it comprises many indigenous elements. *Anisopyge* is a sole North American element, occurring at Primoria and probably further to the west in Armenia.

3. Permian Trilobites in Australia

The occurrence of a *Phillipsia*-like pygidium has been reported by Etheridge from the Permian of Western Australia as early as 1892, but Teichert (1944) was the first to describe Permian trilobites from the continent, namely, *Ditomopyge meridionalis*, nov. from the upper

Wandagee Series in the Minilya river area and *Ditomopyge* sp. from the Fossil Cliff Limestone in the Irwin river area, both in Western Australia. The former species and probably the latter also are Artinskian in age. Stubblefield (1944) also noted the occurrence of *Ditomopyge* in the latter area. *Ditomopyge meridionalis* is an ally of *D. artinskensis.*

Fossil List 4. The Permian trilobite assemblages of the Urals-Mediterranean-Southwest Asiatic area.

Area / Trilobite Genera	South Asia	Mediterranean	Russia & West Asia
Cheiropyge	X		X
Paraphillipsia	X	X	X
Anisopyge			?
Neoproetus		X	
Kathwaia	X		X
Permoproetus		X	X
Paladin	X		
Neogriffithides			X
Microphillipsia		X	
Ditomopyge	X	X	X
Hentigia	X		
Pseudophillipsia	X	X	X
Iranaspidion	X		
Acropyge	X		

In Eastern Australia Waas and Banks (1971) distinguished the following three species of their genus, *Doublatia,* beside two indeterminable pygidia from New South Wales and Tasmania:

Doublatia inflata, nov. from Middle to Upper Permian near Newscastle, New South Wales, and

Doublatia pyriformis, nov. and *Doublatia* sp. from Sakmarian-Artinskian transition, Tasmania.

The authors are of opinion that *Doublatia* is closer to *Ditomopyge* than any other proetids. G. and R. Hahn (1975) included this genus in the Ditomopyginae.

Recently Engle and Laure (1977) added to them *Doublatia matheri,* nov. from the Lower Permian in the Manning district, New South Wales. *Doublatia* as a genus is so far restricted to occur in Southeastern Australia, while *Ditomopyge* is a cosmopolitan genus. Therefore the East Australian sea was localized from the main Tethyan trilobite province (s.l.) in the Permian period.

4. Permian Trilobites in South Asia

In 1897 Diener described two new trilobites, *Phillipsia middlemisi* and *Cheropyge himalayensis* from the Himalaya. The former was collected from Chitichun no. 1, Spiti. Sarkar (1967) referred it to *Ditomopyge* in 1962, while G. & R. Hahn (1970) suggested *Neoproetus* ? for its generic position and late Permian for its age, instead of early Permian or Permo-Carboniferous as considered by Diener and Sarkar. The latter species is accompanied by *Cyclolobus* in Chitichun. It was dated at late Permian, when Grant (1966) described late Permian (late Guadalupian-or early Dzhulfian) trilobites from the Salt Range, West Pakistan as follows:

Ditomopyge fatmii, sp. nov.

Kathwaia capitorosa, gen. et sp. nov.

The following trilobites from Darvaz, Pamir were described in Weber's *Trilobites of the Turkestan,* 1932.

Griffithides netchaevi Weber, 1932

Phillipsia tschernyschewi Netchaev, 1932

Griffithides sp. indet. II

In 1944 the first species was referred by Weber to *Griffithides* (*Cyphinium*), in other words, to *Ditomopyge,* because *Cyphinium* Weber, 1935 is synonymous with *Ditomopyge* Newell, 1931.

Prior to this Weller (1935) has described two species of trilobites from Middle or possibly Upper Permian in the western Karakorum range of Ladakh near the boundary between Kashmir and Tibet as follows:

Paraphillipsia pahara Weller, 1935

Pseudophillipsia ? sp.

The former of the two was synoymized with *Paraphillipsia tschernyschewi* (Netchaev, 1932) by Weber (1944). The age of these trilobites from Darvaz and Karakorum are determined at Artinskian or Middle Permian.

Sarkar (1967) reported the occurrences of two imperfect pygidia of trilobites in the Permian of Yanar, Anatnag district, Kashmir, in calling them as *Pseudophillipsia* sp. indet. and *Cheiropyge* sp. indet. At the same time he proposed *Ditomopyge kashmirensis* for Diener's *Phillipsia* sp. indet. 1915 from the *Fenestella* Series Aishmuquam, Kashmir. Subsequently Tewari (1970) reported that *Phillipsia seminifera* occurred in the Permo-Carboniferous beds on the left bank of the Nala, west of Muth Village, Spiti, Himalaya.

Lapparent and Pillet (1967) reported the find of *Pseudophillipsia* ? sp. at the top of the Lower Permian, Northwest of Tezak, Afghanistan. Recently Haas and Hahns (1980) explicated the fauna of this country with five new species of trilobites collected from platy limestones at four localities in central Afghanistan as follow:

Hentigia bulbops	upper part
Hentigia planops	lower part
Pseudophillipsia (*Carniphillipsia*) *loricata*	upper part
Pseudophillipsia (*Carniphillipsia*) *cooperations*	lower and upper parts
Paladin (*Paladin*) *similator*	lower part

According to them their ages are early and late Artinskian and the associate fossils and lithofacies suggest the warm shallow Permian sea for their habitat.

G. and R. Hahn (1981) described the following trilobites from the high Upper Permian of North Iran.

Acropyge weggeni G. and R. Hahn

Acropyge ? sp. indet.

Iranaspidion sp. indet.

In Central Iran *Iranaspidion sagittalis* Kobayashi and Hamada, 1978, and *Acropyge lanceolata* Kobayashi and Hamada, 1978, occur in the top part of Unit 1 (Taraz, 1971) in the Adabeh region and Unit A, Julfa, in the Permian sequence. This horizon is correlated to the *Neoschwagerina margaritae* Zone of the Akasakan Series (Iranian-Japanese Research Group, 1981) and this in turn to lower Capitanian by Nakazawa (1978).

To the south in Oman, Arabia occur the following two trilobites in the Uralian or Permian:

Pseudophillipsia lipara Goldring, 1957

Pseudophillipsia stentopyge Goldring, 1957

Both of them are referred to *Pseudophillipsia* (*Carniphillipsia*) by G. Hahn and Brauckmann (1975) and G. and R. Hahn and Ramovs (1977).

In summarizing the above statements four or five assemblages are distinguishable among some twenty species of South Asia as follows:

1. Lower Permian or Uralian of Oman
   Two species of *Pseudophillipsia* (*Carniphillipsia*).

2-a. Artinskian trilobites of Afghanistan: *Hentigia, Pseudophillipsia* (*Carniphillipsia*) and *Paladin.*

2-b. Artinskian of Pamir and Karakorum: *Paraphillipsia,* and *Ditomopyge.*

3-a. Upper Permian of Iran: *Iranaspidion, Acropyge.*

3-b. Upper Permian of the Himalaya and Salt Range: *Cheiropyge, Ditomopyge* and *Kathwaia.*

5 Permian Trilobites in the Mediterranean Region

In his classical monograph on the *Fusulina*-limestone fauna of Socio Sicily Gemmellaro (1892) has described the following eight new species of trilobites which are now referred to the genera cited behind these species.

Proetus postcarbonarius Gemm. . . . . *Permoproetus*

Proetus (?) *salomonensis* Gemm. . . . . *Permoproetus* ?

Phillipsia sicula Gemm. . . . . *Neoproetus* (*Siciliproetus*)

Phillipsia oehlerti Gemm. . . . . *Pseudophillipsia* ?

Phillipsia sociensis Gemm. . . . . *Pseudophillipsia* ?

Phillipsia pulchella Gemm. . . . . *Neogriffithides*

Griffithides verrucosus Gemm. . . . . *Neoproetus*

Pseudophillipsia elegans Gemm. . . . . *Pseudophillipsia* (*Pseudophillipsia*)

Pseudophillipsia is his genus founded on *Phillipsia sumatrensis* Roemer, 1880, as its type-species.

Later *Microphillipsia tetraptera* Ruggieri, 1959 was added to them. *Microphillipsia* was the author's new genus instituted by his new species.

Recently H. and G. Termier (1974) described *Pseudophillipsia azzouzi,* sp. nov. from the Permian of Tunisia at the Kazanian-Pamirian boundary.

The Lower Permian trilobite horizon is indicated by *Neogriffithides pulchellus alpinus* (Gortani, 1906) from the *Fusulina*-limestone of the Carnic Alps, containing *Schwagerina princeps* and other fusulinids.

Schreter (1948) described *Phillipsia* (*Pseudophillipsia*) *hungarica,* nov. from the Middle Permian of the Bükke Mountains, Hungary.

Recently G. and R. Hahn and Ramovs (1970) amplified the trilobite fauna of Europe with Middle and Upper Permian species from North West Yugoslavia as follows:

From the Middle Permian (Trogkofelian) of the Karawanken Mountains.

Pseudophillipsia elegans Gemmellaro, 1892

Pseudophillipsia sp.
Neoproetus sp.
Paraphillipsia aff. *taurica* Toumansky, 1935
Ditomopyge aff. *kumpani* (Weber), 1933

From the Upper Permian (Zazarian) of Zazar and Vrzdence, West of Lubljana.

Pseudophillipsia (*Nodiphillipsia*) *solida* Weber, 1944
Pseudophillipsia cf. *hungarica* (Schréter 1948)
Pseudophillipsia n. sp. aff. *sumatrensis* (Roemer, 1880)

In Central and South Europe there are three or four trilobite assemblages as follows:

1. *Neogriffithides* from the Sakmarian of the Carnic Alps

2-a. Middle Permian of the Karawanken: *Paraphillipsia, Neoproetus, Ditomopyge, Pseudophillipsia*

2-b. Middle Permian Socio of Sicily: *Permoproetus, Neoproetus, Pseudoproetus, Microproetus*

3. Upper Permian of the Karawanken: *Pseudophillipsia* (*Nodiphillipsia*)

6. Permian Trilobites in Russia and West Asia

Permian trilobites are widely distributed in the Urals, the Donetz basin, North Caucasus, Crimea, Armenia and Turkestan beside already stated Pamir and Primoria.

Paraphillipsia tschernyschewi Netchaev occurs not only in Darvaz, Pamir but also in Ferghana, Turkestan where in the latter *Griffithides* sp. indet. I and *Griffithides* or *Phillipsia* sp. indet. IV are also known.

a. The Urals and the Donetz Basin

Permian trilobites are known from the Artinskian of West Ural as follows:

Cheiropyge maueri Weber, 1944
Ditomopyge artinskensis (Weber, 1933)
Ditomopyge sylvensis (Weber, 1944)
Ditomopyge ? gen. et sp. indet. (*D. sylvensis* ?)
Gen. et sp. indet. III (cf. *Phillipsia middlemisi*)

In the Donetz basin *Ditomopyge rotundus* (Weber, 1933) ranges from Stephanian to Sakmarian.

b. Crimea

A large number of trilobite species and varieties besides many indeterminable forms were described by Toumansky (1935) from the Artinskian of Crimea. According to G. and R. Hahn's revision they are listed below.

Neogriffithides gemmellaroi Toumansky, 1935
Neogriffithides gemmellaroi crimensis Toumansky, 1935
Neogriffithides aliensis (Toumansky, 1935)
Neogriffithides imailensis Toumansky, 1935

Neogriffithides pulchella mussemensis Toumansky, 1935
Neogriffithides nafensis (Toumansky, 1935)
Neogriffithides aliensis (Toumansky, 1935)
Neogriffithides kojensis (Toumansky, 1935)
Neogriffithides sp. 1, Toumansky, 1935
Neogriffithides ? spp. 2 & 3, Toumansky, 1935
Paraphillipsia karpinskyi Toumansky, 1935
Paraphillipsia v.-n.-weberi Toumansky, 1935
Paraphillipsia ? *taurica* Toumansky, 1935
Paraphillipsia ? *taurica anfensis* Toumansky, 1935
Paraphillipsia ? *netschaewi* Toumansky, 1935
Paraphillipsia ? *russica* Toumansky, 1935
Paraphillipsia ? *baltensis* (Toumansky, 1935)
Pseudophillipsia borissiaki Toumansky, 1935
Pseudophillipsia borissiaki matensis Toumansky, 1935
Pseudophillipsia mustafensis Toumansky, 1935
Pseudophillipsia mustafensis sarabansis Toumansky, 1935
Pseudophillipsia elegans ibrischensis Toumansky, 1935
Permoproetus teschi Toumansky, 1935
Permoproetus gortanii Toumansky, 1935
Permoproetus beschui Toumansky, 1935
Kathwaia girtyi Toumansky, 1935
Brachymetopus ? sp. indet.

c. Caucasus and Armenia

More Permian trilobites were added to the precedings from North Caucasus and Armenia as follows:

From the Upper Permian of North Caucasus
Kathwaia girtyi caucasica (Weber, 1944)
Pseudophillipsia elegans caucasica Weber, 1944
Pseudophillipsia (*Nodiphillipsia*) *solida* Weber, 1944
Cheiropyge ? *caucasica* (Licharew, 1944)

From Armenia
Pseudophillipsia (*Nodiphillipsia*) *paffenholzi* (Weber, 1944); Upper Permian
Anisopyge ? *encrinuroides* (Weber, 1944); Permian

Among some thirty species of the Permian trilobites in European Russia and Western Asia there are two Artinskian assemblages, namely,

Cheiropyge and *Ditomopyge* in the Urals
Neogriffithides, Paraphillipsia, Pseudophillipsia, Permoproetus. Kathwaia and *Brachymetopus* ? in Crimea.

Upper Permian assemblage of Caucasus and Armenia consists of *Kathwaia, Pseudophillipsia, Cheiropyge* ? and *Anisopyge* ?

7. Permian Trilobites of the Ural-Mediterranean-Southwest Asiatic Area

The Permian trilobites in the Urals, Mediterranean, Southern and Western Asia attain some 60 species in 14 genera as follows:

Brachymetopidae: *Cheiropyge*

Phillipsiidae:

Cummingellinae:	*Paraphillipsia*
Griffithidinae:	*Anisopyge* ?, *Neoproetus, Kathwaia* and *Permoproetus*
Ditomopyginae:	*Paladin, Neogriffithides, Microphillipsia, Ditomopyge, Hentigia, Pseudophillipsia, Iranaspidion* and *Acropyge.*

Paladin and *Ditomopyge* are two Permo-Carboniferous cosmopolitan genera, while *Kathwaia, Permoproetus, Hentigia, Iranaspidion* and probably *Cheiropyge* are endemic genera. *Acropyge* is known only from Iran and China. Excluding them five genera, namely *Paraphillipsia, Neoproetus, Neogriffithides, Pseudophillipsia* and *Microphillipsia* are all Eurasiatic genera, while *Anisopyge* ? is only one American genus probably occurring in Armenia.

Paraphillipsia, Neogriffithides and *Pseudophillipsia* are particularly well represented by many species in the Tethyan realm. In the Donetz-Ural region *Ditomopyge* is most common, but the genus is represented by the Eurasiatic *artinskensis* group.

8. Permian Trilobites in the United States of America and Central and South Americas

In the central-western part of the United States the Permian trilobites are represented by *Anisopyge, Vidria, Delaria, Ditomopyge, Ameura* and probably *Cheiropyge* ? and *Pseudophillipsia* or *Paladin* (*Kaskia*).

In California *Griffithides nosoniensis* Wheeler, 1935 from the Kungurian ? Nosoni Formation in Shasta County is a solitary Permian trilobite species which may be either a *Pseudophillipsia* ? (Weller, 1944) or *Paladin* ? (*Kaskia* ?) (G. and R. Hahn, 1970).

The occurrences of *Cheiropyge* are isolated widely in the Urals, Himalayas, and probably in Kansas where in the last *C.* (?) *kansasensis* Weller, 1944, is known from the Lower Permian near Lawrence.

Vidria and *Delaria* are each represented by a Wordian and a Leonardin species both in Texas. G. and R. Hahn accepted the former as a subgenus of *Anisopyge.*

Ameura and *Ditomopyge* which thrived in the Pennsylvanian, have survived until early Permian in Nebraska and some other states.

Anisopyge is a Leonardian-Guadalupian genus in North and Central Americas distributing from Wyoming to Arizona and from Texas to Guatemala. It comprises the following species.

Anisopyge perannulata (Shumard, 1858)
Anisopyge inornata Girty, 1909
Anisopyge sevilloidia Chamberlain, 1970
Anisopyge mckeei Cisne, 1971
Anisopyge hyperbola Chameblain, 1972
Anisopyge whitei Pabian and Fagerstrom, 1972

A. whitei and *A. sevilloidia* are two oldest species appearing in latest Lower or early Middle Permian (Leonardian) age. *Anisopyge* disappeared with *A. perannulata* by the end of the Guadalupian age.

While G. and R. Hahn considered that *Anisopyge* was derived from *Paladin* through *Ditomopyge,* Chamberlain insisted the derivation of *D. sevilloidia* from *Sevillia.* Pabian and Fagerstrom on the contrary agreed with Hahns in the evolution from *Ditomopyge* to *Anisopyge,* and precisely from *D. scitula* to *A. whitei.*

Incidentally, *Anisopyge suchanica* is known from Primoria, U.S.S.R. It is noted further that the Permian species of *Ditomopyse* in Eurasia, Arctic and Australia belong mostly to the *artinskiensis* group, although *D. fatmii* is a member of the *scitula* group.

The Permian trilobites of the area under consideration are distributed in no more than eight genera mentioned below:

Brachimetopidae: *Cheiropyge* ?
Phillipsiidae:
- Commingellinae: *Ameura*
- Griffithiinae: *Anisopyge, Vidria*
- Ditomopyginae: *Paladin* (*Kaskia*), *Ditomopyge, Delaria, Pseudophillipsia* ?

Among them no Eurasiatic genus is contained except for *Pseudophillipsia* ? in California. *Cheiropyge* is an Asiatic genus, and the pygidium on which *Cheiropyge* was originally founded is not well known of *Cheiropyge* (?) *kansasensis. Paladin* and *Ditomopyge* are two well known cosmopolitan genera and in this area the *scitula* group of *Ditomopyge* indicates the American branch.

Ameura, Vidria and *Delaria* are three typical American genera. *Anisopyge* is the leading genus in the Permian trilobites of America one species of which is known from Primoria and the reference of another from Armenia is uncertain. Thus the American fauna typified by three endemic genera in addition to the *Anisopyge* and *Ditomopyge* of the *scitula* group is very distinctive from the Eurasiatic fauna.

Finally, Arellano (1983) denominated *Paladin yampupatensis,* nov. and *Ditomopyge ermeinsi* nov. for Lower Permian pygidia respectively from Yampupata (Siropaca) and Yamichambo, both in Bolivia.

9. Permian Trilobites of Spitsbergen, Alaska and the Arctic Canada

In 1968 Osmólska described *Ditomopyge roemeri spitsbergensis* and *Paladin trigonopyge,* from the Treskelodden beds, Spitsbergen and concluded that they indicate the late Carboniferous age of the beds because of the intimate relation of the former to *Ditomopyge roemeri roemeri* (v. Möller, 1867) and *D. grünewaldti* (v. Möller, 1867) from the Gzehlian Stage of the Urals, Donetz basin and Voronez region, U.S.S.R. and of the latter to *Paladin jurezanensis* (Weber, 1937) from the Upper Carboniferous of the Urals.

Ormiston (1973) reported the occurrence of *Ameura trigonopyge* (Osmólska), *Ditomopyge spitsbergensis* Osmólska and *Ditomopyge* sp. in the Lower Permian of northern Yukon, suggesting the same age of the Treskelodden trilobites of Spitsbergen. On this occasion Ormiston erected *Ditomopyge bjorensis,* nov. from Ellesmere Island whose age is lower Artinskian rather than upper Sakmarian.

Subsequently, in 1977, Chamberlain described *Paraphillipsia aglypta,* nov. and *Cheiropyge himalayensis* Diener from the Lower Permian (lower Wolfacampian) of the Alaska Range and emphasized the Eurasiatic affinities of the Arctic Permian trilobites as revealed by the *Dito-*

mopyge artinskiensis group to which these species of *Ditomopyge* belong.

As pointed out already, *Cheiropyge himalayensis* by Cahmberlain is distinct from Diener's species. Because it is a new species probably of *Cheiropyge, Cheiropyge* (?) *chamberlaini* is proposed for the Alaskan form.

Putting aside this species, the Arctic Permian trilobites belong to *Ameura, Paraphillipsia* and the *artinskiensis* group of *Ditomopyge.* With them the faunal connection may be traced from the Urals to Alaska through Ellesmere Island and Yukon. *Ameura* in Alaska together with *Pseudophillipsia* ? *nosoniensis* in California and *Anisopyge suchanensis* in Primoria shows that the sea of the mid-continent was confluent with the Arctic sea on one side and the Oriental sea on the other through California or western North America.

III. The Permian Trilobite Geography

As discussed above, the Permian trilobites of the Midcontinent of North America and Central and South Americas are so distinct enough from the Tethyan fauna that they can be accepted to be two trilobite realms. The Tethyan realm may be distinguished into the Oriental and Occidental provinces, where the former was extended into Australia. The East Australian trilobites were, however, so much localized that they constituted the Tasman region. The Arctic region was connected with the Tethyan sea through the Urals whose fauna is evidently Eurasiatic. *Ameura trigonopyge* reveals the Arctic sea connection from Spitzbergan to the American realm through Alaska. Likewise *Anisopyge suchanica* indicates the connection of the American realm to the Oriental province of the Tethys.

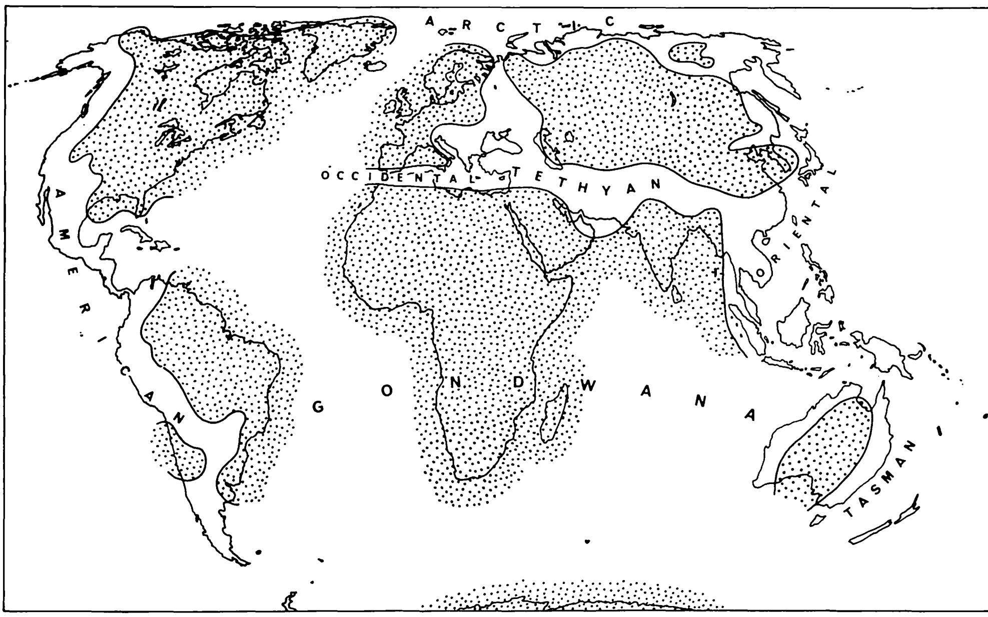
The Permian trilobite provinciality is here schematized as follows:

- Tethyan realm
  - Occidental province
  - Oriental province
    - Tasman region
- American realm
    - Arctic region

Finally, the latest survivor among the Japanese trilobites was *Pseudophillipsia* (*Nodiphillipsia*) *hanaokensis* from the *Reichelina changhsinensis* Zone of Akasaka. Upper Permian trilobites are best represented in China. Besides *Pseudophillipsia obtusicauda* many species of *Pseudophillipsia* and *Acropyge* are widely distributed in Xiangti, Sichuan, Guizhou, Guangdong and Guangxi. *P. qinglongensis, Acropyge multisegmenta* and *A. brevica* occur in the very late Permian Dalong Formation in Guizhou. *P. raggyorcakaensis* is known from the Upper Permian of Xizang (Tibet).

In Central Himalaya *Cheiropyge himalayensis* is found in association with *Cyclolobus* at Chitichun. Recently *Acropyge weggeni* was described together with *Iranaspidion* sp. from the uppermost Permian Nesen Formation in the Elburz Mountains, North Iran. In further west *Pseudophillipsia solida* is reported to occur in the Upper Permian or Zazarian (*Tyloplecta yangtzeensis* Zone) at Vrzdenec, Yugoslavia. They as a whole indicate the Tethyan sea in the late Permian age.

Pseudophillipsia (*Nodiphillipsia*) *solida* was primarily described from the Laba River basin near Urshten, North Caucasus. *P.* (*Nodiphillipsia*) *paffenholzi* from the Vedi-chai River, Armenia is its intimate relative. *Cheiropyge* ? *caucasica* from North Caucasus, *Iranaspidion sagittalis* and *Acropyge lanceolata* from Central Iran, *Kathwaia capitorosa* and *Ditomopyge fatmii* from Kathwai, Pakistan, *Pseudophillipsia* (*Nodiphillipsia*) *ozawai* from Akasaka and *Anisopyge suchanica* from the Shapke depression, Suchan basin, South Primoria, U.S.S.R. may be additional Upper Permian trilobites, if not the latest Middle Permian ones.



Text-fig. 2. Palaeogeographical map showing the Permian trilobite provinciality.

Palaeontology

Introduction and Summary

Among the Japanese trilobites Permian phillipsiids were first discovered by Kotora Jimbo in 1888, and later their occurrences were reported from various localities, but none had been closely examined until Endo and Matsumoto (1962) described *Pseudophillipsia obtusicauda* (Kayser) and *Paladin yanagisawai*, sp. nov. of which the former is here referred to *Pseudophillipsia* (*Nodiphillipsia*) *spatulifera*. Subsequently, Koizumi (1972) instituted a new genus, *Endops* for the latter and at the same time he proposed *Nipponaspis takaizumii*, gen. et sp. nov. In the advanced papers (1980a, b, 1982, 1983) the present authors have already described ten new species as follows:

Paraphillipsia levigata Kobayashi and Hamada, 1980
Neogriffithides imbricatus Kobayashi and Hamada, 1980
Pseudophillipsia intermedia Kobayashi and Hamada, 1980
Pseudophillipsia spatulifera Kobayashi and Hamada, 1980
Cheiropyge (*Suturikephalion*) *koizumii* Kobayashi and Hamada, 1982

Pseudophillipsia (Pseudophillipsia) akasakensis Kobayashi and Hamada, 1984
Pseudophillipsia (Pseudophillipsia) kiriuensis Kobayashi and Hamada, 1984
Pseudophillipsia (Pseudophillipsia) catena Kobayashi and Hamada, 1984
Pseudophillipsia (Nodiphillipsia) ozawai Kobayashi and Hamada, 1984
Pseudophillipsia (Nodiphillipsia) hanaokensis Kobayashi and Hamada, 1984
In this monograph the following nine new species are added to them;
"Neoproetus" akagii, sp. nov.
Paladin (?) *iwaizakiensis,* sp. nov.
Ditomopyge densigranulata, sp. nov.
Pseudophillipsia (Nodiphillipsia) sasakii, sp. nov.
Pseudophillipsia (Nodiphillipsia ?) simplex, sp. nov.
Pseudophillipsia (Nodiphillipsia ?) binodosa, sp. nov.
Ampulliglabella kojimai, gen. et sp. nov.
Ampulliglabella rotunda, sp. nov.
Jimbokranion subovalis, gen. et sp. nov.

These trilobites in addition to several indeterminable forms in Japan are all described in this monograph. On this occasion *Cheiropyge chamberlaini,* sp. nov. and *Pseudophillipsia lui,* sp. nov. are erected; *Iranaspidion sagittalis* and *Acropyge lanceolata* are redescribed; and comments are given on *Brachymetopus* (?) *baxoiensis, Cheiropyge* (?) *kansasensis, Acropyge multisegementa* and some other species.

The Permian trilobites in Japan total at present twenty-two species in eleven genera which are distributed in the following families and subfamilies.

Cheiropyge (Suturikephalion) Kobayashi and Hamada, 1982	Brachymetopinae
Nipponaspis Koizumi, 1972	Linguaphillipsiinae
Paraphillipsia Toumansky, 1935	Cummingellinae
"Neoproetus" Tesch, 1923	Griffithidinae
(?) *Paladin* Weller, 1936	Ditomopyginae
Endops Koizumi, 1972	Ditomopyginae
Neogriffithides Toumansky, 1935	Ditomopyginae
Ditomopyge Newell, 1931	Ditomopyginae
Pseudophillipsia Gemmellaro, 1892	Ditomopyginae
Ampulliglabella, gen. nov.	Phillipsiidae, subfamily uncertain
Jimbokranion, gen. nov.	Phillipsiidae, subfamily uncertain

Cheiropyge was divided into two subgenera, i.e. *Cheiropyge* s. str. and *Suturikephalion* (1980). Likewise, *Pseudophillipsia* was splitted into three subgenera, namely *Pseudophillipsia* s. str., *Carniphillipsia* and *Nodiphillipsia* (1984). The above genera and subgenera in addition to a few others are described or discussed in some details.

Ampulliglabella and *Jimbokranion* are two new genera instituted here respectively on *Ampulliglabella kojimai* and *Jimbokranion subovalis,* both new species. *Ampulliglabella* has the cranidium resembling *Acropyge brevica,* but the preoccipital lobe is tripartite and the pygidium is longer and more segmented in that species. This cephalon is not the less allied to *Thaiaspis,* but the marginal border is well developed and the test smooth in this genus.

Jimbokranion has the glabella resembling *Neoproetus,* but its segmentation is obsolete like *Thaiaspis* in which, however, the glabella is protruded forward and there drooping.

Cheiropyge (*Suturikephalion*) is a subgenus possessing opisthoparian facial sutüres in the cephalon and pleural ribs not distinctly projected beyond the marginal rim on the pygidium.

As already done by Campbell (1977), the family Brachimetopidae is divided into the Cordaniinae and Brachimetopinae and their evolution, particularly the latter subfamily, is here discussed. A note is given on the classification of the family Phillipsiidae.

In short, 22 species in 11 genera and two families are known now of the Permian trilobites in Japan.

Abbreviation of repositories for the specimens described and illustrated is as follows:

PAt = University Museum, University of Tokyo (Palaeozoic-Arthropoda-Trilobita)

All the specimens handled with us in this paper are stored as either originals or replicas under the series of PAt number in the museum for a convenience of research workers. Thus some specimens may have other storage numbers or collection numbers in different organizations or personal depositories as well.

Family Brachymetopidae Prantl and Přibyl, 1950

Brachymetopids and their close allies constitute an independent family in the Proetacea in "Classification des Trilobites" by Hupé (1953, 55), Moore's Treatise, Part O (1959) and Orlov's Osnoby Paleontologii (1960), while Thomas and Owens (1978), Lütke (1980) and Přibyl and Vanék (1981) disagree in its ranking and superfamily reference. Here the family Brachymetopidae is divided into two subfamilies. One is the Cordaniinae ranging from Silurian to Lower Carboniferous and the other the Brachymetopinae, Upper Devonian to Upper Permian. The former differs from the latter principally in the possession of the facial sutures whose anterior branches are widely divergent forward. In the latter subfamily the suture is generally closed, although intermittently it recurs on the dorsal shield. The anterior branch of such a suture, if opened, is quite different from those of the Cordaniinae in the gently arcuate course extending forward in front of the eye.

Since this proposal the authors found that the Cordaniinae has already been instituted by Campbell in 1977 for a subfamily of the Brachymetopidae to include *Cordania* Clark, 1892 and *Radonia* Owens and Thomas, 1975. Here this subfamily is accepted to be more comprehensively as discussed below.

Subfamily Cordaniinae Campbell, 1977

1977. Cordaniidae Campbell, *Okla. Geol. Surv. Bull.*, no. 123, p. 41.
1982. Cordaniinae Kobayashi and Hamada, *Proc. Japan Acad.*, vol. 58–B, no. 3, p. 49.

Since Prantl and Přibyl have instituted the Brachymetopinae in the Otarionidae, this subfamily was promoted to the family rank in the superfamily Proetoidea or Proetacea by Hupé (1953) and in the Treatise (1959) and Osnoby (1960). Among various genera once included in the Brachymetopidae *Namuropyge, Pararchaegonus, Piltonia* and some others were eliminated from the family, while *Brachymetopus* M'Coy, 1847, *Cordania* Clarke, 1892, *Cheiropyge* Diener, 1897, *Mystrocephalia* Whittington, 1960, *Australosutura* Campbell and Goldring, 1960 and *Radonia* Owens and Thomas, 1975 are safely acceptable to be the family members.

Unless Dean's *Otarion* sp. from the Summerford Group (Ordovician) of Newfoundland (1971) is referable to *Radonia* as suggested by Přibyl and Vaněk (1981), the oldest of these genera is *Radonia* known from the Middle Silurian of England and Bohemia, followed by Lower Devonian *Cordania* from eastern North America and *Mystrocepnalia* from late Early to Middle Devonian of eastern and central North America. In these genera the facial sutures are widely divergent anterior to eyes. The sutures are somewhat less divergent and recurved on the frontal border in *Australosutura* in the Lower Carboniferous of Australia and the Americas. Thus these opisthoparian brachymetopids have migrated from Europe to North America and then wide spread in the Southeastern Pacific area through Argentina. Because these older genera of the family have open sutures whereas the suture is generally closed in *Brachymetopus,* they are grouped here in a new subfamily, Cordaniinae. Its distinctive characteristics from the Brachymetopinae are as follows:

Cordaniinae:—Brachymetopids with widely divergent anterior facial sutures, rudimentary lateral furrows discernible in anterior to preoccipital furrows; genal spines present; pygidium with entire margin. Silurian to Carboniferous; Eur-America and South Pacific.

Tschernyshewiella Toll, 1899 bears resemblances to the otarionids on one side and the brachymetopids on the other. Be the genus included in the Brachymetopidae, it must be a member of the Cordaniinae of the family.

Subfamily Brachymetopinae Prantl and Přibyl, 1950

While the four genera of the Cordaniinae are each represented by a few species, *Brachymetopus* is a large genus comprising more than 20 species in addition to some subspecies which as a whole show a great variation. As discussed already (1980), it is appropriate to divide the genus into two subgenera i.e. *Brachymetopus* s. str. and *Brachymetopella. Cheiropyge* is another genus of the subfamily which is the most obscure as it was founded on a pygidium. A new trilobite recently found in Japan reveals a close alliance to *Cheiropyge himalayensis,* but the pleural rib of its pygidium does not terminate at such a projectile as in the type-species. Its cephalon closely resembles *Cheiropyge kansasensis,* but has opisthoparian facial sutures. Therefore a new subgenus *Suturikephalion* was instituted in *Cheiropyge* (1982). Thus the subfamily now consists of two genera and two subgenera each in *Brachymetopus* and *Cheiropyge.*

Brachymetopus is quite distinct from the Cordaniinae not only in the lack of the facial suture but also in the shorter and smaller glabella, obsolete lateral furrows except for the preoccipital pair, well developed eyes far in posterior and close set to the glabella, large preglabellar field, convex marginal border and the development of the crescentic intramarginal depression.

It is noted that the facial suture is open in very rare instances as seen in *Brachymetopus maccoyi sinimarginatus* Hahns from the upper Tournaisian of Spain as reported by Gandl (1973) and in *Brachymetopus* (*Brachymetopella*) *akiyoshiensis* Kobayashi and Hamada from the basal Moscovian of the Akiyoshi Limestone, Japan (1980). These sutures are, however, arcuate and extending forward from the eyes like those of *Suturikephalion.*

In the Cordaniinae *Australosutura* looks most similar to *Brachymetopus* not only in the dorsal aspects but in the posterolateral expansion of the rostrum also. *Brachymetopus* has appeared already in the late Devonian and most fourished in the early Carboniferous period. Because *Australosutura* is an early Carboniferous genus, it must be an off-shoot of the Cordaniinae toward the Brachymetopinae.

While *Brachymetopus* (*Brachymetopus*) declined in late Carboniferous, *Brachymetopus* (*Brachymetopella*) appeared in late early Carboniferous and the latter took the place of the former subgenus. In the formeı the basal lobe is clearly defined by the preoccipital furrow and the pygidium has entire margin in the grown stage. In the latter genus, on the other hand, lateral furrows are all obsolete and sharp marginal spines are generally present on the pygidium. The caphalon and pygidium are semicircular in the former, but they are more or less triangular, loosing genal spines and the cephalon tending to be subangulate in front.

The oldest species of *Cheiropyge* is Upper Carboniferous *Cheiropyge kansasensis* Weller, 1944. According to Weller its generic reference is somewhat uncertain, because its pygidium is so imperfect that its congenity with *Cheiropyge himalayensis* cannot be warranted. On the contray *C. kansasensis* coincides with *Suturikephallion* in most characteristics of the cephalon except for the absence of the facial suture.

The next oldest is Chamberain's *Cheiropyge himalayensis* from the lower Wolfcampian of Alaska. As it disagrees with *C. himalayensis,* it is here denominated *Cheiropyge chamberlaini.* It is represented by a pygidium which is distinct from not only *C. himalayensis* but other pygidia referred to *Cheiropyge.*

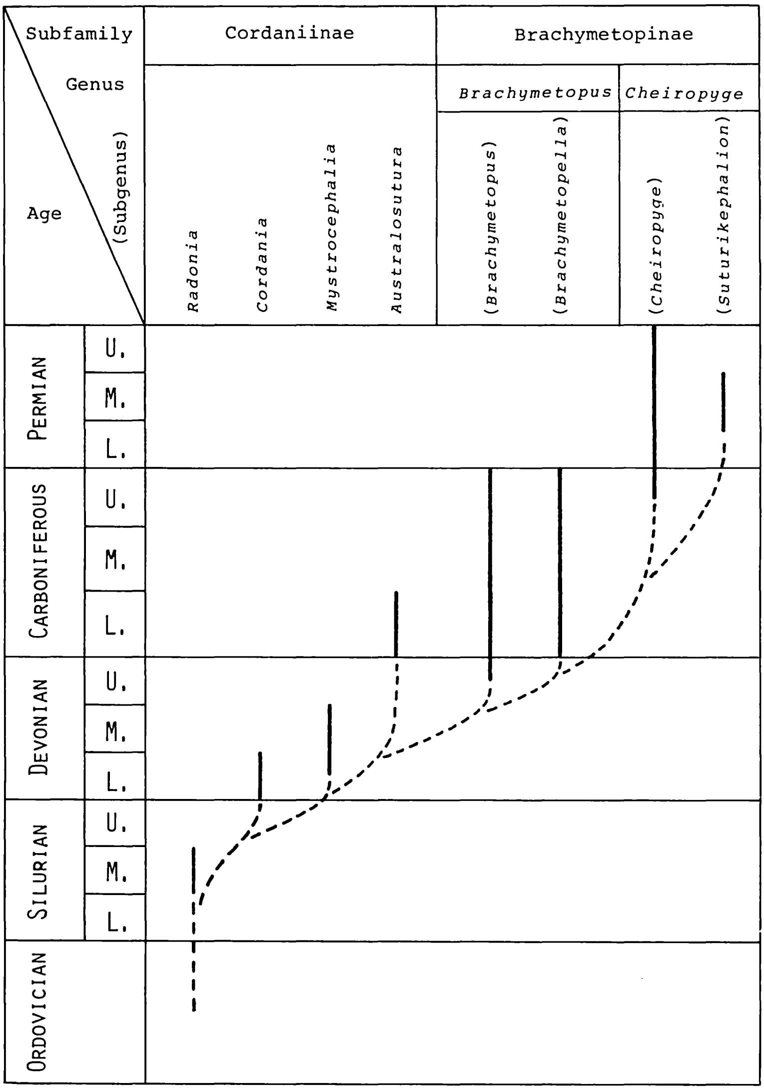
Cheiropyge maueri Weber, 1944, from the Artinskian of the Urals is also represented by a pygidium which is, however, probably congeneric with *C. himalayensis,* although its lateral margin is imperfect.

Like *C. maueri* the pygidium of *Cheiropyge* (*Suturikephalion*) *koizumii* is subtrigonal and its axial and pleural lobes are segmented in similar number. The axial lobe is, however, comparatively slender and the post-axial lappet is more developed in this species, while the pleural lobes are remarkably arching down near the margins in that species. The pygidium of *Cheiropyge himalayensis* is more rounded, its pleural ribs are distinctly projected and pointed at the ends and the post-axial piece is less developed than that of this species. Unfortunately the pygidium of *Cheiropyge kansasensis* is not well known. The generic concept of the cephalon has, however, been supplemented with *C. kansasensis* and its suture is closed. Therefore *Cheiropyge* (*Suturikephalion*) *koizumii* has to be separated from *Cheiropyge* s. str. by the possession of the opisthoparian suture.

C. (*Suturikephalion*) *koizumii* is the best known species of *Cheiropyge* represented by several well preserved dorsal shields. Its age is Middle Permian and probably early Middle Permian. *C. himalayensis* is dated at late Permian by Grant (1966). *Cheiropyge* (?) *caucasica* (Licharew in Weber, 1944) is another high Permian species represented only by a pygidium whose peripheries are imperfect. Its axis, however, has larger median tubercles on some rings like *C.* (*Suturikephalion*) *koizumii.*

Cheiropyge comprising these five or six species in the United States, Alaska, the Urals, Caucasus, the Himalayas and Japan ranges from late Upper Carboniferous to Upper Permian. Its cephalon is known of two species. Assuming that the cephalon of *Cheiropyge* s. str. is represented by *C. kansasensis,* the facial suture was secondarily opened in Middle Permian *C.* (*Suturikephalion*) *koizumii.*

Now the phylogenetic relation of the above genera in the Brachymetopidae is shown in Text-fig. 3. The Brachymetopinae were developed from the Cordaniinae by the fusion of the



Text-fig. 3. Phylogeny of the Brachymetopidae.

facial sutures and other changes in the late Devonian period. Subgenus *Brachymetopella* branched off from *Brachymetpus* s. str. in the late Lower Carboniferous by the effacement of preoccipital and other lateral furrows on the glabella, projection of pleural ribs into marginal spines on the pygidium and other modifications. Among others it is noteworthy that the cephalon became trigonal like that of *Cheiropyge.* It is certain that the *kansasensis-koizumii* lineage was issued from *Brachymetopus* (*Brachymetopella*) during the late Carboniferous Period, or probably from such a form like *Brachymetopus* No. 3 by Weber (1937, pl. 10, fig. 28) from the Stephanian of the Donetz basin.

The intergeneric relation of *Cheiropyge* is suggested in the Text-fig. 3 provisionally. *Cheiropyge* is highly specialized in the subtrigonal cephalon, development of the post-axial lappet and other aspects. The facial sutures recurred intermittently in a few species of the Brachymetopinae, but they were all less divergent, if compared with the Cordaniinae. The reduction of the divergence is, however, already recognizable in that subfamily as a tendency.

Genus *Brachymetopus* McCoy, 1847

G. and R. Hahn and Maass (1981) founded a new species, *Brachymetopus coignouides,* on Sittig's *Brachymetopus* (nov. subgen. aff. *Brachymetopus*) sp. from the Visean of South Schwarzwald which was once regarded as *Coignouina* sp. by G. and R. Hahn (1969). On that occasion these authors erected another new species *Brachymetopus vosegus* for a cephalon and three pygidia from the early Carboniferous of South Vogesen.

Brachymetopids from the Kohlenkalk of Belgium were thoroughly revised by G. and R. Hahn (1982). As the results the following new species and subspecies were added to *Brachymetopus.*

Brachymetopus ouralicus maximowae
Brachymetopus ouralicus esus
Brachymetopus sucellus
Brachymetopus sucellus waulsortensis

The type cephalon of *Brachymetopus coignouides,* 2.5 mm long, has numerous fine marginal spines and a pair of distinct nodes on the posterior cheek borders beside three paired nodes within the cheeks. These characteristics isolate this species from all others of the same genus.

Öpik's *Brachymetopus* ? sp. from the Kukruse-Stufe, Esthonia (1937) is a minute pygidium so unlike the immature pygidia of *Brachymetopus maccoyi spinosus* (Hahn, 1964) that Lütcke (1980) and Přibyl and Vaněk (1981) suggest a juvenalium of the Lichidae.

Barchymetopus (?) *baxoiensis* Qian, 1981

1981. *Brachymetopus* (?) *baxoiensis* Qian, Tibetan Fossils, p. 335, pl. 1, fig. 9.

This species is founded on a complete pygidium exclusive of its damaged frontal margin. The axis is a fourth as wide as the pygidium or a little narrower in anterior, tapering backward more abruptly in anterior half than the remainder, composed of 9 to 10 rings beside somewhat convex, small, blunt terminus; pleural lobe with 6 pairs of pronounced furrows; interpleural furrow weak or obsolete; 6 pairs of distinct convex ribs, 5 pairs of which are extending beyond lateral rim and ending at short spines; behind axis a somewhat depressed area surrounded by an entire narrow rim.

It is a remarkable fact that the pleural ribs are distinctly expanding distally, bending backward, projecting shortly beyond the marginal rim to form rounded termini, instead of sharp spines. Furthermore it possesses post-axial piece comparable with the Diener's posterior axial lappet. Thus it agrees with *Cheiropyge himalayensis* Diener evidently much better than *Brachymetopus strezlskii* McCoy.

Like *C. himalayensis,* this species has six pairs of pleural ribs, but they are all simple and almost equally broad or even tending broader in the posterior ones in that species. On the other hand the first rib of this species which is the anterior band of the first pleural segment is most slender, while the other five ribs are becoming narrower backward. On the anterior two ribs of these five a short but distinct interpleural furrow cuts into the rib from the margin. The so-called lappet-like posterior piece appears somewhat larger and depressed in this whereas it is strongly convex in *C. himalayensis.* Additional distinctions are the broader and more segmented axial lobe and strongly granulate test.

In considering these morphological differences and the much older age of this species, it must be an early parallel offshoot from the Silur-Devonian trunk of the Brachymetopidae, instead of the progenitor of Permo-Carboniferous *Cheiropyge* and its allies.

Occurrence:—Upper Devonian Yarzê Formation at Yarzê of Ra'og, Baxoi district, Xizang (Tibet).

Genus *Cheiropyge* Diener, 1897

Diagnosis:—Pygidium parabolic, moderately vaulted; axial lobe composed of about 15 rings, nearly one-third as wide as pygidium; pleural ribs in six pairs, posterior ones being broader than anteriors; posterior ribs and post-axial lappet bent down rather abruptly toward their margins, each ending at a strong projection to impart the lateral margin a crenate appearance; marginal border absent; test granulose except for furrows.

Type-species:—*Cheiropyge himalayensis* Diener, 1897, from the Chitchun Limestone of Upper Permian (Tatarian), probably Dzhulfian age, Central Himalaya (Tibet).

Remarks:—When Diener proposed *Cheiropyge himalayensis* for a pygidium from Chitchun, Central Himalaya, he emphasized the projection of its pleural ribs to form crenate margins as the most distinctive characteristic of this trilobite. He made a morphological comparison with such trilobites as follows:

Phillipsia (*Brachymetopus*) *lodiensis* Meek, 1875 . . . . *Brachymetopus*
Dalmanites ? *cuyahoae* Calypole, 1884 . . . . *Namuropyge*
Proetus (*Phaeton*) *archiaci* Barrande, 1846 . . . . *Prionopeltis*
Proetus (*Phaeton*) *striatus* Barrande, 1846 . . . . *Prionopeltis*
Proetus (*Phaeton*) *planicauda* Barrande, 1946 . . . . *Phaetonellus*
Cromus transiens Barrande, 1952 . . . . *Encrinurus* (*Encrinurus*)

The present generic position is cited behind each species according to G. and R. Hahn (1969) for the former two Mississippian species and Horny and Bastl (1970) for the latter four which are Ludlovian except for Eifelian *P. planicauda.* Because the comparison prevented Diener from classing the trilobite with any of these genera he was convinced himself in establishing a new genus, although its satisfactory diagnosis could not be given without the knowledge of the cephalon and thorax.

The type-species was founded on a well inflated pygidium steeply slanting near margins. It possesses some 15 axial rings and 6 pairs of simple pleural ribs posterior ones of which are broader and all bent backwards at lateral projections; post-axial piece or lappet isolated from axial lobe clearly; lateral margins strongly indented; no marginal space or limbus is present.

Recently Chamberlain (1977) identified a pygidium from central Alaska with *Cheiropyge himalayensis.* Insofar as can be judged from its description and illustration, its congeneity is not convincing but certainly distinct from Diener's species. Its outline is evidently broader and more rounded. While the axial lobe is regularly tapering in the Himalayan pygidium, it is obviously more rapidly expanding in anterior half than the other in the Alaskan one. The pleural rib is simple in the former, but it is divided by an interpleural furrow into two, each bearing a row of tubercles. The marginal spines are divergent in the Alaskan pygidium, but it is a remarkable tendency for the Himalayan one that their pleural ribs are bent backwards at the terminal projections.

The Alaskan pygidium was obtained from the lower Wolfcampian whereas the Himalayan one is dated at Tatarian-Dzhulfian by Grant (1966) and G. and R. Hahn (1969). In considering that the morphic distinctions correspond to the differences in age and area, the authors propose a new name, *Cheiropyge* (?) *chamberlaini* for the Alaskan form.

Cheiropyge maueri Weber, 1944 is founded on a subtrigonal pygidium from the Artinskian on the western slope of the Urals. It has a multisegmented axial lobe and 6 paired pleural ribs beside an unpaired post-axial piece and a narrow pleural rib along the anterior margin which corresponds to the anterior band of the first pleura. The axial lobe is prominent, very stout and divided into an anterior main rib and a posterior riblet by an interpleural furrow. The axial rings and pleural ribs and riblets each bear a row of tubercles. Whether or not the lateral margin is indented is not clear, although the post-axial piece as well as posterior pleural ribs appear to extend beyond the postero-lateral margins.

Barchymetopus (?) *caucasicus* Licharew in Weber, 1944 is represented by another pygidium from the Upper Permian limestone, North Caucasus. Compared to the preceding, the axial lobe is slender and the axial rings are more numerous, although the segmentation becomes obscure in posterior. The axial lobe is said to be produced into a spine curved upward at the end. Six paires are countable of simple pleural ribs, but unfortunately the marginal part of the pygidium is unpreserved. The axial rings and pleural ribs are decorated by rows of tubercles; median tubercles on the rings commonly larger than others. As suggested by G. and R. Hahn (1969), this species is more probably a *Cheiropyge* than a *Brachymetopus*, although it is not diagnostic of the former genus.

Cheiropyge sp. indet. by Sarkar (1967) from Yanar, Kashmir is an imperfect pygidium. Its subtrigonal outline and the mode of pleural ribbing are suggestive of *Cheiropyge*. It is, however, quite distinct from all of the known species of the genus in the unusual narrow cylindrical axis.

Finally, *Brachymetopus* ? sp. indet. described by Toumansky (1935) from the upper Artinskian of Crimea was referred to *Cheiropyge* with query by G. and R. Hahn (1969). It is represented by two fragments of a tuberculate free cheek with a small eye with which nothing can be here commented.

Distibution:—Upper Carboniferous to Upper Permian: Himalaya, Urals and (?) Caucasus in Eurasia and Alaska in North America.

Cheiropyge (?) *kansasensis* Weller, 1944

The cephalon of this species agrees with *Cheilopyge* (*Suturikephalion*) *koizumii* in the conspicuous marginal band obtusely pointed in front, rounded genal angles and other characteristics of the cephalon, precisely, a small unfurrowed glabella, improminent basal lobes, large prominent eyes near glabella, preglabellar limb and cheeks of moderate size and inclination. The marginal band is, however, said simply flat and facial sutures are not apparent. In the type specimen seven thoracic segments are attached to the cephalon and their pleurae bent down in the lateral half.

The associate pygidium was not illustrated, but it is said that the axis is composed of as many as 20 segments; pleural lobe of 6 segments separated by compound furrows, i.e. principal and subsidiary ones; flange wide corrugated by ribs which extend as round terminal crenulations. The post-axial piece or lappet is obscure. The pygidium is ornamented by tiny granules as well as the cephalon and thoracic segments.

According to Weller only the pygidial characters of *Cheiropyge himalayensis* are known and the pygidium of *Cheiropyge kansasensis* is imperfectly preserved so that its reference to *Cheiropyge* is somewhat uncertain. The Kansas species differs from the Himalayan species by the greater relative width of its pygidium and larger number of axial segments. In the forking of the pleural furrow this pygidium may be comparable with those of *C. maueri* and *C.* (*Suturikephalion*) *koizumii*. *C. caucasica* has axial rings as many as 20.

Occurrence:—The Kaskell Limestone, Kansas, U.S.A. whose age is very late Pennsylvanian, inatead of early Permian, as the limestone is located in the lower part of the Vigilian Stage in the "Correlation of the Permian Formations of North America" (1960).

Subgenus *Suturikephalion* Kobayashi and Hamada, 1982

1982. *Cheiropyge* (*Suturikephalion*) Kobayashi and Hamada, *Proc. Japan Acad.*, vol. 58-B, no. 3, p. 50.

Diagnosis:—Cephalon subtrigonal, but genal angle is well rounded; intramarginal depression expanding mesially and narrowing postero-laterally; glabella small; lateral furrows absent; eyes very large, located far posteriorly; facial auture present. Thorax probably composed of nine segments. In pygidium axial lobe divided into 15–16 rings beside well developed post-axial lappet; pleural ribs countable 6, swelling distally, but scarcely projected beyond marginal rim. Test granulose.

Type-species:—*Cheirrepyge* (*Suturikephalion*) *koizumii* Kobayashi and Hamada, 1982.

Remarks:—This subgenus has the cephalon very similar to that of *Cheiropyge* (?) *kansasensis,* but the facial suture is present. The pygidium resembles that of *Cheiropyge himalayensis,* but its pleural ribs do not ending in such projections as Diener emphasized. The post-axial lappet is, on the other hand, so well developed as it embraces the terminus of the axial lobe.

Distribution:—Middle Permian; Eastern Asia (Japan).

Cheiropyge (*Suturikephalion*) *koizumii* Kobayashi and Hamada, 1982

Plate I, figs. 1 ~ 11; Text-fig. 5-h

1978. *Cheiropyge* aff. *himalayensis* Koizumi and Sasaki, *Chigaku-Kenkyu*, vol. 29, p. 229, pl. 1, figs. 1–8.
1982. *Cheiropyge* (*Suturikephalion*) *koizumii* Kobayashi and Hamada, *Proc. Japan Acad.*, vol. 58-B, no. 3, p. 51, figs. 1–5.

Description:—Dorsal shield fairly well inflated, roughly twice longer than broad; cephalon and pygidium subtriangular, the former a little larger than the latter; thorax subquadrate; cephalon about one-tenth shorter than thorax and so much longer than pygidium.

Cephalon widest at a little anterior to genal angles which are well rounded; genal spine absent; antero-lateral margin straight or gently concave and meeting with its counter to form an angle of 100 degrees or more, marginal border thick; intramarginal depression well developed in median part where it is subtriangular but concave inward on the posterior side and becoming a pair of normal marginal furrows postero-laterally. Principal part of the cephalon essentially similar to that of *Brachymetopus.* Glabella a little longer than a half of cephalon and one-fourth as wide as cephalon, well rounded in front, slowly expanding backward and more distinctly expanded laterally at neck ring; lateral furrows absent on glabella; occipital furrow as strong as axial furrow; occipital ring narrowing laterally. Eyes very large, about two-thirds as long as glabella, forming large ovoids together with palpebral lobes and located near glabella. Coarse granules densely distributed on glabella and cheeks; two pairs of particularly large tubercles found near anterior ends of the glabella and eyes. Anterior branch of facial suture diagonally extending from axial furrow between the two tubercles on each side and gradually turning inward crossing anterior border. Marginal border and depression ornamented by somewhat finer granules.

Thorax composed apparently of 9 segments; axial lobe narrowing back very slowly; axial ring nearly as wide as or a little narrower than pleura; pleural rib prominent near its posterior margin and bent forward at lateral end where the pleura is truncated; a row of fine granules aligned on pleural ribs and posterior margin of axial ring.

Pygidium trigonal, almost as wide as long; axial lobe a little narrower than pleural lobe, long conical, but abruptly terminating at about one-sixth of pygidial length from posterior periphery; 15 to 16 axial rings countable on the lobe, 10 of which are very distinct. Pleural lobe divided into six pairs of stout ribs besides anterior band of the first pleura and the terminal ribs which the latter are fused in form of so-called lappet by Diener, embracing posterior terminus of the axis. Anterior ribs provided with a linear riblet on posterior side, while posterior ribs are broader than the other; all of these ribs separated by profound furrows and becoming more stout in themselve, then suddenly bent down near periphery. Ornamentation similar between thorax and pygidium; median tubercles appear on axial rings more commonly on posterior than anterior rings.

Observation:—The above proportional length among the cephalon, thorax and pygidium is given with reference to a complete dorsal shield which is laterally compressed to some extent Pl. I, fig. 1.

The granulation on the marginal border and depression is not always quite distinct, but it is very obscure in an internal and external moulds of a cephalon. Likewise, the prominence of two pairs of the tubercles and the preservation of the anterior facial suture vary among the cephala and even between the two sides of a cephalon, notwithstanding the fact that the sutures are quite distinct in the cephalon Pl. I, fig. 5 and the two pairs of the tubercles very prominent in the cephala Pl. I, figs. 2a–b, 3.

In the dorsal view the pleural ribs of the pygidium appear to be protruded laterally, but the protrusion is still inconvincing. They may be overhanging near the periphery in some deformed pygidia. On the other hand it is seen in a pygidium Pl. I, figs. 11a–b that the anterior ribs are clearly truncated at the pygidial margin as does the thoracic pleura. The separation of a riblet behind the main rib by a linear interpleural furrow can be clearly seen on four anterior ribs on the left pleural lobe of this and another pygidium Pl. I, figs. 10a–b.

Comparison:—This pygidium can be distinguished from the monotypic pygidium of *Cheiropyge himalayensis* principally in the inprominent terminal protrusion of pleural ribs. Furthermore its outline is subtrigonal with non-crenate lateral margins, prominent median tubercles on some rings of the axial lobe which is comparably slender, forked anterior pleural ribs and the well developed post-axial piece in this species.

In the double pleural ribs on the trigonal pygidium it resembles *Cheiropyge maueri*, but the axial lobe is considerably stout and the axial and pleural lobes are significantly bent down near the periphery in that species. On account of the slender axis carrying nodose median tubercles it may be nearest to *Cheiropyge* (?) *caucasica*, although the marginal parts of the pygidium are unpreserved in the latter.

Occurrence:–Quarry, Omote-matsukawa, Kesennuma City, Miyagi Prefecture; Iwaizaki-Stage.

Repository:–PAt16657 (Holotype); PAt1660, 16661, 1666 (Paratypes); PAt 16658, 16657, 16662 ~5, 1667.

Family Phillipsiidae Oehlert, 1864

In 1886 Oehlert classified the proetids into the Proetidae and Phillipsiidae and 5 genera besides 2 subgenera. Sixty years later Přibyl (1945) recognized 5 subfamilies, 31 genera and 14 subgenera in the Proetidae inclusive of the Phillipsiinae, while R. & E. Richter and Struve (1959) distinguished 6 subfamilies, 41 genera and 18 subgenera in the Proetidae s. str. in Moore's Treatise. In 1973 the authors listed 22 subfamilies in adding 16 subfamilies to them, 10 of which were proposed after 1959. The evaluation of these subfamilies, however, greatly varies among palaeontologists.

Subfamily Proetinae Salter, 1864
Subfamily Tropidocoryphinae Přibyl, 1945
Subfamily Prionopeltinae Přibyl, 1945
Subfamily Dechenellinae Přibyl, 1945
Subfamily Proetidellinae Hupé, 1953
Subfamily Astycorphinae Hupé, 1953
Subfamily Denemarkiinae Hupé, 1953
Subfamily Eodrevermanniinae Hupé, 1953
Subfamily Cyrtosymbolinae Hupé, 1953
Subfamily Pteropariinae Hupé, 1953
Subfamily Corniproetinae Rud. & E. Richter, 1956
Subfamily Scharnyiinae Osmólska, 1957
Subfamily Drevermanniinae Maximova, 1960
Subfamily Decoroproetinae Erben, 1966
Subfamily Eremiproetinae G. Alberti, 1967
Subfamily Schizoproetinae Yolkin, 1968
Subfamily Lepidoproetinae Pillet, 1968
Subfamily Piriproetinae Pillet, 1969
Subfamily Perliproetinae Pillet, 1969
Subfamily Cyphoproetinae Pillet, 1969
Subfamily Ungliproetinae Pillet, 1969
Subfamily Crassiproetinae Osmólska, 1970

In the monograph on the Devonian trilobites of the Armorican massive (1972) Pillet divided the proetids into the Proetidae, Dechenellidae, Tropidocoryphidae and Otarionidae and subdivided the Dechenellidae into the Dechenellinae, Lacunoporaspinae (nov.) and Schizoproetinae. In the "British Ordovician and Silurian Proetidae (Trilobita)" Owens recognized the Proetinae, Schizoproetinae Cornuproetinae, Tropidocoryphinae and a new subfamily, Warburgellinae and *Crassiproetus* in the second subfamily. The Warburgellinae was soon transferred from the Proetidae into the Brachymetopidae by Owens and Thomas (1975). The Warburgellinae Yolkin, 1974 which is a junior synonym of Owen's subfamily is, on the contrary, proposed as a subfamily of the Dechenellidae.

If the following six subfamilies are transferred into the Proetidae from the Phillipsiidae, the subfamkly number of the former family attains about 30. As this number is really extraordinarily large in the trilobite classification, any grouping of the families and subfamilies in the Proetacea is desirable to indicate their phylogenetic relationship.

Subfamily Phillipsiinae Oehlert, 1886
Subfamily Griffithidinae Hupé, 1953
Subfamily Ditomopyginae Hupé, 1953
Subfamily Cummingellinae G. & R. Hahn, 1967
Subfamily Thaiaspidinae Osmólska, 1970
Subfamily Linguaphillipsiinae G. & R. Hahn, 1972

In Lütke's classification of the older Palaeozoic Proetina (1980) the superfamily Proetacea Salter, 1964, nov. is divided into two families and about 15 subfamilies as follows:

Family Proetidae
- Subfamily Proetinae including *Ungliproetus*
- Subfamily Cyphoproetinae (i.e. Warburgellinae Owens, 1973) including *Warburgella*
- Subfamily Dechenellinae including *Lacunoporaspis*
- ? Subfamily Schizoproetinae
- Subfamily Cornuproetinae including *Cornuproetus* (*Piriproetus*) and *Lepidoproetus*
- Subfamily Drevermanninae
- Subfamilies "Cyrtosymbolinae", Phillipsiinae, Linguaphillipsiinae, Cummingellinae, Griffithidinae and Ditomopyginae

Family Tropidocorphyidae
- Subfamily Tropidocoryphinae including *Tropidocoryphe* (*Astrycoryphe*) and *Pteroparia*
- Subfamily Proetidelliinae including *Decoroproetus* and *Prionopeltis*
- Subfamily Eremiproetinae.

The Eodrevermanniinae and Scharyiinae are tentatively transferred into the Aulacopleuridae.

According to G. and R. Hahn (1967) the derivation of the following subfamilies of the Proetidae is traceable as below:

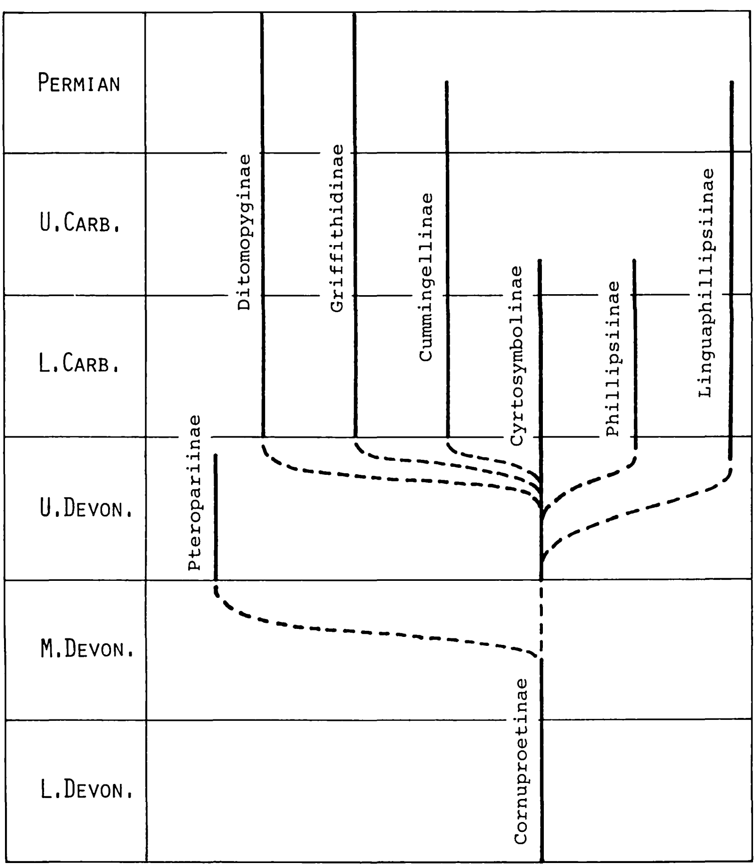
1. The Cyrtosymbolinae from *Ungliproetus unguloides* (Barrande, 1846).
2. The Phillipsiinae from *Archaegonus* (*Pseudowaribole*) *octofer* R. & E. Richter, 1926 in the Cyrtosymbolinae.
3. The Cummingellinae from near *Cornuproetus* (*Cornuproetus*) *ornatus* (Goldfuss, 1843) in the Cornuproetinae.
4. The Griffithidinae 1 including the *Griffithides* and *Cyphinoides* groups from near *Proetus* (*Proetus*) *bohemicus* Hawle and Corda, 1847 in the Proetinae.
5. The Griffithinae II or the *Paladin* group from *Griffithidella* (*Thigriffides*) *roundyi* (Girty, 1926) in the *Cyphinoides* group of the Griffithidinae I.

At that time they were of opinion that *Thaiaspis* and *Ditomopyge* were referrable to the Griffithidinae II, instead of accepting as two distinct subfamilies i.e. Thaiaspidinae and Ditomopyginae. Subsequently they founded a new subfamily Linguaphillipsiinae in the Proetidae in 1972. Then they accepted the Ditomopyginae in the Proetidae in 1975.

Because Hahns have most elaborated in the phillipsid studies in these years, this taxonomic treatment became widely used as it is accepted in Lütke's recent classification. G. and R. Hahn and Brauckmann (1980), on the other hand, revived the Phillipsiidae for the above six subfamilies in addition to the Pteropariinae. Because it is what the authors expected in 1973, the revival of the Phillipsiidae is welcome, although much still remains to warrant the monophyletism of the family.

Assuming Hahns and Brauckmann's concept of phylogenetic relation shown in their text-figure quoted in Text-fig. 4 of this paper, however, the authors consider that the late Devonian Pteropariinae is better to be excluded, because it is isolated from the Cyrtosymbolinae and other subfamilies as a lateral off-shoot of the Cornuproetinae.

More recently G. and R. Hahn (1982) erected a new subfamily, Cystispininae to include *Cystispina* (*Cystispina*) R. and E. Richter 1939, *Cystispina* (*Spatulina*) Osmólska, 1962, *Globusia* Osmólska, 1973, *Globusoidea* G. Hahn & Brauckmann 1980, *Wagnerispina* Gandl, 1977, *Spinibole* (*Spinibole*) Chlupác, 1966, *Spinibole* (*Vandegrachtia*) Brauckmann, 1974, *Spinibolops* G. & R. Hahn, 1971, *Xenadoche* G. & R. Hahn, 1982, *Tawstockia* Brauckmann, 1974, and *Diacoryphe* R. & E. Richter, 1951. This subfamily is most characterized by the genal spines swollen, either cylindrical and then not subdivided, or more drop-like in shape and then subdivided into 2 cysts arranged one upon the other. It is distributed in the Lower Carboniferous of England, Germany, Poland, Moravia, Central Asia and Malaysia besides the Namurian of Spain. This is an aberrant branch well flourished in the Kulm facies.



Text-fig. 4. Phylogeny of the Phillipsiidae (after Hahn and Brauckmann, 1980).

Subfamily Linguaphillipsiinae G. and R. Hahn, 1972
Genus *Nipponaspis* Koizumi, 1972

Diagnosis:–Cephalon with long pear-shaped glabella constricted in mid-length, four pairs of lateral furrows, completely isolated basal lobes on large posterior part behind the constriction, very large holochroal eyes in posterior, simply flat marginal border and short genal spines. Thorax composed of nine segments; pleuron with prominent fulcrum at its geniculation. Pygidium with about 13 axial rings and 8–9 pleural ribs anterior ones of which are divided into two bands; low post-axial ridge distinct. Test smooth.

Type-species:–Nipponaspis takaizumii Koizumi, 1972.

Remarks:–This genus is most similar to *Linguaphillipsia* and *Palaeophillipsia,* but it can be distinguished from them by the greater posterior expansion and stronger middle constriction of the glabellar outline, four, instead of three lateral furrows, where the middle two are short, anterior one is a pit and the posterior one isolates a basal lobe completely. The holochroal eyes are somewhat larger and their posterior termini reach the posterior cheek border. The glabella touches with the frontal border which is simply flat and depressed.

Compared to this genus, *Linguaphillipsia* has a more segmented pygidium with 14–18 axial rings and 9–13 pleural ribs. The axial lobe extends as far as the posterior border or even it invades into the border in that genus, while a post-axial ridge is present in *Nipponaspis.*

Linguaphillipsia and *Palaeophillipsia* are two Lower Carboniferous genera of which the latter is indigenous to Japan whereas the former is wide spread in Eurasia and Australia. Chamberlain (1977) referred *Gitarra leonensis* Romano, 1971, from the Westphalian of Northwest Spain to *Nipponaspis.* Later the reference was accepted by G. and R. Hahn (1975). This Middle Carboniferous species resembles *Nipponaspis* particularly in the outline of the glabella, size and position of the eyes and the double pleural ribs of the pygidium. But it differs from *Nipponaspis* in the number of lateral glabellar furrows and the partial effacement of the posterior lateral furrows of the glabella. Its pygidium has 9–10 axial rings and 6–7 pleural ribs. Furthermore, its axial lobe of the thorax is extraordinarily broad, if compared to the pleural lobe. In considering these distinctions together with the spatio-temporal difference of the occurrence, the Spanish Westphalian *Gitarra leonensis* is not a missing link, but it represents by itself a side off-shoot in the evolutional line from *Linguaphillipsia* to *Nipponaspis.*

Distribution:–Middle-Upper Permian; Eastern Asia (Japan).

Nipponaspis takaizumii Koizumi, 1972

Plate II, figs. 1–5; Text-fig. 5–a

1972. *Nipponaspis takaizumii* Koizumi, *Chikyu-Kagaku,* vol. 26, no. 1, p. 22, pl. II, figs, 1–6, text-fig. 2.

Description:–Dorsal shield elliptical, elongate and rather flattish, although the axial part is moderately convex.

Cephalon a little longer than pygidium, subtriangular, but provided with short genal spines. Glabella pear-shaped, gently convex, one-third as wide as cephalon, reaching narrow depressed frontal border, more expanded in posterior than the other, and constricted between the two parts; four pairs of lateral furrows present in the posterior part where the most anterior ones are simple pits at the constriction; three others all oblique and their length increasing posteriorly;

last pair reaching the profound occipital furrow, isolating ovately trigonal basal lobes; three lateral lobes anterior to the basal lobes separated from one another, similar in breath and smaller than basal ones. Occipital ring a little thickened mesially, bearing a median tubercle.

Eyes reniform, large, about two-thirds as long as glabella, extended backward from glabellar constriction; fixed cheek narrow; free cheek moderate in breadth and surrounded by marginal border and narrow marginal furrow. Facial sutures running forward from eyes, but slightly laterally and then turning inward on the marginal border; their posterior branches extending from eyes laterally and then diagonally through posterior cheek border.

Hypostoma subtrigonal; anterior wings strongly produced (Koizumi, 1972, pl. 2, fig. 4).

Thorax parallel-sided, a little shorter than pygidium, composed of nine segments; axial lobe nearly as wide as pleural lobe; pleural furrows well developed in adaxial half of pleuron; fulcrum prominent on anterior margin at one-third from axial furrow; anterior band largely facetted in abaxial two-thirds and truncated at lateral end.

Pygidium parabolic, wider than long and a little longer than thorax; axial lobe divided into about 13 rings by broad ring furrows, conical, but truncated shortly inside of posterior marginal border; pleural lobe depressed below axis, very slowly slanting laterally and posteriorly, divided by pleural furrows into 8 or 9 flat-topped pleural ribs; anterior ribs subdivided into two subequal bands by a weak interpleural furrow; anterior band of the first pleuron, like thoracic one, bears a prominent fulcrum wherefrom the band is facetted; marginal border fairly broad, inclined outward without interruption from ribbed part.

Test smooth.

Observation:—In the holotype innumerable lenses are well preserved on the large holochroal eyes. Like in this shield, in two isolate pygidia it is seen that the axial lobe terminates suddenly at a short distance from the posterior border. A low and more or less trigonal elevation is present at this interspace. In these specimens the test of the marginal border is unpreserved and only striae of the doublure are there impressed.

Occurrence:—Middle Permian (*Yabeina* Zone), Takakura-yama Formation; G2 valley, Yotsukura-cho, Iwaki City, Fukushima Prefecture; collected by Takaizumi.

Repository:—Holotype, PAt 16672; Paratype, PAt 16674; PAt 16673, 16675 and 16676.

Subfamily Cummingellinae G. and R. Hahn, 1967

Genus *Paraphillipsia* Toumansky, 1935

Paraphillipsia karpinskyi Toumansky, 1935 from Crimea which is the type-species of *Paraphillipsia* is early Middle Permian or late Artinskian in age. *Paraphillipsia tschernyschewi* (Netschajew, 1932) with which *Paraphillipsia pahara* Weller, 1935, is synonymous occurs in the lower Artinskian of Darwar, Pamir and Kashmir, India. Recently *Paraphillipsia inflata* Kobayashi and Hamada, 1979 was described from the Sakmarian or Lower Permian of Thailand. Beside them *Paraphillipsia* sp. indet. (pygidium and 5 thoracic segments) is reported by Weber (1944) to occur in the Permian of the Sutschan basin, Primorie, U.S.S.R. *Anisopyge* ? sp. (Mansuy, 1912) also a pygidium, from the Middle Permian of Laos belongs probably to this genus.

Thus the genus was extensively distributed from Crimea to the Far East through the Himalaya and Southeast Asia in the Permian period, and most flourished in the Artinskian, but appeared already in the Sakmarian of Thailand.

Paraphillipsia levigata Kobayashi and Hamada, 1980

Plate III, figs. 5–9; Text-fig. 5–b

1966. *Neoproetus* sp. Imamura, *Jour. Geol. Soc. Japan*, vol. 72, no. 9, p. 451, figs. 12–d.
1980. *Paraphillipsia levigata* Kobayashi and Hamada, *Proc. Japan Acad.*, vol. 56–B, no. 3, p. 121, figs. 1–3.

Description:—Cephalon semicircular, well convex; glabella broader in anterior than posterior, gently narrowing between the two sides, slowly ascending forward, then suddenly drooping and overhanging at frontal margin; basal lobe medium in size, well rounded on postero-lateral side, and on the opposite side limited by distinct linear furrow which is bent at midway forming an obtuse angle; two weak short linear lateral furrows parallel to each other and close-set, posterior one of which is separated from the preoccipital furrow more widely; neck ring expanded forward in median part remarkably; occipital furrow deep; its median sectant gently arcuate with backward convexity; axial furrow less pronounced than occipital one, but distinct; fixed cheeks narrowing forward from eyes which are fairly large and opposed at the middle contraction of the glabella; free cheek medium in size, divided by marginal furrow into outer border and inner roll of subequal breadth.

Pygidium fairly broad, well vaulted; axial lobe clearly outlined by distinct narrow furrow, wider than a third of pygidium, breviconic, truncated at terminus, divided into 9 to 10 rings by narrow linear furrows; pleural lobe gradually arching down laterally from axial furrow, divided into about 7 to 8 flattopped ribs by linear furrows which, however, die out at midway to two-thirds from axial furrow to lateral margin; marginal rim very narrow and depressed.

Test very sparcely granulate.

Observation:—This species is represented by a cranidium, a free cheek and two pygidia in a smaller one of which three thoracic segments are anchylosed with it. The pleurae of these segments are strongly geniculated at about one-third from the axial furrow. In the larger pygidium the pleural furrows are longer.

Beside these specimens Imamura's pygidium appears to belong to this species, insofar as can be judged from his illustration (1966).

Comparison:—The cephalon is typical of *Paraphillipsia*. Compared to *Paraphillipsia karpinskyi* Toumansky, the type-species, the glabella is less expaned laterally in anterior, pre-occipital lobe shorter and eyes are somewhat larger in this species.

Another close ally is *Paraphillipsia inflata* Kobayashi and Hamada with which it agrees better than *P. karpinskyi* in the convexity of the cranidium, but the cranidium is more parallel sided in *P. inflata*.

The pygidium of this species fits in *Paraphillipsia* in convexity, breviconic axis and linear furrows. In *Neoproetus* and *Permoproetus* the pygidium looks broader and ring and pleural furrows are much more pronounced.

In *Paraphillipsia karpinskyi* the pygidium is less segmented. Namely, its axis is composed of 8 rings and its pleural lobe of 5 ribs. This species agrees better with *Paraphillipsia taurica* in the number of segmentation. Some anterior pleural ribs are, however, divided into two unequal bands and the axial lobe is evidently narrower in that spcecies.

The axial lobe is broader in *Paraphillipsia v.-n.- weberi* Toumansky. In the breadth of the lobe this species may be comparable to the type-species, but it is longer. Its subtruncated terminus is an important characteristic of this species.

Occurrence:—Middle Permian, Shimoyama Limestone.

Repository:—Holotype: PAt 16683, Paratype: PAt 16686; PAt 16684, 16685 and 1668–7.

Subfamily Griffithidinae Hupé, 1953

Genus *Neoproetus* Tesch, 1923

"*Neoproetus*" *akagii* Kobayashi and Hamada, sp. nov.

Plate III, figs. 1–4; Text-fig. 5–d

1971. *Griffithides* sp. Akagi, *Jour. Fac. Education, Tottori Univ. Nat. Sci.*, vol. 22, no. 2, p. 81–83, pl. 1, figs. 106.
1971. (?) *Paladin* sp. Akagi, *Ibid.*, vol. 22, no. 2, p. 83–84, pl. 1, figs. 6–8.

Description:—Main glabellar lobe strongly convex, oval, regularly expanding forward, drooping in front, narrowing backward as far as blunt end; lateral furrows absent; basal lobe extending laterally, united with palpebral lobe without interruption of axial furrow, and elevating as high as top of main lobe; occipital furrow deep; neck ring normal in size; palpebral lobe semicircular; fixed cheek very narrow; test smooth or with minute tubercles.

Observation:—Six thoracic segments are attached with a strongly inflated pygidium. In cross section the axial lobe is well rounded in thorax, but more or less trapezoidal in pygidium. The thoracic pleuron is distinctly divided into two subequal bands by a strong pleural furrow. The axis of the pygidium is slightly wider than the pleural lobe exclusive of the marginal border. It is divided into about 12 axial rings. The pleural lobe is horizontal in the inner part and gently arching down to the depressed marginal border in the other part. Plaural ribs are 9 to 10 in number. Two other pygidia in the collection are of the same kind.

Remarks:—At a glance this cranidium closely resembles *Neoproetus* (*Triproetus*) *subovalis* Kobayashi and Hamada, 1979, but it has no lateral furrows on the glabella. In the conjugation of the basal lobe with the palpebral lobe this cranidium is quite unique. This species represents a new genus or subgenus by itself, although no name is proposed here, as the cranidium is imperfect. The associate pygidia look also similar to *Neoproetus* (*Triproetus*) *subovalis* in many aspects, but they are a few more segmented in this species.

Occurrence:—Hillside of Mihara-noro, Tojo Town, Hiroshima Prefecture; Lower Permian *Pseudoschwagerina* Zone, Miharano Formation.

Repository:—Holotype, PAt 16679; Paratype PAt 16680; PAt 16681, 16682.

Subfamily Ditomopyginae Hupé, 1953

Genus *Paladin* Weller, 1936

Paladin (?) *iwaizakiensis* Kobayashi and Hamada, sp. nov.

Plate IV, figs. 5–8; Text-fig. 5–i

Description:—Cephalon semicicular, provided with a pair of short genal spines. Glabella composed of a long main lobe and a pair of elongate basal lobes beside neck ring; main lobe expanding forward, well rounded in front and slightly encloaching into anterior marginal furrow; lateral furrows absent; eyes large, opposed at basal lobes; fixed cheek very narrow; free cheek fairly wide; marginal rim narrow; marginal furrow rather broad.

Pygidium broad, semicircular; axial lobe relatively narrow, three-fourths as long as pygidium, composed of 9 to 10 rings, and suddenly rounded off at posterior end; pleural field with 6 to 7 ribs separated by wide furrows; marginal border ill-defined.

Test with minute granules.

Occurrence:—Late Middle Permian *Yabeina shiroiwensis* Zone in the Iwaizaki Limestone; Iwaizaki, Kesennnuma City, Miyagi Prefecture; Takakura-yama Formation; Takakura-yama, Yotsukura, Fukushima Prefecture.

Repository:—Holotype, PAt 16692; Paratype, PAt 16694; PAt 16693.

Genus *Endops* Koizumi, 1972

Diagnosis:—Cephalon with short genal spines; glabella encloaching frontal border halfway, flask-shaped, composed of a large main lobe and a pair of very tiny basal lobes beside neck ring; eyes holochroal, well developed, and opposed at posterior part of glabella. Thorax composed of 10 segments. Pygidium semicircular; axis relatively short, composed of 8–9 axial rings; pleural ribs 6–7 in number, extending almost as far as pygidial margin. Test granulose.

Type-species:—*Paladin yanagisawai* Endo and Matsumoto, 1962.

Remarks:—As Endo and Matsumoto referred this trilobite to *Paladin,* it resembles that genus, but the frontal lobe of glabella is considerably expanded laterally and the basal lobes are extraordinarily tiny. In the pygidium pleural ribs extending almost as far as their whole length; marginal border ill-defined. Test granulose.

In the cephalic aspect, particularly in the glabellar outline, this trilobite looks closer to *Thaiaspis,* but the basal lobes are absent in that genus. The pygidium of this trilobite is fairly broad, if compared with those of *Paladin* and *Thaiaspis.*

Distribution:—Middle Permian; Eastern Asia (Japan).

Endops yanagisawai (Endo and Matsumoto, 1962)

Plate IV, figs. 1–4; Text-figs. 5–c

1962. *Paladin yanagisawai* Endo and Matsumoto, *Sci. Rep. Saitama Univ. ser. B.,* vol. 4, p. 158–159, pl. 9, figs. 1–6.
1967. *Paladin yanagisawai* by Yanagisawa, *Sci. Rep. Tohoku Univ.* (*Geol.*), vol. 39, no. 1, p. 103, pl. 3, figs. 2–3.
1971. *Paladin yanagisawai* by Takaizumi, *Chigaku-Kenkyu,* vol. 22, p. 25–28, pl. 1, figs. 1–3.
1972. *Endops yanagisawai* by Koizumi, *Chikyu-Kagaku,* vol. 26, no. 1, p. 19–22, pl. 1, figs. 1–4, text-fig. 1.

Description:—Dorsal shield elongate elliptical, but parallel-sided at thorax and fairly well inflated, most convex at axial lobe and geniculate at thoracic pleural lobes.

Cephalon except for short genal spines, semicircular, a little shorter than thorax; glabella of overturned flask-shape, subcircular in large anterior part, cylindrical in smaller posterior part excluding the basal part where the unfurrowed main lobe suddenely narrows and a pair of small basal lobes are there isolated by diagonal preoccipital furrow; occipital ring and furrow distinct; Glabella encloaching halfway into frontal border. Eyes reniform, opposed at the posterior glabella, embracing crescentic palpebral lobes. Fixed cheek narrow; free cheek moderate in size;

marginal border separated from cheek roll by narrow marginal furrow. Facial suture semicircular anteriorly to the eye and more or less diagonal in posterior to the eye, but with convexity on anterolateral side and cutting the median point of posterior margin of the cheek.

Thorax composed of ten segments; axial lobe a little narrower than pleural lobe, high and regularly convex; pleural lobe geniculate at a point slightly inside of the median point; pleural furrow running across pleuron diagonally; fulcrum prominent at geniculation.

Pygidium a little shorter than cephalon, semicircular in outline. Axial lobe slightly narrower than one-third the pygidium, about one-fourth as long as the pygidium, outlined by deep axial furrows rounded at the end and divided into 8 to 9 axial rings by transversal furrows. Pleural lobe divided into 6–7 ribs by pleural furrows terminating near the margin.

Test granulose.

Observation:—The eyes are very large, strongly convex, and holochroal. Innumerable lenses are well preserved. On the free cheek there is an obtuse trifurcate ridge. Its antero-lateral branch along the eye is particularly prominent. By exfoliation it is seen that the striated doublure occupies about one-fourth the pygidial length.

Occurrence:—Middle Permian (*Yabeina* Zone); Takakura-yama Formation; G_2 valley, Takakura-yama, Yotsukura-town, Iwaki-City, Fukushima Prefecture.

Repository:—PAt 16688 ~ 16691.

Genus *Neogriffithides* Toumansky, 1935

Neogriffithides was founded by Toumansky (1935) on *Neogriffithides gemmellaroi* Toumansky, 1935 from the upper Artinskian or the Sosio Stage of Crimea. It is accompanied there by a few other species of the same genus which are, however, represented only by pygidia or imperfect specimens. He included in this genus *Phillipsia pulchella* Gemmellaro, 1892, from the *Fusulina* limestone of the Sosio Stage in Sicily. Subsequently Gortani (1906) founded its variety *alpina* nov. in the Sakmarian of the Carnic Alps. Furthermore G. and R. Hahn (1970) suggested that *Phillipsia* sp. indet. by Tesch, 1923b, from the Permian of Letti, Indonesia is probably referable to this genus.

In adding *Neogriffithides imbricatus* from Japan the genus is known at present to have been distributed from the Alps and Sicily to the Far East through Crimea in the Lower and Middle Permian times.

Neogriffithides imbricatus Kobayashi and Hamada, 1980

Plate I, figs. 12a–c 13; Text-fig. 5–j

1980. *Neogriffithides imbricatus* Kobayashi and Hamada, *Proc. Japan Acad.*, vol. 56–b, no. 3, p. 121, figs. 4a–c.

Description:—Pygidium subtrigonal, strongly inflated and distinctly trilobed; anterior margin nearly transversal, but rounded at lateral ends; lateral margins broadly arcuate and meeting each other in posterior, forming a blunt angle. Axial lobe strongly arched up above pleural lobes, longiconic, but subtruncated at posterior terminus, composed of 18 or more rings; crest line descending more strongly in posterior terminus where the lobe is overhanging; median part of axial ring remarkably warped up and protruded backward; ring furrows weak on lateral slopes, considerably strengthened mesially where the axial rings look imbricated. Pleural lobe slightly sloping down adaxially in inner half, but it is strongly slanting down in outer half, divided into 12 ribs besides the first narrow rib; pleural furrow weak on axial side, well pronounced on the other side where a few anterior ribs are bisected by short interpleural furrows. Marginal border narrow, but well defined, roof-shaped in cross section. Test smooth.

Observation:—The holotype is a nearly perfect pygidium. The second pygidium is imperfect, but has a similar outline. Its pleural furrows are more pronounced and distinct in their whole length. The anterior pleural ribs are forked by incision of a short interpleural furrow. The marginal border is comparatively broad. The outer slope of the border is striated by some irregular subparallel lines.

The axial lobe of the second pygidium reveals the imbrication of the median crest of the axial rings, typical of this species.

Comparison:—The pygidium of *Neogriffithides* bears a significant aspect quoted that "a very high, keel-like or apically slightly rounded axis overlapping the limb." It has 17 to 20 axial rings and 11 to 12 pleural ribs; its marginal border narrow. The type-species is *Neogriffithides gemmellaroi* Toumansky whose pygidium is subtriangular in outline. Its axial lobe has the arching crest like this species. That species, however, has the stronger ring, pleural and interpleural furrows, somewhat narrower and depressed marginal border and tuberculate test. The very prominent median crests of the axial rings and their imbrication are two most distinctive aspects among the species of this genus.

Occurrence:—Middle Permian; Mt. Ryozen, Shiga Prefecture.

Genus *Ditomopyge* Newell, 1931.

Remarks:—Cyphinium Weber, 1933 is now generally accepted as a junior synonym of *Ditomopyge* Newell, 1931. This genus is intimately related to *Paladin* (*Kaskia*) on one side and *Pseudophillipsia* on the other. It can, however, be easily discriminated from *Paladin* (*Kaskia*) essentially by the presence of the median preglabellar lobe in *Ditomopyge*. From *Pseudophillipsia Ditomopyge* is distinguishable by the inflated glabella encroaching on the frontal rim, indistinct lateral furrow, straight posterior border of the glabella and smaller number of segmentation of the pygidium which is typically shorter in outline and its axis much broader, if compared to *Pseudophillipsia*.

This genus is commonly divided into two groups. Namely, in the *artinskiensis* group the axial lobe of the pygidium is distinctly trapezoidal in cross section, while it is simply rounded or more or less flattopped in the *scitula* group. Excluding specifically indeterminable forms, G. and R. Hahn (1970) listed 21 species in their catalogue. The *artinskiensis* group which is wide spread in Eurasia and Australia in the Upper Carboniferous and Permian rocks comprises 9 species one of which is Teichert's from Australia (1944) and others are all Weber's species (1932, 1933, 1937). The *scitula* group includes 5 species which are all North American except for Grant's species from the Upper Permian of Pakistan. In America this group died out in the Wolfcampian.

Beside them there remain seven species whose grouping is not cited in the catalogue and for two of them the reference to *Ditomopyge* is uncertain.

In Hahns' catalogue *Phillipsia roemeri* Moeller, 1867 and *Ditomopyge roemeri spitzbergensis* Osmólska, 1968 are located in *Paladin* (*Kaskia*), but Chamberlain (1970) referred the former to *Ditomopyge* and Ormiston (1973) accepted the latter as a distinct species of *Ditomopyge* and added a new species, *Ditomopyge bjorensis* from Ellesmere Island. Chamberlain (1977) emphasized that the *scitula* group is distinctive of the Mid-Continent-Andean realm as the *artinskiensis* group in the Eurasiatic-Arctic realm.

Prior to this Goldring (1957) pointed out that *Ditomopyges* with and without the flat frontal border in the cephalon may be divided into separate genera or subgenera. This opinion was later supported by Ormiston (1973). Meek and Worthen (1873), however, stated in their original diagnosis of *Phillipsia (Griffithides) scitula* that "Glabella broadly rounded and sloping in front where it is without a projecting marginal rim (p. 613)". On the other hand the glabella invades into the frontal border not only in *Cyphinium artinskiensis,* but also in *Cyphinium kumpani.* The frontal border is, however, completely exposed in the dorsal view in *C. kumpani* var. *planiloba* (Weber, 1933). Thus the bipartation of *Ditomopyge* inclusive of *Cyphinium* requires a comprehensive revision.

Ditomopyge densigranulata Kobayashi and Hamada, sp. nov.

Plate IV, figs. 9–11; Text-fig. 5–e

Description:—Cephalon semicircular, moderately inflated; glabella gradually expanding forward and extending as far as anterior marginal furrow; lateral furrows absent; preoccipital lobe tripartites into a broad median lobe and a pair of small round basal lobes; occipital furrow deep; neck ring fairly wide; eyes medium in size, located anterior to basal lobes; fixed cheek narrow; free cheek broad; genal spine very short or absent; lateral marginal border and furrow well developed; test densely granulate.

Observation and Comparison:—The cephalon is ornamented densely by coarse granules. *Ditomopyge fatmii* Grant, 1966, from the top of the Middle *Productus* Limestone (Upper Permian) of the Salt Range is quite distinct from this species in having smooth test, slow tapering of the glabella and the mode of the tripartition of the preoccipital lobe.

Occurrence:—Quarry, Omote-Matsukawa, Kesennuma City, Miyagi Prefecture.

Repository:—Holotype, PAt 16696; PAt 16697, 16698.

Genus *Pseudophillipsia* Gemmellaro, 1892

Gemmellaro (1892) founded *Pseudophillipsia* on *Phillipsia sumatrensis* Roemer. The second species was *Pseudophillipsia elegans* Gemmellaro. Weber (1933) and Gheyselinck (1937) accepted this genus as a subgenus of *Griffithides,* while Toumansky (1935) and many others evaluated it as an independent genus. It resembles *Ditomopyge* and *Permoproetus* in the cephalon with the trisected preoccipital lobe, but it is quite different from those two genera in its multisegmented pygidium with distinct marginal border.

Recently G. Hahn and Brauckmann (1975) splitted *Pseudophillipsia* into two subgenera, namely, *Pseudophillipsia* (*Pseudophillipsia* and *Carniphillipsia*) where the former is a Permian subgenus, but the latter ranges from Westphalian to Middle Permian. The chief distinctions between the two subgenera are as follows:

Subganus	*Carniphillipsia*	*Pseudophillipsia*
three lateral lobes of main glabellar lobe	weak or absent	distinct
axial rings of pygidium	17–21	20–27
pleural ribs of pygidium	9–13	12–17

Besides the type-species the two authors referred eleven species to subgenus *Pseudophillipsia,* but for five of them with question, as follows:

Pseudophillipsia (Pseudophillipsia) obtusicauda (Kayser, 1883)
P. (P.) elegans Gemmellaro, 1892
P. (P.) borissiaki Toumansky, 1935
P. (P.) gemmellaroi Canavari, 1935
P. (P.) paffenholzi Weber, 1939
P. (P.) solida Weber, 1944
P. (Pseudophillipsia ?) acuminata Mansuy, 1912
P. (P. ?) mustafensis Toumansky, 1935
P. (P. ?) timorensis (Gheyselinck, 1937)
P. (P. ?) armenica Weber, 1944
P. (P. ?) hungarica (Schréter, 1948)

Lately the following nine species were added to the genus *Pseudophillipsia* from Tunisia and China.

Pseudophillipsia azzouzi H. et G. Termier, 1974
Pseudophillipsia chongqingensis Lu, 1974
Pseudophillipsia qinglogensis Qian, 1977
Pseudophillipsia pyriformis Qian, 1977
Pseudophillipsia anshuensis Qian, 1977
Pseudophillipsia subcircularis Lu, 1977
Pseudophillipsia heshanensis Qian, 1977
Pseudophillipsia huishuiensis Yin, 1978
Pseudophillipsia raggyorcakaensis Qian, 1981

In Japan *Pseudophillipsia* or *P. obtusicauda* has been reported to occur in the Kesennuma district in the Kitakami Mountains, North Japan, and Kuzuu, the Ashikaga Mountains, Kwanto region. Lately the present authors have described *Pseudophillipsia spatulifera* from Kamiyatsuse, Kesen district and *Pseudophillipsia intermedia* from Neo, Gifu Prefecture, West Japan.

Recently the authors (1984) discriminated *Pseudophillipsia (Nodiphillipsia)* from *Pseudophillipsia* s. str. as a new subgenus with *Pseudophillipsia spatulifera* as the type-species, and described three new species, *P. (Pseudophillipsia) kiriuensis, P. (Pseudophillipsia) akasakensis* and *P. (Pseudophillipsia) catena.*

Distribution:—Upper Carboniferous (Stephanian) to Upper Permian; Eurasia from Tunisia to Japan through Sicily, the Alps, Karawanken, the Moscow basin, Crimea, Caucasus, Armenia, Afghanistan, Xizang, South China and Indonesia.

Subgenus *Pseudophillipsia (Pseudophillipsia)* Gemmellaro, 1892

According to G. and R. Hahn and Ramovs (1970), *Pseudophillipsia sumatrensis* (Roemer), 1880, from the upper Middle Permian or Kazanian (*Verbeekina* Zone) of Padang, Sumatra, has the glabella expanding forward to the broadly rounded frontal margin, three pairs of lateral lobes separated by lateral furrows, occipital lobes trisected into a broad median and two slightly elongate lateral lobes and the medium sized eyes opposed at the middle and posterior lateral glabellar lobes. Such characteristics are also recognizable in *P. elegans* Gemmellaro from the *Fusulina*-limestone of the Socio Stage, i.e. Artinskian or lower Middle Permian and *P. borissiaki* Toumansky from the Artinskian of Crimea. *P. azzouzi* H. et G. Termier from the upper Kazanian of Tunisia appears to have four lateral lobes, although the most anterior one is poorly outlined. The axial rings and pleural ribs of the pygidium number respectively 27 and 15–17 in *P. sumatrensis*, 25–27 and 15 in *P. elegans*, 25 and 13 in *P. borissiaki* and 31 and 14 in *P. azzouzi*.

According to G. Hahn and Brauckmann's restudy on *P. obtusicauda* (Kayser) 1883 three lateral lobes are clearly defined on the glabella by lateral furrows. The middle and posterior lobes terminate with nodes on the left side of the observer. Three nodes or tubercles are prominent, but lateral lobes and furrows are obscure on the right side. The median preoccipital lobe is very small in comparison with lateral ones. The type specimen appears to be deformed to some extent.

It is probable that the lobation became obsolete and only these terminal nodes remained on the right side by lateral compression. Therefore it is difficult to place in *P.* (*Pseudophillipsia*) or *P.* (*Nodiphillipsia*). This Kayser's type specimen was obtained from the Lopingian (Upper Permian) reddish gray limestone in Mingshan coal-field, Lopinghsien, Province Kiangsi, Central China.

The occurrences of *Pseudophillipsia obtusicauda* in Japan were reported by Endo and Matsumoto (1962) and others, but none is exactly identifiable with this species. Most of them, if not all, belong to *Pseudophillipsia* (*Nodiphillipsia*) as described later. On the other hand three species from the Middle Permian at Kiriu and Akasaka were found to belong to this subgenus. They are *P.* (*Pseudophillipsia*) *kiriuensis*, *P.* (*Pseudophillipsia*) *akasakensis* and *P.* (*Pseudophillipsia*) *catena*.

In China *Pseudophillipsia obtusicauda* was reported by Lu (1974) to occur in the Loping and Changhsing Formations at Wenxinxiang, Chongquing, Sichuan. According to him three pairs of diagonal lateral furrows are present on the glabella, but they are quite weak in the illustration. Eyes are larger and located more posteriorly than in *P. obtusicauda*. The frontal border is unusually thick and strongly convex and clearly separated from the glabella by a profound marginal furrow. As it is certain that it is distinct from Kayser's species, a new name *Pseudophillipsia lui*, is proposed for it in honour of Dr. Lu Yenhao. Its pygidium has 22 to 23 axial rings and 13 to 14 pleural ribs.

Zhou (1977) reported *P. obtusicauda* from the Changhsing Formation in Guangxi. It is represented by a subtriangular pygidium having 20 binodose axial rings and 12 pairs of pleural ribs. It disagrees with Kayser's as well as Lu's form in the outline and segmentation.

Pseudophillipsia chongpingensis Lu, 1977 found in the same formation with *Pseudophillipsia lui* at Wanxinxiang is an aberrant form having many pustules on the frontal lobe of the glablella and a large median pustule in the pygidium on each ring of the axial lobe which is triangular, instead of trapezoidal, in cross section.

Qian (1977) described five new species of *Pseudophillipsia* from the Upper Permian at Qinglong and Anshun, Guizhou, in three of which the cephala were known. *P. qinglongensis*, having two pairs of lateral furrows in different length on the glabella in front of the trisected preoccipital lobe, belongs evidently to this subgenus. The lateral glabellar furrows appear to be short and weak in *P. pyriformis* and *P. anshunensis*. They disappear completely in *P. raggyorcakaensis* Qian, 1981 from the Upper Permian of Xizang. None of them, however, has lateral glabellar nodes as seen in *P.* (*Nodiphillipsia*). Therefore the effacement of the lateral furrows on the glabella must have been the leading trend of evolution which took place in *Pseudophillipsia* (*Pseudophillipsia*) in China in the late Permian age.

Pseudophillipsia (*Pseudophillipsia*) *kiriuensis* Kobayashi and Hamada, 1984

Plate VII, figs. 1–3; Plate VIII, figs. 1–6; Text-fig. 6–b

1984. *Pseudophillipsia* (*Pseudophillipsia*) *kiriuensis* Kobayashi and Hamada, *Proc. Japan Acad.*, vol. 60–B, no. 1, p. 2, fig. 1a–b.

Description:—Cranidium with strongly inflated glabella which arches down forward through its main lobe; this lobe narrowing regularly backward with nearly straight lateral margins in posterior portion, its frontal lobe most expanded and rounded in front. In the posterior part of the main lobe three lateral lobes are indicated only by short lateral incisions; breadth of main lobe across posterior lateral lobes a half or less of its frontal lobe. The preoccipital lobe nearly as wide as frontal lobe is trisected by strong furrows into a median lobe and a pair of basal lobes in equal size; median lobe broad, subquadrate to elliptical; basal lobes roundly triangular; occipital lobe twice as wide as median lobe. Palpebral lobe semicircular, extending from anterior lateral lobe to anterior half of basal lobe. Occipital, preoccipital, axial and preglabellar furrows all distinct. Fixed cheek anterior to palpebral lobe very narrow; frontal border equally narrow.

Pygidium semicircular, moderately inflated. Axial lobe a third as wide as pygidium, gently convex, elevated above pleural lobes, more or less flattened on top, regularly tapering backward, and arching down slowly in anterior part but somewhat abruptly in posterior half, rounded at terminus, and divided into some 22 axial rings by strong ring furrows, but the furrows become weak in lower part of lateral slope. Pleural lobe subhorizontal in adaxial side but arching down on the other side, and divided into 14 to 15 ribs by strong pleural furrows; a few anterior ribs, however, subdivided into a broad anterior band and a narrow posterior one by a linear interpleural furrow. Along the articulating margin the anterior band of the first pleuron forms a narrow and short ridge on the axial side, while the posterior band of the pleuron extends as far as the antero-lateral extremity of the pygidium. Marginal border behind the posterior band narrow, smooth and depressed.

Test smooth.

Observation:—The axial lobe of the pygidium is not distinctly trapezoidal in cross section. In its exfoliated part a pair of nodose projections are recognizable on the two sides of the summit part. There is, however, no row of tubercles either on the axial ring or pleural rib. Nothing is known of the free cheek and thorax.

Comparison:—This species is similar to *Pseudophillipsia spatulifera* in the outline of the glabella and intermediate between that species and *P. sasakii* in the forward invasion of the frontal lobe. Although this pygidium is semicircular in outline, it is different from *Pseudophillipsia binodosa* in the cross section of the axial lobe. Furthermore, *P. binodosa* has two or more axial rings, whereas this species has one more pleural rib.

The pygidium of this species looks most similar to that of *Pseudophillipsia* (*Carniphillipsia* ?) *intermedia* in general aspects, but less segmented in that species.

Occurrence:—Common in the Nabeyama Series at Kiriu, Tochigi Prefecture; a pygidium found in the lower division (*Parafusulina* Zone) of the Akasaka Limestone at Akasaka, Gifu Prefecture.

Repository:—Holotype, PAt 16711; Paratype, PAt 16710, 16711; PAt 16716 ~ 8.

Pseudophillipsia (*Pseudophillipsia*) *kiriuensis* forma *subtrigonalis* Kobayashi & Hamada, forma nov.

Plate VII, figs. 4–6

This form agrees with the typical form of this species in essential characteristics, but it is distinct in the somewhat longer and subtriangular outline and more or less narrower axis.

It is represented by three pygidia, of which the best preserved one (pl. 7, Fig. 4) showes that the three margins are gently arcuate. Two lateral margins meet behind the axial lobe in describing a broad arc. In this pygidium the axial lobe is divided into more than nineteen axial rings, although terminal rings are not countable. The axial rings total probably 22 or so. Thirteen ribs are present on the pleural lobe of this specimen and 13 or 14 ribs on the left pleural lobe of another specimen.

This form resembles *Pseudophillipsia* aff. *simplex* closely.

Occurrence:—Kiriu; Middle Permian.

Repository:—PAt 16713 ~ 5.

Pseudophillipsia (*Pseudophillipsia* ?) *kuzuensis* Kobayashi and Hamada, sp. nov.

Plate VI, figs. 7, 8.

1979. *Pseudophillipsia* sp. Koizumi, Yoshino and Kojima, *Chikyu-Kagaku*, vol. 33, no. 6, p. 353, figs. 1a–e.

Description:—Pygidium more or less semicircular, as long as wide, gently inflated. Axial lobe a little narrower than pleural lobe, gently convex above the latter, slowly tapering back as far as well rounded terminus; its summit horizontal in anterior half but slant with small angle in the remainder. Pleural lobe also horizontal in adaxial side, but warping down in the other one-third. Axial lobe and pleural lobes divided into about 22 rings and 14 ribs by narrow furrows respectively; anterior ribs subdivided by still finer linear pleural furrows into a broad main rib and a narrow riblet of which the latter corresponds to the anterior band of the pleuron; anterior band of the first pleuron thicker and a prominent process rising up from the articulating margin at about two-thirds from the axial furrow. Marginal border flat, narrow and smooth. Test apparently smooth, but extraordinarily fine striation is present (see Koizumi *et al.*, 1979, fig. 1e).

Comparison:—Compared to *Pseudophillipsia kiriuensis* this pygidium is somewhat longer and evidently less inflated, the axial lobe relatively narrow and the ring and pleural furrows are quite slender. These two species are, however, allied to each other in the number of segmentation of these lobes and the general outline of the pygidium.

Occurrence:—Yamasuge, Kuzuu Town; Middle Permian Yamasuge Limestone, Nabeyama Formation. Because the pygidium is contained in limestone, its outline and convexity are little deformed.

Repository:—Holotype, PAt 16707.

Pseudophillipsia (Pseudophillipsia) akasakensis

Kobayashi and Hamada, 1984

Plate IX, figs. 1, 2; Text-fig. 6–k

1984. *Pseudophillipsia (Pseudophillipsia) akasakensis* Kobayashi and Hamada, *Proc. Japan Acad.*, vol. 60–b, no. 1, p. 2, figs, 2a–b.

Description:—Cephalon semicircular, but more or less elongated and moderately inflated. Glabella exclusive of basal lobes suboval, or pyriform; frontal lobe sphaeric, most expanded laterally through its center; three pairs of lateral lobes separated from one another by two pairs of lateral furrows; furrow in front of anterior lateral lobe shallow; axial furrows running straight into glabella, becoming confluent with median preoccipital furrow and reaching occipital furrow; preoccipital median lobe subquadrate; basal lobe large and subtrigonal; neck ring broad and mesially thickened. Cheek very small; eyes large, slightly lower than the glabellar top and provided with a narrow ridge along its lateral margin; palpebral lobe semicircular and sloping down toward glabella; cheek roll clearly separated from the ridge and issuing a sharp intragenal branch diagonally; marginal border well developed; lateral border somewhat thickening toward frontal border which, however, halfway invaded by glabella; anterior marginal border narrow and vertical in front; marginal furrow deep; genal spine probably present. Facial suture extending forward from eye, forming gentle curve; its posterior branch crossing cheek roll and cutting posterior border near its mid-point. Test smooth.

Pygidium nearly as long as wide and well inflated; lateral margin nearly straight; anterior margin broadly arcuate; posterior margin well rounded. Axial lobe slightly broader than pleural lobe, highly elevated, subtrapezoidal in cross section, gently convex on top; its lateral slope steep, even concave partly; the lobe divided by deep furrows into more than 23 axial rings with a row of small tubercles along each posterior margin. Pleural lobe convex, a little slanting adaxially, broadly warping down toward marginal furrow, divided by profound furrows into more than 18 pleural ribs which are distinctly bent forward on axial side; a row of small tubercles aligned along posterior margin of each rib. Marginal furrow deep; marginal border steeply slanting with weak convexity.

Observation:—The holotype specimen is a rolled shield whose nine thoracic segments are ill-preserved and partly displaced. The lateral margin of the pygidium meets with the inner margin of the cephalic marginal border on its ventral side. The genal spine is not preserved on the specimen, but the concavity of the lateral and posterior borders near their junction in the dorsal view and the acute angle between them suggest a missing spine of this trilobite. The posterior terminus of the pygidium is broken off, but it is presumable that the axial rings and pleural ribs, if complete, number about 25 and 19 respectively.

Comparison:—The sphaeric frontal lobe of the glabella, very large lateral preoccipital lobes, narrow ridge along the large eye and trifurcate carination on the free cheek are important characteristics of this species. *Hentigia bulbops* Haas, Hahn and Hahn, 1980 also has such a ridge along the eye, but it is quite different from this species in the glabellar outline and other aspects of the cephalon and also the much less segmented pygidium.

Occurrence:—The *Neoschwagerina* Zone (?)-*Yabeina* Zone of the Akasaka Limestone at Akasaka, Gifu Prefecture.

Repository:—Holotype, PAt 16721; PAt 16722.

Pseudophillipsia (*Pseudophillipsia*) *catena*

Kobayashi and Hamada, 1984

Plate X, figs. 6–11; Tex-fig. 6–c

1984. *Pseudophillipsia* (*Pseudophillipsia*) *catena* Kobayashi and Hamada, *Proc. Japan Acad.*, vol. 60–b, p. 2, figs. 3a–b.
1984 *Pseudophillipsia* sp. Kojima *et al.*, *Chigaku-Kenkyu*, vol. 34, nos. 1/6, p. 121, figs. 3, 6.

Description:—The glabella exclusive of the basal lobes is subovate and gently convex. Three pairs of lateral lobes clearly separated from one another by lateral furrows. The median pre-occipital lobe is subquadrate and moderate in size. The frontal border is slightly convex and separated from the glabella by a linear marginal furrow.

A free cheek having a long genal spine is found associated with a cranidium of this species in the same limestone block.

The associate pygidium is subtrigonal, fairly long and subangulate in posterior. The axial rings are binodose on the top. The pleural ribs and furrows are subequal in breadth. The tubercles on the ribs commonly extend into the furrow forming bars. The axial rings attain more than 28 and the pleural ribs 17 to 18. The narrow and convex marginal rim is separated from the pleural lobe by the profound marginal furrow.

In the multisegmentation of the pygidium this species is nearer to *P.* (*P.*) *sumatrensis* Roemer than *P.* (*P.*) *borissiaki* Toumansky. These two species are, however, quite different from this in the glabellar outline. This cranidium looks very similar to that of *P.* (*Nodiphillipsia*) *ozawai*, but the lobated glabella excludes this species from the subgenus *Nodiphillipsia.*

Occurrence:—An imperfect cranidium and two pygidia, one of which is nearly complete, from the *Neoschwagerina* Zone of the Akasaka Limestone at Akasaka, Gifu Prefecture.

Repository:—Holotype, PAt 16731; Paratype, PAt 16733, 14734; PAt 16730, 16732, 16735.

Subgenus *Pseudophillipsia* (*Carniphillipsia*)

G. Hahn and C. Brauckmann, 1975

G. Hahn and C. Brauckmann distinguished two subgenera in the genus *Pseudophillipsia.* Their new subgenus, *Carniphillipsia,* differs from *Pseudophillipsia* s. str. principally in the undeveloped lateral glabellar furrows and lobes except for preoccipital ones on the cephalon and the paucisegmentation of the pygidium, precisely speaking, 17–21 axial rings and 9–13 pleural ribs in *Pseudophillipsia* (*Carniphillipsia*), but 20–27 axial rings and 13–17 pleural ribs in *P.* (*Pseudophillipsia*).

The type-species is *Pseudophillipsia ogivalis* Gauri, 1965, from the Stephanian, ? Gsehlian, Carnic Alps.

The other species and subspecies of the subgenus are as follows:

P. (*C.*) *ogivalis javornikensis* Hahns and Ramovs, 1977, Gsehlian, Karawanken

P. (*C.*) *rakoveci* Gauri, 1965, Gshelian, Karawanken

P. (*C.*) *semicircularis* Gauri, 1965, Stephanian, ? Gsehlian, Carnic Alps.

P. (*C.*) *semicircularis savensis,* Hahns & Ramovs, 1977, Gsehlian, Karawanken

P. (*C.*) *lipara* Goldring, 1957, Uralian, or uppermost Carboniferous or lowest Permian, Oman

P. (*C.*) *stenopyge* Goldring, 1957, Uralian, Oman

P. (*C.*) *praepermica* Weber, 1933, Westphalian-Stephanian, Moscow basin, Ferghana, Turkestan and the Urals

P. (*C.*) *liparoides* Hahns and Ramovs, 1977, Upper Carbon. ? Gsehlian, Karawanken

Furthermore it is suggested by Hahn and Brauckmann that *Pseudophillipsia oehlerti* (Gemmellaro, 1892) and *P. sosiensis* (Gemmellaro, 1892), both represented by pygidia only, from the Artinskian Sosio Stage of Sicily may be referable to this subgenus.

Recently a few species were added to them, namely,

P. (*C.*) *loricata* Haas and G. and R. Hahn, 1980 and

P. (*C.*) *cooperations* Haas and G. and R. Hahn, 1980 from the Artinskian of Afghanistan and

P. (*C.* ?) *intermedia* Kobayashi and Hamada, 1980 from the Middle Permian of Japan

Judging from these species its geological range is from Westphalian to Middle Permian with the acmic prominence in the Stephanian or Gsehlian. Its distribution extends from Ferghana-Turkestan and Japan in the east to the Eastern Alps or possibly Sicily in the west and the Ural Mountains and the Moscow basin in the north and Oman in the South.

Pseudophillipsia (*Carniphillipsia* ?) *intermedia*

Kobayashi and Hamada, 1980

Plate XI, figs. 1, 2; Text-fig. 6–d

1980. *Pseudophillipsia intermedia* Kobayashi and Hamada, *Proc. Japan Acad.,* vol. 56–B, no. 3, p. 123, fig. 5, no. 6a–c.

Description:–Cranidium with broad glabella whose main lobe is strongly convex, very large, subquadrate, expanding forward; its anterior margin broadly arcuate and rounded at two lateral ends; no furrow on this lobe; occipital and preoccipital furrows equally well pronounced; preoccipital lobe divided into a broad median part and a pair of basal lobes which are diagonally elongated; occipital ring distinctly expanded mesially. Frontal border narrow, convex, separated from glabella by deep furrow; fixed cheek very narrow; eyes relatively small, opposed at midlength of cranidium.

Pygidium a little broader than long, parabolic in outline with nearly straight anterior margin, but well rounded at antero-lateral part, widest at about a quarter of length behind articulating margin; axial lobe occupying one-third of pygidium, long conical, prominent, trapezoidal in cross section, composed of about 23 rings, truncated at rear end; pleural lobe arching down in outer part, sloping down gently and becoming subhorizontal in the other part, divided into 17 to 18 convex simple ribs by profound pleural furrows; marginal furrow deep;

marginal border narrow and convex.

Test smooth.

Comparison:–In the lack of lateral furrows this cranidium agrees with *Pseudophillipsia* (*Carniphillipsia*). It resembles *P.* (*C.*) *ogivalis javornikensis* Hahn and Ramovs, 1977, closely, although the main glabellar lobe is smaller, and eyes are much larger and located more posteriorly in that species. The associate pygidium of this species is, on the contrary, disagrees with the subgenus in the multisegmentation, namely, *Carniphillipsia* has 17–21 axial rings and 9–13 pleural ribs, while *Pseudophillipsia* s. str. has 20–27 axial rings and 12–17 pleural ribs. Hence the name *Pseudophillipsia intermedia.* The pygidium in fig. 6a–c, (Kobayashi and Hamada, 1980) which was mislabelled in laboratory, is excluded from this species.

Occurrence:–Middle Permian *Parafusulina-Neoschwagerina* Zone; Neo, Gifu Prefecture.

Repository:–Holotype, PAt 16736; Paratype, PAt 16737.

Subgenus *Pseudophillipsia* (*Nodiphillipsia*) Kobayashi and Hamada, 1984

Diagnosis:–*Pseudophillipsia* with three pairs of lateral nodes or tubercles in place of lateral lobes; lateral furrows effaced. Pygidium has 22 to 28 or more axial rings and 10 to 18 pleural ribs.

Type-species:–*Pseudophillipsia spatulifera* Kobayashi and Hamada, 1980.

Remarks:–*Pseudophillipsia* as a genus can be divided into three subgenera. *Pseudophillipsia* s. str. typified by *Phillipsia sumatrensis* Roemer, 1880 has three pairs of lateral lobes separated by short lateral furrows in front of the trisected preoccipital lobe. These lateral furrows and lobes are effaced completely or almost completely in *Pseudophillipsia* (*Carniphillipsia*) G. Hahn and Brauckmann, 1975, founded on *Phillipsia ogivalis* Gauri, 1965. The lateral lobes and furrows are obsolete, but there remain three pairs of button-like circular tubercles in place of the lobes on the glabella in *P.* (*Nodiphillipsia*).

According to Hahn and Brauckmann (1975) the axial rings and pleural ribs are respectively 17 to 21 and 9 to 13 in *Pseudophillipsia* (*Carniphillipsia*) and 20 to 27 and 13 to 17 in *Pseudophillipsia* (*Pseudophillipsia*) which included *P.* (*Nodiphillipsia*) at that time. *Pseudophillipsia* (*Nodiphillipsia*) here proposed has 20 to 25 axial rings and 10 to 18 or more pleural ribs.

These characteristics are all clearly shown in *Pseudophillipsia spatulifera.* The cephalon of *Pseudophillipsia* (?) *solida* Weber, 1944 from the Upper (?) Permian in the Malaia Laba basin, North Caucasus also represents the typical aspects, but the other parts of its dorsal shield is unknown. The cephalon and pygidium are known of *Cyphinium* (?) *paffenholzi* Weber, 1944, from the Upper (?) Permian in the Vedi-chai River basin, Armenia. It is referable to this subgenus, but the lateral nodes are rudimentary in this species.

Besides *P. spatulifera* from the Middle Permian Kanokura Formation *P.* (*Nodiphillipsia*) *ozawai* and *P.* (*Nodiphillipsia*) *hanaokensis* were already described by the authors (1983) respectively from the *Yabenina globosa* Zone and the *Reichelina changhsingensis* Zone of the Akasaka Limestone in Japan.

On this occasion the following species are added to them from the Kesennuma district:

Pseudophillipsia sasakii, sp. nov.

Pseudophillipsia simplex, sp. nov.

Pseudophillipsia binodosa, sp. nov.

The cephalon is known of *Pseudophillipsia spatulifera, P. (Nodiphillipsia) ozawai, P. (Nodiphillipsia) hanaokensis* and *P. sasakii.* Their difference is particularly significant in the outline of the main glabellar lobe, and the invasion of the frontal lobe of the glabella into the anterior marginal border and furrow. The pygidia of these Japanese species may be divided into the subtrigonal and semicircular groups. The axial lobes are trapezoidal in cross section in some but in others well rounded. The trapezoidal ones have commonly a pair of nodes on the summit level of the axial ring. All of these pygidia are multisegmented and more than 20 axial rings are countable.

Occurrence:—This subgenus appeared in the Middle Permian or probably upper Middle Permian in Japan and widespread in Asia in the late Permian age.

Pseudophillipsia (Nodiphillipsia) spatulifera

Kobayashi and Hamada, 1980

Plate V, figs. 1–3; Plate VI, figs. 1–3; Plate VIII, figs. 7, 8; Text-fig 6–g

1961. *Pseudophillipsia* sp. Araki, *Chigaku-Kenkyu,* vol. 12, no. 6, p. 226, figs. 1–5.
1962. *Pseudophillipsia obtusicauda* (Kayser), Endo and Matsumoto, *Sci. Rep. Saitama Univ.,* Ser. B, vol. 4, no. 2, p. 155, pl. 1, figs. 1a–b, 2–3, 5, (?) 4.
1966. *Pseudophillipsia obtusicauda* (Kayser), S. Jimbo, *Jour. Geol. Soc. Japan,* vol. 72, no. 12, p. 193, figs. 2–2.
1968. *Pseudophillipsia obtusicauda* Kayser, Araki and Koizumi, *Chigaku-Kenkyu,* vol. 19, no. 6–8, p. 152, pl. 1, figs. 1–4, pl. II, fig. 7.
1978. *Pseudophillipsia* aff. *obtusicauda* (Kayser), Koizumi and Sasaki, *Ibid.,* vol. 29, nos. 7–9, p. 300, pl. 2, figs. 1–3.
1980. *Pseudophillipsia spatulifera* Kobayashi and Hamada, *Proc. Japan Acad.,* vol. 56–B, no. 4, p. 195, figs. 1a–b, 2a–d, 3a–b.

Desctiption:—Cephalon subtrigonal, but rounded in front of glabella, surrounded by thick marginal border, forming salient crest on lateral sides with profound marginal furrow on the inner side; lateral and posterior borders combined at genal angle whence issues a large spatulate genal spine nearly as far as thoracic length; lateral and posterior marginal furrows confluent with each other at the angle; median furrow extending therefrom into narrow summit level of genal spine. Glabella somewhat larger than cheek, composed of a suboval or pentagonal main lobe and a trisected preoccipital lobe beside large neck ring; main lobe provided with three pairs of lateral lobes in form of prominent tubercles; preoccipital lobe clearly divided into a relatively broad median lobe and a pair of basal lobes produced upward and backward; preoccipital and occipital furrows well developed; occipital ring very large, subtrapezoidal, sloping forward from tuberculate posterior margin; median tubercle absent on the ring. Fixed cheek narrow; eyes large, prominent, extending from middle lateral node to part of basal lobe, as wide as cheek roll; palpebral lobe semicircular, sloping inward rather steeply; facial sutures divergent from eyes as far as parallels through eye-limits; sutures subparallel to each other for a short distance behind eyes and then crossing posterior cheek border diagonally from median point of its anterior margin.

Thorax a little shorter than cranidium, composed of nine segments, more or less broadened in mid-length; axial lobe nearly as wide as pleural lobe; axial ring strongly convex; pleuron suddenly geniculate, subhorizontal and transversal on axial side, but steeply sloping down and extending postero-laterally from geniculation where a small but distinct fulcral process is present; a row of tubercles alined on posterior ring margin.

Pygidium a little longer than cephalon, parabolic in outline, or subtrigonal but well rounded at three angles, slightly longer than wide, widest shortly behind articulating margin. Axial lobe nearly as wide as pleural lobe, prominent, trapezoidal in cross section, composed of 24–25 axial rings, separated from one another by deep ring furrows, tapering backward slowly in main part, but abruptly near terminus where it is overhanging; summit of each ring divided into a pair of nodes and a median flat interval; its lateral slope subvertical, but its lateral quadrate terminus is slanting down to axial furrow; a few rear axial rings excavated on top in form of median slit. Pleural lobe limited by a relatively weak axial furrow, sloping inward gently in adaxial part and strongly arching down in abaxial part, divided into 12 ribs by profound furrow, ornamented by a row of small tubercles along posterior margin; process-bearing riblet present along anterior margin. Marginal border of moderate breadth, depressed, separated from ribbed part by shallow furrow, and gently warped up behind axial lobe.

Observation:–An internal mould of a cranidium from Anabuchi clearly reveals most aspects, namely, the pentagonal main lobe of the glabella, tripartition of the preoccipital lobe and so forth. It is particularly noteworthy that the frontal lobe extends as far as the anterior outline of the cephalon where the narrow frontal rim lies beneath the lobe and the doublure is slanting therefrom downward and backward.

In another cranidium of Anabuchi which is an external mould shows the palpebral lobe and the posterior branch of the facial suture explicitly. The median preoccipital lobe is subtrapezoidal and the basal lobe hemispheric, but the sharp apex is excentric and shifted back from centre. The facial suture runs from eye backward and adaxially before reaching the posterior border furrow, and then turning outward, it cuts the posterior cheek margin at the mid-point. A platy genal spine issues from the right free cheek which is attached to the cranidium.

Among the typical pygidia and additional ones from Anabuchi the row of tubercles along the posterior margin of the axial ring or the pleural rib are very distinct in some but obscure in others. Similarly the strength of the ring furrows varies particularly on the lateral slop. They may be persistent from the top to lateral ends, but they may become obsolete on the lateral slops. However, the axial rings are all trapezoidal in cross section and binodose on the top.

In this species the basal lobe of the glabella is protruded upward and backward and more or less pointed, like the same lobe of *Neoproetus (Triproetus) subovalis* Kobayashi and Hamada, 1979, from the Lower Permian of Thailand. In *Iranaspidion sagittalis* Kobayashi and Hamada, 1978, from the Upper Permian of Iran the basal lobe is binodose and each node somewhat pointed on the top in that species. Its pygidium has the rear slit on the axial lobe like this species as well as *P. sumatrensis* and some others of the same genus (Goldring, 1957). These must be the indication of phylogerontic specialization.

The genal spines are rather seldom to be preserved in *Pseudophillipsia,* but it is known that the spine is moderate in length in *P. sumatrensis.* In certain species of *P. (Carniphillipsia)*, particularly in *P. (C.) ogivalis javonikensis* G. and R. Hahn and Ramovs, 1977, from the Upper Carboniferous of Karawanken, the spines are very long. The spines of the present species is quite unusual in that they are long, large and spatulate in lateral view and projected backward on the two sides of the thorax like its lateral walls. Insofar as the authors are aware, there is no comparable genal spines among the known trilobites.

In the thorax an axial ring is divided into a less convex somewhat larger half-ring and a more convex slightly narrower annulus, as seen in the first and nineth segments. The pleurae have a fulcral process at each geniculation or shortly on its adaxial side. It is small and prominent. In comparison to the posterior band of the pleuron the anterior band is very narrow but distinct on the adaxial side of the process.

In the pygidium the process-bearing anterior band is represented by a riblet along the anterior margin. The succeeding 12 ribs are considerably broader than the riblet. The axial rings are just about twice the pleural ribs plus the first riblet in number.

Finally, in a paratype cephalon of *P. spatulifera* (1980, fig. 3) the anterior border is exposed in front of the glabella by pushing up the border by the secondary deformation, causing the partial separation of it from the glabella along the anterior border furrow. The border and the glabella, however, still maintains the subtrigonal outline and the border is quite sharp on the top, if compared with this species.

Comparison:—The Kesennuma district in northern Miyagi Prefecture is very productive of Permian trilobites. Araki (1961), Endo and Matsumoto (1962), Jimbo (1966), Araki and Koizumi (1968) and Koizumi and Sasaki (1978) called the common trilobites there as *Pseudophillipsia* sp., *Pseudophillipsia obtusicauda* or *Pseudophillipsia* aff. *obtusicauda.* This kind of trilobites have invariably the glabella overhanging the anterior border, three pairs of lateral nodes and trisected preocipital lobe. In its pygidium the axis is trapezoidal in cross section and the axial rings binodose. Their collections contain four trilobites with genal spines which are narrow, half the thorax or longer and sharply pointed at the ends. It is quite probable that these forms belong to *Pseudophillipsia spatulata,* beside a similar form here, called *Pseudophillipsia sasakii,* sp. nov.

The subtrigonal outline of the cephalon, salient crest of marginal border, unusally well developed marginal furrow, large spatulate genal spine, subpentagonal main glabellar lobe encroaching the frontal border, three pairs of nodose lateral lobes, extraordinarily prominent basal lobe and large eyes on the cephalon, and the binodose axial rings and the terminal slit of the axial lobe on the pygidium are quite distinctive of this species.

This species is evidently more allied to *Pseudophillipsia obtusicauda* than *P. sumatrensis* in the glabellar configuration and the binodose axial rings of the pygidium, but the outline of its pygidium agrees better with *P. sumatrensis* than the other, insofar as can be judged from the illustrations of these two species by Fliegel (1901), Frech (1911), Goldring (1957), G. Hahn and Brauckmann (1975), and others. Because the cephalon of *P. obtusicauda* is imperfectly preserved in the holotype specimen, it is difficult to make its exact comparison with this species.

Occurrence:—Middle Permian Kanokura Series; Yatsugamoridaira-yama (Araki, 1961), Kamiyatsuse, Yahagi and Tagara (Endo and Matsumoto, 1962), branch stream of Shigaji-sawa on the western slope of Kurosawa-yama (Jimbo 1966), Shigeji-iri, Kamiyatsuse (Koizumi and Sasaki, 1968), Anabuchi (Koizumi and Sasaki, 1978), and Kamiyatsuse, Kesennuma City, Miyagi Prefecture (Kobayashi and Hamada, 1980). New material is obtained from Anabuchi and Quarry, Omote-Matsukawa, Kesennuma City.

Repository:—Holotype, PAt 16699; Paratype, PAt 16700; PAt 16719a, b.

Pseudophillipsia (*Nodiphillipsia*) *sasakii* Kobayashi and Hamada, sp. nov.

Plate VI, figs. 4–6; Text-fig. 6–e

In this species the glabella invades forward any further beyond the anterior marginal furrow so that the anterior border is clearly visible in the dorsal view. It is very thick and well rounded on top, instead of being a narrow sharp ridge.

In the holotype specimen the frontal lobe of the glabella is separated from the anterior border by a linear anterior furrow in the median part, but on the lateral sides it is expanding. The anterior border is well rounded, while it is more arcuate and even angulate in *Pseudophillipsia spatulifera.* The frontal lobe of the glabella is also well rounded in this species, while it is subangulate in front and the main lobe of the glabella looks subpentagonal in *P. spatulifera.* Nevertheless the two species are very similar to each other in the three pairs of lateral lobes, tripartition of the preoccipital lobe, the occipital and palpebral lobes and so forth. In the holotype of this species the left free cheek is displaced backward from the cranidium. The genal part is unpreserved in the two cheeks, but the eyes may be located a little posteriorly and more or less smaller, if compared to *P. spatulifera.* The lateral border and furrow are well developed in this species. The course of the facial suture is not different between the two species.

Another specimen having a broad glabella well rounded anteriorly is tentatively referred to this species, notwithstanding that the anterior border is unpreserved. It is an interesting question whether or not, the subtrigonal pygidium goes with this cephalon.

Occurrence:–Anabuchi, Kesennuma City, Miyagi Prefecture.

Repository:–Holotype, PAt 16704; PAt 16705, 6.

Pseudophillipsia (*Nodiphillipsia* ?) *simplex* Kobayashi and Hamada, sp. nov.

Plate XIII, fig. 9; Text-fig. 6–h

Description:–Pygidium long, subtriangular, moderately inflated; lateral margin more arcuate in posterior than anterior. Axial lobe nearly as wide as pleural lobe exclusive of lateral border, high up above pleural lobe, longiconic, slowly tapering backward, but abruptly rounded near the end, divided into more than twenty rings by narrow furrows which become obsolete on lateral side. Pleural lobe divided into thirteen flattopped ribs by simple pleural furrows like ring furrows, but more linear. Marginal border narrow and depressed.

Observation:–The type pygidium is lateraly compressed secondarily. As the result its breadth is reduced; convexity of axial and pleural lobes strengthened so much that the lateral sides of the former are nearly vertical and the latter forms a ridge a little inside of its midway by geniculation. It is presumable that the axial lobe was more or less trapezoidal in cross section. No distinct nodes can be seen on the axial rings. The external mould of this pygidium looks rough on the surface by irregular pits, probably due to erosion of coarse matrix of its mother rock. The original test is most probably smooth or non-tuberculate.

Comparison:–This pygidium resembles that of *Pseudophillipsia spatulifera* in the outline and convexity of the pygidium, proportional breath of trilobation and the number of segmentation, but this is quite distinct from that species in the very weak ring furrows, linear pleural furrows and absence of nodes and tubercles.

Occurrence:–Anabuchi, Kesennuma City, Miyagi Prefecture.

Repository:–Holotype, PAt 16758.

Pseudophillipsia (*Nodiphillipsia* ?) aff. *P.* (*N.* ?) *simplex* Kobayashi and Hamada

Plate XIII, figs. 10–12

Three imperfect pygidia from quarry G. allied to *P. simplex* in the non-binodose and well rounded axial rings. The pleural furrows are, however, not linear but as strong as the ring furrows.

Occurrence:—Cutting G, Omote-Matsukawa, Kesennuma City, Miyagi Prefecture.

Repository:—Holotype, PAt 16758.

Pseudophillipsia (*Nodiphillipsia* ?) *binodosa* Kobayashi and Hamada, sp. nov.

Plate VI, figs. 9, 10; Plate XIII, figs. 7, 8; Text-fig. 6–g

Description:—Pygidium broader than long, semicircular in outline and strongly inflated. Axial lobe as wide as pleural lobe, highly evlevated above the latter, trapezoidal in cross section, with flat top half as wide as axial lobe and nodose at its lateral ends; lateral slope steep. The lobe divided into 24 axial rings by strong transverse furrows which, however, become obsolete in lower part of the lateral slope; the lobe gently tapering backward and drooping at terminus where a short slit cuts in; axial ridge present there on the bottom. Pleural lobe roof-shaped, rounded on top, slanting gently inward and steeply outward, divided into 13 ribs by broad and deep furrows. Marginal border very narrow. Test smooth.

Occurrence:—Four pygidia are collected from Anabuchi, Kesennuma City, Miyagi Prefecture.

Repository:—Holotype, PAt 16709.

Pseudophillipsia (*Nodiphillipsia* ?) aff. *P.* (*N.* ?) *binodosa* Kobayashi and Hamada

Plate VIII, fig. 9.

Description:—This form resembles the preceding closely in the semicircular outline, simple and numerous segmentation, and narrow marginal border, but not so strongly inflated. Principal distinction lies in the strong ring furrows which are intercrossed by an equally strong longitudinal furrow, isolating a row of terminal nodes on each side in this form.

There are two external moulds of pygidia. A specimen is the left half of a pygidium which allows the authors the above observation. The axis is composed of more than 20 rings and the pleural lobe of 12–13 ribs. This and another fragmentary pygidium show that the axial lobe is trapezoidal in cross section, though it is very low and besides the terminal nodes of the lateral slope each axial ring bears a pair of nodes at the lateral ends of the top sectant.

Occurrence:—Quarry, Omote-Matsukawa, Kesennuma City, Miyagi Prefecture.

Repository:—PAt 16720.

Pseudophillipsia (*Nodiphillipsia*) *ozawai* Kobayashi and Hamada, 1984

Plate IX, figs. 3–5; Text-fig. 6–i

1984. *Pseudophillipsia* (*Nodiphillipsia*) *ozawai* Kobayashi and Hamada, *Proc. Japan Acad.*, vol. 60–B, no. 1,

p. 2, figs. 4a–b.
1984. *Pseudophillipsia* sp. Kojima *et al., Chigaku-Kenkyu,* vol. 34, nos. 1/6, p. 121, figs. 2, 5.

Description:–Glabella exclusive of basal lobes pyriform, broadest through mid-length of frontal lobe, narrowing regularly toward median preoccipital lobe; three pairs of lateral lobes indicated by small, circular lateral nodes; lateral furrows completely effaced; median preoccipital lobe approximate to a lateral node in size, but more or less broader than long; palpebral lobe semicircular and flat; fixed cheek extending forward from the lobe along axial furrow with slow increase in its breadth; frontal border divided into narrow inner furrow and ridged marginal rim. Pygidium fairly long, subtrigonal, but broadly rounded in posterior; axial lobe one-third as wide as pygidium, slightly elevated above pleural lobe, flattopped, somewhat nodose at lateral ends of the top band; pleural lobe subhorizontal on inner side, but gradually arching down in the outer side; axial rings number 24 to 25 and pleural ribs about 17; a row of tubercles alined on posterior margin of rib; marginal border narrow, convex and separated from pleural lobe clearly by deep furrow.

Comparison:–This species is represented by an imperfect cranidium and two nearly complete pygidia. The cranidium is similar to that of *P.* (*Pseudophillipsia*) *catena,* but it has three pairs of lateral nodes on the glabella. This cranidium is moderately inflated among the Akasaka trilobites. The associated pygidium is quite different from *P. catena* in the well rounded posterior outline.

Occurrence:–The *Yabeina globosa* Zone; Hanaoka, Akasaka, Ogaki City, Gifu Prefecture.

Repository:–Holotype, PAt 16723; PAt 16724.

Pseudophillipsia (*Nodiphillipsia*) *hanaokensis*

Kobayashi and Hamada, 1984

Plate X, figs. 1–5; Plate XI, figs. 3, 4; Text-fig. 6–a

1984. *Pseudophillipsia* sp. by Kojima *et al., Chigaku-Kenkyu,* vol. 34, nos. 1/6, p. 121, figs. 1, 4.
1984. *Pseudophillipsia* (*Nodiphillipsia*) *hanaokensis* Kobayashi and Hamada, *Proc. Japan Acad.,* vol. 60–B, no. 1, p. 2, figs. 5a–b.

Description:–Carapace strongly inflated. Glabella highly convex; main lobe suboval; three pairs of its lateral lobes indicated by small, well rounded nodes or tubercles, anterior pair of which are somewhat weaker than the others; lateral furrows effaced; preoccipital lobe divided into three subquadrate parts by profound furrows; median part broader than long, while basal

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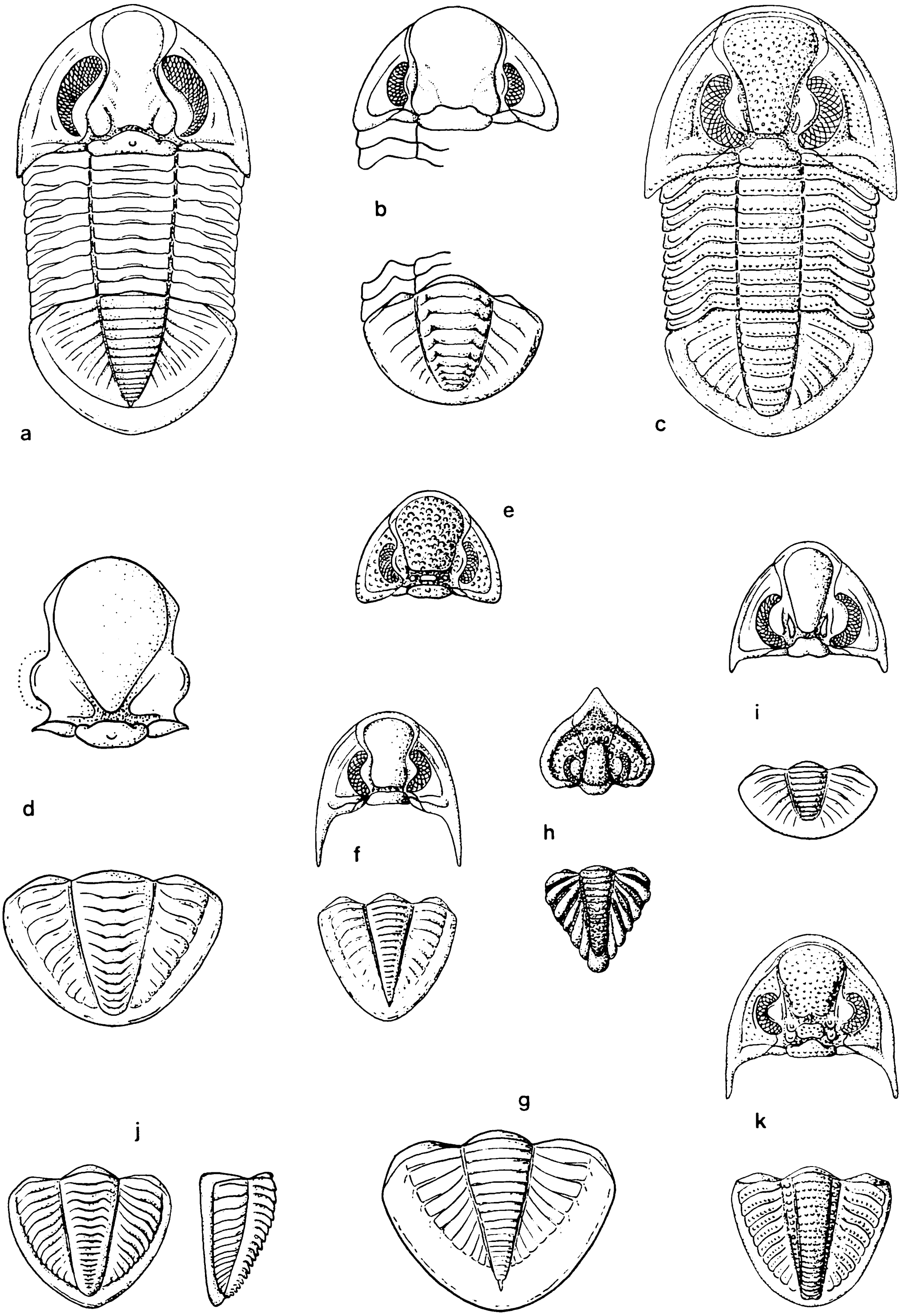
Text-fig. 5. Restoration of some Permian trilobites from Japan – 1.
a. *Nipponaspis takaizumii* Koizumi, 1972, x 2
b. *Paraphillipsia levigata* Kobayashi and Hamada, 1980, x 2.5
c. *Endops yanagisawai* (Endo and Matsumoto, 1962), x 3
d. *"Neoproetus" akagii* Kobayashi and Hamada, sp. nov., x 3
e. *Ditomopyge densigranulata* Kobayashi and Hamada, sp. nov., x 3
f. *Ampulliglabella kojimai* Kobayashi and Hamada, sp. nov., x 3
g. *Ampulliglabella rotunda* Kobayashi and Hamada, sp nov., x 3
h. *Cheiropyge* (*Suturikephalion*) *koizumii* Kobayashi and Hamada, 1982, x 3
i. *Paladin* (?) *iwaizakiensis* Kobayashi and Hamada, sp. nov., x4
j. *Neogriffithides imbricatus* Kobayashi and Hamada, 1980, x 3
k. *Iranaspidion sagittalis* Kobayashi and Hamada, 1978, x 2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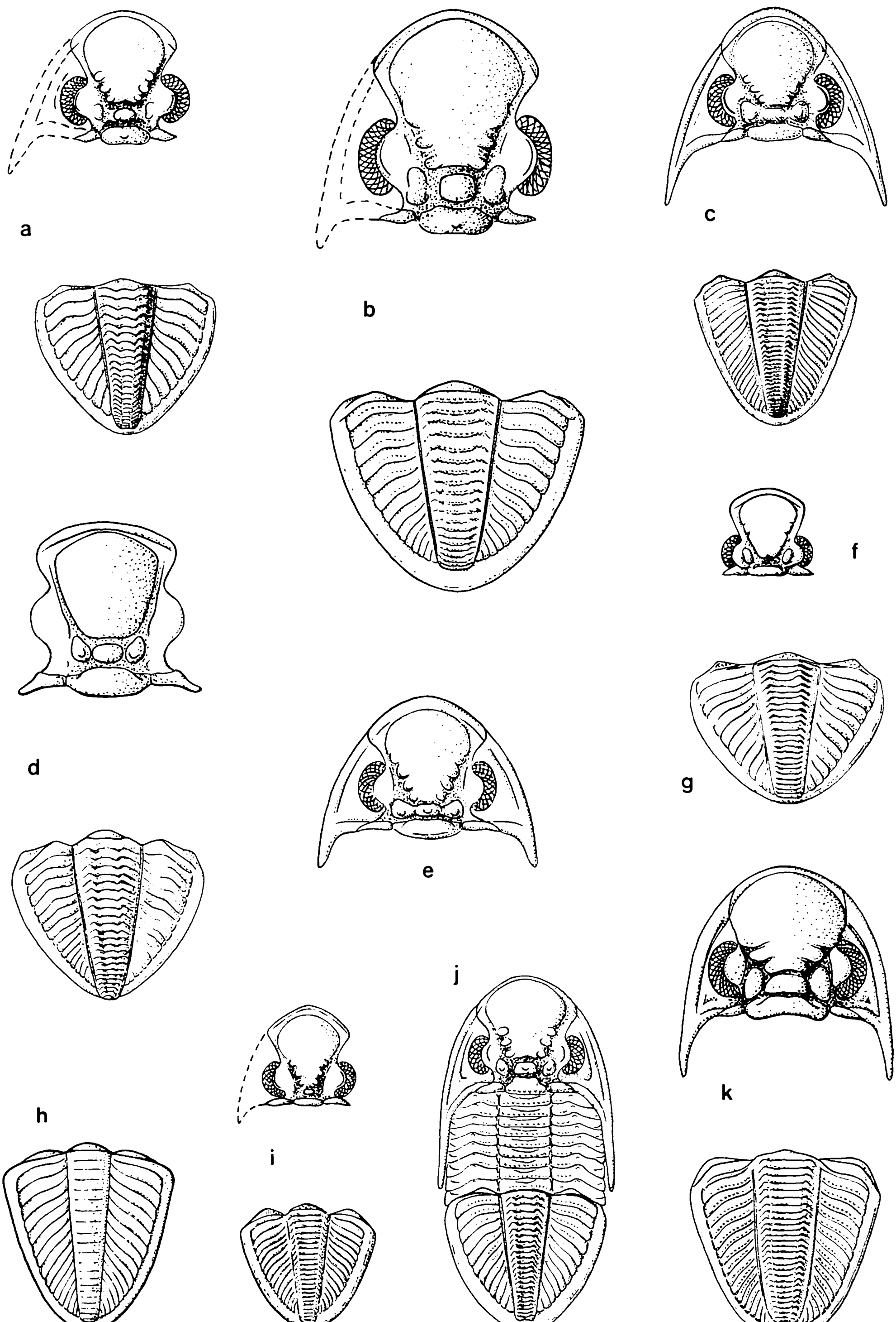
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lobes are elongated longitudinally; occipital lobe fairly large and provided with a median tubercle near posterior margin; occipital and preoccipital lobes strongly bent up toward axis; glabella extended onto frontal border, but separated from the border by narrow and deep marginal furrow; palpebral lobes opposed at eyes in posterior and steeply sloping toward axial furrows; facial suture extending diagonally along frontal lobe of glabella.

Pygidium subtriangular, broadly arcuate laterally, well rounded in posterior, relatively broad, well inflated; axial lobe highly elevated above pleural lobe, trapezoidal in cross section, descending in posterior, particularly near terminus, where it is subvertical or even overhanging posterior border; axial rings countable 24 to 25, distinctly separated from one another by strong ring furrows, more or less nodose on the two sides of flat top; segmentation weakened on lateral slopes; pleural ribs gently slanting inward and abruptly arching down near lateral margin, and divided into 10 to 11 pleural ribs by profound furrows; first rib extending to lateral end of articulating margin; marginal border narrow and depressed.

Comparison:—The carapace is strongly inflated in this species. The lateral nodes on the glabella are very prominent. The median preoccipital lobe is subquadrate and large in this species. The frontal marginal furrow is deep and the frontal rim strongly convex. The pygidium is strongly inflated and more or less roundly trigonal. The axial rings, 24 to 25 in number, are nodose at the lateral ends of the flat top. Only 10 to 11 ribs are countable on the pleural lobes in this species.

Occurrence:—Three cranidia and two pygidia from the *Reichelina changhsingensis* Zone of the Akasaka Limestone, at Akasaka, Gifu Prefecture, West Japan.

Repository:—Holotype, PAt 16725, Paratype, PAt 16726, 16728; PAt 16727, 16724.

Pseudophillipsia (?) sp. indet.

Plate II, fig. 7

Crudely deformed pygidium subtriangular in outline; axial lobe relatively narrow, divided into more than 20 rings; pleural ribs 14 or more; marginal border narrow and depressed.

Occurrence:—Upper (?) Permian; east side of railway, north of Zenchaya, Shishiori Village, Motoyoshi County, Miyagi Prefecture; Yamashita collection.

Repository:—PAt 16678.

Genus *Iranaspidion* Kobayashi and Hamada, 1978

1978. *Iranaspidion* Kobayashi and Hamada, *Proc. Japan Acad.*, vol. 54–B, no. 4, p. 157.

Text-fig. 6. Restoration of some Permian trilobites from Japan – 2.

a. *Pseudophillipsia (Nodiphillipsia) hanaokensis* Kobayashi and Hamada, 1984, x 3.5
b. *Pseudophillipsia (Pseudophillipsia) kiriuensis* Kobayashi, Hamada and Koizumi, 1984, x 3
c. *Pseudophillipsia (Pseudophillipsia) catena* Kobayashi and Hamada, 1984, x 1
d. *Pseudophillipsia (Carniphillipsia ?) intermedia* Kobayashi and Hamada, 1980, x 5
e. *Pseudophillipsia (Nodiphillipsia) sasakii* Kobayashi and Hamada, sp. nov. x 2
f. *Jimbokranion subovalis* Kobayashi and Hamada, gen. et sp. nov. x 2
g. *Pseudophillipsia (Nodiphillipsia ?) binodosa* Kobayashi and Hamada, sp. nov. x 1.5
h. *Pseudophillipsia (Nodiphillipsia ?) simplex* Kobayashi and Hamada, sp. nov. x 3.5
i. *Pseudophillipsia (Nodiphillipsia) ozawai* Kobayashi and Hamada, 1984, x 1.5
j. *Pseudophillipsia (Nodiphillipsia) spatulifera* Kobayashi and Hamada, 1980, x 1.5
k. *Pseudophillipsia (Pseudophillipsia) akasakensis* Kobayashi and Hamada, 1984, x 1.2

1981. *Iranaspidion* Kobayashi and Hamada, *Geol. Surv. Iran, Rep.*, no. 49, p. 55.

Diagnosis:—Isopygous Ditomopyginae having a sagittal incision in posterior of main lobe, trisected preoccipital lobe and binodose basal lobe on glabella and a median slit on terminal two axial rings on pygidium.

Type-species:—*Iranaspidion sagittalis* Kobayashi and Hamada, 1978.

Remarks:—As described in the monotypic species, the genus is allied to *Pseudophillipsia* and *Ditomopyge* in one or another character. In the glabellar outline and obsolete anterior lateral lobes it agrees better with *Ditomopyge.* The pygidium of *Ditomopyge* is, however, less segmented. In this respect this pygidium is nearer to that of *Pseudophillipsia,* but the axial lobe is not trapezoidal in cross section. The most distinctive of this genus are the sagittal incision of the main lobe and the binodose basal lobe of the glabella in the cephalon and the median slit of the axial lobe in the pygidium, all of which reveal the phylogerontic specialization. The sagittal furrow in different pattern seen in *Crotalocephalina* (*Geracephalina*) is another example of the final specialization which occurred in the Cheiruridae (Kobayashi and Hamada, 1977).

Distribution:—Middle and Upper Permian; South Asia (Iran).

Iranaspidion sagittalis Kobayashi and Hamada, 1878

Plate XIV, figs. 1–4; Text-fig. 5–k

1978. *Iranaspidion sagittalis* Kobayashi and Hamada, *Proc. Japan Acad.*, vol. 54–b, no. 4, p. 158, figs. 1–4.
1981. *Iranaspidion sagittalis* Kobayashi and Hamada, *Geol. Surv. Iran Rep.*, no. 49, p. 56, pl. 1, figs. 1–3.

Description:—Cephalon parabolic, strongly convex, arching toward its center and provided with long genal spines. Glabella slowly expanding forward and rounded along frontal marginal furrow; main glabellar lobe large, subquadrate, cut by a short sagittal furrow in posterior; its lateral furrows and lobes obsolete; preoccipital lobe trisected by diagonal furrows into a broad median part and long binodose lateral parts, i. e. basal lobes; preoccipital furrows confluent in the middle part; their posterior branches diagonal and meet with arcuate occipital furrow; occipital ring beaded in a double row; axial furrow profound and almost straight. Eyes semicircular, large, prominent, set close to glabella; fixed cheek narrow; lateral and posterior borders fairly broad; marginal furrow deep. Facial sutures running forward from eyes along axial furrows but bent inward on anterior border; behind eyes they extend longitudinally, but soon become diagonally on borders and cutting posterior cheek margins at median points.

Thorax composed of 9 segments; axial ring slightly narrower than pleuron, strongly convex; pleuron flat in inner part and slanting in outer part.

Pygidium parabolic, as long as broad, well inflated, but marginal border narrow, flat and depressed. Axial lobe long, conical, rounded at terminus, composed of 23 rings or so which are separated by deep furrows; each ring ornamented by a row of tubercles, trisected by furrows into a median part and paired lateral parts; first axial ring and articulating half-ring non-trisected and non-tuberculate. Pleural lobe consists of gently sloping inner part and convex outer part of which the latter is arching down to lateral border; the lobe divided by deep pleural furrows into 12 pleural ribs beside anterior band which is broadened laterally and facetted; pleural ribs ornamented with tubercles, 9 in anterior, but reduced in number posteriorly; twelfth rib indicated simply by a short elevation. Lateral border flat, smooth, slightly broadened posteriorly. First pleural rib running into lateral border; posterior border just behind axial lobe a little bent up; this elevation bisected by a shallow median depression. Beyond this elevation a very short, low and vertical ridge is seen on the bottom of the terminal slit.

Observation:—Three complete shields among eight specimens are all enrolled in the asaphid type. The cephalon is more convex than the pygidium. Therefore no hypostoma is visible. Judging from the size and position the binodose posterior lateral lobe of the glabella must be the preoccipital lateral lobe or the so-called basal lobe, instead of two posterior lateral lobes united. The genal spine is extending back as far as the fifth thoracic segment. The axis of the pygidium is most convex at about one-third from the anterior margin. Its cross section is not trapezoidal.

Comparison:—The present pygidium looks very similar to those of *Pseudophillipsia lipara* Goldring, 1957 and *Pseudophillipsia paffenholzi* (Weber, 1944) in outline and particularly to the latter in the possession of tuberculation.

Goldring (1957) called attention to the terminal median septum in the axial lobe of the pygidium which he found by rubbing down the specimens of *Pseudophillipsia lipara* Goldring, 1957, from the Uralian or Artinskian of Oman, Arabia. Then he noted that the septa are probably present in *Pseudophillipsia sumatrensis* Roemer, 1880, (Kazanian, Sumatra), *Pseudophillipsia* ? sp. indet. no. 3 by Toumansky, 1935, (Middle Permian, Crimea), *Pseudophillipsia elegans* Gemm. var. ? Weber, 1944, (Upper Permian, Caucasus), and *Pseudophillipsia elegans* var. *caucasica* Weber, 1944, (ditto). Insofar as can be seen in the illustrations of these Permian trilobites, their peculiar structures belong possibly to the same kind as the median slit. Neither the slit nor the septum is as yet known in other trilobites than the Permian ones of *Iranaspidion* and *Pseudophillipsia.*

Occurrence:—Ishii and others distinguished three parts in the Unit I bed at the southwestern extremity of the Kuh-e-hambast Range, Central Iran (Taraz, 1971), namely, the *Eopolydiexodina-Verbeekina* faunule in the lower part, *Neoschwagerina craticulifera, N. margaritae* and others in the middle and minute *Chusenella* and *Schwagerina* in the upper part. At the fossil locality (between L 6a–66) the trilobites were contained in the higher horizon of the last part together with abundant brachiopods in 10 meters' thickness of pink coloured tuff interbedded with limestone. While most brachiopods belong to the Gnishik fauna of Transcaucasus, the *Chusenella-Schwagerina* fauna shows that the upper part of the Unit I bed is nearly coeval with the *Lepidolina asiatica* Zone in Southeast Asia (Ishii 1966; Ishii, Kato and Nakamura 1969). Therefore the trilobites must be late Guadalupian in age.

Subfamily Uncertain

Genus *Ampulliglabella* Kobayashi and Hamada, gen. nov.

Diagnosis:—Cephalon semicircular in outline, gently inflated and provided with a pair of genal spines; marginal border fairly broad, flat or even concave and produced into genal spines of moderate size. Glabella of overturned flask-shape, subcircular in anterior, cylindrical in posterior and more or less contracted between two parts; frontal lobe protruded into frontal border for some distance; only occipital furrow strong; eyes very large, semicircular, located far posteriorly and set close to glabella.

Pygidium roundly subtrigonal or semicircular, surrounded by fairly broad, flat, depressed border; axial lobe composed of 15 to 20 or more rings; pleural ribs simple, 9 to 14 in number;

post-axial ridge or minute posterior marginal spine may be present.

Test smooth.

Type-species:–*Ampulliglabella kojimai* Kobayashi and Hamada, sp. nov.

Remarks:–The cranidium of *Acropyge brevica* Yin, 1978 from the Upper Permian Dalong Series in Guizhou is closely allied to this genus in the outline of the glabella and the depressed broad marginal border, but it disagrees with *Ampulliglabella* essentially in tripartition of the preoccipital lobe and a pair of strong pits on the axial furrows behind the expanded frontal lobe. This genus looks similar to *Acropyge* in the outline of the pygidium, but relatively broad and less segmented in this genus. The post-axial ridge and posterior marginal spine are well developed in that genus.

In the cephalon lateral furrows are absent and the posteriorly located large eyes are typical of *Thaiaspis,* but the depressed marginal border is well developed in this cephalon. In *Thaiaspis* the pygidium is not mucronate; post-axial ridge is unknown. The test is commonly tuberculate or granulate in that genus, but smooth in this genus.

Gitarra Gandl, 1968, from the upper Tournaisian of Germany and the Westphalian of Spain (Romanov, 1971) resembles this genus in the developed eyes in posterior and the broad marginal border and good sized genal spines, but the glabella is more expanded in posterior than anterior and basal lobes are well defined in that genus.

Distribution:–Middle Permian: North Japan.

Ampulliglablella kojimai Kobayashi and Hamada, sp. nov.

Plate XII, figs. 1–11; Text-fig. 51–f

1968. *Paladin* sp. Araki and Koizumi, *Chigaku-Kenkyu,* vol. 19, no. 6, p. 153, pl. 1, figs. 6–8, pl. 2, figs. 9–10.

1978. Thaispinae, gen. et sp. nov. Koizumi and Sasaki, *Chigaku-Kenkyu,* vol. 20, nos. 7–9, pl. 6, figs. 1–7.

Description:–Cephalon semicircular in outline, moderately inflated, rising up toward posterior part of glabella, provided with fairly large genal spines. Glabella sphaeric in anterior, cylindrical in posterior, but with low convexity; frontal lobe subcircular, or elliptically expanded, a little encroaching frontal border; remaining part of glabella nearly parallel-sided, but more or less contracted in mid-length of glabella; lateral and preoccipital furrows obsolete; occipital furrow profound; neck ring of moderate size; eye-bands lunate, large, embracing semicircular depressed area and opposed on the two sides of glabellar posterior; frontal border about one-sixth as long as cephalon, flat and depressed; lateral borders broader and extending into genal spines of moderate length; facial suture describing a large arc from anterior end of eye.

Pygidium more or less trigonal, nearly as long as wide and moderately inflated. Axial lobe as wide as pleural lobe exclusive of lateral border in anterior, long, conical, regularly tapering back and depressed near inner margin of posterior border, divided into 16 or more flat-topped axial rings by narrow and shallow furrows; small post-axial ridge present; pleural lobe gently convex, divided into about 10 simple ribs by pleural furrows, more or less broader and deeper than ring furrows; marginal border fairly broad, nearly uniform in breadth, smooth, distinctly depressed; marginal furrow indistinct; lateral periphery more arcuate in posterior half than anterior and meeting its counter forming an angle behind axis wherefrom a minute spine may issue.

Test smooth.

Observation:—The holotype cephalon collected by Araki from the quarry II (pl. XII, fig. 1) enables one to figure out the complete cephalon. The marginal border is depressed and somewhat concave, broadened toward genal angle and protruded into a broad spine of moderate length. The cheek roll is relatively narrow; diagonal obtuse ridge issues from the eye on its posterior lateral side. On the glabella of this cephalon a broad preoccipital lobe and a pair of lateral lobes are discernible to be outlined by rudimentary furrows. The preoccipital lobe is, however, not trisected.

A paratype cranidium from Myoga-zawa II (Pl. XII, fig. 3) which is laterally compressed secondarily, carries a distinct tubercle at the centre of the occipital ring. Lateral and preoccipital furrows are completely effaced on this glabella.

There are three free cheeks of which the genal spines are a little shorter than the sagittal length of the cephalon. Seven thoracic segments are attached to a paratype pygidium from Anabuchi (Pl. XII, fig. 8) among which the ultimate segment lies largely concealed beneath the preceding one. Their pleurae are facetted distinctly at about one-third or two-fifths from the axial margin where the pleurae are geniculate. Such a facet is present also on the anterior margin of the first pleural segment of the pygidium. It is clearly seen that a minute ridge issues behind the axial lobe of the paratype pygidium (Pl. XII, figs. 11).

Comparison:—This species agrees best with *Acropyge brevica* in outline of the pygidium, but its axial lobe and marginal border are evidently broader and lateral margins more arcuate. Its caudal spine is incomparably tiny as seen in the inner mould of the paratype pygidium from Anabuchi. The pygidium is apparently a few less segmented in this species than *A. brevica.*

Occurrence:—Middle Permian; Myoga-sawa, Anabuchi, Quarry in Kesennuma City, Miyagi Prefecture.

Repository:—Holotype, PAt 16740; Paratype, PAt 16747; PAt 16741–16746, 16748–16750.

Ampulliglabella rotunda Kobayashi and Hamada, sp. nov.

Plate XIII; fig. 1–6; Text-fig. 5–g

Description:—Pygidium semicircular, broader than long. Axial lobe one-third or less than anterior pygidial breadth, conical, composed of about 20 rings; its terminus blunt but therefrom a short post-axial ridge is extending into posterior border. Pleural lobe divided into 10 to 11 ribs by narrow, but deep furrows; all of them truncated along inner margin of border except for the first rib which runs into the border as far as antero-lateral margin. Marginal border very broad, flat and slightly concave; marginal furrow absent.

Observation and Comparison:—As seen in the type pygidium (Pl. XIII, fig. 1), the anterior band of the first pleura forms a low rib. Some pygidia are deformed by longitudinal compression. As the result some pleural ribs are strengthened and prolonged into lateral border, more or less alternately.

Compared with the preceding, the pygidium of this species and its marginal border are both broader. The post-axial ridge is present as in *Ampulliglablella kojimai,* but the posterior margin of the border is entire.

Occurrence:—Middle Permian; Quarry, Anabuchi and Hokyoji in Kesennuma City, Miyagi Prefecture.

Repositry:—Holotype, PAt 16751; PAt 16752a, b, 16753–5.

Genus *Acropyge* Qian, 1977

Diagnosis:—Cephalon with glabella of overturned flask-shape; median preglabellar lobe present; lateral furrows absent; frontal marginal border moderate in size and depressed. Cheek and thorax unknown. Pygidium subtrigonal, long and mucronate; axial lobe composed of 20–28 rings; pleural ribs 12–14; post-axial ridge commonly present.

Type-species:—*Acropyge multisegmenta* Qian, 1977.

Remarks:—Qian described the type-species in Chinese and illustrated the monotypic pygidium, but he gave no generic diagnosis. The posterior terminal part of the type pygidium was not well preserved. The second species is *Acropyge lanceolata* Kobayashi and Hamada, 1978, which is known only of the type pygidium from the Upper Permian of Central Iran. Its most important distinction from *A. multisegmenta* lies in the presence of a prominent post-axial ridge crossing the outer pleural slope and extending through the posterior border on the well mucronate pygidium. Subsequently, in the same year, *Acropyge brevica* Yin was described from South China. Its pygidium is most closely related to *A. multisegmenta* except for the shorter outline.

Acropyge weggeni G. and R. Hahn, 1981 from the uppermost Permian of the Elburz Mountains, North Iran is the fourth species which is represented by a long triangular pygidium whose axial lobe is trisected into the broad main part and paired rows of squares along the lateral margin. Like *Acropyge lanceolata* the axial lobe terminates shortly inside of the marginal border and the post-axial ridge extends from the terminus of the axial lobe to the posterior end of the pygidium.

The cranidium referred to *Acropyge brevica* has the glabella strongly expanded laterally in anterior and nearly parallel-sided in posterior, though somewhat broadened at the neck ring. The marginal border of medium size is depressed, flat or even concave and provided with a narrow but distinct frontal rim. A median preoccipital lobe is present on the glabella. Distinct paired pits are present on the axial furrows behind the frontal lobe. The cranidium of this species is certainly more related to *Ampulliglabella* than *Pseudophillipsia* (*Carniphillipsia*) in the outline of the glabella and the flat depressed marginal border. The pygidium resembles *Pseudophillipsia* s. str. as well as typical *Ampulliglabella* in the outline, but the axial lobe is very narrow. It is more segmented than *Ampulliglabella* and less so than *Pseudophillipsia* s. str.

Distribution:—Middle and Upper Permian; Eastern and Southern Asia (China and Iran).

Acropyge multisegmenta Qian, 1977

1977. *Acropyge multisegmenta* Qian, *Acta Pal. Sinica,* vol. 16, no. 2, p. 284, pl. 1, fig. 9.

Description:—Pygidium elongate trigonal; axis narrow, long, convex, composed of more than 20 rings; terminus extending as far as posterior margin of border; axial lobe clearly tripartite, very clearly segmented in median part, but weakly on lateral sides; pleural lobe moderately inflated, clearly segmented; pleural ribs countable 14; marginal border flat, arcuate slightly in anterior but more in posterior where spine issues.

Occurrence:—Upper Permian Dalong Series; Qinglong, Guizhou Province, South China.

Acropyge lanceolata Kobayashi and Hamada, 1978

Plate XIV, fig. 5

1978. *Acropyge lanceolata* Kobayashi and Hamada, *Proc. Japan Acad.*, vol. 54–B, no. 4, p. 160 figs. 5a–b.

Description:—Pygidium elongate trigonal whose lateral margin is long, broadly arcuate, but becoming straight or even concave near post-axial ridge and at length meeting its fellow in forming an acute angle. Axial lobe narrow, a fourth as wide as pygidium, a little longer than two-thirds the pygidium, roof-shaped, regularly tapering back and terminating at rounded tip at a short distance inside the marginal border; crest line of axial lobe highest at one-third of pygidium from anterior; post-axial ridge narrow, extending from the tip as far as the posterior end; axial lobe composed of more than 20 rings, 17 of which are in its three-fourths; ring furrow weak; axial furrow strong. Pleural lobe broad, nearly horizontal on inner side, very slowly arching down on outer side, divided into 14 ribs, 13 of which each consists of a broad anterior slope and subvertical posterior slope along deep pleural furrow, but the most posterior pair of ribs are united into a prominent post-axial ridge; the ridge, however, much lower than the axial lobe. Lateral border smooth, nearly flat, narrow, but regularly broadened posterirly; marginal furrow absent; lateral margins forming an angle of 80 degrees at junction.

Comparison:—This species agrees so closely with *Acropyge multisegmenta* Qian, 1977 in mucronate pygidium, narrow multisegmented axial lobe and in the number of pleural ribs that they are considered congeneric. The axial rings are, however, not trisected in this species. It has such a distinct post-axial ridge on the mucronate part, but no mention is given about the ridge in Qian's description, nor his illustration shows any trace of such a ridge. On the contrary, the axial lobe appears to reach the inner margin of the marginal border in his pygidium.

In the fusion of the last pair of pleural ribs in this pygidium the post-axial ridge may be comparable to the simple median rib in the Scutelluidae.

Occurrence:—Upper Guadalupian Unit A; Julfa, Iran; Murata coll.

Repository:—Holotype, PAt 16764; Paratype, PAt 16763; PAt 16765.

Genus *Jimbokranion* Kobayashi and Hamada, gen. nov.

Diagnosis:—Cephalon gently convex toward its center; glabellar segmentation obsolete; its main lobe subovate with nearly straight lateral margins and broadly rounded in front; sagittal furrow distinctly incising into the lobe from deep and well developed occpital furrow; occipital ring about a third narrower than glabella; basal lateral lobe depressed; marginal rim and furrow narrow; eyes fairly large and located in posterior; fixed cheeks very narrow anterior to them; test smooth.

Type-species:—*Jimbokranion subovalis* Kobayashi and Hamada, sp. nov.

Denomination:—A new name for this unique trilobite is proposed in honour of Kotora Jimbo, Professor of the University of Tokyo, to memorize his discovery of trilobites first in

Japan at a few places in the southern Kitakami Mountains in 1888 (Harada, 1890).

Distribution:—Permian, Japan.

Jimbokranion subovalis Kobayashi and Hamada, sp. nov.

Plate II, fig. 6; Text-fig. 6–f

1968. *Paladin yanagisawai* by Araki and Koizumi (*non* Endo and Matsumoto, 1962), *Chigaku-Kenkyu*, vol. 19, no. 6, p. 152, pl. 1, fig. 5, pl. 2, fig. 8.

Description:—Cranidium gently inflated; main lobe of glabella suboval, broadly rounded in front, well expanded forward, and narrowing backward regularly; its posterior margin about one-third as wide as frontal lobe; short sagittal furrow cutting into main lobe from occipital furrow; basal lateral lobes depressed and clearly isolated from main lobe by straight extension of anterior axial furrows; two pairs of rudimentary lateral furrows discernible on glabella by cross light; occipital ring a little wider than a half of glabella; occipital furrow well developed. Eyes fairly large, located far posteriorly; frontal rim and furrow very narrow. Test smooth.

Observation:—The axial furrows along the anterior part of the glabella are straight, extending into its posterior portion, separating the preoccipital basal lobes. This lobe is outlined laterally by a narrow posterior axial furrow. Eyes are not well preserved. The right eye which embraces the anterior part of the basal lobe, seems to be fairly large. The fixed cheek is very narrow in front of the basal lobe, but slightly broadened anteriorly. The anterior branch of the right facial suture is straight, but suddenly bent inward in crossing the marginal rim.

Comparison:—The type cranidium from Hosoo-zawa was primarily identified by Sasaki and Koizumi (1968) with *Paladin yanagisawai* Endo and Matsumoto, 1961, from Takakura-yama on which Koizumi founded *Endops* later in 1972. The Hosoo-zawa cranidium is quite different from *Endops* in its configuration and texture.

The outline of this glabellar main lobe resembles that of *Neoproetus*, but they are quite different in the mode of glabellar convexity. Like *Iranaspidion* this trilobite has the sagittal furrow which is, however, extending forward from the preoccipital furrow in that genus. In this genus the preoccipital median lobe is completely absorbed into the main lobe. In the effacement of the glabellar segmentation this genus may be comparable with *Thaiaspis*, but that genus can easily be distinguished from this by the projection and drooping of the glabella in front. Thus the combination of these characteristics is quite unique. Therefore it is certain that this trilobite represents an unnamed genus by itself, although this species is imperfectly known.

Occurrence:—Shale of the Kanokura Series at the lower part of Hosoo-zawa, Kamiyatsuse, Kesennuma City, Miyagi Prefecture in the Tohoku region of Northeast Japan; Middle Permian.

Repository:—Holotype, PAt 16677.

Griffithid, gen. et sp. indet.

Plate I, fig. 14

An imperfect pygidium before hand is, if complete, parabolic in outline and a little broader than long. The lateral margin increases its curvature in posterior. The axial lobe bordered by profound axial furrows is a little narrower than one-third the pygidium in anterior, but the lobe is narrowing more rapidly in posterior than the other. The flat or low convex axial rings are separated from one another by narrow ring furrows. Because 15 rings are countable on this specimen, the total number may be about 20. The pleural ribs are about 14 in all. The pleural furrows are much broader than the ring furrow. A few anterior ribs are divided into unequal two bands by a narrow furrow. The marginal border appears moderate in breadth and somewhat concave, although its inner margin is not sharp. Small tubercles are scattered on the pleural ribs and axial rings. Several tubercles are seen to be aligned on the posterior margin of an anterior axial ring.

This pygidium resembles those of *Paladin* and *Kaskia*, but the axial and pleural lobes are generally less segmented in these genera. In the multi-segmentation it agrees better with *Neogriffithides*, but the typical pygidium of that genus is more or less triangular in outline and its axial lobe looks allied to that of *Pseudophillipsia*. It is most difficult to determine the taxonomic position of such a fragmentary pygidium, deformed by secondarily depression, loosing its original convexity.

Occurrence:—Newly found in 1982 from the phyllitic slate of the Tamba Group exposed near the waterfall called Minoo in Osaka Prefecture in West Japan. This group represents the Chichibu Group of the Yamaguchi facies which is almost unfossiliferous except for rare occurrences of small limestone lenses containing fusulinids and corals, mostly Permian in age (Matsushita, 1971). Such a discovery of Permo-Carboniferous trilobite in this area is quite unexpected.

Repository:—PAt 16670. (Osaka Nat. Hist. Mus. Coll.)

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Place Names

Abahanaerzi 阿巴哈納尔旗
Anhui 安 徽
Anshun 安 順
Apashachi 阿巴嘎旗
Bacon-xian 八宿県
Changhsing 長 興
Chengfanguan 程番関
Chihsia (Qixia) 栖 霞
Chongqing, Chungking 重 慶
Dalong, Talung 大 隆
Guangdong, Kwangtung 広 東
Guangxi, Kwangsi 広 西
Guishui 恵 水
Guizhou, Kweichou 貴 州
Heshan 合 山
Hubei, Hupeh 湖 北
Huishui 恵 水
Hunan 湖 南
Jiangxi 江 西
Jiaozishan, Chiaotsushan 轎子山
Kansu, Gansu 甘 粛
Lhünzhub-xian 林周県
Lianhsien 漣 県
Longtan, Lungtan 龍 潭
Loping 楽 平
Maping 馬 平
Maokou 茅 口
Nayong 納 雍
Ningxia 寧 夏
Qinglong, Chinglung 晴 隆
Qujiang 曲 江
Raggyorcaka 熱覚茶卡
Ra'og 然 烏
Shaanxi 陝 西
Shuanghu 双 湖
Sichuan, Sz'chuan 四 川
Suolun, Soron 索 倫
Tianshenggiao 天生橋
Urulung 烏魯龍
Xijiang 浙 江
Xinjiang 新 疆
Xiongencuo 雄恩錯
Xizang (Tibet) 西 蔵
Yarze-xiang 雅則郷
Yungchang 永 昌
Zhesi, Cheszu 哲 斯
Zhongying, Chungying 中 営

Postscript

1. Recently the following six new species of Permian trilobites were described from East China (Nanjing Inst. Geol. Min. Resources, 1982).

1. *Pseudophillipsia shangaoensis* Zhang W. Z., 1982, from Upper Permian, Jiangxi.
2. *Pseudophillipsia tongluoensis* Ju, 1982, from Lower Permian, Xijiang.
3. *Pseudophillipsia triangulata* Ju, 1982, from Lower Permian, Xijiang.
4. *Pseudophillipsia mengshanensis* Liu, 1982, from Lower Permian, Jiangxi.
5. *Pseudophillipsia wueiensis* Zhang, 1982, from Lower Permian, Anhui.
6. *Brachymetopus* (*Brachymetopina*) *gaoanensis* Zhong Q. Z, 1982, from Upper Permian, Jiangxi.

The first species is represented by a cranidium with three pairs of lateral nodes beside the trisected preoccipital lobe as typical of *Pseudophillipsia* (*Nodiphillipsia*). In the second species a pair of lateral nodes in front of the trisected preoccipital lobe are well developed and close-set with each other at the contraction of the glabella. This species may be another species of the same subgenus.

In the third species the preoccipital lobe is trisected and its median part very broad. The main part of the glabella as long as broad and trapezoidal in outline expanding forward, is unfurrowed. In the fourth species a pair of basal lobes are large, and trigonally ovate, well convex and unfurrowed main lobe of the glabella is protruded between the basal lobes.

The fifth species is founded on a semielliptical pygidium of *Pseudophillipsia* with 22 axial rings and 12 pairs of pleural ribs.

The cephalon and pygidium is known of the sixth species. Its two cephala (Zhong, pl. 125, figs. 8–9) have distinct facial sutures. In one of them (fig. 8) the free cheek is a little displaced from the cranidium whose frontal margin is subangulate. The pygidium has six pairs of pleural ribs which are protruded at the termini. It is quite probable that this species belongs to *Cheiropyge* (*Suturikephalion*).

Finally, *Brachymetopus* (*Brachymetopina*) *zhenanensis* Zhou, 1983, was described by Zhou from Middle Carboniferous in Shaanxi and *Brachymetopus* sp. from Middle Carboniferous in Xinjiang-Wiwuer Autonomic Province by Zhang, 1983.

2. Emphasizing the cephalic axial characters for phylogeny, Owen (1983) proposed a new classification of all genera of Permian trilobites into two families and five subfamilies of the Proetidae as below.

Proetidae
- Proetinae: *Neoproetus, Kathwaia, Neogriffithides*
- Cyrtosymbolinae: *Hildaphillipsia*
- Weaniinae: *Nipponaspis Endops, Boublatia, ? Microphillipsia*
- Cummingellinae: *Paraphillipsia*
- Ditomopyginae: *Ditomopyge, Pseudophillipsia, Iranaspidion, Acropyge, Timoraspis, Anisopyge, Delaria, Vidria, Ameura, Paladin*

Brachimetopidae: *Brachymetopus, Cheiropyge, Loeipyge*

The geological range of these genera in the Permo-Carboniferous period and their phylogenetic relation to the Carboniferous and Devonian genera are shown in a text-figure. This author is of opinion that the Permian proetoids were derived from *Proetus* (*Gerastos*), *Lacunoporaspis* and *Schizoproetus* of the Devonian period. The geographic distribution of selected genera is shown in a Permian world map.

3. Finally, a brief note is appended on the Anujaspisinae Balashova of the Proetidae, 1960, as it is often overlooked. It was created on *Anujaspis* Balashova, 1960 whose type-species is *Anujaspis anuja* Balashova, 1960, from the Artinskian of the River Oleshchonoy, Northeast USSR. The second species is *A. tilmani* Balashova, 1980, from the same locality. They are blind proetids having large oval glabellae which are reaching the marginal border furrow in front and outlined by deep axial and occipital furrows. Among the three pairs of oblique lateral furrows on the glabella the posterior ones are particularly profound; nine segments present in thorax; pygidium broad, semicircular, with 9-10 axial rings and pleural ribs which the latter are each divided into a prominent anterior and a narrow posterior band. The genal angle is pointed in the type-species, but a short genal spine issues in the second species whose test is densely granulate.

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Plate I

Explanation of Plate I

Cheiropyge (*Suturikephalion*) *koizumii* Kobayashi and Hamada, 1982 . . . . p. 38

Fig. 1. Holotype shield (inner mould) showing general outline. From a quarry in Omote-Matsukawa, Miyagi Prefecture. x 5.2 (Sasaki coll.), PAt 16657.

Figs. 2–6. Four cephala showing the spatulate anterior border. 2, a latex replica with 8 thoracic segments, x 4.9 (Sasaki coll.), PAt 16658, 3, x 4.9 (Sasaki coll.), PAt 16659, 4, x 4.2 (Sasaki coll. PAt 16660, 5, a paratype cephalon, x 5.2 (Sasaki coll.), PAt 16661. 6, a paratype cephalon, x 4.7 (Sasaki coll.), PAt 16662.

Fig. 7. A latex replica of a right free cheek, x 5.2 (Sasaki coll.), PAt 16663.

Fig. 8. A pygidium with 8 thoracic segments, x 4.8 (Sasaki coll.), PAt 16664.

Figs. 9–11. Three pygidia. 9, x 4.5 (Sasaki coll.), PAt 16665, 10, x 4.5 (Sasaki coll.), PAt 16666, 11, a paratype pygidium, x 4.6 (Sasaki coll.), PAt 16667.

Neogriffithides imbricatus Kobayashi and Hamada, 1980 . . . . p. 48

Fig. 12. Holotype pygidium showing the characteristic segmentation on the axial lobe, x 5.0. From Mt. Ryozen, Shiga Prefecture, PAt 16668.

Fig. 13. Another pygidium, x 4.8, PAt 16669.

Griffithid, gen. et sp. indet. . . . . p. 74

Fig. 14. A latex replica of an incomplete pygidium showing the multisegmented lobes. From the slate bed exposed at Minoo, Osaka Prefecture, x 2.5 (Osaka Nat. Hist. Mus. coll.), PAt 16670.

Pseudophillipsia (?) sp. indet. . . . . p. 10

Ifg. 15. A latex replica of a slightly deformed pygidium from Shiwa-cho, Iwaté Prefecture, x 2.8 (Sato coll.), PAt 16671.

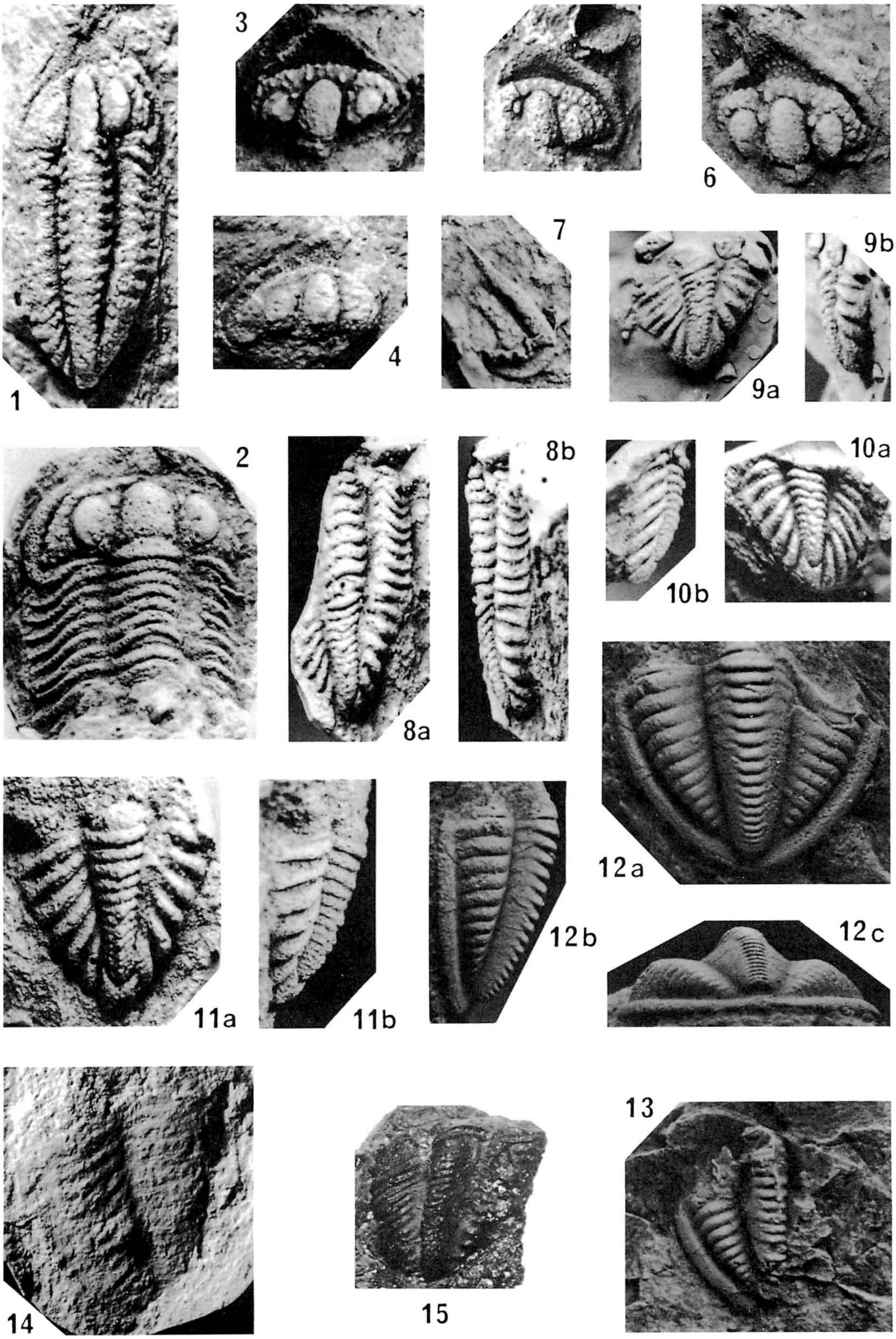
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Plate II

Explanation of Plate II

Nipponaspis takaizumii Koizumi, 1972 . . . . p. 43

Fig. 1. Holotype dorsal shield (inner mould) from Takakura-yama, Fukushima Prefecture (Takaizumi coll.). 1a, x 1.6, 1b, left lateral view, x 1.6, 1c, x 4.7, PAt 16672.

Fig. 2. Rubber replica of an incomplete dorsal shield (Koizumi coll.), x 5.0, PAt 16673.

Fig. 3. Paratype cranidium (inner mould) (Suzuki, T. coll.), x 4.9, PAt 16674.

Figs. 4, 5. Two pygidia from the same locality (inner moulds) (Suzuki, T. coll.), 5, x 4.4, 5, x 4.6, PAt 16675, PAt 16676 respectively.

Jimbokranion subovalis Kobayashi and Hamada, gen. et sp. nov. . . . . p. 74

Fig. 6. Holotype cranidium from Hosoo-zawa, Kesennuma City, Miyagi Prefecture (Araki coll.), x 3.0, PAt 16677.

Pseudophillipsia sp. indet. . . . . p. 67

Fig. 7. A deformed pygidium from Shishiori, Miyagi Prefecture (Yamashita, N. coll.), x 1.2, PAt 16678.

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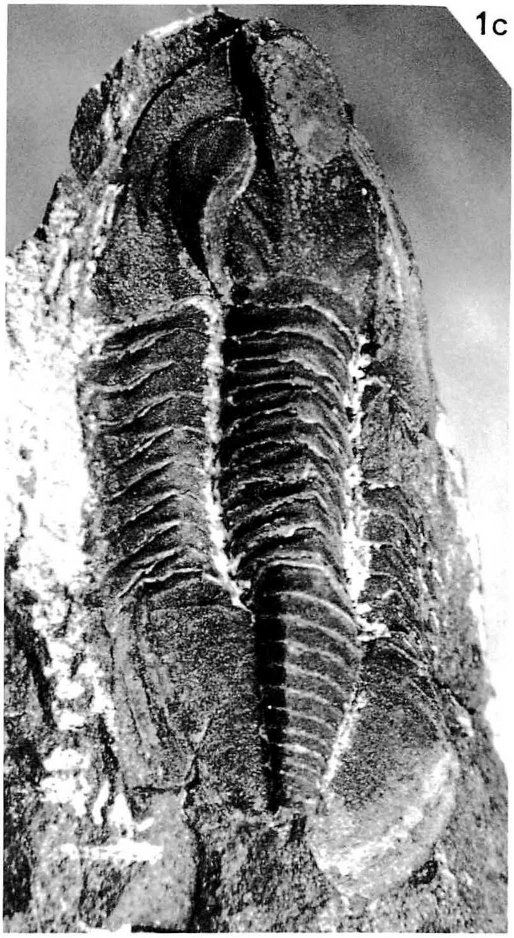

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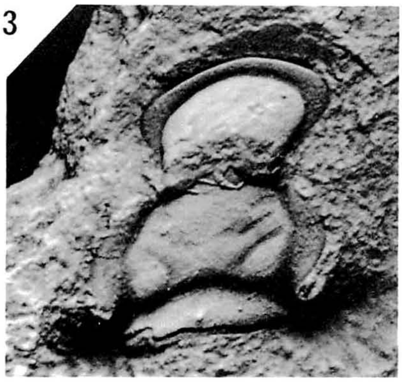

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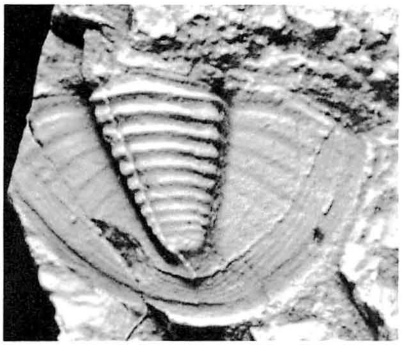

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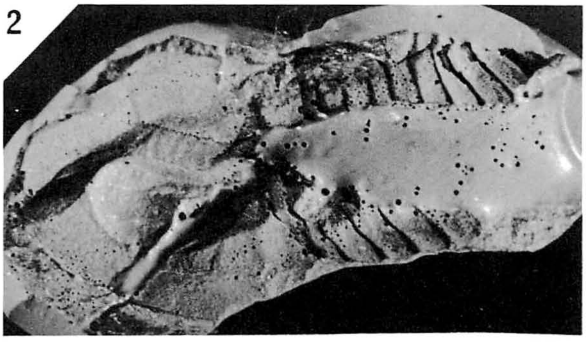

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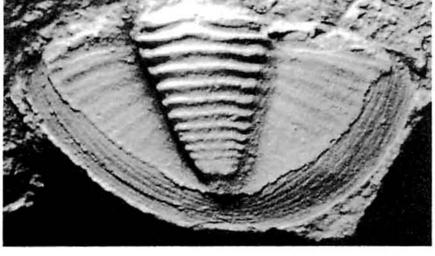

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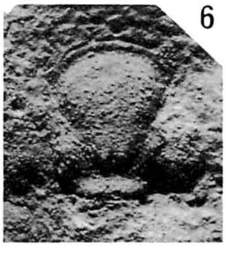

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Plate III

Explanation of Plate III

"Neoproetus" akagi Kobayashi and Hamada, sp. nov. . . . . p. 46

Fig. 1. Holotype cranidium showing the well-rounded frontal part. From Miharano, Hiroshima Prefecture (Akagi coll. no. 22146), x 4.2, PAt 16679.

Fig. 2. Paratype pygidium with 6 thoracic segments (Akagi coll.), x 4.5, PAt 16680.

Figs. 3, 4. Two pygidia showing the general outline. 3 (Akagi coll.), x 4.4, 4 (Akagi coll. no. 22098), x 2.8, PAt 16681 and PAt 16682, respectively.

Paraphillipsia levigata Kobayashi and Hamada, 1980 . . . . p. 45

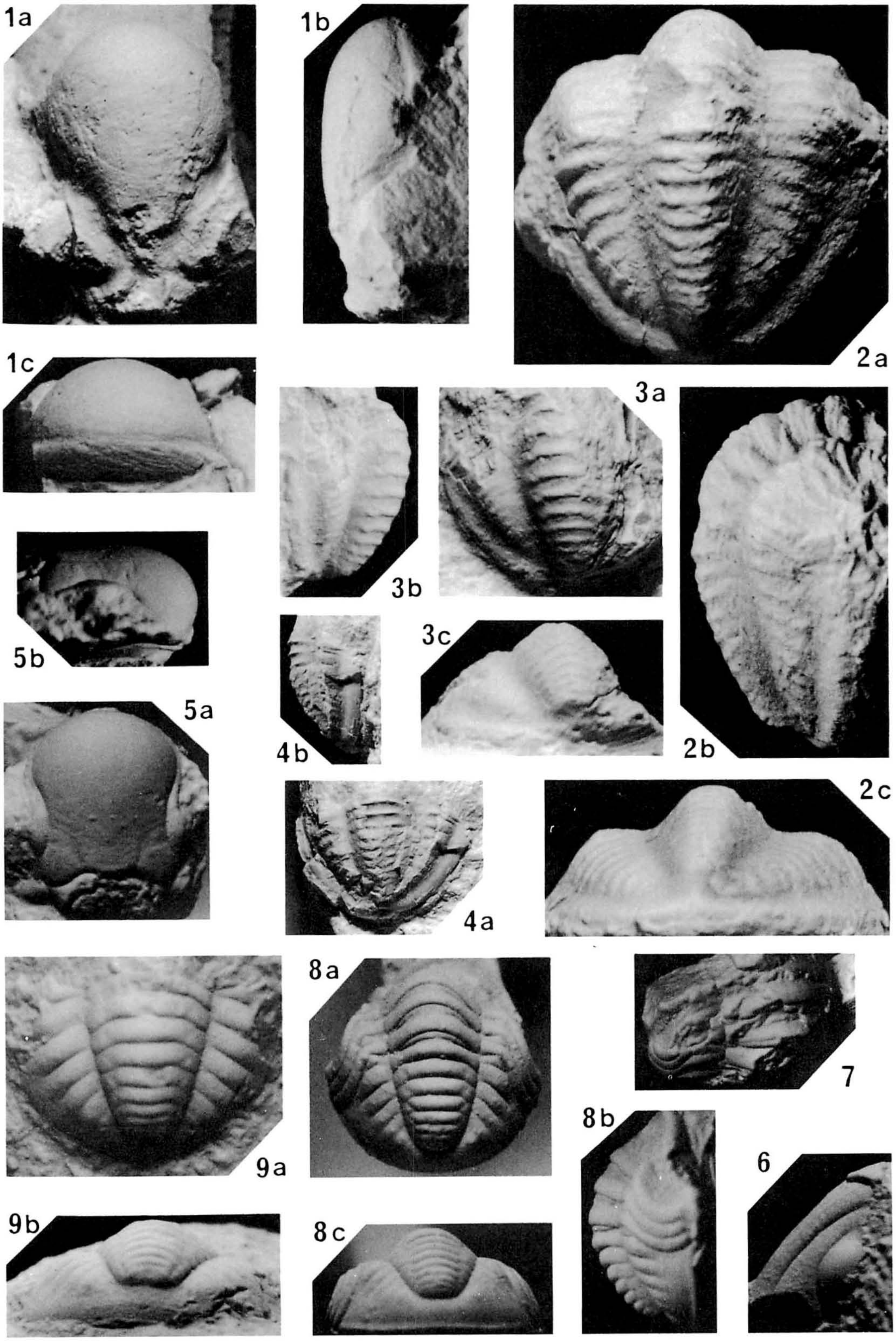
Fig. 5. Holotype cranidium from Shimoyama, Kochi Prefecture (Mitsumoto coll.), x 6.6, PAt 16683.

Fig. 6. Left free cheek (Mitsumoto coll.), x 6.3, PAt 16684.

Fig. 7. Thoracic segments (Hamada coll.), x 5.0, PAt 16685.

Fig. 8. Paratype pygidium (Hamada coll), x 7.8, PAt 16686.

Fig. 9. Another pygidium with three thoracic segments (Mitsumoto coll.), x 8.1, PAt 16687.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8c

Plate IV

Explanation of Plate IV

Endops yanagisawai (Endo and Matsumoto, 1962) . . . . p. 47

Fig. 1. Dorsal shield (inner mould) from Takakura-yama, Fukushima Prefecture (Koizumi coll.), x 4.5, PAt 16688.

Fig. 2. Another dorsal shield (Latex replica) (Koizumi coll.), x 4.4, PAt 16689.

Fig. 3. An internal mould of another dorsal shield (Koizumi coll.), x 1.8, PAt 16690.

Fig. 4. An external shield of cephalon (Hamada coll.), x 4.9, PAt 16691.

Paladin (?) *iwaizakiensis* Kobayashi and Hamada, sp. nov. . . . . p. 46

Fig. 5. Holotype cephalon from Iwaizaki, Kesennuma City, Miyagi Prefecture (Koizumi coll), x 4.6, PAt 16692.

Fig. 6. Another cephalon from the same horizon at the locality (Suzuki, T. coll.), x 5.1, PAt 16693.

Figs. 7, 8. Two pygidia showing the half moon shape of the pygidial shield. 7, x 4.9 (Suzuki, T. coll.), PAt 16694, 8, Paratype, x 4.9, PAt 16695.

Ditomopyge densigranulata Kobayashi and Hamada, sp. nov. . . . . p. 50

Fig. 9. Holotype cranidium from Kesennuma City (a quarry), Miyagi Prefecture (Sasaki coll.), x 5.0, PAt 16696.

Fig. 10. An incomplete cranidium (Sasaki coll.), x 5.4, PAt 16697.

Fig. 11. Free cheek (Sasaki coll.), x 5.4, PAt 16698.

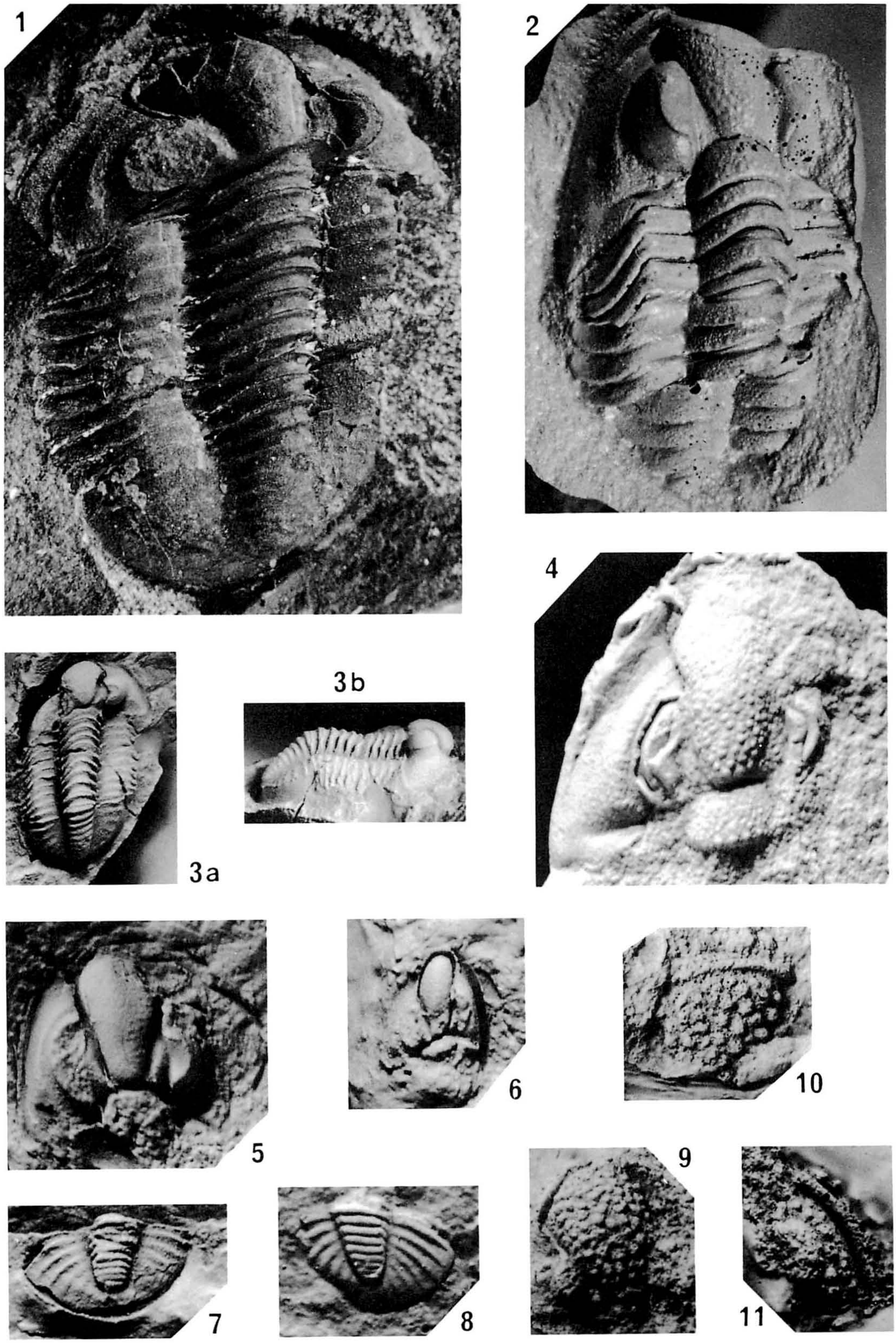
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Plate V

Explanation of Plate V

Pseudophillipsia (*Nodiphilllipsia*) *spatulifera* Kobayashi and Hamada, 1980 . . . . p. 59

Fig. 1. Holotype dorsal shield (inner mould) from Shigeji-zawa, Kesennuma City, Miyagi Prefecture (Kojima coll.), x 3.0, PAt 16699. a. dorsal, b. left lateral, c. frontal views of the specimen.

Fig. 2. External replica of the holotype specimen. a. dorsal, b. oblique, c. left lateral views of the replica, x 2.0. d. right lateral, e. posterior and f. dorsal views of the pygidium, x 3.0. Note the presence of a distinct caudal depression on the axial lobe.

Fig. 3. Paratype cephalon (external replica) from the same locality (Kojima coll.), x 1.9, PAt 16700.

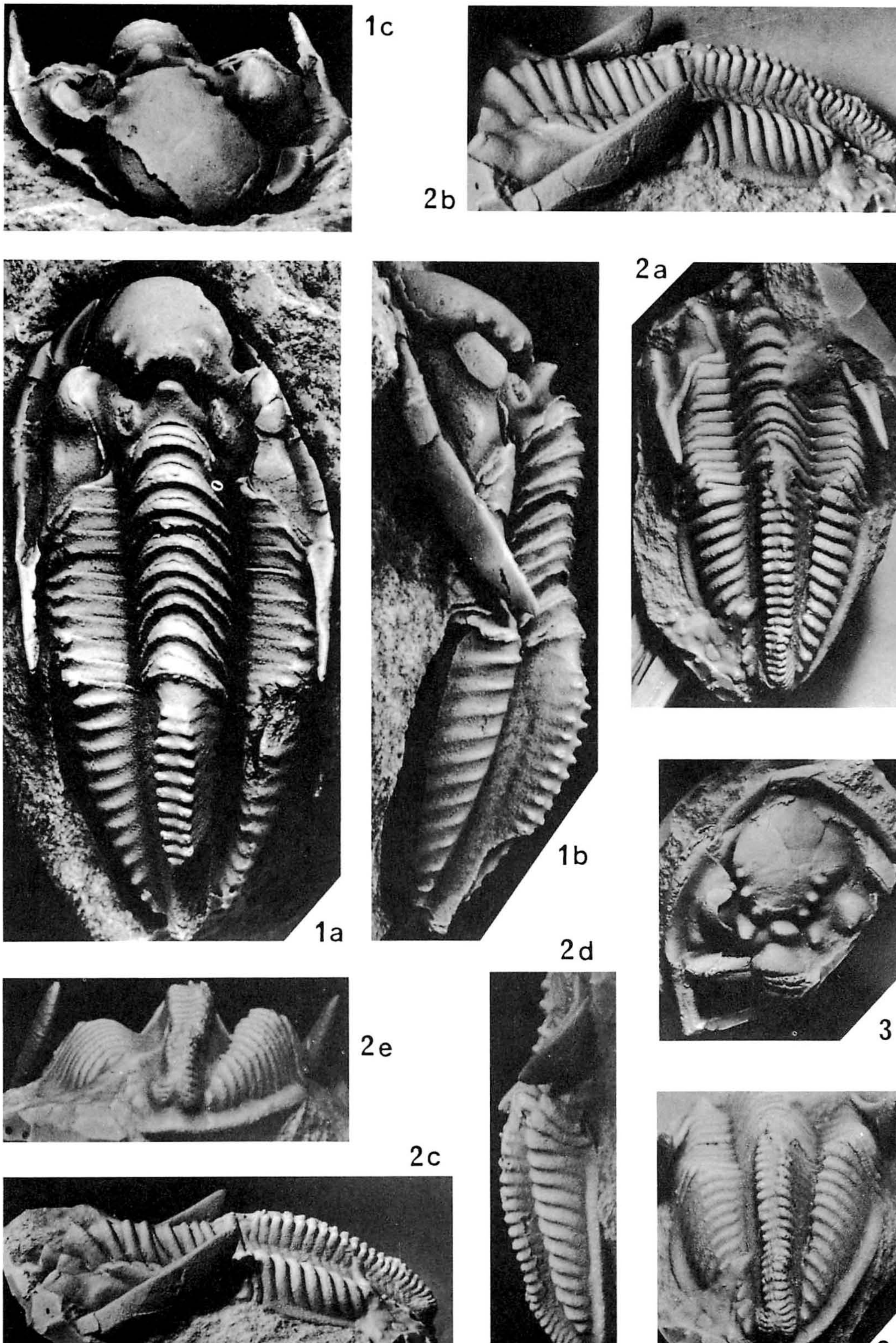
1c
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Plate VI

Explanation of Plate VI

Pseudophillipsia (*Nodiphillipsia*) *spatulifera* Kobayashi and Hamada, 1980 . . . . p. 59

Fig. 1. A cranidium from Anabuchi, Kesennuma City, Miyagi Prefecture (Sasaki coll.), x 3.1, PAt 16701.

Fig. 2. Latex replica of another cephalon to show the thick neck ring and long genal spine (Sasaki coll.), x 3.0, PAt 16702.

Fig. 3. Slightly deformed inner mould of a pygidium (Sasaki coll.), x 2.7, PAt 16703.

Pseudophillipsia (*Nodiphillipsia*) *sasakii* Kobayashi and Hamada, sp. nov. . . . . p. 61

Fig. 4. Holotype cephalon (external mould) from Anabuchi, Kesennuma City, Miyagi Prefecture (Sasaki coll.), x 3.1, PAt 16704.

Fig. 5. Another cranidium (external mould) (Sasaki coll.), x 3.1, PAt 16705.

Fig. 6. Associate pygidium (external mould) (Sasaki coll.), x 2.9, PAt 16706.

Pseudophillipsia (*Pseudophillipsia* ?) *kuzuensis* Kobayashi and Hamada, sp. nov. . . . . p. 54

Fig. 7. SEM image of the holotype pygidium (adopted from Koizumi *et al.*, 1979) from Kuzuu, Tochigi Prefecture (Tochigi Pref. Mus. coll.), x 7.5, PAt 16707.

Fig. 8. Dorsal (a), rear (b) and left lateral (c) views of the same specimen, x 5.0.

Pseudophillipsia binodosa Kobayashi and Hamada, sp. nov. . . . . p. 63

Fig. 9. Inner mould of a pygidium from Omote-Matsukawa, Kesennuma City, Miyagi Prefecture (Araki coll.), x 2.9, PAt 16708. a. dorsal, b. right lateral and c. posterior views.

Fig. 10. Holotype pygidium (external latex replica), x 2.7, (Araki coll.), PAt 16709, a. dorsal, b. right lateral, c. posterior views respectively.

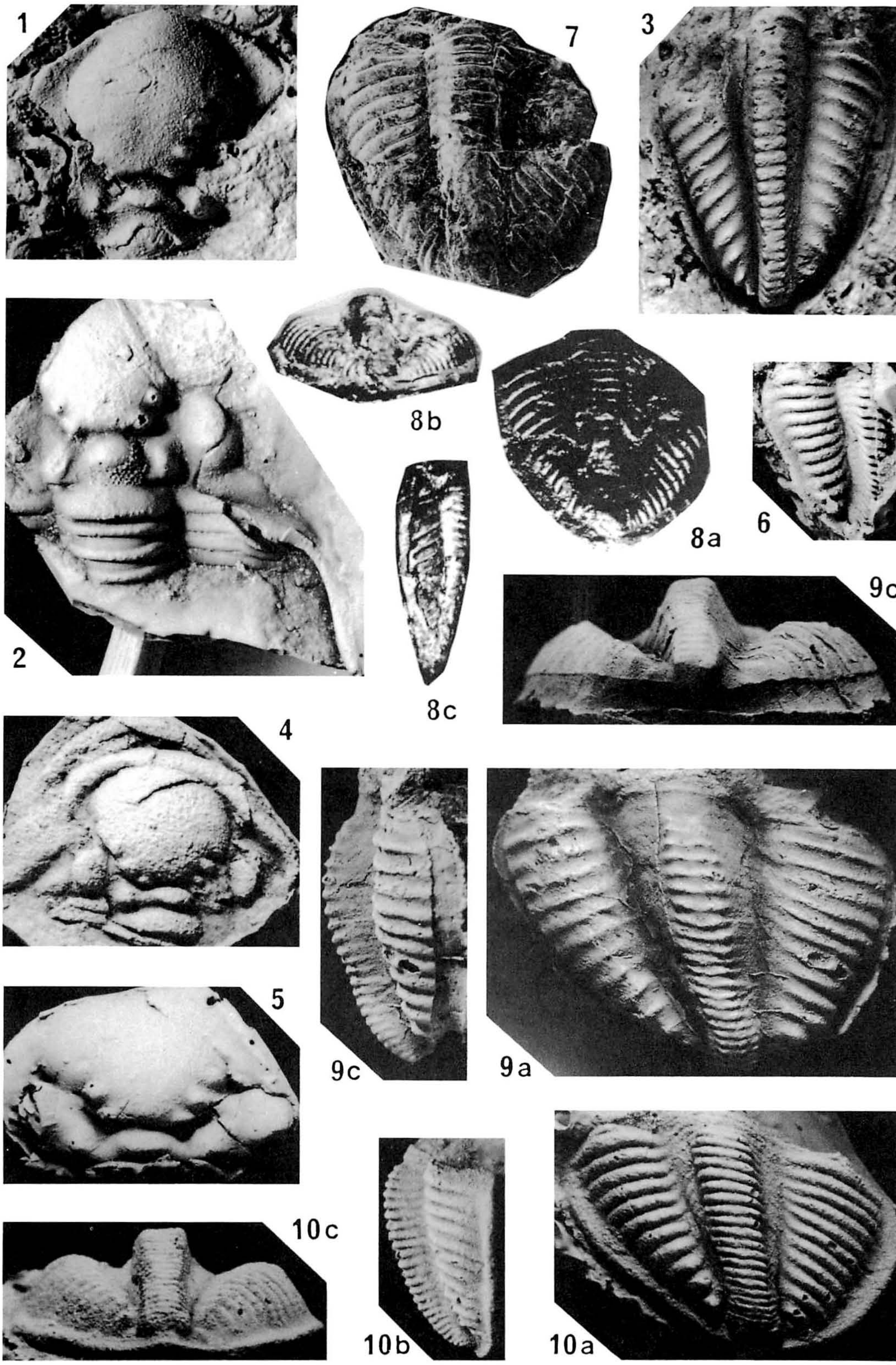
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Plate VII

Explanation of Plate VII

Pseudophillipsia (*Pseudophillipsia*) *kiriuensis* Kobayashi and Hamada, 1984 . . . . p. 53

Fig. 1. Paratype cranidium (inner mould) from Takanida-zawa, Kiriu City, Gunma Prefecture (Hayashi *et al.* coll.), x 4.5, PAt 16710.

Fig. 2. Holotype cranidium (inner mould) (Hayashi *et al.* coll.), x 4.8, PAt 16711.

Fig. 3. Paratype pygidium (Hayashi *et al.* coll.), x 4.7, PAt 16712.

Pseudophillipsia (*Pseudophillipsia*) *kiriuensis* forma *subtrigonalis* Kobayashi and Hamada, forma nov. p. 54

Fig. 4. Type pygidium showing its subtrigonal outline (Hayashi *et al.* coll.), x 5.0, PAt 16713.

Figs. 5, 6. Two pygidia. 5 (Hayashi *et al.* coll.), x 4.7, PAt 16714, 6 (Hayashi *et al.* coll.), x 4.2, pat 16715.

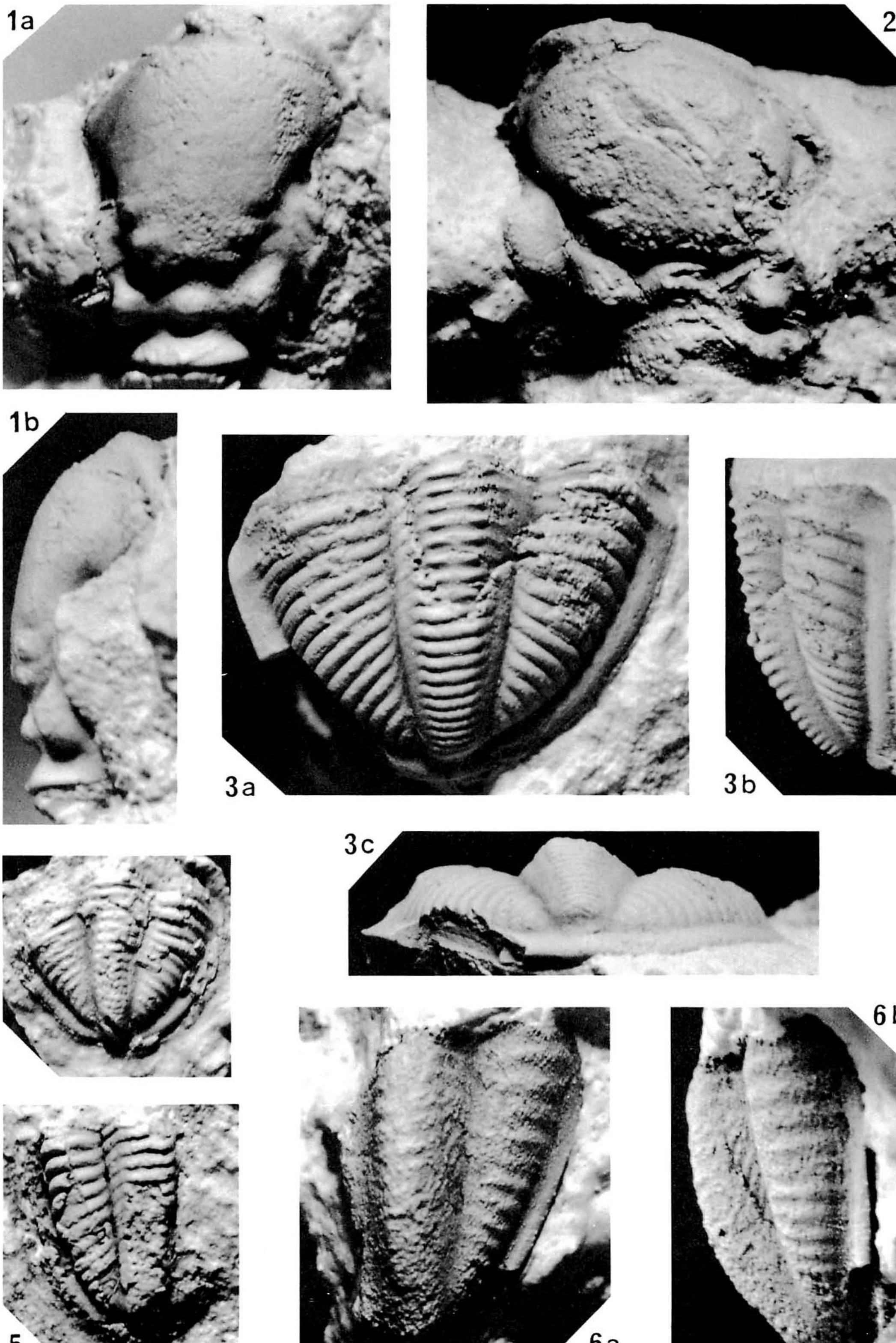
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Plate VIII

Explanation of Plate VIII

Pseudophillipsia (*Pseudophillipsia*) *kiriuensis* Kobayashi and Hamada, 1984 . . . . p. 53

Figs. 1–3. Three cranidia from Kiriu, Gunma Prefecture. 1 x 6.7, 2 x 6.7 (silicon rubber replicas), 3 x 1.5, internal mould. Coll. by T. Ono and T. Hamada, PAt 16716.

Fig. 4, 5. Two pygidia (silicon rubber replicas) from the same locality. 4 x 1.7, 5 x 1.8. Coll. by Ono, PAt 16717.

Fig. 6. Pygidium from Kinsho-zan, Akasaka, Gifu Prefecture (*Parafusulina* zone), x 3.4. Coll. by Y. Tanaka. 6d x 6.4, PAt 16718. (Kojima *et al.*, 1984, p. 121, fig. 7)

Pseudophillipsia (*Nodiphillipsia*) *spatulifera* Kobayashi and Hamada, 1980 . . . . p. 59

Figs. 7, 8. Two pygidia (slightly deformed internal moulds), 7 x 1.7, 8 x 1.7. Coll. by H. Araki from Kamiyatsuse, Kesennuma, PAt 16719a, PAt 16719b.

Pseudophillipsia (*Nodiphillipsia*) aff. *binodosa* Kobayashi and Hamada . . . . p. 63

Fig. 9. An incomplete pygidium showing pleural margin and distinct nodes on the edge of the axial lobe. x 4.6 (silicon rubber replica). Coll. by Sasaki from Omote-Matsukawa, Kesennuma, Miyagi Prefecture, PAt 16720.

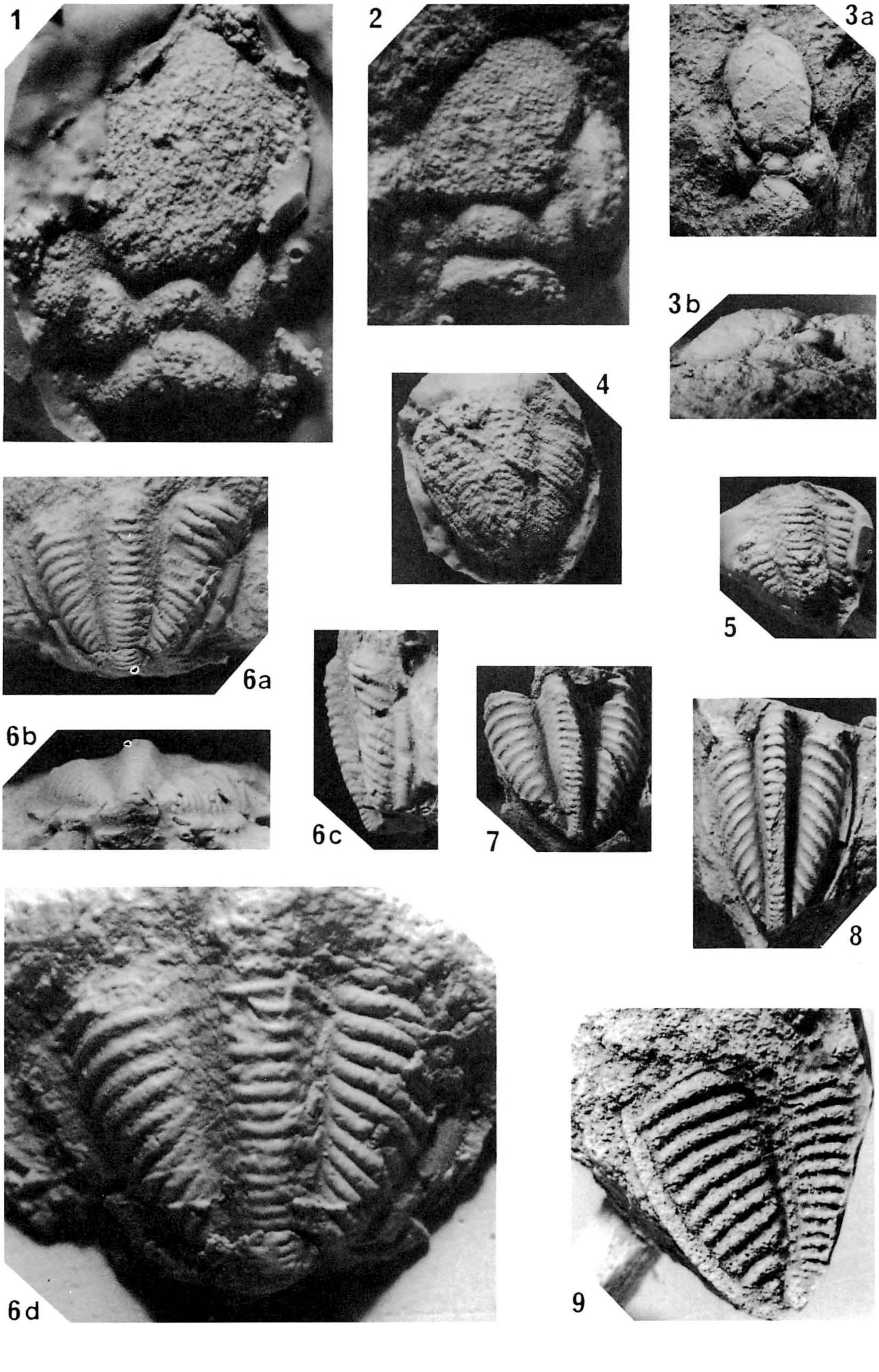
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Plate IX

Explanation of Plate IX

Pseudophillipsia (*Pseudophillipsia*) *akasakensis* Kobayashi and Hamada, 1984 . . . . p. 55

Fig. 1. Holotype specimen (enrolled specimen), x 2.0. 1a, dorsal, 1b, frontal, 1c, left lateral, 1d, right lateral views of the cephalon. 1e, dorsal, 1f, left lateral, 1g, right lateral and 1h, posterior views of the pygidium of the same specimen.

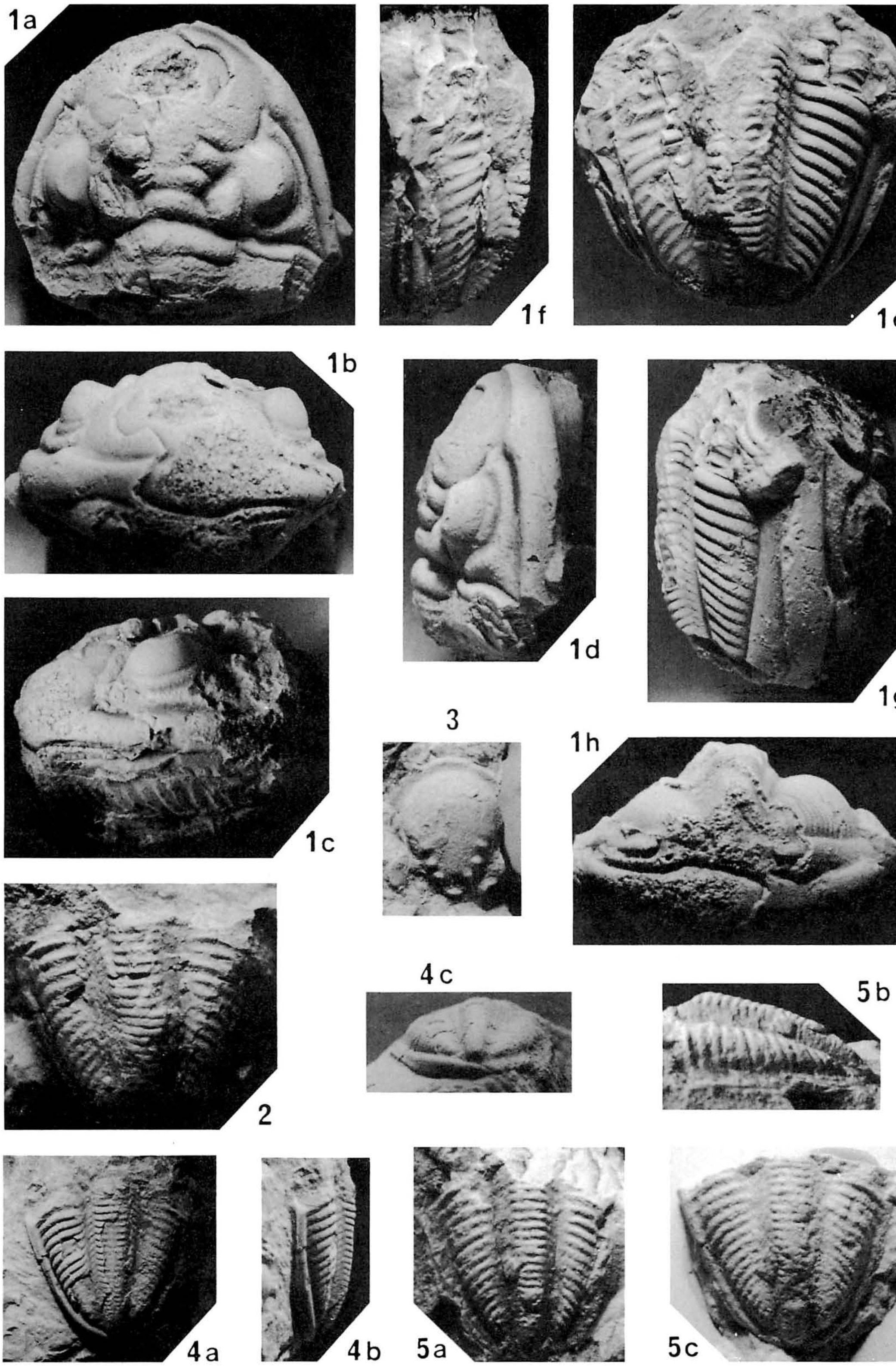
Coll. by Okada from the *Neoschwagerina* Zone (?) of the Akasaka Limestone, Gifu Prefecture, PAt 16721.

Fig. 2. A pygidium from the same locality, x 2.0 Coll. by Y. Tanaka. PAt 17622.

Pseudophillipsia (*Nodiphillipsia*) *ozawai* Kobayashi and Hamada, 1984 . . . . p. 63

Fig. 3. Holotype cranidium showing small lateral furrows and nodes of the cranidium. x 1.7, Coll. by Hayano from the *Yabeina* Zone of the Akasaka Limestone Gifu Prefecture. (Y-2) PAt 16723.

Figs. 4 5. Two pygidia from the same locality. 4 (Y-2) x 1.8, 5 x 2.9 Coll by Hayano (Y-8) PAt 16724. (Kojima *et al.*, 1984, p. 121, fig. 2)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5c

Plate X

Explanation of Plate X

Pseudophillipsia (*Nodiphillipsia*) *hanaokensis* Kobayashi and Hamada, 1984 . . . . p. 64

Fig. 1. Holotype cranidium from the *Codonofusiella-Reichelina* Zone, Hanaoka, Kinsho-zan, Akasaka, Gifu Prefecture (Kojima coll., M-3), x 6.0, PAt 16725.

Fig. 2. Paratype cranidium (Hayano coll., M-2), x 5.8, PAt 16726.

Fig. 3. Another cranidium (Kojima coll., MH-1), x 2.7, PAt 16727.

Fig. 4. Paratype pygidium (Kojima coll., M-2), x 3.0, PAt 16728. (Kojima *et al.*, 1984, p. 121, fig. 1)

Fig. 5. Another pygidium, x 3.0, PAt 16729.

Pseudophillipsia (*Pseudophillipsia*) *catena* Kobayashi and Hamada, 1984 . . . . p. 56

Fig. 6. A cranidium from the *Neoschwagerina* Zone of Kinshozan, Akasaka, Gifu Prefecture (Kojima coll., N-6), x 1.8, PAt 16730. (Kojima *et al.*, 1984, p. 121, fig. 6)

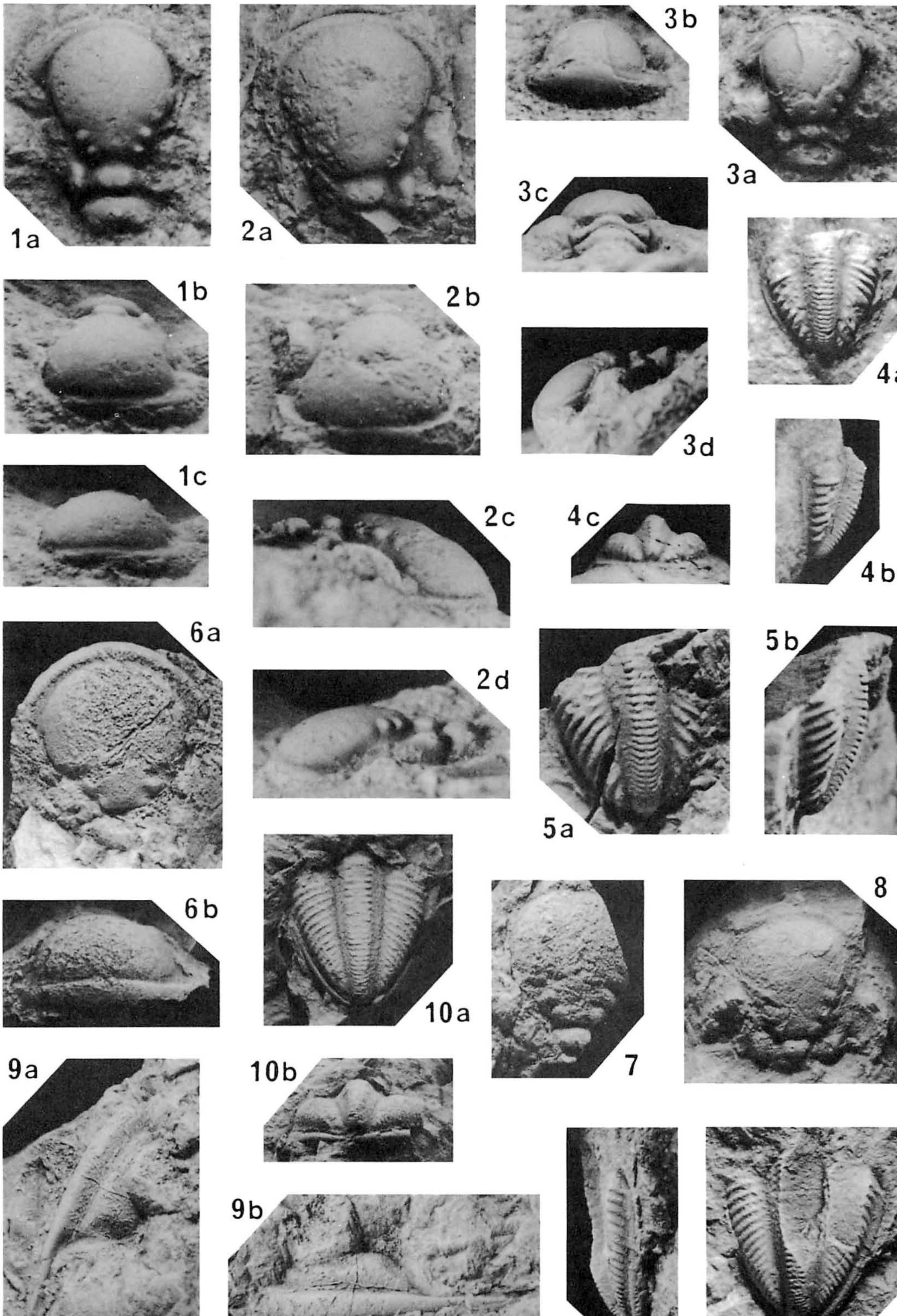
Fig. 7. Holotype cranidium from the same horizon (Kojima coll., N-4), x 1.8, PAt 16731.

Fig. 8. Another cranidium (Kojima coll., N-1), x 2.2, PAt 16732.

Fig. 9. Paratype free cheek (Kojima coll., N-1': on the same slab as N-1), x 2.0, PAt 16733.

Fig. 10. Paratype pygidium (Hayano coll., N-3), x 1.8, PAt 16734. (Kojima *et al.*, 1984, p. 121, fig. 3)

Fig. 11. Another pygidium (Hayano coll., N-1), x 1.7, PAt 16735.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5a
6b
10a
8
7
9a
10b
9b
11b
11a

Plate XI

Explanation of Plate XI

Pseudophillipsia (*Carniphillipsia* ?) *intermedia* Kobayashi and Hamada, 1982 . . . . p. 57

Fig. 1. Holotype cranidium from the *Parafusulina* zone at Neo, Gifu Prefecture (Inoué coll.), x 6.9, PAt 16736.

Fig. 2. Paratype pygidium from the same locallty (Inoué coll.), x 2.8, PAt 16737.

Pseudophillipsia (*Nodiphillipsia*) *hanaokensis* Kobayashi and Hamada, 1984 . . . . p. 64

Fig. 3. Cranidium from Hanaoka-yama, Akasaka, Gifu Prefecture (Sugawara coll.), x 3.2, PAt 16738.

Fig. 4. Pygidium from the same locality (Ono coll.), x 3.0, PAt 16739. Note the presence of caudal incision on the axial lobe.

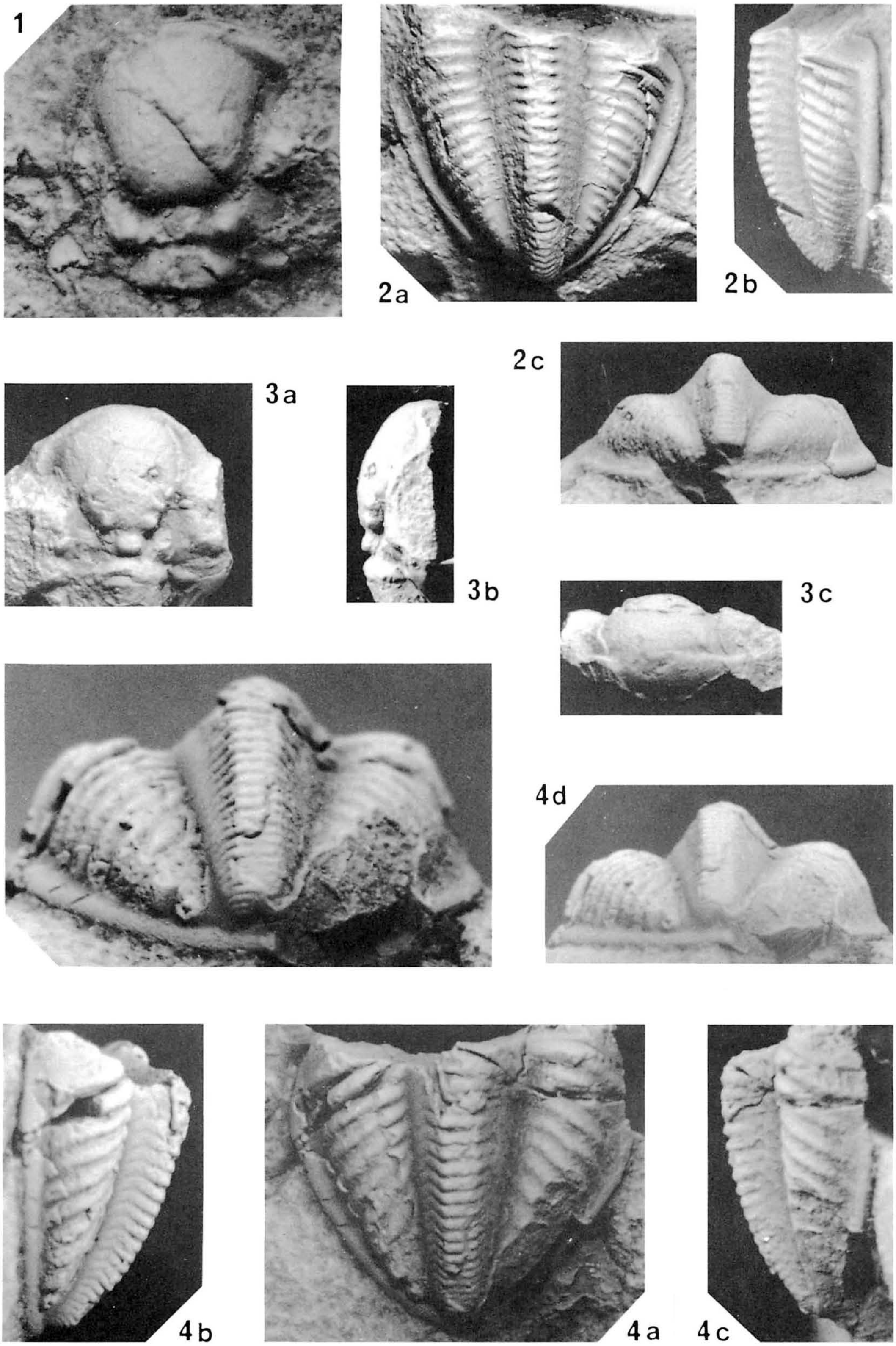
1
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Plate XII

Explanation of Plate XII

Ampulliglabella kojimai Kobayashi and Hamada, sp. nov. . . . . p. 70

Fig. 1. Holotype cephalon (inner mould) from Omote-Matsukawa, Kesennuma City, Miyagi Prefecture (Sasaki coll.), x 3.7, PAt 16740.

Fig. 2. An incomplece cephalon showing the suture line and a genal spine (Sasaki coll.), x 5.0, PA 16741.

Fig. 3. Small cranidium (Sasaki coll.), x 5.2, PAt 16742.

Fig. 4. Deformed cranidium (external mould) (Sasaki coll.), x 5.0, PAt 16743.

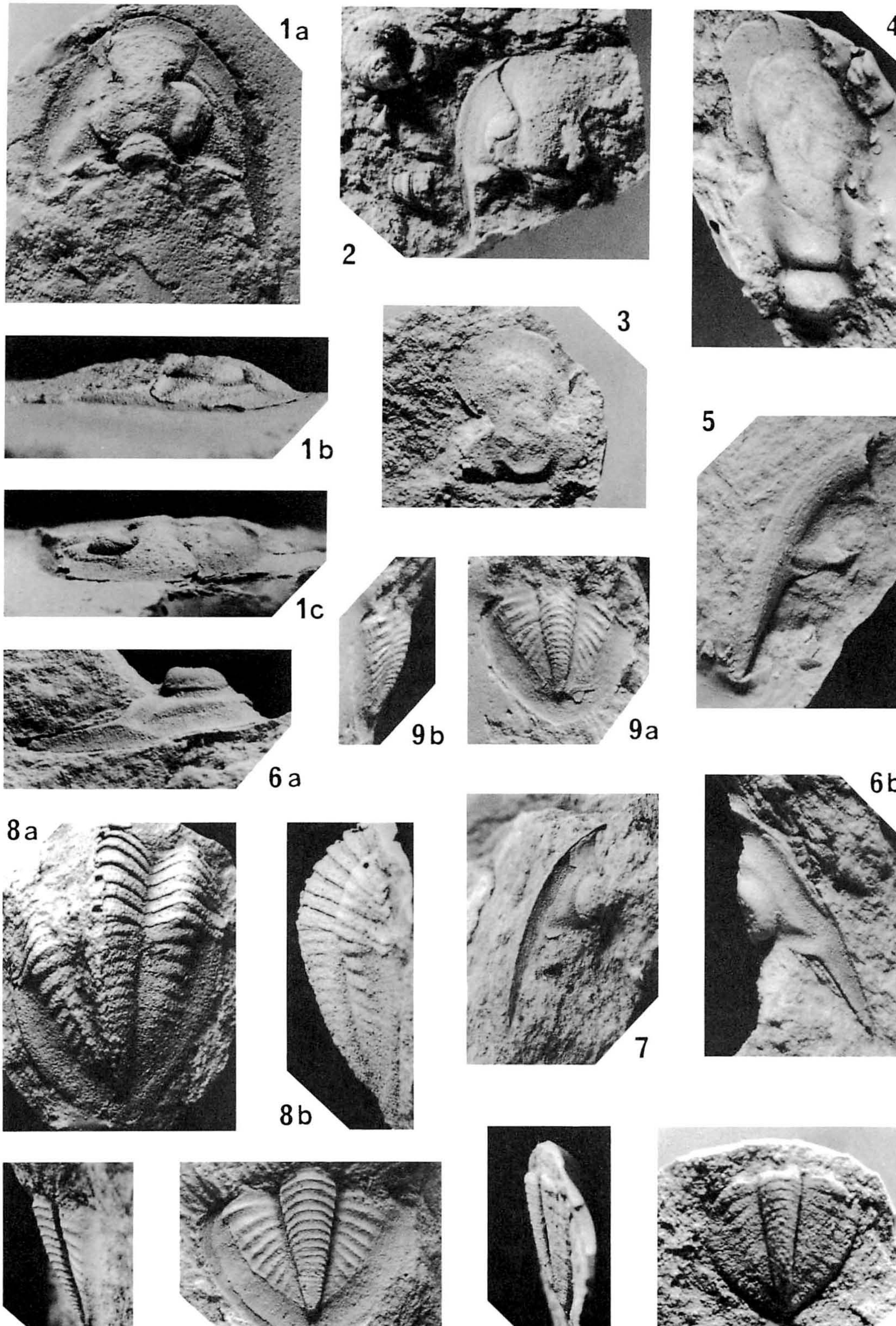
Fig. 5. Free cheek (ventral side) (Sasaki coll.), x 3.1, PAt 16744.

Fig. 6. Another free cheek (inner mould) (Sasaki coll.), x 3.7, PAt 16745.

Fig. 7. Inner mould of a free cheek (Sasaki coll.), x 3.8, PAt 16746.

Fig. 8. Paratype pygidium with seven thoracic segments from Anabuchi, Kesennuma City (Sasaki coll.), x 3.8, PAt 16747.

Figs. 9–11. Three pygidia (9, 10, inner moulds and 11, external mould) showing the subtriangular shape of the carapace. 9, x 2.7 (Pat 16748), 10, x 2.9 (PAt 16749), 11, x 6.8 (PAt 16750).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11b
11a

Plate XIII

Explanation of Plate XIII

Ampulliglabella rotunda Kobayashi and Hamada, sp. nov. . . . . p. 71

Fig. 1. Holotype pygidium from a quarry, Kesennuma City, Miyagi Prefecture showing the general feature (Sasaki coll.), x 4.8, PAt 16751.

Figs. 2–6. Five pygidia (Sasaki coll.). 2, x 4.4 (PAt 16752a), 3. x 5.0 (PAt 16752b), 4, x 5.2 (PAt 16753), 5 from Hogyoji, x 5.0 (PAt 16754) and 6 from Anabuchi, Kesennuma City, x 4.7 (PAt 16755).

Pseudophillipsia (*Nodiphillipsia* ?) *binodosa* Kobayashi and Hamada, sp. nov. . . . . p. 63

Figs. 7, 8. Two pygidia (latex replicas) from Anabuchi, Kesennuma City showing a long and stout axial-lobe (Sasaki coll.). 7, x 3.2 (PAt 16756), 8, x 3.2 (PAt 16757).

Pseudophillipsia (*Nodiphillipsia* ?) *simplex* Kobayashi and Hamada, sp. nov. . . . . p. 62

Fig. 9. Holotype pygidium from a quarry, Kesennuma City (Sasaki coll.), x 5.0, PAt 16758.

Pseudophillipsia (*Nodiphillipsia* ?) aff. *P. simplex* Kobayashi and Hamada . . . . p. 63

Figs. 10–12. Slightly deformed three pygidia from a quarry, Kesennuma City (Sasaki coll.). 10, x 5.8 (PAt 16759), 11, x 5.0 (PAt 16760), 12, x 5.0 (PAt 16761).

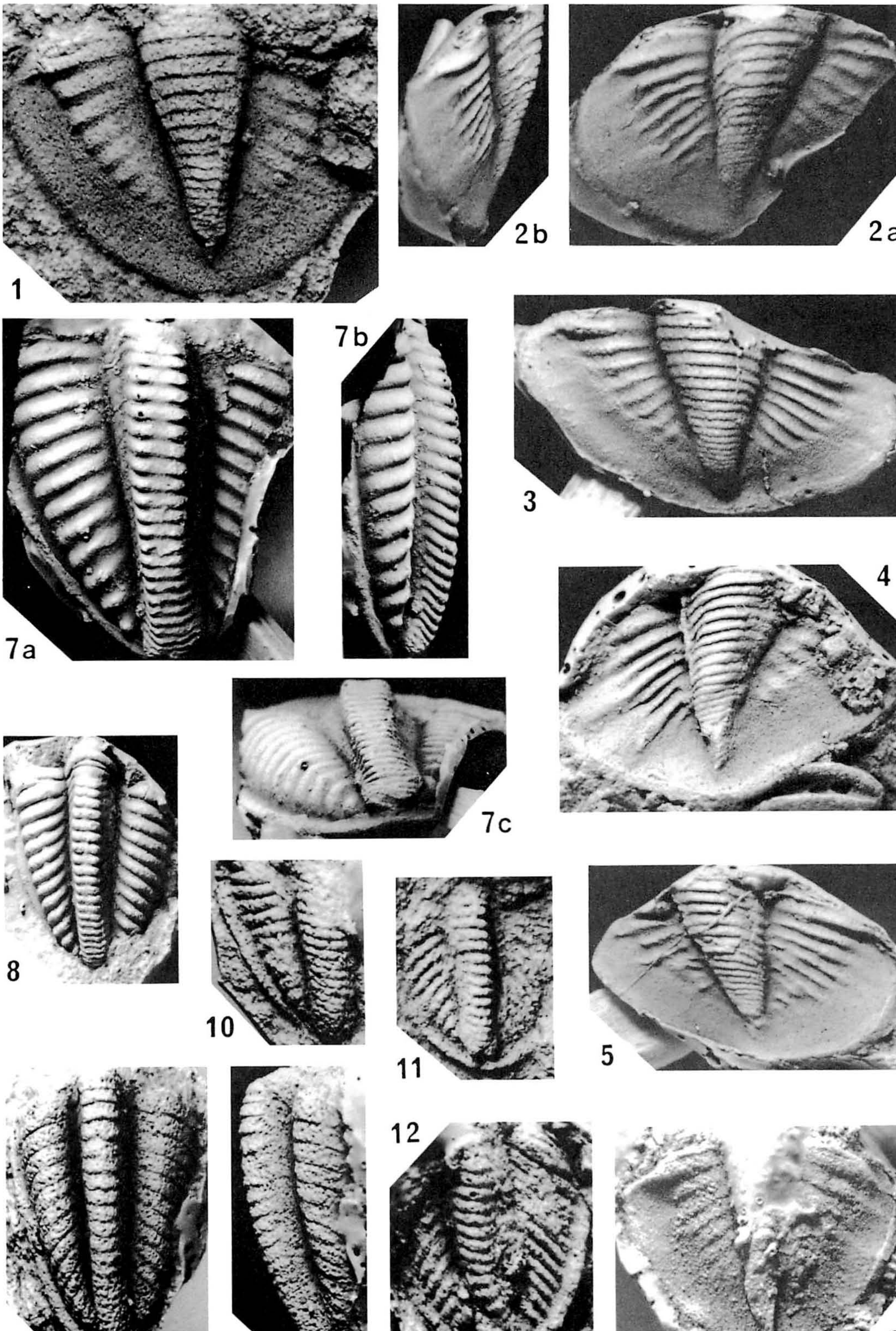
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Plate XIV

Explanation of Plate XIV

Iranaspidion sagittalis Kobayashi and Hamada, 1978 . . . . p. 68

Fig. 1. Dorsal and lateral views of paratype specimen from Central Iran, x 3.6, PAt 16762.

Fig. 2. Another paratype cephalon, x 3.5, PAt 16763.

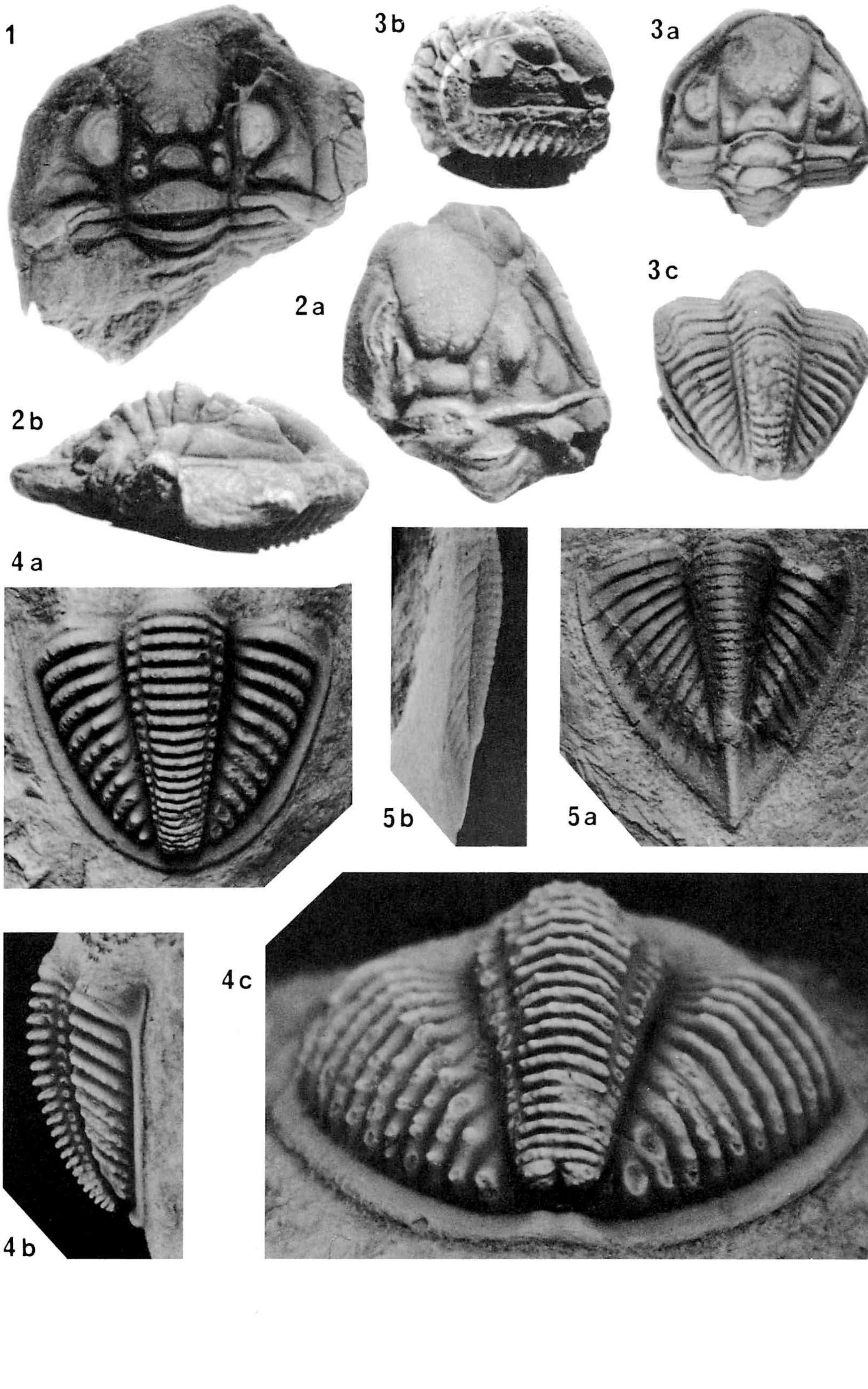
Fig. 3. Enrolled holotype specimen, x 3.6, PAt 16764.

Fig. 4. A complete pygidium showing dorsal and posterior views, x 4.4, 4c, x 9.2, PAt 16765.

Acropyge lanceolata Kobayashi and Hamada, 1978 . . . . p. 63

Fig. 5. Dorsal (a) and lateral (b) views of the holotype pygidium from Central Iran, x 4.4, PAt 16766.

(All figures reproduced from Kobayashi and Hamada, 1978, p. 160)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