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DEVONIAN TRILOBITES OF JAPAN

IN COMPARISON WITH ASIAN, PACIFIC AND OTHER FAUNAS

By

Teiichi KOBAYASHI and Takashi HAMADA

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

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and

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Abstract

KOBAYASHI, T. and HAMADA, T. (1977): Devonian Trilobites of Japan in comparison with Asian, Pacific and other Faunas. *Palaeont. Soc. Japan, Sp. Pap. No. 20*, pp. 202, pls. 13.

A rich collection of Devonian trilobites from Fukuji and Oisé areas in the Hida plateau, West Japan here described contains 24 species. Their age is in a range from Gedinnian to Eifelian. An ecological consideration is made of the Fukuji fauna. Besides, four Middle Devonian species are known from the Kitakami mountains, Northeast Japan. These Japanese trilobites belong to the Scutelluidae, Odontopleuridae, Lichidae, Cheiruridae, Phacopidae, Calymenidae, Proetidae, Dechenellidae and the Otarionidae. Little is so far known of the Upper Devonian ones.

The Devonian trilobites of Japan comprise no element typical of the Rhenish fauna, Appohimchi fauna or the Malvinokaffric fauna. The Oriental trilobite subprovince was proposed recently for the area of Eastern Asia extending from the Yangtze basin (Central China to Viet-Nam) to the Chichibu geosyncline (Japan) and the Burmese-Malayan geosyncline. This subprovince was combined with the Tasman-New Zealand subprovince in the Western Pacific province which in turn was a part of the Old World realm.

As the result of an extensive comparison among the known trilobite faunas the authors are enabled to distinguish two realms, five provinces and ten subprovinces. The Old World realm consists of the Rhenish-Bohemian, Arcto-Pacific and Western Pacific provinces and the New World realm of the Eastern Americas province and the Malvinokaffric province.

On this occasion three forms of trilobites from Northeast China (Manchuria) and Thailand are described two of which being new species. Comments are given on several species from China and Indochina. Many new species are found among the Japanese trilobites. *Hidascutellum* is a new genus of the Scutelluidae, and *Geracephalina* a new subgenus of *Crotalocephalina*. Certain families and genera are discussed in some detail.

Among the secondary stocks of the Trilobita those of odontopleurids, and cheirurids are more probably derived from the Corynexochidian stock than any other primary stock originated in the early Cambrian Period. Specializations which occurred on the glabella and the axial lobe of the dorsal shield are discussed in some length. The trilobation is quite conspicuous

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* Studies on Japanese Trilobites and Associate Fossils, III.

on the glabella of certain polymeric trilobites whereas it is more advanced in the pygidium than the cephalon in the agnostidians. Progressive and retrogressive specializations are seen on the glabella of the Cheiruridae in the phylogerontic stage.

Finally, this volume consists of 154 pages of text and 13 plates in total. Twelve lists, eight tables, and five text-figures are inserted in the text and a bibliography in 23 pages, an index in 20 pages and postscripts and place names in alphabet and Chinese characters are appended in the terminal part.

Preface

In Japan the Trilobita belonged to a little known group in the Devonian biota as represented only by five species, viz. *Phacops okanoi, Phacops nonakai, Thysanopeltis paucispinosa, Dechenella minima* and *Crotalocephalus japonicus* beside a few specifically indeterminable forms. All of these species were found in the Sakari area in the Kitakami mountains, Northeast Japan, except for the last species which was collected from the Fukuji area in the Hida plateau, Southwest Japan.

Recently the Fukuji and Oisé areas respectively in the eastern and western part of the plateau were found to be very prolific in trilobites and other fossils. The present authors examined a large number of trilobites collected from the two areas by many persons. As the result they could distinguish 24 species in addition to two subspecies in 12 genera and 7 families of trilobites. Their age is in a range from Gedinnian to Eifelian whereas the Sakari trilobites are Eifelian-Givetian. These Devonian trilobites are all described in this volume. Little is, however, known as yet of Upper Devonian trilobites in Japan.

In the biostratigraphic part of this volume the geological age of the Japanese trilobites and the ecological condition of the Fukuji fauna are discussed in some length. Then, summarizing the existing knowledge on Devonian trilobites of Eastern Asia, some 100 species in total, are analysed. They belong to 38 genera and 13 families. Setting aside the trilobites of the Eastern Mongolian geosyncline, those known from the Chichibu geosyncline in Japan, the Yangtze basin of Central and South China and adjacent Indochina and the Burmese-Malayan geosyncline constitute the Oriental trilobite subprovince of the Western Pacific province. The Kroh fauna in the Thai-Malay peninsula is, however, very aberrant.

A critical review of Devonian trilobites is made of the rest of the Asiatic continent and areal specialities are pointed out. For example, the Rhenish facies is so far confined to South Asia to the west of the Himalayas. The Mongolian and Siberian faunas bear their own characteristics. The Devonian trilobites of Asia so far known at present consist of about 80 genera in 14 families among which there are many endemic genera and subgenera. The Pseudotrinodidae reveal a unique family indigenous to the Thai-Malay peninsula.

As the result of an extensive review on the Devonian trilobites in other continents, the trilobite world of the Devonian Period is tentatively divided into two realms, five provinces and ten subprovinces. The early and middle Devonian trilobite provinces are shown in a palaeogeographic map. Furthermore, the base of the Devonian System in Asia and neighbouring continents is briefly discussed with reference to trilobites and conodonts.

In the palaeontological part twenty-six species of Devonian trilobites of Japan in sixteen genera and nine families are all described and illustrated beside three species from Thailand and North Manchuria, Northeast China. Comments are presented on seven trilobite species from South China and Indochina. A new genus, *Hidascutellum* and a new subgenus, *Crotalocephalina* (*Geracephalina*) are proposed in this monograph.

Seven families of the Trilobita are discussed at least two of which are considered to be corynexochidian derivatives. As a general problem of trilobitology progressive and retrogressive specializations seen on the glabella as well as the axial lobe of the dorsal shield are discussed in some detail.

The Devonian trilobites of the Fukuji fauna described in this monograph were greatly amplified by Messrs. H. KOIZUMI, Y. OKAZAKI, T. ONO, T. OHNO, Y. TANAKA, S. YAMAKOSHI, S. WAKATA and other persons to whom the authors express their warm thanks. In the course of this study the authors have received assistances in various ways from many geologists and palaeontologists, particularly from Professor A. J. BOUCOT of the Oregon State University, Corvalis, Dr. Ivo CHULPĀČ and Dr. Jiři VANĚK of the Ustředni ústav geologicky, Praha, Prof. K. ERBEN of the Universität, Bonn, Dr. Z. A. MAXIMOVA of the VSEGEI, Leningrad, Dr. A. R. ORMISTON, AMOCO Production-Company, Tulsa, Oklahoma, Prof. T. HANAI of the University of Tokyo, Dr. N. KAMBE of the Geological Survey of Japan, Prof. T. KAMEI of the Kyoto University, Prof. H. IGO of the Tsukuba University, Prof. T. MATSUMOTO and Prof. K. KANMERA of the Kyushu University. The authors thank here to all of them sincerely for their kindness. Finally, it is recorded with high appreciation that this monograph is a product of a research on Japanese trilobites and associated fossils undertaken with a grant in aid of the Japan Academy and its publication is facilitated through Special Papers No. 20 of the Palaeontological Society of Japan with a subsidy from the Ministry of Education.

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Biostratigraphy

I. The Trilobite-bearing Devonian Formations in Japan

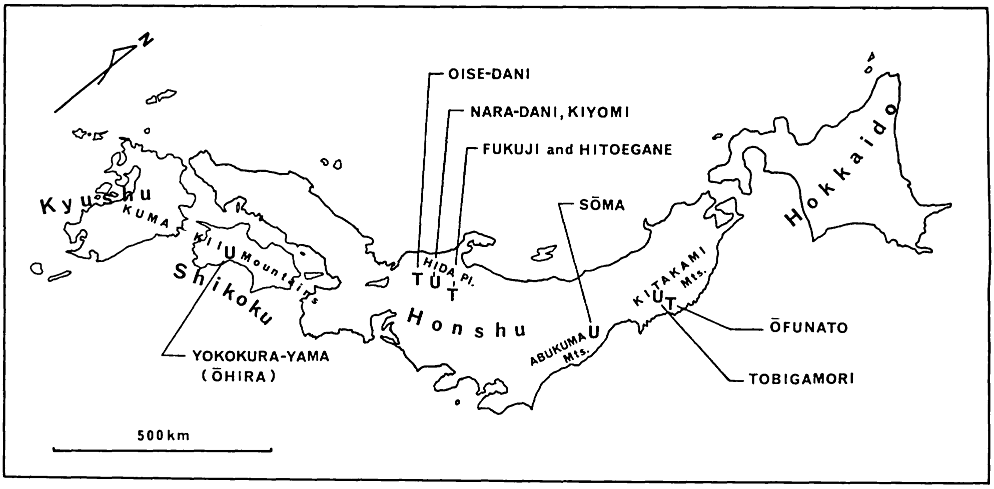
In Japan Carboniferous had long been the oldest fossiliferous system until NODA discovered Upper Devonian brachiopods in his Tobigamori formation in Nagasaka district, Iwaté Prefecture, in Northeast Japan and YABE identified *Spirifer verneuili* among them (YABE and NODA, 1933, NODA, 1934). Subsequently *Halysites* and other Silurian fossils were found in the Sakari district by ONUKI (1937) and Silurian-Devonian rocks were classified by SUGIYAMA (1940) into five units, namely, the Silurian Kawauchi and Takainari Series and the Devonian Ōno, Nakazato and Ōmori Series in ascending order. According to ONUKI (1969) the Takainari Series is unconformably overlain by the Ōno Series, but according to MURATA and others (1974) the Takainari and the uppermost part of the Kawauchi Series are referrable to the Ōno Series and the Ōno and Kawauchi Series redefined by them are conformable with each other. As detailed later, *Phacops* and a few other trilobites were reported to occur in the Nakazato and Ōmori Series by SUGIYAMA, OKUBO and others.

In the Hida plateau of West Japan, *Favosites* found at Fukuji had been considered a Silurian tabulate coral by SUGIYAMA (1941) and KAMEI (1951) until KOBAYASHI and IGO (1965) and HAMADA (1959) pointed out the Devonian age of the so-called Silurian rocks of Fukuji, in describing *Crotalocephalus japonicus* and discussing *Favosites hidensis* respectively. The trilobites from Fukuji and Oisé in the Hida plateau constitute the principal part in the description of this monograph.

Incidentally, the existence of Silurian rocks in the Fukuji area was verified at length by *Encrinurus fimbriatus* KOBAYASHI and HAMADA, 1974, which was discovered at a new locality, Hitoégané, adjacently in the northeast, but isolated from the Devonian area in the west within the Fukuji district.

It is known at present that the Devonian formations exist not only in Northeast Japan but also in the inner and outer zones of Southwest Japan (HAMADA in TAKAI et al., 1963), although each locality is a very small area (see Text-fig. 1). Devonian fossils are especially rare in the outer zone. No Devonian trilobite is so far collected from the outer zone of Southwest Japan. It is, however, of great interest that *Leptophloeum rhombicum* DAWSON was discovered by HIRATA (1966) in his Ochi formation at Mt. Yokokura. It is nearly coeval with the plant-bearing bed of the Tobigamori formation from which TACHIBANA (1963) reported *Leptophloeum* cf. *rhombicum* and *Cyclostigma* sp.

The Devonian biota of Japan consists of various corals, brachiopods, trilobites and other fossils including land plants, of which descriptive works were done only partly on corals, brachiopods, trilobites, cephalopods, ostracods, trilobites and plants by SUGIYAMA and OKANO (1941), OKUBO (1950), TACHIBANA (1950, 1953), HAYASAKA and MINATO (1954), OZAKI (1957), KAMEI (1955), KOBAYASHI and IGO (1956), KOBAYASHI (1958), HAMADA (1959, 1971), KOBAYASHI and HAMADA (1965) and OKAZAKI (1974) beside a preliminary fossil list of the Devonian fauna of the Fukuji Series by KAMEI (1961).



Text-fig. 1. Devonian areas and trilobite localities in Japan.
T: Lower and Middle Devonian trilobite localities.
U: Upper Devonian fossil localities without trilobites.

Thus the larger part of the Devonian fossils still remains undescribed. The trilobites have been such a rare group that only a few species already described were nearly all that have been collected from the Sakari district. Fortunately it was found recently that the Fukuji Series at Fukuji and Oisé was rich in trilobites (KOIZUMI and KAKEGAWA, 1970, OKAZAKI, TANAKA and TANAKA, 1974). A large collection which was made by YAMAKOSHI and many other persons was submitted to the authors for description. The Fukuji trilobite fauna which comprises 24 species including some exactly indeterminable ones is indeed the richest Devonian trilobite fanna so far known in the Northwestern Pacific side. The age of the Fukuji fauna is within the limits from lower Gedinnian to lower Eifelian. It is noteworthy that the lowest Gedinnian conodont horizon was discovered by IGO, KOIKE and IGO (1975) very recently.

II. Devonian Trilobites of Japan and the Age of the Trilobite Horizons

a. Devonian trilobites of the Fukuji Series in the Hida plateau and their age

In the Inner Zone of West Japan pre-Carboniferous fossils are known from three small areas in the Hida plateau called Fukuji, Naradani and Oisé districts from the east. Middle Palaeozoic rocks occur there in tectonic slices shut in within the shattered zone along the Median Line of the Inner Zone (KOBAYASHI, 1951). Because the geologic structure is strongly disturbed in the zone, it requires much more detailed field survey before its stratigraphic sequence can be established precisely.

SUGIYAMA (1941) was the first to call for attention to Silurian *Favosites* cf. *asper* which had been procured by KOZU (1911) at Fukuji, Kami-takara village, Yoshiki county, Province Hida, Gifu Prefecture. Subsequently, *Favosites* limestones were found at Oisé and other places in the upper Kuzuryu tributary, Fukui Prefecture by ISHIOKA and KAMEI (1950) and at Naradani, Kiyomi village, Ōno county, Gifu Prefecture by FUJIMOTO, KANUMA and MIDORIKAWA (1953).

The Silurian formation in question is composed of shale, sandy shale, clayslate, limestone and acidic tuff among which the *Favosites* limestone is most conspicuous. The best known of the formation among the three areas is the Fukuji district. KAMEI (1950) mapped the geology of this district and classified the Silurian Fukuji formation, 260 to 280 m thick, into three parts. Later (1955) he zonated it into two zones and four subzones by means of *Favosites* as tabulated below. He correlated the lower zone (F_1) to the Middle Silurian Kawauchi formation of the Kitakami mountains, Northeast Japan and considered the upper part to be probably Upper Silurian.

Table 1. The Fukuji Series and its *Favosites* zones (after KAMEI, 1955).

Upper limestone and shale member (130m thick)	F_{2d} (sandy shale)	*F. ichinotanensis* subzone	*Favosites hidensis* zone
	F_{2c} (limy shale)	*F. flexuosus* subzone	
	F_{2b} (limestone)	*F. uniformis* subzone	
Middle tuff member (50m thick)	F_{2a} (tuff & limestone)	*F. hidensis* subzone	
Lower limestone member (80–100m thick)	F_1	*F. baculoides* zone	

KOBAYASHI and IGO (1956), on the contrary, pointed out the Emsio-Eifelian age of the upper part (F_{2d}), in describing *Cheirurus* (*Crotalocephalus*) *japonicus*, nov. and proposed "Takaharagawa formation" for the Devonian part. Subsequently, HAMADA (1959) discussed *Favosites hidensis* and in placing the *hidensis* zone in the Middle and Lower Devonian, he suggested that the lower part (F_1, F_{2a}) may be Gedinnian or Siegenian.

Then, KAMEI (1961) transferred the *Favosites*-bearing Fukuji formation inclusive of the Takaharagawa formation to Middle Devonian or Eifelian on the basis of the inclusion of *Gephuropora*, *Tipheophyllum* and *Keriophyllum* in addition to *Undispirifer* and *Elyta* according to MINATO's identification of these brachiopods. In agreement with MINATO (1959), KAMEI concluded that the Fukuji formation was heteropic from, but synchronous with the Middle Devonian Nakazato Series of the Kitakami mountains. Thus, the age of the formation became a moot question.

Beside these articles there were descriptions of a nautiloid (KOBAYASHI, 1958), an ostracod (HAMADA, 1959) and a trilobite (KOBAYASHI and HAMADA, 1965), and more recent studies on *Calceola* sp. indet. (HAMADA, 1971), *Rhizophyllum* (KAMEI et al., 1973) and some trilobites (OKAZAKI, 1974). At length a Silurian spot was documented with *Encrinurus fimbriatus*, nov. which was discovered at Hitoègané within the Fukuji district, but outside of the above mentioned Devonian area, as the trilobite was described in a monograph on *Silurian Trilobites of Japan* by KOBAYASHI and HAMADA (1974).

Fossil list 1. Devonian trilobites of Japan.

Trilobites / Distribution	Fukuji Series						Nakazato Series
	Fukuji				Hitoégané	Oisé-dani	Kitakami
	Kinma-michi	Kanajiro-zako	Ichino-tani	Sorayama			
1. *Hidascutellum multispiniferum*, n. sp.		C				C	
2. *Scutellum densigranulatum*, n. sp.	R?	R			?		
3. *Scutellum* (?) sp. indet.					R		
4. *Thysanopeltella* (*Septimopeltis*) *paucispinosa* (OKUBO)							R
5. *Primaspis* (?) *tanakai*, n. sp.		R					
6. *Ceratocephala nipponica*, n. sp.				R			
7. *Craspedarges superbus*, n. sp.				A			
8. *Acanthopyge* (*Lobopyge* ?) sp. indet.				R			
9. *Crotalocephalina* (*Crotalocephalina*) sp. indet.			C				
10. *C.* (*Pilletopeltis*) *japonica* (KOBAYASHI & IGO)	C	C	C			C	
C. (*P.*) *japonica granulata*, n. subsp.		R					
11. *C.* (*P.*) *kameii*, n. sp.		C					
12. *C.* (*Crotalocephalides*) sp. indet.			R				
13. *C.* (*Crotalocephalides* ?) sp. indet.				R			
14. *C.* (*Geracephalina*) *secta*, n. subgen. et n. sp.				A		C	
C. (*G.*) *secta projecta*, n. subsp.		C	C				
15. *C.* (*G.*) *convexa*, n. sp.		C	C				
16. *C.* (*G.*) *euryrachis*, n. sp.	C		C	C			
17. *Crotalocephalina*, subgen. et sp. indet.		R					
18. *Phacops okanoi* SUGIYAMA							R
Phacops cf. *okanoi* SUGIYAMA							R
19. *Reedops nonakai* (OKUBO)							R
20. *Gravicalymene yamakoshii*, n. sp.	C	C		A		A	
21. Flexicalymenid, gen. et sp. indet.	R						
22. *Proetus* (*Coniproetus*) *fukujiensis*, n. sp.				C			
23. *Unguliproetus oisensis*, n. sp.						A	
24. Proetid, gen. et sp. indet. a				R		R	
25. Proetid, gen. et sp. indet. b				R			
26. Proetoid, gen. et sp. indet.			?	R		R	
27. *Dechenella* (*Dechenella*) *minima* OKUBO							R
28. *Otarion megalops*, n. sp.				R			

R: rare, C: common, A: abundant.

Although no trilobite was so far uncovered in the Naradani district, the Fukuji and Oise districts are known now to be rich in trilobites. Not only there are common trilobites between these two districts, but also the same *Favosites* limestone occurs in all of the three areas. Therefore the Devonian strata of these areas are here collectively called the Fukuji formation. The Fukuji trilobites described in this monograph total 24 species in addition to two subspecies in 11 genera and 7 families, namely, the Scutelluidae, Odontopleuridae, Lichidae, Cheiruridae, Calymenidae, Proetidae and the Otarionidae.

Among the eleven genera a new genus, *Hidascutellum*, and *Craspedarges* whose age is a matter of dispute should be excluded out of chronological discussion. The known geological range of the remainder is as follows:

Scutellum, s. str.	Middle Silurian-early Upper Devonian (Adorfian)
Primaspis	Middle Ordovician-early Middle Devonian
Ceratocephala	Middle Ordovician-Middle Devonian
Acanthopyge, s. l.	Middle Silurian-Middle Devonian
Crotalocephalus, s. l.	Middle Silurian-Middle Devonian
Gravicalymene	Middle Silurian-Lower Devonian (or lowest Eifelian)
Proetus	Middle Ordovician-Middle Devonian
Unguliproetus	Lower Devonian-Middle Devonian
Otarion	Middle Ordovician-Upper Devonian

Incidentally, the range of *Primaspis* is cited *Mid. Ord.-Up. Ord. ? Sil.* in MOORE's Treatise, but according to CHATTERTON (1971) *Primaspis* (*Taemaspis*) ranges from the Silurian (upper Wenlockian) to the Lower or Middle Devonian (upper Emsian or lower Eifelian).

All of these genera appeared in the Ordovician or Silurian Period except for the last appearance of *Unguliproetus* in the early Devonian. *Gravicalymene* first died out with Lower Devonian or at the beginning of Middle Devonian, followed by six genera which survived until Middle Devonian and the two others remained by Upper Devonian or its early age.

For a further limitation the subgeneric range must be brought into consideration. *Proetus* (*Coniproetus*) to which a proetid species from the *Gravicalymene* bed of Sorayama, Fukuji district belongs is so far known only from the rocks from Silurian to Lower Devonian in Europe and North Africa (ALBERTI, 1969). Therefore this subgenus combined with *Gravicalymene* suggests the Lower Devonian or older age of the *Coniproetus* horizon.

Since the senior author has described *Cheirurus* (*Crotalocephalus*) *japonicus* with IGO, *Crotalocephalus* of Europe and North Africa was examined in a great detail. According to LÜTKE (1965) *Crotalocephalus articulatus* (MÜNSTER) represents the *articulatus* group by itself, if *Cr. cordai* (BARRANDE) of dubious reference be ignored. MÜNSTER's species which is the type-species of the genus occurs in Wenlock-lower Ludlow beds and morphologically quite isolated from all other crotalocephalids. Devonian ones belong exclusively to *Crotalocephalina* which involves four subgenera

Table 2. Correlation of the Devonian trilobite horizons in Japan.

Age \ District		Hida	Kitakami	
Etroeungtian			*Palaeophillipsia* horizon	
Famennian			? Omori phacopid horizon	
Frasnian				
Givetian			*minima* horizon	Nakazato Series
Eifelian	upper		*paucispinosa* horizon	
	lower			
(*cultrijugatus*) Emsian		Fukuji Trilobites		
Siegenian	upper			
	lower			
Gedinnian				
Up. Silurian		Hitoégané Tril.		

including a new subgenus, *Geracephalina*. The geological ranges of the three others are shown below.

GEOLOGICAL AGE / SUBGENUS	SILURIAN		LOWER DEVONIAN			MID. DEV.	
	Wenlock.	Ludlov.	G. / Siegenian	Siegenian / Emsian	Emsian	Eifel.	Givet.
			Lochkov.	Prag.	Z.		
Crotalocephalus	—	—				?	
Crotalocephalina			—	—	—	—	
Pilletopeltis				—	—	—	—
Crotalocephalides				—			

Geological range of four subgenera of *Crotalocephalus* (after LÜTKE, 1965 and G. ALBERTI, 1969). G: Gedinnian, Z: Zlichovian.

Subgenus *Pilletopeltis* to which *Cr. japonicus* belongs, is well represented in the Fukuji fauna. In addition, the two other Devonian subgenera are found also in the fauna. Assuming the above subgeneric range be applicable to the Fukuji fauna at its face value, two subgenera *Crotalocephalina* and *Pilletopeltis* combined limit the *Crotalocephalina* beds in a range from Praguian to lower Eifelian and *Crotalocephalides* does the *Crotalocephalides* horizon within the Praguian. Unfortunately *Crotalocephalina* s. str. and *Crotalocephalides* are represented in the fauna by poor specimens. The above age determination is, however, in support of *Rhizophyllum enorme* ETHERIDGE (Siegenian-Emsian, Australia) identified by KATO (KAMEI et al., 1973). At the same time, this chronology does not contradict against the inclusion of *Hidascutellum*, nov. and *Craspedarges* in the Fukuji fauna, because, as discussed later, the closest allies of *Hidascutellum multispiniferum*, nov. are *Bojoscutellum crassicostatum* ŠNAJDR from the Lower Devonian Koneprusy formation of Bohemia and *Weberopeltis aculeatus* (WEBER) from the upper Ludlovian of the Urals and the age of Australian *Craspedarges wilcanniae* GÜRICH is probably Lower or Middle Devonian rather than Upper Devonian.

Beside these the Fukuji fauna contains *Crotalocephalina* (*Geracephalina*). This new subgenus includes *Crotalocephalus expansus* MAXIMOVA (1968) from the upper part of the Kochbaital horizon in central Kazakhstan whose age is lowest Devonian rather than uppermost Silurian (MAXIMOVA, 1971). Therefore it is probable for the lower limit of the Fukuji trilobite beds to extend as far as the base of the Devonian System.

As shown in the fossil list, *Crotalocephalina* (*Pilletopeltis*) *japonica* and *Cr.* (*Geracephalina*) *euryrachis* are known from three places among Sorayama, Ichinotani, Kanajiro-zako and Kinma-michi and *Cr.* (*Geracephalina*) *secta projecta* and *Cr.* (*G.*) *convexa* from Ichinotani and Kanajiro-zako, but many other trilobites were recorded from only any one of the four places.

Kanajiro-zako, Sorayama, Ichinotani and Kinma-michi yielded 11, 9, 7 and 5 forms of trilobites respectively. Some of them were collected from exposures, but some others found among boulders and river floats. Most of KOIZUMI and KAKEGAWA's collection were floats at Osobu-dani and Kanjiro-zako in the Takahara-gawa area. These collectors consider from their lithology and topography of the area that they have been derived from KAMEI's F_{2b} subzone in Osobu-dani branch of the Ichinotani stream.

At present it is unknown how many distinct trilobite horizons are safely distinguishable by means of trilobite associations. Much is not known also of the stratigraphic relation among trilobite horizons. If there is any horizon which contains neither one of *Crotalocephalina*, *Unguliproetus* and *Craspedarges*, but other trilobites, its age is difficult to say out of trilobite ranges whether it is really Devonian or whether it is older.

At Sorayama *Gravicalymene yamakoshii* and *Proetus* (*Coniproetus*) *fukujiensis* often occur together at different spots of exposures and may be accompanied by different forms of *Crotalocephalina*. *Cr.* (*Pilletopeltis*) *japonica* and *Otarion megalops* are, however, rare trilobites procured at one or another point. *Craspedarges superbus* is found profused at a spot of Sorayama isolated from these trilobites. On the Sorayama promenade some trilobite horizons are distinguishable. The orthoceratid-bearing bed yields *Gravicalymene yamakoshii* and *Crotalocephalina* (*Geracephalina*) *bisecta* commonly. Assuming that there is no overturn of the present sequence, the main *Craspedarges superbus* bed lies above the orthoceratid-bearing bed. Below this bed are seen two distinct trilobite beds, namely, the *Proetus* (*Coniproetus*) *fukujiensis* bed above and the *Otarion megalops* bed below.

Recently IGO, KOIKE and IGO (1975) discovered conodonts at Sorayama. The sequence of the so-called Fukuji fossil garden by them is as below.

Lower part: Black calcareous shale intercalating argillaceous limestone layers: Crinoid stems, brachiopods, orthoceratids and other fossils. ....more than 8.5 m thick
Middle part: Black thin-bedded very argillaceous limestone intercalating thin shale layers: Trilobites, brachiopods and others. ....7.5 m thick
Upper part: Medium to thickly bedded dark gray to black very fossiliferous limestone intercalating thin layers of black limestone: *Favosites*, rugose corals, stromatoporoids, brachiopods and other fossils. ....more than 11 m thick

According to them the above sequence corresponds to part of KAMEI's lower Fukuji formation, i.e. the F_1 zone. They obtained *Drepanodus* spp., *Panderodus striatus striatus* (STAUFFER) and *Panderodus* sp. from the upper part of the orthoceratid black shale and *Drepanodus* spp., *Icriodus woschmidti worschmidti* ZIEGLER, *Panderodus* sp. and *Spathognathodus remscheidensis* ZIEGLER from the trilobite-bearing black limestone from which OKAZAKI reported *Crotalocephalus japonicus*. The latter conodont horizon is lowest Gedinnian in age.

They found furthermore *Panderodus striatus striatus* (STAUFFER) and *Panderodus* cf. *subquadratus* (STAUFFER) at Ichinotani near the top of the KAMEI's bed 9 or the upper part or his F_{b2} zone which lies approximately 200 m above the trilobite-bearing thin-bedded limestone. Because these species are known from the Emsian of South-eastern Spain, they contend the upper Fukuji formation to be possibly upper Emsian.

As detailed in the palaeontological part of this volume *Crotalocephalus* (*Crotalocephalus*) *japonicus* by OKAZAKI, 1974 comprises different forms in two or more subgenera of genus *Crotalocephalina*. No trilobite from Sorayama at hand is exactly identifiable with *Crotalocephalina* (*Pilletopeltis*) *japonica*. It is uncertain that the orthoceratid-bearing black shale by IGO et al., corresponds exactly to the afore-mentiond orthoceratid-bearing bed which yields *Gravicalymene yamakoshii* and *Crotalocephalina* (*Geracephalina*) *secta* commonly, because trilobites appear uncommon or absent in IGO and other's black shale. It is more difficult to allocate the trilobite horizons of Sorayama promenade in the sequence given by IGO et al. safely.

It is far more difficult to correlate fossil beds of the four areas of Fukuji district because of dense forest and geologic structure strongly complicated by intense folding and faulting. Because the exposure of rocks is relatively better, KAMEI took the Ichinotani stream for the type section of the Fukuji Series. His classification and zonation, however, require much revision.

Of the upper limit of the whole Fukuji formation it may extend beyond the Emsian stage, if the middle Devonian age of some corals and brachiopods emphasized by KAMEI and MINATO can be brought into consideration. More precisely, the age of three coral genera and two brachiopod genera in concern are according to MOORE's Treatise, Part F. 1956 is as follows:

Gephuropora	L. M. Dev., E. Austral.-Belg.
Heterophrentis (i.e. *Tipheophyllum*)	L. Dev.-Mid. Dev., N. Am.
Keriophyllum	M. Dev., Eu.
Undispirifer	M. Dev. (Givet.)-U. Dev. (Fras.), Eu.
Elita (i.e. *Elyta*)	M. Dev.-U. Dev., Cosmop.

Thus, *Undispirifer* is a sole genus whose age is definitely Givetian and later. Because the reference of the Fukuji brachiopod to either *Undispirifer* or *Elita* was indeterminable for MINATO exactly, it cannot be a definite determiner. On the other hand *Gephuropora* is restricted to Eifelian. Therefore, if its identification is reliable, the *Gephuropora* horizon may be Eifelian in age, although none of these Fukuji species referred to these genera has been either described or illustrated. *Calceola* has long been a keen index to Middle Devonian, but it is known now to range widely from upper Emsian to lower Frasnian (HAMADA, 1971). Therefore any further restriction cannot be made with *Calceola* sp. indt. from Fukuji. By these reasons it cannot be said definitely that neither corals nor brachiopods so far known allow one to insist Givetian age of the Fukuji fauna. In other words, it is quite improbable that the trilobite beds which are distributed widely from bottom probably to top reach as high as Givetian. It is now warranted that the Fukuji formation is within the range from Gedinnian to Eifelian or probably lower Eifelian and by no means contemporaneous with the Middle Devonian Nakazato Series, although the basal part of the latter may happen to be coeval with the top part of the former. Judging from the known trilobites the upper limit may be Emsian inclusive of the *cultrijugatus* beds or thereabout.

The Oisé area in the upper Kuzuryu tributary is another Devonian area from where are known four species of trilobites. *Unguliproetus oisensis* is the most common trilobite at Oisé, but unknown from the Fukuji district. The association of *Gravicalymene yamakoshii* either with *Unguliproetus oisensis* or *Proetus* (*Coniproetus*) *fukujiensis* means probably a slight time-displacement between the *oisensis* horizon of Oisé and the *fukujiensis* horizon of Fukuji but these two horizons are evidently within the life range of *G. yamakoshii*. *Hidascutellum multispiniferum*, *Crotalocephalina* (*Pilletopeltis*) *japonica* and *Gravicalymene yamakoshii* occurring both in Oisé and Fukuji areas show that the trilobite faunas of the two areas are not much different in age.

Finally, Hitoégané is an isolated small area in the northeastern part of the Fukuji district. The present authors (1965) have described *Scutellum* ? sp. as a Silurian trilobite. It is represented by an imperfect pygidium which is known now to be very similar to that of *Hidascutellum multispiniferum*. Therefore, it suggests the presence of Devonian rocks in Hitoégané. Then, the relation between this scutelluid horizon and the Silurian *Encrinurus fimbriatus* horizon becomes an important problem.

b. Palaeoecology of the Fukuji trilobites

Now the biotope of the Fukuji Series in which these trilobites are contained is discussed. This discussion is made in comparison with the Devonian Kroh fauna of Malaya and the Silurian Yokokura fauna in Shikoku Island, Japan. The most conspicous aspect of the Fukuji trilobites is the development of protuberances, such as nodes and spines on the carapace. *Hidascutellum* has this kind of cephalon having most numerous spines or protuberunces in the Scutelluidae, although the spines are neither so large nor so long as those of *Ancyropyge*. *Hidascutellum* is most closely allied to *Weberopeltis* in cephalon, although the pygidium of *Hidascutellum* has an entire margin.

Craspedarges is a lichid having the pygidium with well developed numerous spines. It is certainly a remarkable distinction from *Apolichas truncatus* of the Yokokura fauna, since marginal spines are almost completely truncated on the pygidium of the Yokokura lichid.

Crotatocephalina also has lateral spines produced from the pleural lobes of the pygidium. It is particularly noteworthy that *Cr.* (*Geracephalina*) *convexa* has sharp paired vertical spines on the axial rings including the occipital ring, beside the long lateral spines of the thoracic and pygidial pleurae, because such axial spines are quite rare in *Crotalocephalina* and its allies. *Primaspis* and *Ceratocephala* are well known spiny trilobites. Two cephala of *C. nipponica*, one small and the other moderate in size and a very small cephalon of *Primaspis* ? *tanakai* are contained in the Fukuji collection.

Genal spines are present in two proetids and *Otarion megalops* which are comparatively long for these genera, and evidently more developed, if compared with the Yokokura proetids. The pygidium of *O. megalops* is serrated along the margin which is uncommon for *Otarion*. It is quite unusual that pregenal spines, though short, are maintained in *Crotalocephalina* (*Crotalocephalides* ?) sp. indet. until the mature stage. An exception of Fukuji species of *Crotalocephalina* is *Cr.* (*Geracephalina*) *euryrachis* in which genal spines are rudimentary. *Gravicalymene yamakoshii* is another exception among Fukuji trilobites which lacks genal spines. The genal angle is, however, fairly well pointed in *G. yamakoshii* for the Calymenidae. It would be reasonable to consider that the spines served generally for self-guard.

Beside the trilobites the Fukuji fauna comprises various animals such as anthozoans, tabulate corals, stromatoporoids, conulariids, brachiopods, pelecypods, gastropods, nautiloids, crinoids, ostracods, conodonts, fishes and others among which fishes and nautiloids were presumably powerful enemies for the trilobites.

Because the Kroh trilobites of Perak, Malay are mostly blind or degenerated eyebearers, their habitat is judged to have been either an aphotic zone or a disphotic zone. *Plagiolaria poothaii* having normal phacopid eyes, though reduced in size, is a member of this fauna which suggests the latter zone for its habitat. Many of the trilobites were probably bottom dewellers. Most carapaces are dismembered, but postmorten transportation was almost negligible in distance for some individuals. This mode of fossil occurrences suggests a dark quiet muddy bottom which have been probably a shelter for *Pseudotrinodus*, *Blanodalmanites* and *Bailielloides*. It is possible that the muddy floor of Kroh was a moulting site for them (KOBAYASHI and HAMADA, 1972).

Because none of the Fukuji trilobites is blind, their habitat was within the photic zone. Spiny *Ceratocephala nipponica* having short but stalked eyes would have been a good swimmer and probably nocternal. Most carapaces of the Fukuji trilobites are dismembered, but some cephala and thoraces are not, as exemplified by some remains of *Otarion megalops* and *Crotalocephalina* (*Pilletopeltis*) *japonica*. Though less common, the dorsal shield is complete as illustrated in fig. 3, Pl. 8 of *Cr.* (*P.*) *japonica*.

While the bottom water of Kroh was stagnant, the Fukuji sea was fairly well agitated and ventilated. It is evident, however, that the sea was by no means so rough as the Silurian Yokokura sea, as thoroughly discussed already (KOBAYASHI and HAMADA, 1974). The Yokokura trilobites are all dismembered and no thoracic segment has as yet been found. Morphologically, it is a remarkable contrast that many of the Yokokura trilobites have carapaces strongly convex or even globular and spines are absent, or they are incomparably shorter than those of the Fukuji trilobites. The mother rock is light coloured pure limestone which is a kind of reef-breccia and halysitid limestone is its leading coralline component. The limestone of the *Sphaerexochus hiratai* horizon in particular suggests that it was deposited in a very rough oceanic side of a reef slope.

In comparison with the Kroh sea of Malaya the Fukuji sea was shallower and probably in the photic zone. It was not stagnant as the Kroh sea, but not so rough as the Yokokura sea and the water was not so purified by oceanic current. The Fukuji sea was probably nearer to land compared to the Yokokura site. Its neritic fauna consists of various animals and the trilobites suggest severe struggle of existence among them.

c. Devonian trilobites from the Kitakami mountains and correlation of trilobite horizons in Japan

In the Sakari district, Ōfunato city, Iwaté Prefecture the Ōno Series which is considered generally Lower Devonian contains some corals but no trilobite. The middle division of the Kitakami Devonian is the Nakazato Series from which a few trilobites are reported beside various brachiopods, some corals and other fossils. SUGIYAMA and OKANO (1941) described *Phacops* (s. str.) sp. indet. from the southeastern foot of Takainari-yama which was an antero-lateral fragment of a cephalon. Later SUGIYAMA (1974) named it *Phacops okanoi* and compared it with *Phacops latifrons*.

Subsequenstly OKUBO (1951) described *Thysanopeltis paucispinosa* nov. from the middle part of a valley between Ohmori and Higuchizawa and *Dechenella minima* nov. from the middle part of Higuchizawa. He considered them two Middle Devonian species. Later KOBAYASHI (1957) restudied them and dated *Scutellum* (*Thysanopeltella*) *paucispinosa* and *Dechenella* (*Dechenella*) *minima* at Eifelian and Givetian respectively. According to the recent classification of the Scutelluidae the former belong probably to *Thysanopeltella* (*Septimopeltis*) (KOBAYASHI and HAMADA, 1974) and the range of subgenus *Septimopeltis* is restricted to Eifelian in Bohemia (PŘIBYL and VANĚK, 1971). In the pentagonal outline of the pygidium this Jananese species looks more specialized than *T.* (*S.*) *clementa* (BARRANDE). Therefore *D. minima* may be a little younger than *T.* (*S.*) *paucispinosa*. According to OKUBO the *paucispinosa* horizon lies about 100 m below the *minima* horizon.

OKUBO (1956) amplified the Nakazato fauna in describing 10 species of brachiopods and *Phacops nonakai*, nov. also from the middle part of Higuchi-zawa. This trilobite, however, may be better placed in *Reedops*. As this trilobite horizon is located in the upper part of the Nakazato Series, its age is probably Givetian and near the *minima* horizon.

Beside them *Phacops* sp. was reported from the Ōmori Series lying immediately above the Nakazato Series. It was a poorly preserved pygidium not yet described. Otherwise the Ōmori Series is unfossiliferous.

SUGIYAMA (1944) described *Palaeophyllipsia japonica*, gen. et sp. nov. from the uppermost Devonian at Chōanji in the same district, but later studies by OKUBO (1951) and others have shown the lowest Carboniferous age of the Chōanji fossil bed. According to ENDO and MATSUMOTO (1962) the trilobite is probably conspecific with *Phillipsia ohmoriensis* OKUBO, 1951, although the identification cannot be thoroughly confirmed because the type specimen was lost. By these reasons *P. japonica* is here eliminated from the Devonian fauna of Japan.

The Tobigamori Series of the Nagasaka district with which the Nakakura formation by TACHIBANA is synonymous yeilds Upper Devonian *Spirifer* (*Cyrtospirifer*) *verneuili* MURCHISON and many other brachiopods and several molluscus beside *Leptophloeum* and *Cyclostigma*, but rare trilobite. It is overlain by the Karaumedate formation containing the Etroeungtian fauna in the lower part and the Tournaisian fauna in the upper part. *Griffithides* (?) sp. and *Phillipsia* sp. which TACHIBANA (1952) collected from the lower part of the Karaumédaté formation are as yet neither described nor illustrated.

In conclusion the age of the Fukuji trilobite beds are in a range from Gedinnian to Emsian or lower Eifelian and those of the *paucispinosa* and *minima* horizons of the Ōno Series are Eifelian or upper Eifelian, and Givetian respectively (see Table 2).

III. Devonian Trilobites of Eastern Asia

a. The Mongolian geosyncline

From the viewpoint of the high altitude geotectonics of Asia it can be said that the Mongolian geosyncline s. l. is a megageosyncline between the Angara megakraton and the Koreo-Chinese heterogen (KOBAYASHI, 1953). Biogeographically it is a grand highway of equatorial migration for halobios in the middle Palaeozoic Era. In the west it was combined with the Sayan-Altai geosyncline, while in the east it extends as far as the Okhotsk sea. Hence the name Mongolian-Okhotsk geosyncline as commonly so-called by Soviet geologists.

The Manmo Group was proposed for the collective term of sediments accumulated in this geosyncline (KOBAYASHI and NONAKA, 1942). The oldest fossiliferous beds in the eastern part of the geosyncline yield Lower Cambrian *Redlichia* and archeocyathids in Transbaikalia, Ordovician graptolites, trilobites and brachiopods in the Great Khingan range, Silurian shelly faunule in the East Manchurian mountainous land but the oldest fossils are Lower Devonian in the north Manchurian plateau. The group is tentatively divided into three parts, namely, the Sinian-Silurian Infra-Manmo Subgroup, Silurian-Carboniferous lower Manmo Subgroup and the Permian-Middle Triassic upper Manmo Subgroup, all of which are intensely folded and faulted by the Triassic Akiyoshi and older orogenies (KOBAYASHI, 1971).

The sea flooded there extensively in the Silurian Period. Trilobites, mostly Wenlockian, are known from Western Mongolia, the Upper Amur valley and the East Manchurian mountainous land. The Devonian trilobites are also reported from several localites as summarized below.

1. *Mongolia*

In 1937 TSCHERNYSHEVA has described the following trilobites from the Lower Devonian of the Khangai highland (1) and the south slope of the Bairim range (2) in Mongolia.

Phacops sp.	(1, 2)
Dalmanites aff. *multiannulatus* CHERNYCHEV	(2)
Dalmanites sp. no. 1.	(2)

Dalmanites sp. no. 2.	(2)
Dalmanites sp. no. 3.	(2)

Recently MAXIMOVA (1974) added three species of early Middle Devonian trilobites from the Mongolian Altais as follows:

Radiolichas (?) *asiaticus* MAXIMOVA
Paciphacops (*Viaphacops*) *mongolicus* MAXIMOVA
Dechenellurus sp.

2. *The Amur region*

According to MODZALEVSKAYA (1967) trilobites occur successively in the Lower and Middle Devonian formations in the Upper and Middle Amur region including Verkneye Priamurye (VP), Zeisky region (Z) and Urmisky region (U) as follows:

(1) Gedinnian-Helderbergian, lower part of Bolsheneverskaya suite in VP.

Paciphacops (*Paciphacops*) *logani asiaticus* (MAXIMOVA) (VP)
Calymene sp. (Z)
Proetus (*Crassiproetus*) sp.
Dechenellurus cf. *granifer* MAXIMOVA

(2) Coblenzian-Ulsterian, upper part of Bolsheneverskaya suite.

Paciphacops (*Paciphacops*) *mushensis* (MAXIMOVA)
Paciphacops (*Viaphacops*) aff. *cristata* (HALL)
Dalmanites urkanensis (MAXIMOVA) (VP)
Anchiopella extrema MAXIMOVA
Odontochile (*Kasachstania*) aff. *ulrichi* (DELO) (VP)

(3) Eifelian (Onondaga) limestone, Jmatchinskaya suite.

Paciphacops (*Viaphacops*) *pipa* (HALL and CLARKE)
Reedops aff. *cephalotes* HAWLE et CORDA
Odontochile (*Reussia*) *kailensis* MAXIMOVA (Z)
Calymene sp.

(4) Givetian (or Hamilton) Oldoiskaya suite in VP.

Acanthopyge aff. *haueri* BARRANDE
Phacops guranensis MAXIMOVA
Phacops rana subsp. *milleri* STEWART
Dechenella (?) *bejensis* MAXIMOVA

3. *North and Central Manchuria, Northeast China*

In the Lesser Khingan range the Coblenzian-Eifelian Houlungmen formation is very fossiliferous. Recently the junior author (1971) described 30 species of brachiopods in 29 genera which were considered Siegenian-Emsian, and possibly early Emsian age. Fossil collections made by KONDO, YAMAMOTO and NONAKA from the formation near Houlungmen contain various fossils, beside these brachiopods, including a phacopid and a dalmanitid which are described here with the names mentioned below.

Phacops (subgen. nov. ?) *manchuricus* KOBAYASHI and HAMADA, sp. nov.
Odontochile sp. indet.

While the former resembles *Paciphacops* (*Viaphacops*) *altaicus* (TCHERNYSHEV) as well as *Phacops subcristata* KHALFIN, the latter is allied to *Probolium altaicum* (KHALFIN).

The below mentioned trilobites were reported from North and Central Manchuria, but they are neither described nor illustrated.

A trilobite resembling *Basilicus* cf. *nobilis* BARRANDE (?) is reported from the Nichiuho formation which overlies slightly metamorphosed Silurian-Ordovician formations unconformably and considered Gedinnian-Ludlovian in age (WANG and YÜ, 1964).

Phacops breviceps BARRANDE was collected in the Great Khingan range from the Lukou formation which extends from Lower Devonian to Silurian and overlies the Ordovician Suhuho Group unconformably (WANG and YÜ, 1964).

Proetus-like trilobite is reported to occur in the Middle Devonian Heitai formation in East Manchuria where it overlies Pre-Cambrian (?) gneiss. Many species of corals, bryozoans, brachiopods and a blastoid were described from the formation near Heitai by YABE (1940), YABE and SUGIYAMA (1942), MU (1955), YANG (1956), HOU (1959), and others. These authors disagree with one another in the age of the fauna, their opinions deviating from early Devonian to Frasnian, but the age is probably middle Devonian.

4. *Primoria, U. S. S. R.*

To the east beyond the national border the following calymenids were recently discovered in terrigenous strata of the Grodekovsk region, West Primoria.

Fossil list 2. Devonian trilobites of the Mongolian geosyncline.

Area Trilobites	Mongolia	Upper Amur	Lesser Khingan	Primoria
Acanthopyge aff. *hammeri* BARRANDE		×		
Radiolichas ? *asiaticus* MAXIMOVA	B			
Phacops guranensis MAXIMOVA		×		
Phacops milleri STEWART		×		
Phacops (subgen. nov. ?) *manchuricus* KOBAYASHI & HAMADA			×	
Phacops sp.	A			
Reedops aff. *cephalotes* HAWLE et CORDA		×		
Paciphacops (*Paciphacops*) *logani asiaticus* MAXIMOVA		×		
Paciphacops (*Paciphacops*) *mushensis* (MAXIMOVA)		×		
Paciphacops (*Viaphacops*) *mongolensis* MAXIMOVA	B			
Paciphacops (*Viaphacops*) *pipa* (HALL & CLARKE)		×		
Paciphacops (*Viaphacops*) aff. *cristata* (HALL)		×		
Dalmanites aff. *multiannulatus* OHERN	A			
Dalmanites urkanensis MAXIMOVA		×		
Dalmanites spp. nos. 1-3	A			

Anchiopella extrema MAXIMOVA		×		
Odontochile aff. *ulrichi* (DELOV)		×		
Odontochile (*Reussia*) *kailensis* MAXIMOVA		×		
Odontochile sp. indet.			×	
Calymene aff. *blumenbachi* BRONGNIART				×
Calymene 2 spp.				×
Proetus (*Crassiproetus*) sp.		×		
Dechenella ? *bejensis* MAXIMOVA		×		
Dechenellurus cf. *granifer* MAXIMOVA		×		
Dechenellurus sp.	B			

TSCHERNYSHEVA (1937), West Mongolia (A)
MAXIMOVA (1974), Mongolian Altai (B)
MAXIMOVA (1969) in MODZALEVSKAYA, Amur
KOBAYASHI and HAMADA (1976, this paper), Lesser Khingan
MAXIMOVA and ORGANOVA (1959), Primoria

Calymene ex gr. *blumenbachi* BRONGNIART (pygidium)
Calymene sp. (cepahlon and thorax)

The latter resembles *Calymene platys* HALL and CLARKE from the lower Middle Devonian of North America, while the former is closely allied to *Calymene macrocephala* MAXIMOVA from the Lower Devonian of Northeast Pribalkhash, Kazakhstan. Their age is considered to be Lower Devonian by MAXIMOVA and ORGANOVA (1959).

As shown in Fossil list 2, 28 species of trilobites including specifically indeterminable forms which were described from the zone of the Mongolian geosyncline are distributed in 12 genera and 7 families, viz. the Odontopleuridae, Lichidae, Phacopidae, Dalmanitidae, Calymenidae, Proetidae and the Dechenellidae. They are contained in Lower and Middle Devonian rocks, more widely in the Lower Devonian than the Middle Devonian ones and so in the Eifleian than the Givetian stage. Four fossil beds are distinguished in the Upper and Middle Amur region. These trilobite horizons of the Mongolian geosynclinal zone are tentatively correlated and shown in table 3.

Table 3. Correlation of the Devonian trilobite horizons in the Mongolian geosyncline.

Devonian		West Mongolia	Upper and Middle Amur		Lesser Khingan	Primoria
Upper						
Middle	Givetian	Mongolian Altai	Oldoiskaya suite			
	Eifelian		Jmatchinskaya suite			
Lower	Coblenzian	Bairim Range	Upper part	Bolsheneverskaya suite	Houlungmen	Grodakovsk
	Siegenian-Gedinnian		Lower part			

Acanthopyge, *Phacops*, *Dalmanites*, *Odontochile* and *Calymene* are almost cosmopolitan genera and *Reedops* is known from three northern continents. *Dechenella* is unkown from Australasia except for *Dechenella* (*Eudechenella*) *mackayi* ALLAN whose generic reference is a question.

Radiolichas is a rare Middle Devonian genus in Germany. *Anchiopella* (or *Anchiopsis*) and *Crassiproetus* are on the other hand two North American genera occurring in the Mongolian geosynclinal zone. In 1960 MAXIMOVA instituted *Dechenellurus* on *Dechenellurus ursus* MAXIMOVA to include some species in Kazakhstan, Far East of the U.S.S.R. and North America. *Paciphacops* is another genus she proposed with *Phacops logani* HALL as its type-species (1972). These trilobite genera indicate the faunal connection from Kazakhstan to North America through the Mongolian geosyncline.

It is certain that the Mongolian geosyncline was an important route of migration in the northern hemisphere. When the whole fauna of the geosyncline is clarified, however, the faunal composition will be found to be very complicated. The junior author has already found among the Houlungmen brachiopods various elements, namely, *Bifida* and some other genera reveal affinities to the Rhenish-Bohemian faunas and further to the Cordilleran faunas, *Chonostrophiella* and *Dalejina* which are Appalachian and Appalachian-Bohemian genera respectively and *Wilsoniella* and *Reeftonia* which are Uralian (Altai) and Tasman-New Zealand genera respectively (1971a).

Finally, it is noted that the *Clymenia* limestone marks off the top of the Devonian sequence in the northern part of the Great Khingan range (CHANG, An-chi, 1958, 1960), although no Upper Devonian trilobite is as yet known in the Mongolian geosynclinal zone.

b. The Chungchao massif

The so-called Chungchao massif by HUANG extends from North China to Korea and South Manchuria. Older sedimants were accumulated on the massif in the areas which the senior author collectively called "Hwangho basin". These sedimentary areas were different in outline and the thickness of contemporaneous sediments greatly varied among the areas, because the Chungchao massif is a heterogen or a heterogeneous aggregate of kratonic, and quasikratonic blocks and minor geosynclines.

Two geosynclines were wedged into Korea from the east side. The Sinian and Cambro-Ordovician sediments accumulated in the P'yeongnam geosyncline in North Korea and the Liaotung peninsula of South Manchuria attained more than 10 kilometers in thickness. The thickness of the Cambro-Ordovician formation there was about 1,000 to 1,300 m. In the Okch'eon geosyncline in South Korea the Cambro-Ordovician formation which overlies metamorphic rocks of the Pre-Cambrian basement is 1,500 to 2,000 m on an average thickness. In other words it is much thicker in the Okch'eon geosyncline than in the P'yeongnam geosyncline. It is a general tendency for the thickness of the Cambro-Ordovician formation to decrease westerly into the Shansi and Shensi basins from the P'yeongnam-Liaotung geosyncline.

The Hwangho basin was emergent in the middle Palaeozoic times from Ashgillian to early Carboniferous except for these two minor geosynclines. The Silurian sea has ingressed into part of the P'yeongnam geosyncline as indicated by Silurian corals contained in boulders of the older Mesozoic Kyeomip'o limestone conglomerate (KOBAYASHI and HAMADA, 1974).

A few Devonian corals were reported from two localities in the two geosynclines as follows:

i. Imoktong, Cheongseong-ni, Sinchang-myeon, Suncheon-kun, P'yeongan-namdo, North Korea; P'yeongnam geosyncline (YABE and SUGIYAMA, 1939).
ii. Kosuri, Kumko-myeon, Tangyang-kun, Chungch'eong-bukto, South Korea; Okch'eon geosyncline (YABE and SUZUKI, 1940).

According to KATO (1972), however, their identification is erroneous. More precisely, their *Phillipsastrea* sp. and *Disphyllum* (*Phacelophyllum*) sp. are respectively *Arachnastraea kaipingensis* (GRABAU) and *Diphyphyllum* sp. which indicate the middle Carboniferous age for the Devonian Cheongseong-ni Series which was proposed for these fossil beds. Be KATO's opinion acceptable, the series is nothing but part of the Hongjeom (or Koten) Series in the Moscovian—early Triassic P'yeongan Group.

On the other hand several Devonian brachiopods were reported by PAK to occur in the Kyeomip'o limestone conglomerate near Kyeomip'o, Hwanghae-do, North Korea together with Silurian and older fossiliferous boulders as derived fossils (KATO, 1972). Although the authors have no access to PAK's report, his find suggests that sea ingressed into a certain limited area in North Korea in the middle ? Devonian age. No Devonian trilobite is, however, as yet found from Korea.

c. Northwest China

The Devonian System is widely distributed in the Chinese Altai, Eastern Tienshan, West Kuenlun and Kilien-shan as ascertained by various brachiopods, corals and other fossils including land plants in the upper part. Devonian trilobites appear very scarce, although Upper Devonian *Proetus* is reported from the western part of the Tsaidam basin (WANG and YÜ, 1964).

d. Central and South China and North Viet-Nam

The Yangtze basin became emergent extensively near the end of the Silurian Period when the so-called Kwangsi disturbance by TING has taken place in Kwangsi

Table 4. Division of the Devonian System in China and its correlation to the European sequence.

WANG and YÜ (1964)			WANG, YÜ and WU (1974)	European Sequence		
Series	Stage		Stage	Bohemia		West Europe
Upper	Hsikuangshan		Hsikuangshan	Famennian		
	Yütienchiao		Yütienchiao	Frasnian		
Middle	Tungkangling		Tungkangling	Givetian		
	Yüchiang	Tiaomachien	Peiliu	Eifelian		Couvinian
		Yüchiang	Yüchiang	Zlichovian	Coblenzian	Emsian
Lower	Szupai		Nakaoling	Praguian		Siegenian
	Lunghuashan		Lienhuashan	Lochkovian		Gedinnian

and adjacent Kwantung. There the base of the Devonian formation is marked off by a strong unconformity. A contemporaneous movement occurred in the Tsinlingshan where the Devonian sequence begins with a tremendously thick clastic sediments.

Lower Devonian formations are known to exist only in East Yunnan, West Szechuan, Kwangsi and North Kwangtung. Sea, however, flooded again extensively in the Yangtze basin in the middle and late Devonian epochs. Embracing this basin from the east side, Fukienia protruded from the Chungchao massif as a peninsula between the Yangtze basin and the Chichibu geosyncline and extended largely to the southeast side of the lower Yangtze in Table 4.

The Devonian stratigraphy of China once schematized by WANG and YÜ in 1964 was recently revised and correlated to European classical sequence by WANG, YÜ and WU (1974) as shown in Table 4.

This classification is made in China chiefly on the basis of brachiopods and corals. The boundary between the lower and middle divisions is drawn there between the Siegenian and Emsian, instead of the Coblenzian and Eifelian stages.

Trilobites are neither common nor very varied and only ten species or so have so far been known from Central and South China. YIN (1938) described an occurrence of *Calymene maloungkaensis* MANSUY and *Proetus indosinensis* MANSUY in the Pochiao shale of East Yunnan. The former was later transferred to *Gravicalymene* by LU et al. (1965). The latter was reported also from the Eifelian of Kwangsi. Two of them were known to be Eifelian trilobites of Szechuan (WANG and YÜ, 1964).

Recently four species of trilobites were added to the Kwangsi fauna by CHANG (1974) as follows:

Gravicalymene maloungkaensis (MANSUY) from the lower part of the upper Yüchiangian Tingting formation at Luofu, Nantan.

Dechenella (?) *liujingensis* CHANG from the upper Yüchiang formation at Liouching, Heng-hsien.

Phacops guangxiensis CHANG and *Phacops luofuensis* CHANG from the Peiliuan Tanghsiang formation at Luofu, Nantan.

Prior to this *Dechenella* aff. *macrocephala* (HALL) was reported to occur in the Middle Devonian at Kaiyuan (Tche-T'souen, environs d'Ami-cheou in PATTE, 1929) in Yunnan. This form was later referred to *Monodechenella* of *Dechenella* by LU et al. (1965), because *Proetus macrocephalus* HALL is the type-species of *Monodechenella*.

In 1937 SUN described *Cyphaspis tiaomachienensis* nov. from the Middle Devonian Tiaomachien formation and *Proetus chengi* nov. from the upper Hsikuangshan formation, both in Hunan. The former was later transferred to *Otarion* by LU (1957) and its age was considered late Eifelian by TIEN (1957). The latter was placed in *Dechenella* with querry by LU and others (1965). It is noted further that the latter has been procured probably from the Frasnian Yütienchiao formation, instead of the Famennian Hsikuangshan formation s. str. *Phacops granulatus* MÜNSTER was reported from the Hsikuangshan formation (WANG and YÜ, 1964).

CHANG (1955) described *Typhoproetus sinensis* nov. from the Upper Devonian at Lingchan, Kwangsi. In North Kuantung *Dechenella* cf. *kuhuaensis* YOH was reported to occur in the late Upper Devonian Maotzuling shale in the upper part of the Kuhua limestone formation (Stratigraphic Tables of China, Suppl., 1958), although the authors could not see yet YOH's descriprion of *D. kuhuaensis.*

Finally, *Proetus* (*Euproetus*) *mediospinus* REED (1929) occurs in Eifelian limestone at Chinchangkai, northeast Tali, Central Yunnan.

In the Indochinese peninsula the Lower Devonian seems to be represented mostly by the Old Red Sandstone facies, although marine sediments are continuous from Silurian to Devonian near Vinh. The Emsian and higher Devonian rocks are fossiliferous. The Emsian and Couvinian ones are especially rich in corals, brachiopods and other fossils including trilobites.

In North Viet-Nam *Proetus namanensis* MANSUY, 1916, was described from the Emsian shales of Na-man and Kim-lu in the Thak-khe sheet area, Tonkin. Beside some indeterminable trilobites Eifelian ones are as follows:

Lichas aff. *decheni* HOLZAPFEL (PATTE, 1926)
Calymene maloungkaensis MANSUY, 1916 ....*Gravicalymene*
Proetus indosinensis MANSUY, 1916 ....*Dechenella*
Proetus blondeli PATTE, 1929..............................*Dechenella* ?
Proetus (?) sp. (MANSUY, 1918) ....*Proetus* (*Proetus*) *vietnamensis* KOBAYASHI and HAMADA, 1974
Cyphaspis giraudi MANSUY, 1918 ....*Otarion*

These trilobites are widely distributed in Tonkin and (?) *Proetus indosinensis* was reported to occur in Schistes à *Spirifer speciousus* de Tho-phuong, near Thanh-hoa, Annam.

Recently four phacopids were added to the Eifelian fauna of North Viet-Nam by MAXIMOVA (1965) from Provinces Son-La (a) and Bankan (b) as follows:

Plagiolaria (?) *orientalis* MAXIMOVA (b)
Denckmannites vietnamicus MAXIMOVA (a)
Denckmannites sp. (b)
Ductina vietnamensis MAXIMOVA (b)

The authors' comments are given on certain species from China and Viet-Nam in the palaeontological description.

Fossil list 3. Devonian trilobites of Central and South China and North Viet-Nam.

Area and Age Trilobites	China	Viet-Nam	L. Dev.	M. Dev.	U. Dev.
Lichas aff. *declieni* HOLZAPEL		×		×	
Phacops guangxiensis CHANG	×			×	
Phacops luofuensts CHANG	×			×	
Phacops transversalis YI and HSIANG	×			×	
Plagiolaria nandanensis CHANG	×			×	
Plagiolaria ? *orientalis* MAXIMOVA		×		×	
Denckmannites vietnamicus MAXIMOVA		×		×	
Denckmannites sp. by MAXIMOVA		×		×	
Ductina vietnamensis MAXIMOVA		×		×	
Gravicalymene maloungkaensis (MANSUY)	×	×		×	

Proetus mediospinus REED	×			×	
Proetus namanensis MANSUY		×	×		
Proetus vietnamensis KOBAYASHI and HAMADA		×	×		
Dechenella indosinensis (MANSUY)		×	×		
Dechenella ? liujingensis CHANG	×				
Dechenella ? chengi (SUN)	×				×
Basidechenella ? blondeli (PATTE)		×			
Monodechenella aff. *macrocephala* (HALL)		×		×	
Typhoproetus sinensis CHANG	×				×
Otarion giraudi (MANSUY)		×			
Otarion tiaomachienensis (SUN)	×				
Cyphaspides orientalis YI and HSIANG	×			×	
Cyphaspides paradoxus YI and HSIANG	×			×	

Of the age of *Calymene maloungkaensis* in Viet-Nam the limestone-shale beds containing this trilobite together with *Spirifer speciosus* were placed by MANSUY and other French geologists in the Eifelian stage in the sense inclusive of the *cultrijugatus* beds or Couvinian (GIGNOUX, 1955). The *cultrijugatus*-Schichten have, however, been referred in part to the Coblenzian (KAYSER, 1923) and still located at the transition between the Emsian and Eifelian stages or in the former stage (BRINKMANN, 1960, GRABERT, 1967). The Eifelian age of *Gravicalymene maloungkaensis* was previously accepted also in China, but recently it is taken for a member of Yüchiangian fauna whose age is Emsian-Zlichovian or pre-Eifelian (WANG, YÜ and WU, 1974). Now the authors contends to be relevant that the age of the *maloungkaensis* horizon is approximate to the *cultrijugatus*-Schichten in Europe and within the range from upper Emsian to lower Eifelian.

As shown in Fossil list 3, some twenty species of Devonian trilobites known from Central and South China and North Viet-Nam belong to twelve genera in six families, namely the Lichidae, Phacopidae, Calymenidae, Proetidae, Dechenellidae and Otarionidae, most species of which are Emsian-Eifelian in age.

The occurrence of *Ductina* at Ban-kan is noteworthy as it is an Upper Devonian genus of Europe. Two Viet-Nam species of *Denckmannites* would be links of Australian forms with the Europe-Mediterranean ones of the same genus. Combined with *Plagiolaria poothaii* of the Thai-Malay peninsula *Plagiolaria ? orientalis* probably indicates the Oriental Tentaculiten-fazies of the Coblenzian-Eifelian age.

Gravicalymene maloungkaensis is an exception in distribution so wide from Viet-Nam to South and Central China on one side and possibly to the Shan States, Burma on the other. The *maloungkaensis* horizon is within the time limits of the Fukuji fauna and probably penecontemporaneous with the *Gravicalymene* bed of Sorayama, although their faunal assemblages are not quite similar to each other.

e. The Burmese-Malayan geosyncline

In Southeast Asia there was the Burmese-Malayan geosyncline in the Palaeozoic Era (KOBAYASHI, 1973, HAMADA et al., 1975). It was extended from the Shan plateau, Burma and West Yunnan to the Thai-Malay peninsula and further into Borneo. In Burma the Silurian-Devonian boundary is very gradual. The age of the Zebingyi stage in East Burma has long been a moot question, because it contains Silurian graptolites as well as Devonian shelly fossils. Recently Lower Devonian graptolites were found in the geosynclinal sediments in Burma, Thailand and Malaya. Devonian trilobites are known as far as Perak in Malaysia to the south.

1. *Burma*

In the Shan States the Zebingyi Series has long been referred to the Silurian System notwithstanding the fact that the Hercynian elements were contained in the Zebingyi fauna. The series yields four species of trilobites as follows:

Dalmanites (*Odontochile* ?) *swinhoei* REED at Zebingyi
Phacops shanensis REED at Kyinganaing
in the Northern Shan States, and
Phacops ponensis REED
Phacops cf. *sternbergi* BARRANDE
in the trilobite bed near Pon in the Southern Shan States.

REED noted that *D.* (*O.*) *swinhoei* is intimately related to *Phacops sternbergi* from the Lower Devonian of Bohemia. So is *P. shanensis* and *P. ponensis* to *P. latifrons* and *P. fecundus* from the Lower Devonian or early Middle Devonian.

D. swinhoei was found associated with *Monograptus dubius*, the typical Wenlock species but ranging up to lower Ludlow. Therefore its age was a question, but the three others are, as pointed out already (KOBAYASHI and HAMADA, 1971), have no objection against their Devonian age.

According to BERRY and BOUCOT (1972), "*Monograptus dubius*" and "*M.* cf. *riccartonensis*" from Pyintha, Northern Shan States belong to the *M. hercynicus* group; *Monograptus dubius* from Twinnge, Northern Shan States is probably a new species most similar to Emsian *Monograptus atopus*. Therefore it is warranted that part of the Zebingyi beds is Lower Devonian.

The Padaukpin limestone in the Lower Plateau Limestone in the Northern Shan States contains

Phacops latifrons (BRONN var.)
Phacops (*Dalmanites*) cf. *stellifer* BURM.
Phacops (*Dalmanites*) *punctatus* STEIN.

They were considered by REED (1908) to be Eifelian in age. This chronological conclusion was further confirmed by ANDERSON et al. (1969) in their study on brachiopods.

The Wetwin shale intercalated in the lower part of the Plateau Limestone yields *Phaetonides* aff. *cyclurus* HALL which species was described primarily from the lower Helderberg Group but the Wetwin fauna is considered close to the Hamilton fauna of North America.

It is noteworthy that *Calymene* cf. *maloungkaensis* MANSUY was reported to occur in the Lawksawk State (SAHNI in HERON, 1936) since it reveals affinities of the Burmese fauna to those of North Viet-Nam and South China.

Recently U Thaw TINT and U Ula WAI (1970) described Siegenian (?) trilobites from the lower unit of the Lower Plateau Limestone exposed about one and a half miles north-northwest of the Taungtaloen Peak (4,064 feet) east of Medaw, Maymyo district as follows:

Scutellum (*Scutellum*), n. sp.
Phacops giganteus, n. sp.
Phacops taungtalonensis, n. sp.
Phacops thahlai, n. sp.
Phacops minutus, n. sp.

According to them the trilobite beds belong to the Hercynian facies higher than the Zebingyi beds and their equivalents containing *Phacops shanensis* REED and *Phacops* (*Dalmanites*) *swinhoei* REED in the Northern Shan States and *Phacops ponensis* REED and *Phacops* cf. *sternbergi* BARRANDE in the Southern Shan State. The Eifelian Padaukpin coralline beds containing *Phacops latifrons* lie well far above the Taungtalone *Phacops-Scutellum* faunal zone.

2. *The Thai-Malay peninsula*

In Thailand the existence of the Devonian rocks was first proved with *Plagiolaria poothaii* KOBAYASHI and HAMADA, 1969 and its varietal form which were procured in the *Tentaculites* facies between Trang and Phatthalung in the peninsular part. Their age was considered Emsio-Couvinian.

Crossing the national border a very unique fauna of a similar age was discovered in Malaya at Kroh in upper Perak which included the following trilobites:

Pseudotrinodus enigma KOBAYASHI and HAMADA, 1971
Agnostoid, gen. et 2 spp. indet.
Plagiolaria poothaii KOBAYASHI and HAMADA, 1969
Blanodalmanites nubelania KOBAYASHI and HAMADA, 1971
Blanodalmanites kokeshiformis KOBAYASHI and HAMADA, 1971
Perakaspis trapezoidalis KOBAYASHI and HAMADA, 1971
Perakaspis (*Krohbole*) *elongata* KOBAYASHI and HAMADA, 1971
Perakaspis (*Krohbole* ?) *burtoni* KOBAYASHI and HAMADA, 1971
Perakaspis (?) sp. indet.
Proetoid, gen. et sp. indet.
Bailielloides inexpectans KOBAYASHI and HAMADA, 1971
Harpes (s. l.) *kylindrorhachis* KOBAYASHI and HAMADA, 1971

Because visual organs are degenerated in the Kroh trilobites and they suffered little from postmortem destrution, their habitat would have been a deep and dark quiet shelter. Because the Kroh brachiopods are dwarfed, stagnant water on muddy bottom was unfavourable for the benthic life.

Pseudotrinodus is possibly an isolated relic genus of the Agnostida.

Another locality of *Pseudotrinodus* is in the Kanchanaburi district, West Thailand where *P. constricutus*, nov. described in this monograph was found together with a small proetoid free cheek and other fossils.

Finally, the Langgon red beds in Northwest Malaya yield *Langgonbole vulgaris* KOBAYASHI and HAMADA, 1973 at Pulau Langgon, Langkawi Islands, *Waribole perlisensis* KOBAYASHI and HAMADA, 1966, in Perlis and *Macrobole kedahensis* KOBAYASHI and HAMADA, 1973 and *Diacoryphe* ? sp. in Kedah. The first species is probably early Famennian or older, the second late Femennian and the last two early Tournaisian.

Fossil list 4. Devonian trilobites of the Burmese-Malayan geosyncline.

Trilobites \ Area	Burma	Thailand	Malaya
Pseudotrinodus enigma Kobayashi and Hamada			K
Pseudotrinodus constrictus Kobayashi and Hamada		×	
Agnostoid 2 spp.			K
Scutellum (*Scutellum*) sp. by Tint and Wai	T		
Phacops latifrons (Bronn) var.	P		
Phacops shanensis Reed	Z		
Phacops ponensis Reed	Z		
Phacops cf. *sternbergi* Barrande	Z		
Phacops giganteus Tint and Wai	T		
Phacops taungtalonensis Tint and Wai	T		
Phacops thahlai Tint and Wai	T		
Phacops minutus Tint and Wai	T		
Plagiolaria poothaii Kobayashi and Hamada		×	K
Plagiolaria poothaii Kobayashi and Hamada var.		×	
Dalmanites punctatus Stein.	P		
Dalmanites cf. *stellifer* Burm.	P		
Odontochile ? *swinhoei* Reed	Z		
Blanodalmanites nubelania Kobayashi and Hamada			K
Blanodalmanites kokeshiformis Kobayashi and Hamada			K
Gravicalymene maloungkaensis (Mansuy)	(T)		
Perakaspis trapezoidalis Kobayashi and Hamada			K
Perakaspis (*Krohbole*) *elongata* Kobayashi and Hamada			K
Perakaspis (*Krohbole* ?) *burtoni* Kobayashi and Hamada			K
Perakaspis ? sp. indet.			K
Proetoid, gen. et sp. indet.		×	K
Prionopeltis aff. *cyclurus* (Hall)	W		
Bailielloides inexpectans Kobayashi and Hamada			K
Langgonbole vulgaris Kobayashi and Hamada			L
Waribole perlisensis Kobayashi and Hamada			L
Harpes (s. l.) *kylindrorhachis* Kobayashi and Hamada			K

P : Padaukpin, Z : Zebingyi, T : Taungtalone,
W : Wetwin, K : Kroh, L : Langgon red beds

In summarizing the above statements it is found that the Devonian trilobites of the Burmese-Malayan geosyncline total 30 species and 14 or more genera in 8 families, namely the Pseudotrinodidae, Scutelluidae, Phacopidae, Dalmanitidae, Calymenidae, Proetidae, Dechenellidae and Harpidae. *Plagiolaria* and *Gravicalymene maloungkaensis* are two key trilobites showing the faunal connection with trilobite faunas of North Viet-Nam. The Kroh fauna comprising so many new genera is quite aberrant.

f. The Devonian trilobites of Eastern Asia

As shown below the Devonian trilobites so far known from Eastern Asia total 100 species including specifically indeterminable ones. They are distributed in 39 genera and 12 families.

Taxa rank Area		Species	Genera	Families
Mongolian geosyncline	(1)	28	11	7
Yangtze basin	(2)	20	12	6
Chichibu geosyncline	(3)	21	15	9
Burmese—Malayan geosyncline	(4)	31	14	8

Area Taxa	(1)	(2)	(3)	(4)
Pseudotrinodidae				1
Scutelluidae			3	1
Odontopleuridae	1		1	
Lichidae	1	1	1	
Cheiruridae			1	
Phacopidae	2	4	2	2
Dalmanitidae	3			3
Calymenidae	1	1	1	1
Proetidae	1	1	1	2
Dechenellidae	2	4	1	3
Otarionidae		1	1	
Harpidae				1

* Number without brackets means a number of genera in each family.

The geographical distribution of these genera in East Asia is shown in Fossil list 9 on page 42 *et seq.*

1. Nearly cosmopolitan genera: *Scutellum, Ceratocephala, Lichas,* s.l., *Acanthopyge, Phacops, Dalmanites, Odontochile, Calymene, Proetus,* s.l., *Otarion, Harpes,* s.l.
2. Northern hemisphaeric genera: *Reedops, Dechenella, Basidechenella.*
3. Eurasiatic genera and subgenera (North Africa inclusive): *Crotalocephalina* (*Crotalocephalides*), *Plagiolaria, Ductina, Thysanopeltella* (*Septimopeltis*), *Radiolichas, Proetus* (*Coniproetus*), *Unguliproetus, Prionopeltis, Typhoproetus, Waribole.*
4. Asian-North American genera and subgenera: *Paciphacops* (*Paciphacops, Viaphacops*), *Anchiopella, Crassiproetus, Dechenellurus, Monodechenella.*
5. Eurasian-Australian genera and subgenera: *Crotalocephalina* (*Crotalocephalina, Pilletopeltis, Geracephalina*), *Denckmannites, Gravicalymene.*
6. Western Pacific genera: *Craspedarges.*
7. Endemic genus to Japan: *Hidascutellum.*
8. Endemic genera and subgenera to the Thai-Malay peninsula: *Pseudotrinodus, Blanodalmanites, Perakaspis* (*Perakaspis, Krohbole*), *Bailielloides, Langgonbole.*

More than a half of the above genera are distributed world-wide or extensively in the northern continents. Among the remaining genera about a third of them are Eurasiatic genera. Another one-third of them are endemic and most of such genera belong to the aberrant Kroh fauna (8). Still another one-third of genera show affinities either to the North American fauna (5) or to the Australian fauna (6). The genera of the former category are known all from the Mongolian geosyncline except for *Monodechenella*. Those of the latter category occur in Eastern Asia in the Oriental regions including the Yangtze basin, Chichibu and Burmese-Malayan geosynclines.

From the Devonian palaeogeographic point of view Eastern Asia can be divided into the Mongolian and Oriental subprovinces and the latter subdivided into these three regions.

The trilobites of the Mongolian subprovince are characteristized by the inclusion of genera showing affinities to eastern North American faunas.

The Oriental subprovince reveals closer faunal relationship toward Australasia than North America, although *Monodechenella* is a North American genus. The generic composition is fairly different among the three Oriental regions, but *Gravicalymene* occurs in Japan, South China, North Viet-Nam and probably in Eastern Burma. The Kroh fauna of the Thai-Malay peninsula is very unusual and quite distinct from the Burmese fauna, but *Plagiolaria* is a linking genus between the Kroh fauna and the Eifelian fauna of Son-La and Ban-kan, North Viet-Nam, both in the so-called *Tentaculites* facies.

Gravicalymene was a leading genus not only of the oriental faunas but also of the faunas of New Zealand and the Tasman geosyncline. *Craspedarges* is an endemic genus to the Western Pacific province.

g. Correlation of the Devonian trilobite horizons in Eastern Asia

In the Devonian Period there were in Eastern Asia the Mongolian geosyncline, Chungchao massif, Yangtze basin, Chichibu geosyncline and the Burmese-Malayan geosyncline. The Mongolian geosyncline extending latitudinally was separated from the Yangtze basin by the Chungchao massif, but the geosyncline was probably contact with the Chichibu geosyncline between Primoria and the Hida plateau.

The Chungchao massif was widely emergent in the Middle Palaeozoic Era except for North Korea where it is certain that sea ingressed during the Silurian Period. It is, however, yet uncertain whether or not a Devonian ingression has there taken place. At any rate neither Silurian nor Devonian trilobite has so far been reported from Korea.

In the Devonian Period the Fukien peninsula wedged in between the Yangtze basin and the Chichibu geosyncline from South Korea. The basin, however, largely opened its mouth in the southwest toward Viet-Nam as well as Burma. The Chichibu geosyncline was on the other hand bifurcated westerly and its branch on the continental side ran into North Viet-Nam, while another branch on the oceanic side was connected with the Burmese-Malayan geosyncline through Borneo. although no fossil older than Permian is as yet known from Taiwan and the Philippines. It is presumed that the Indosinian massif was intercalated between these two branches.

In the Mongolian geosyncline the best Devonian sequence is found in the upper and middle Amur region where the Lower and Middle Devonian strata are classified into four suites, all yielding trilobites. The Houlungmen trilobites of the Lesser Khingan range are about the same age with the upper Solsheneversk fauna.

The Fukuji trilobites are within a range from Gedinnian to Eifelian and the younger part of this fauna is nearly coeval with the Yüchiang fauna of China. The age of the Ōno trilobites are all Middle Devonian. *Gravicalymene yamakoshii* is intimately related to *G. maloungkaensis* widely distributed in South China, North Viet-Nam and probably in East Burma, although they are two distinct species. The *Thysanopeltella* (*Septimopeltis*) *paucispinosa* and *Dechenella minima* horizons are most probably Eifelian and Givetian respectively.

Now it is certain that the Zebingyi trilobites are mostly Devonian or Lower Devonian ones. The Padaukpin and Wetwin trilobites are Middle Devonian and the former is Eifelian in age. The Emsio-Eifelian trilobites of the Kroh fauna are wide spread in the Thai-Malay peninsula. They are quite distinct from the Burmese ones probably because of the difference of their ecological condition. *Plagiolaria* in this fauna is a phacopid genus known not only in Thailand and Malaysia but also in Kwangsi and North Viet-Nam. The Langgon red beds in Malaya yield Upper Devonian and Tournaisian trilobites.

These trilobite-bearing Devonian formations in Eastern Asia are tentatively correlated as shown in Table 5.

It can hardly be overlooked that trilobites have flourished in Eastern Asia most in the Praguian-Zlichovian or Emsian-Eifelian times. The Gedinnian, Givetian, Frasnian and Famennian ones are contained in the lower Bolsheneverskaya suite and the lower

Table 5. Correlation of the Devonian trilobite horizons in Eastern Asia.

<table>
<tr><th>Age
Area</th><th>Gedinnian</th><th>Siegenian</th><th>Emsian</th><th>Eifelian</th><th>Givetian</th><th>Frasnian</th><th>Famennian</th></tr>
<tr><td rowspan="2">Mongolian Geosyncline</td><td colspan="3">lower upper
Bolsheneverskaya</td><td>Jmatchinsk</td><td>Oldoisk</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Houlungmen</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Chichibu Geosyncline</td><td colspan="4">Fukuji</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Ōno+Nakazato</td><td></td><td></td></tr>
<tr><td rowspan="2">Central and South China</td><td></td><td></td><td colspan="2">Yüchiang</td><td></td><td>Yütienchiao</td><td></td></tr>
<tr><td></td><td></td><td colspan="2">Peilieu</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">North Viet-Nam</td><td></td><td></td><td colspan="2"><i>G. maloungkaensis</i></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td><i>P. namanensis</i></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">Burma</td><td colspan="3">Zebingyi</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>Padaukpin</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>Wetwin</td><td></td><td></td><td></td></tr>
<tr><td>Malaya</td><td></td><td></td><td colspan="2">Kroh</td><td></td><td></td><td>Langgon</td></tr>
</table>

Fukuji Series (1), the Oldoiskaya suite and the upper part of the Ōno series (2), the Yütienchiao stage (3) and the lower part of the Langgon red beds (4) respectively.

IV. Devonian Trilobites of South Asia

In South Asia the best Devonian sequence is known from Bithynia, West Turkey where Palaeozoic strata from Ordovician to Middle Carboniferous are accumulated continuously as thick as 3,000 m. The Devonian sediments about 700 m thick are divided into three formations by Haas (1967) as below.

Tuzle formation	Denizli beds	Givetian to Upper Devonian
	Gelze beds	Eifelian
Marmara formation	Dele beds	
	Kurtdoğmuş beds	Upper Emsian
	Kartal beds	
	Soğanli beds	Lower Emsian-Siegenian
Akviran formation	top part of	Gedinnian

As shown in Fossil list 5, Devonian trilobites described by Richters (1937) and Haas (1968) attain 60 species in 27 genera and 12 families, namely, the Scutelluidae, Odontopleuridae, Lichidae, Cheiruridae, Phacopidae, Dalmanitidae (Dalmanitinae, Acastavinae, Asteropyginae), Calmoniidae, Calymenidae, Homalonotidae, Proetidae, Dechenellidae, and the Otarionidae. *Cheirurus* (*Crotalocephalus*) *copius* and *Cornuproetus* (*Lepidoproetus*) *regius* from the Soğanli beds are allied to Praguian species of Bohemia and Morocco. The beds (marl with limestone nodules) belong to the mixed Hercynian-Rhenish litho- and bio-facies, in the higher part of which appear asteropygids and acastids. The Rhenish aspect becomes emphasized in the superjacent Kartal beds (sandy shale) by appearance of homalonotids and disappearance of Hercynian elements. The Kurtaoğmaş beds (calcareous graywacke and thick bedded crinoidal limestones) are of the Rhenish facies, but reveal some facies differentiation.

In the Dele beds all of the Rhenish elements disappear from the Bithynian shore. *Odontochile spinifera orientalis*, *Cheirurus* (*Crotalocephalus*) *sternbergi*, *Phacops* (*Reedops*) *sternbergi filius* and *Cornuproetus* (*Cornuproetus*) *exanthemoides filius* show that the Dele fauna is late Emsian, while *Leonaspis leucothea* from the Gebze beds is so closely allied to *L. elliptica* that it indicates Eifelian age of the beds. The Gebze beds (marl and marly limestone) and the Denizli beds (nodular limestone) contain Hercynian cephalopods.

In Afghanistan Middle and Upper Devonian marine limestone formation is underlain by non-fossiliferous sediments which are clastic beds, 2,000 m thick, lying on Ludlovian marl in Central Afghanistan and evaporites and red beds in Western Afghanistan (Durkoop et al., 1967). Similar Lower Devonian red beds are present in Eastern and Southern Iran (Ruttner et al. 1968, Huckriede et al. 1962). Only Upper Devonian sublittoral sediments are known in the Elburz range, North Iran (Gaetani, 1967).

Pillet and de Lapparent (1969) described Devonian trilobites from Central and Eastern Afghanistan as follows:

Middle Devonian: Said Habib and Bakan

Scutellum aff. *flabelliferum* (GOLDFUSS)
Dalmanitacea
Asteropyge sp.
Neocalmonia imperfects PILLET
Neocalmonia sp.

Frasnian: Badragha, Ghouk, Bokan

Scutellum costatum PUSCH
Phacops sp.
Asteropyge sp.
Neocalmonia quadricosta PILLET
Burmeisteria (*Digonus*) sp.

Famennian: Ghouk, Robat-e-Pai

Phacops accipitrinus (PHILLIPS)
Phacops accipitrinus, subsp. nov.

Neocalmonia was proposed as a new genus of the Calmoniidae by PILLET (1969) on *Neocalmonia quadricosta* nov. from the lower Frasnian at Badragha, Central Afghanistan.

Fossil list 5. Devonian trilobites of West Turkey.
(After RICHTERS, 1937 and HAAS, 1968)

Age Trilobites	Siegenian	Low. Emsian	Up. Emsian	Eifelian	Givet.-Up. Dev.
Spiniscutellum larviferum HAAS		×			
Leonaspis panoptes HAAS	×				
Leonaspis belisatius HAAS			× ×		
Leonaspis leucothea HAAS				×	
Leonaspis aff. *hoernesi* (BARR.)			×		
Lobopyge erinacea HAAS		×			
Lobopyge ? pulex HAAS			×		
Crotalocephalus copiosus HAAS	×				
Crotalocephalus sternbergi sternbergi (BOECK)			×		
Phacops (*Phacops*) *turico turico* RICHTERS					×
Phacops (*Phacops*) *turico praecedens* HAAS				×	
Phacops (*Phacops*) *pantichionensis* HAAS			×		
Phacops (*Phacops*) *proponticus* HAAS			×		
Phacops (*Phacops*) *corallinus corallinus* RICHTERS			×		
Phacops (*Phacops*) *corallinus successor* HAAS			×		
Phacops (*Phacops*) *confluens* RICHTERS				×	
Phacops (*Reedops*) *sternbergi filius* HAAS			×		
Phacops (*Reedops*) *seleniomma* HAAS			×		
Phacops (*Trimerocephalus*) *mastophthalmus* RICHTERS					×
Odontochile spinifera orientalis HAAS			×		

Pelitlina goltzi HAAS				×	×		
Centauropyge pronomacea HAAS						×	
Cryphina personata HAAS				×			
Comura (*Turcopyge*) *eduardi* RICHTERS				×			
Echinopyge cathamma HAAS				×			
Feruminops crepida HAAS					×		
Feruminops ? *declivis* (RICHTERS)				×			
Asteropyge (*Rhenops*) *hammerschmidti* RICHTERS				Up. Coblenz.			
Metacanthina anatolica HAAS			×	×			
Metacanthus asiatica (VERNEUIL)			×	×			
Metacanthus acinacifera HAAS					×		
Metacanthus incisa HAAS				×			
Metacanthus fastigata HAAS					×		
Pseudocryphaeus asteriferus HAAS				×			
Pseudocryphaeus proteus HAAS				×			
Pseudocryphaeus prostellans (RICHTERS)		×					
Pseudocryphaeus nais HAAS		×					
Pseudocryphaeus ? *cameratus* HAAS		×					
Pseudocryphaeus ? *ecthetus* HAAS				×			
Pseudocryphaeus ? *phylax* HAAS					×		
Sanidopyge baykali HAAS							×
Asteroides (*Asteroides*) *consobrinus consobrinus* HAAS			×	×			
Asteroides (*Asteroides*) *consobrinus asinarius* HAAS					×		
Asteroides (*Asteroides*) *paeckelmanni* (RICHTERS)						×	
Asteroides (? *Asteroides*) *psilodora* HAAS					×		
Asteroides (? *Asteroides*) *aspidium* HAAS				×			
Asteroides (*Talus*) *bithynica* HAAS		×	×				
Gravicalymene eunoa HAAS	×	×					
? *Homalonotus salteri* VERNEUIL				(Kartal)			
Trimerus (*Dipleura*) *fornix* HAAS			×	×			
Parahomalonotus gervillei (VERNEUIL)			×				
Proetus (*Proetus*) *bufo* HAAS				×			
Cornuproetus (*Cornuproetus*) *exanthemoides subsolanus* HAAS					×		
Cornuproetus (*Cornuproetus*) *chouberti acrodactylium* HAAS				×	×		
Cornuproetus (*Sculptoproetus*) *sculptus* (BARR.)					×		
Cornuproetus (*Lepidoproetus*) *regulus* HAAS		×					
Tropidocoryphe sp.						×	
Dechenella ? (*Basidechenella*?) sp.						×	
Otarion (*Otarion*) *hystrix* HAAS	×	×					
Otarion (*Otarion*) *hydrocephalum hydrocephalum* ROEMER					×		
Otarion (*Otarion*) *goerlichi* HAAS						×	
Harpidella cimex HAAS					×		

Durkoop et al. (1967) listed the following trilobites from the Middle and Upper Devonian of Afghanistan.

Afghanopyge celata, n. gen. & sp.	Up. Dev.
A. scalpta, n. sp.	Mid. Dev.
Asteropyge sp.	Up. Dev.
Otarion sp.	Mid. Dev.
Phacops sp.	Up. Dev.
Phacops accipitrinus	ditto
Phacops batilliferus	ditto
Quadroglyphaeus kakari, n. gen. & sp.	ditto
Quadroglyphaeus obtusus, n. sp.	ditto
Scutellum sp.	ditto
Treveropyge sp.	Mid. Dev.

Subsequently, Haas and Mansink (1969) splitted *Neocalmonia* which they considered a genus of the Asteropyginae of the Dalmanitidae, instead of the Calmoniidae, into three subgenera and they described ten species from Afghanistan and East Iran as follows:

Neocalmonia (*Bradocryphaeus*) *afghanica* H. & M.	Eifelian-Givetian
Neocalmonia (*Heliopyge*) *caelata* H. & M.	Givetian
Neocalmonia (*Neocalmonia*) *quadricosta* Pillet	Frasnian
N. (*N.*) *milistana* H. & M.	Frasnian
N. (*N.*) *imperfecta* Pillet	Frasnian
N. (*N.*) *brinkmanni* H. & M.	Frasnian
N. (*N.*) *batillifera* H. & M.	Frasnian
N. (*N.*) *kakari* H. & M.	Frasnian
N. (*N.*) *thaumata* H. & M.	Frasnian
Neocalmonia ? *persica* (R. & E. Richter, 1926)	Frasnian (Iran)

Devonian rocks appear to be distributed widely in Northern Pakistan and the Western Himalayas, although much remains to be investigated (Stauffer, 1967, Chaeterji, 1967).

In Chitral, North Pakistan *Proetus chitralensis* Reed, 1911, was described from the neighbourhood of the Baroghil pass and

Phacops aff. *latifrons* Bronn
Phacops sp.
Dalmanites (*Asteropyge*) *koraghensis* Reed
Dalmanites (*Asteropyge*) sp.

from Koragh ridge (Reed, 1922). The latter four trilobites are Upper Devonian or Frasnian and the former one is considered Lower Devonian.

Devonian trilobites so far known from Southn Asia from Turkey to Pakistan total about 90 species some 50 of which are Lower Devonian ones of Bithynia, whereas almost all of Afghanistan and Pakistan are Middle and Upper Devonian trilobites.

In the Bithynian fauna the Acastavinae and Asteropyginae of the Dalmanitidae and the Calmoniidae are well represented by many genera including Haas' new genera and subgenera as follows:

Subfamily Acastavinae Struve, 1958
    Pelitlina, nov.
    Centauropyge, nov.

Subfamily Asteropyginae DELO, 1935
  Cryphina OEHLERT, 1889
  Comura (*Turcopyge*, nov.)
  Echinopyge, nov.
  Feruminops, nov.
  Asteropyge (*Rhenops*, RICHTER & RICHTER, 1943)
  Metacanthina PILLET, 1954
  Pseudocryphaeus PILLET, 1954
  Sanidopyge, nov.
Family Calmoniidae DELO, 1935
  Asteroides (*Asteroides* DELO, 1935)
  Asteroides (*Talus*, nov.)

Among them only *Asteropyge* is distributed easterly as far as Chitral in South Asia.

Pelitlina and *Centauropyge* of the Acastavinae and *Echinopyge*, *Feruminops* and *Comura* (*Turcopyge*) of the Asteropyginae are all upper Emsian trilobites indigenous to Turkey. *Sanidopyge* is a Middle Devonian genus of the Bosporus region. *Asteroides* (*Talus*) ranges in Turkey from Praguian probably to lower Emsian.

Among three new subgenera of *Neocalmonia*, *Neocalmonia* (*Neocalmonia*) is restricted to the Frasnian of Afghanistan, *N.* (*Bradocryphaeus*) is distributed in Spain, South England, North France, Belgium, Rheinischen Schiefergebirge, ? East Thuringia and Afghanistan from Eifelian to Frasnian and *Neocalmonia* (*Heliopyge*) in the Givetian and the Fransnian of North Spain, Belgium and Afghanistan.

The family Homalonotidae is represented in South Asia by the followings:

Homalonotus: Lower Devonian of Bithynia
Trimerus (*Dipleura*): ditto
Burmeisteria (*Digonus*): Frasnian of Pakistan
Parahomalonotus: Lower Devonian of Bithynia

These trilobite families and subfamilies typical of the Rhenish magnifacies (ERBEN, 1962) are totally unrepresented in Eastern and Sontheastern Asia. On the contrary, the Scutelluidae, Odontopleuridae, Lichidae, Cheiruridae, *Odontochile*, Calymenidae, Proetidae, Otarionidae, and Harpedidae characteristic of the Hercynian magnifacies as well as dechenellids and crytosymbolids typical of the mixed facies of Europe are present in the Eastern and Southeastern faunas.

V. Devonian Trilobites of Siberia and Turkestan, U.S.S.R.

Marine Devonian formations are distributed widely around the Siberian platform and partly on it. Trilobites appear to be especially rich in its southwest side. Before going further, the correlation of the D_1, D_2 and D_3 divisions of the U.S.S.R. to the other sequences of Europe, China and North America is shown in Table 6, because the lower boundary of the Devonian System to be drawn either at the base or the top of the Tiverian has been an important problem and because the division of the system in the U.S.S.R. disagreed with that of the classical one in Western Europe, as does that of China. (RZHONSNITSKAYA, 1967, NALIVIKIN et al., 1973).

In his "*Trilobites of the Turkestan*", 1932, WEBER described about 45 species of

Fossil list 6. Devonian trilobites of Turkestan.
(After WEBER, 1932)

Trilobite species	S.-D.	L. Dev.	M. Dev.	U. Dev.	Revision
Bronteus lichaoides WEBER	133				*Scutellum*
Bronteus nalivkini WEBER			13		*Breviscutellum* ?
Bronteus tarak WEBER			54		*Weberopeltis*
Bronteus yakovlevi WEBER			13		*Thysanopeltella* ?
Bronteus radiatus WEBER			13		*Weberopeltis sidereus* (WEBER) 1945
Bronteus elegans PEETZ		16, 268			*Scutellum*
Bronteus, n. sp.		507			
Bronteus sp. indet.		289			
Acidaspis cornuta WEBER			697		*Isopleura*
Lichas (*Euarges*) *planus* WEBER			37		*Acanthopyge*
Lichas sp. (*L. planus*)		23	697		*Acanthopyge*
Lichas haueri BARRANDE		16 ?, 268, 285			*Acanthopyge*
Lichas sp. indet.	133				*Acanthopyge* ?
Cheirurus sternbergi BOECK			697		*Crotalocephalina* (*Pilletopeltis*)
Cheirurus sternbergi BOECK ?		1300			
Cheirurus sp. (*Ch. sternbergi*)			697		
Cheirurus strabo WEBER		23			*Cheirurus*, s. str.
Cheirurus sp. (*Ch. pengelli* WHIDB.)		16			
Phacops cf. *sternbergi* HAWLE et CORDA		1300			*Reedops* ?
Phacops turanicus WEBER		268			
Phacops zorgensis KAYSER		31			*Phacops* (*Boeckops*)
Phacops sp. I		31			
Phacops sp. II		31			
Phacops cf. *batracheus* WHIDBORNE			697		
Phacops sp. III		1300			
Phacops sp. IV	63b				
Phacops sp. V		268, 510			
Calymene sp. indet.			54		
Proetus bohemicus HAWLE et CORDA		268, 285, 1300			*Proetus* (*Bohemiproetus*)
Proetus sp. (*P. bohemicus* ?)		285, 289			
Proetus cf. *oehlerti* BAYLE		31 ?, 268			
Proetus chitralensis REED		510			
Proetus cf. *orbitatus* NOVAK		23			*Proetus* (*Orbitoproetus*) ?
Proetus aff. *gosseleti* BARROIS		268	333		
Proetus lepidus BARRANDE		1899a			*Lepidoproetus* (*Lepidoproetus*)
Proetus (?) cf. *champerowni* WHIDB.	20				*Astycoryphe*?
Proetus triangulus WEBER			697		

Proetus sp. I				67-68	Cyrtosymbolid ?
Proetus (*Cyrtosymbole* ?) sp. II				67-68	
Cyphaspis ocellata WHIDBORNE			697		*Otarion*
Harpes reticulatus altaicus WEBER		590			*Reticuloharpes*
Harpes, n. sp.		507			
Harpes sp. I		285			
Harpes sp. II			697		
Hypostoma, gen. indet. II			P		

Loc. No.	Age	Locality	Collection
13	M. Dev.	*Bronteus yakovlevi* accompanied by *Calceola sandalina*; river Kainemia; Volgulka river, Lunik coal-field, Ural	N. YAKOVLEV
16	L. Dev.	Chil-mairam range, Ferghana	D. MUSHKETOV
20	U. Sil.	With Middle Devonian forms?; Keklik-Uchar, Ferghana	J. RHEINWALD
23	L. Dev.	On Mt. Khodja-bektau, Ferghana	D. MUSHKETOV
31	L. Dev.		J. RHEINWALD
32	M. Dev.	Lunievsk coral-field, river Kainemia; Volgulka river, Ural	N. YAKOVLEV
37	M. Dev.	Khodjent district	O. NEUMANN
54	M. Dev.	Khodjent district	O. NEUMANN
63b	Sil.-Dev.		WEBER
67-68	U. Dev.	Chil-mairam, Ferghana	NALIVKIN
133	Sil.-Dev.		WEBER
268	L. Dev.	Ferghana	WEBER
285	L. Dev.		WEBER
289	L. Dev.	Ferghana	WEBER
333	M. Dev.	Ferghana	NALIVKIN
507	L. Dev.	Ferghana	D. MUSHKETOV
508?	L. Dev.	Ferghana	
510	L. Dev.	Ferghana	D. MUSHKETOV
590	L. Dev.		D. MUSHKETOV
697	M. Dev.	Liaglian gorge, Ferghana	NALIVKIN
1300	L. Dev.	Ferghana	WEBER
1899a	L. Dev.		WEBER
P	M. or L. Dev.	With *Bronteus nalivkini*; east slope of Keklik-Uchar	NALIVKIN

Devonian trilobites including a few Silurian-Devonian transitional ones and many specifically indeterminable ones (see Fossil list 6). They were distributed in 9 genera and 8 families, namely, the Bronteidae, Odontopleuridae, Lichadidae, Cheiruridae, Phacopidae, Calymenidae, Proetidae and the Harpedidae. Some 10 species of trilobites are either identifiable with or comparable to European ones. Another ten are WEBER's species. Beside these one is PEETZ's and another REED's which the last is *Proetus chitralensis* REED from the Lower Devonian of Pakistan. It has already been noted that he reported *Crotalocephalina*, viz. *Crotalocephalus myops* and *C. myops interruptus* from three upper Ludlovian localities (KOBAYASHI and HAMADA, 1974), but they may have been procured

Table 6. Correlation of the Devonian System of the northern continents.

China	Europe				U.S.S.R.		North America	
Hsikuangshan	Dasberg-Stufe		Etroeungt-Fazies Famennian		Famennian	D₃	Bradfordian	
	Hemberg-Stufe							
	Nehden-Stufe						Chautauquan	
Yütienchiao	Adorf-Stufe		Frasnian		Frasnian		Senecan	Chemung
								Finger Lake
Tungkangling	H	Srbsko	Givetian		Givetian	D₂	Erian	Tonghanic
								Tioughnioga
Peiliu		Hlubočepy	Eifelian	Couvinian	"Eifelian"			Cozenovia
Yüchiang	G	Zlíchov	Coblenzian	Emsian			Ulsterian	Onesquethaw
		Prag			"Coblenzian"	D₁		
Nakaoling	F			Siegenian	"Gedinnian" Krekovian			Deerpark
Lienhuashan		Lochkov	Gedinnian					Helderberg
					Tiverian			
Wang, Yü and Wu (1974)	Horny and Prantl (1970)		Brinkmann (1960)		Rzhonsnitskaya (1967)		Cooper et al. (1947)	

from the Silurian-Devonian passage beds or the Tiverian stage.

Devonian trilobites in addition to some upper Ludlovian ones which were described from Kuznetsk, the Mountain Altai, the Rudny Altai, Central Kazakhstan and west Siberia respectively by TCHERNYSCHEVA, 1951, KHALFIN, 1955, MAXIMOVA, 1960, 1968 and YOLKIN, 1968 attain nearly 170 species and subspecies in more than 40 genera and subgenera and 12 families, namely, the Scutelluidae, Odontopleuridae, Lichidae, Cheiruridae, Phacopidae, Dalmanitidae, Homalonotidae, Proetidae, Dechenellidae, Otarionidae and the Harpidae.

In Central Kazakhstan the Upper Silurian Kochbaital horizon yields *Crotalocephalus expansus* which is typical of *Crotalocephalina* (*Geracephalina*). MAXIMOVA (1967) noted that *Decoroscutellum indefensum* was close to *Decoroscutellum lepidum* (BOUČEK) of the Lochkov beds and she concluded that the younger part of the Kochbaital including both late Silurian and early Devonian trilobite elements may be early Devonian in age. This part was considered equivalent to the Tiver stage in Podolia which is post-Ludlovian according to NIKIFOROVA. Recently MAXIMOVA (1971, 1972) proposed to draw the boundary in question at the base of the Ainasu beds, i. e. the lower Kochbaital horizon, emphasizing the appearance and development of *Dicranurus*, *Crotalocephalus* (i. e. *Crotalocephalina*), *Paciphacops*, *Scutellum*, s. str. and *Odontochile* including three subgenera, *Kasachstania*, *Reussia* and *Odontochile* s. str.

The next higher is the Praguian Sardzhal horizon which contains *Reedops cephalotes* and *Crotalocephalina hexaspinus*. The former is a Praguian phacopid and the latter diagnostic of *Crotalocephalina* (*Crotalocephalina*) whose range in the European-Mediterranean region is, according to LÜTKE (1965) and ALBERTI (1962), from Lochkov to early Eifelian. This horizon is overlain by the lower Eifelian Kazak horizon, then

Fossil list 7. Devonian trilobites of Kuznetsk, Altai and Kazakhstan.

Species	S_2	D_1^1	D_1^2	D_2^1	D_2^2	D_3	Revision
Bronteus costatus PUSCH						Ku	*Scutellum*
Bronteus elegans PEETZ =*Scutellum elegans* (PEETZ)			Ku	Ku, A			
Bronteus tullius HALL				Ku, A			" *Scutellum* "
Bronteus sibiricus TSCHERN. =*Scabriscutellum sibiricum* (TSCHERN.)			Ku	Ku, A			
Bronteus arcticus WEBER				Ku			*Thysanopeltella* (*Arctipeltis*)
Bronteus eugeni TSCHERN.				Ku			*Thysanopeltella*
Bronteus tenuistriatus TSCHERN.				Ku	Ku		*Bojoscutellum*
Bronteus mirabilis TSCHERN.						Ku	*Scutellum*
Bronteus signatus GOLDFUSS	Ku						*Scabriscutellum*
Bronteus pustulatiformis TSCHERN.	Ku						*Decoroscutellum*
Bronteus aff. *pustulatus* BARRANDE				Ku			*Metascutellum* ?
Bronteus aff. *bischofi* ROEMER				Ku			
Bronteus sp. no. 1	Ku						
Bronteus sp. no. 2	Ku						
Scutellum alutaceum (GOLDFUSS)						A	
Scutellum longicaudatum (MAXIMOVA)						A	
Scutellum cf. *orientalis* (MAXIMOVA)						A	
Scabriscutellum aff. *scabrum* GOLDFUSS				A			
Weberopeltis aff. *bublitchenkoi* MAXIMOVA				A			*Thysanopeltella* (*Altaepeltis*)
Weberopeltis kurjensis MAXIMOVA				A			*Thysanopeltella*
Scutellum michnevitchi MAXIMOVA	Ka						*Scabriscutellum*
Scutellum aff. *lichaoides* (WEBER)	Ka						
Decoroscutellum indefensum MAXIMOVA	Ka	Ka					
Bojoscutellum ? aff. *paliferum* (BEYRICH)			Ka				
Acanthaloma (*Acanthaloma*) *tenella* MAXIMOVA						A	*Leonaspis* (*Leonaspis*)
Acanthaloma (*Ketteraspis*) cf. *derelicta* (BARRANDE)			Ka				*Leonaspis* (*Ketteraspis*)
Acanthaloma (*Ketteraspis*) aff. *pigra* (BARRANDE)				Ka			*Leonaspis* (*Ketteraspis*)
Acanthaloma longispina BAL.	Ka						*Leonaspis*
Dicranurus sp.		Ka					
Ceratocephala sp.		Ka					
Lichas (*Euarges*) *sibiricus* TSCHERN.				Ku	Ku		*Acanthopyge*
Lichas (*Euarges*) *parvulus* var. *convexus* TSCHERN.			Ku				*Acanthopyge*
Lichas (*Euarges*) *altirhachis* TSCHERN.	Ku						*Acanthopyge*
Lichas (*Euarges*) sp. no. 1	Ku						
Acanthopyge aff. *haueri* (BARRANDE)			Am	A			
Acanthopyge aff. *contusa* (HALL and CLARKE)				A			

Acanthopyge ? sp.				A			
Lobopyge (*Lobopyge*) *limbata* MAXIMOVA		Ka	Ka				
Lobopyge (*Lobopyge*) *brevis* MAXIMOVA			Ka				
Lobopyge (*Lobopyge*) *longiaxis* MAXIMOVA			Ka				
Lobopyge (*Lobopyge*) sp.			Ka				
Cheirurus aff. *welleri* RAYMOND	Ku						
Cheirurus myops ROEMER =*Crotalocephalus myops* (ROEMER)	Ku	Ku		A			*Crotalocephalina*
Cheirurus yavorskyi TSCHERN.		Ku					*Crotalocephalina*
Cheirurus strabo WEBER			Am				
Crotalocephalus sternbergi BOECK			Am				*Crotalocephalina* (*Pilletopeltis*)
Cheirurus parvus TSCHERN.				Ku			*Crotalocephalina* (*Pilletopeltis* ?)
Crotalocephalus aff. *uratjubensis* WEBER				A			*Crotalocephalina* (*Crotalocephalina* ?)
Crotalocephalus sp.			Ka				
Cheirurus quenstedti orientalis MAXIMOVA	Ka						*Dideropteon*
Cheirurus sp.	Ka						
Crotalocephalus expansus BAL.	Ka						*Crotalocephalina* (*Geracephalina*)
Crotalocephalus gemmatus (WEBER)	Ka						*Dideropteon* ?
Crotalocephalus cf. *sternbergi* (BOECK)	Ka						*Crotalocephalina* (*Pilletopeltis* ?)
Crotalocephalus hexaspinus MAXIMOVA			Ka				*Crotalocephalina* (*Crotalocephalina*)
Phacops rana GREEN					Ku	Ku	*Phacops* (*Phacops*)
Phacops fecundus BARRANDE		Ku	Ku	Ku	Ku		*Ananaspis*
Phacops sublatifrons TSCHERN.				Ku			
Phacops aff. *shanensis* REED	Ku						
Phacops subcristata KHALFIN			Am				
Phacops altaicus TSCHERN.				A			*Paciphacops* (*Viaphacops*)
Phacops sternbergi HAWLE et CORDA				A			*Reedops*
Phacops potieri ulbensis MAXIMOVA				A			
Phacops oculeus MAXIMOVA				A			
Phacops postaltaicus MAXIMOVA				A		A	
Phacops loganops MAXIMOVA				A		A	
Phacops cf. *cristata* var. *pipa* HALL and CLARKE				A			*Paciphacops* (*Viaphacops*) ?
Phacops cf. *altaicus* TSCHERN.				A			*Paciphacops* (*Viaphacops*) ?
Phacops aff. *loganops* MAXIMOVA				A			*Paciphacops* (*Paciphacops*) ?
Phacops aff. *pronini* MAXIMOVA						A	
Phacops sp.				A			
Phacops fecundus orientalis MAXIMOVA	Ka						
Phacops ainasuensis BAL.	Ka						
Phacops kasachstanicus BAL.	Ka						

Phacops logani balchaschensis MAXIMOVA		Ka					*Paciphacops* (*Paciphacops*)
Phacops kotanbulakensis MAXIMOVA		Ka					
Phacops saryarkensis MAXIMOVA		Ka					*Paciphacops* (*Paciphacops*)
Phacops aff. *boecki* HAWLE et CORDA		Ka					
Phacops praepipa MAXIMOVA			Ka				*Paciphacops* (*Viaphacops*)
Phacops dentatus MAXIMOVA			Ka				*Paciphacops* (*Viaphacops*)
Phacops ex gr. *cristata* HALL				Ka			*Paciphacops* (*Viaphacops*) ?
Phacops pustulatus MAXIMOVA				Ka			*Paciphacops* (*Viaphacops*)
Phacops acutus MAXIMOVA				Ka	Ka		
Phacops angulatus MAXIMOVA			Ka				*Paciphacops* (*Paciphacops*)
Paciphacops aff. *fecundus degener* (BARRANDE)				Ka			*Paciphacops* (*Paciphacops*) ?
Phacops rhinoceros MAXIMOVA				Ka			
Phacops aff. *pustulatus* MAXIMOVA				Ka			*Paciphacops* (*Viaphacops*) ?
Phacops sp. α	Ka						
Phacops sp. β	Ka						
Reedops cephalotes (HAWLE et CORDA)			Ka				*Reedops* (*Reedops*)
Reedops aff. *sternbergi* (HAWLE et CORDA)		Ka	Ka				
Phacopidella primitiva MAXIMOVA				A			
Phacopidella sp.				A			
Probolium altaicum (KHALFIN)			Am				
Probolium ? sp. α				A			
Probolium ? sp. β				A			
Dalmanites septicostatus MAXIMOVA	Ka						*Odontochile* (*Kasachstania*)
Dalmanites kasachstanicus BAL.	Ka						*Odontochile* (*Kasachstania*)
Dalmanites saryarkensis MAXIMOVA	Ka						*Odontochile* (*Kasachstania*)
Odontochile kiikbaica MAXIMOVA	Ka	Ka					*Odontochile* (*Reussia*)
Odontochile pristina MAXIMOVA	Ka						*Odontochile* (*Odontochile*)
Odontochile graciosa BAL.	Ka						*Odontochile* (*Odontochile*)
Odontochile idonea MAXIMOVA		Ka					*Odontochile* (*Reussia*)
Odontochile batymarginata MAXIMOVA	Ka	Ka					*Odontochile* (*Reussia*)
Odontochile aff. *micrurus* (GREEN)			Ka				
Odontochile crassa MAXIMOVA			Ka				*Odontochile* (*Odontochile*)
Odontochile frontale MAXIMOVA			Ka				

Odontochile ulrichi asiatica MAXIMOVA			Ka				*Odontochile* (*Kasachstania*)
Odontochile carinata MAXIMOVA			Ka				*Odontochile* (*Odontochile*)
Odontochile bifurcata MAXIMOVA			Ka				*Odontochile* (*Odontochile*)
Odontochile arcuata MAXIMOVA			Ka				
Odontochile aff. *carinata* MAXIMOVA				Ka			
Odontochile sp. α		Ka					
Calymene ex gr. *blumenbachi* BRONGNIART				A			
Calymene kokbaitalensis MAXIMOVA		Ka					
Calymene weberi MAXIMOVA	Ka	Ka					
Calymene aff. *weberi* MAXIMOVA	Ka						*Calymene blumenbachi asiatica* WEBER (pars 1951, pl. 4, fig. 8)
Calymene sp.	Ka						
Trimerus sp.	Ka						
Proetus carinatus KHALFIN				Am			*Khalfinella*
Proetus buchi HAWLE et CORDA			Ku				*Cornuproetus* (*Buchioproetus*)
Proetus subplanata var. *granulata* TSCHERN.		[in conglomerate]					*Cornuproetus* (*Quadratoproetus*)
Proetus peetzi TSCHERN.					Ku		*Proetus* (*Proetus*)
Proetus lazutkini TSCHERN.				Ku	Ku		*Proetus* (*Proetus*)
Proetus kuznetskiensis TSCHERN.				Ku			*Praedechenella*
Proetus ex gr. *bohemicus* HAWLE et CORDA			Ku	A			*Proetus* (*Bohemiproetus* ?)
Proetus aff. *laevigatus* MAUER					Ku		*Unguliproetus* (*Unguliproetus* ?)
Proetus sp.					Ku		*Proetus* (*Proetus*) *peetzi* ?
Proetus (*Proetus*) *oehlerti* BAYLE				A			
Proetus (*Proetus*) *sibiricus* TSCHERN.				A			
Proetus (*Proetus*) *bohemicus supraconvexus* MAXIMOVA				A			
Proetus (*Proetus*) ex gr. *bohemicus* HAWLE et CORDA				A			
Proetus aff. *retroflexus* BARRANDE				A			*Proetus* (*Proetus*)
Proetus (*Proetus*) *pseudocarbonicus* MAXIMOVA				A			Dechenellid
Cornuproetus altaicus MAXIMOVA				A			
Cornuproetus cf. *holzapfeli* (NOVAK)				A			*Lepidoproetus* (*Diademoproetus*) ?
Eremiproetus cf. *eremita* (BARRANDE)				A			
Proetus (*Crassiproetus*) *globosus* MAXIMOVA			Ka				
Dechenella salairica TSCHERN.			Ku	Ku			*Schizoproetus*
Dechenella batchatensis TSCHERN.				Ku			*Ganinella*
Dechenella cf. *dombrowiensis* GÜRICH				Ku	Ku		*Ganinella* ?
Dechenella cf. *onyx* RICHTER				Ku	Ku		

Dechenellurus ursus MAXIMOVA			Ka	Ka			
Dechenellurus granifer MAXIMOVA		Ka	Ka	Ka			
Dechenellurus parvus MAXIMOVA			Ka				
Dechenellurus profusus MAXIMOVA			Ka				
Dechenellurus aff. *parvus* MAXIMOVA			Ka				
Dechenellurus granifer MAXIMOVA			Ka				
Dechenella ? aff. *planimarginata* (MEEK)			Ka				
Praedechenella kazachstanica MAXIMOVA			Ka				
Cyphaspis convexa HAWLE et CORDA			Ku	Ku	Ku		*Otarion*
Otarion kiikbaicum MAXIMOVA		Ka					
Harpes reticulatus HAWLE et CORDA		Ku	Ku	A			*Reticuloharpes*
Harpes reticulatus HAWLE et CORDA var. *altaicus* WEBER				A			*Reticuloharpes* ?
Harpes pansa MAXIMOVA	Ka						

Ku: Kuznetsk basin, TSCHERNYSCHEV (1951)
Am: Mountain Altai, KHALFIN (1955)
A: Rudny Altai, MAXIMOVA (1960)
Ka: Central Kazakhstan, MAXIMOVA (1968)

Fossil list 8. Dechenellids of West Siberia.
(After YOLKIN, 1968)

Species / Age	D_1^1	D_1^2	D_2^1	D_2^2
Lacunoporaspis antiqua YOLKIN	A			
Lacunoporaspis contermina contermina YOLKIN			Am	
Lacunoporaspis contermina convexa YOLKIN			S, Am	
Lacunoporaspis pulchella (KHALFIN)			Am	
Khalfinella prima YOLKIN	Am			
Khalfinella attenuata YOLKIN		S, Am		
Khalfinella glabra YOLKIN		S, Am		
Khalfinella elegantula YOLKIN			S	
Khalfinella carinata (KHALFIN)			S, Am	
Praedechenella kuznetskiensis (N. TSCHERNYSHEVA)			S, Am	
Praedechenella liniclivosa MAXIMOVA			S	
Basidechenella altaica YOLKIN			Am	
Basidechenella kuvaschensis YOLKIN			Am	
Schizoproetus salairica (N. TSCHERNYSHEVA)				S
Ganinella gurjevskiensis YOLKIN	S			
Ganinella tchernyschevae YOLKIN		S, Am		
Ganinella diversa YOLKIN		S, Am		
Ganinella dombrowiensis dombrowiensis (GÜRICH)			S	
Ganinella dombrowiensis brevis (GÜRICH)			S, Am	
Ganinella batchatensis (N. TSCHERNYSHEVA)			S, Am	
Ganinella schebalioensis YOLKIN			Am	

S: Salair, Am: Mountain Altai

the latter by the upper Eifelian Besoba horizon and the last in turn by the Givetian Aidarla horizon.

According to RZHONSNITSKAYA (1976) the D_1-D_2 boundary is relevant to be drawn between the lower and upper Emsian. YOLKIN (1967) zonated the late Lower Devonian-early Middle Devonian formations in Salair and the Mountain Altais by means of dechenellids with the result he reached the conclusion that the boundary in question should be drawn in this area beneath the *Khalfinella eleganta-Ganinella dombrowiensis dombrowiensis* zone in the Salairkinsk beds of Salair and the Kireyevsk beds of Altai. He correlated the base of these beds to the base of the *cultrijugatus* beds of Ardennes and the top of the Zlichov stage of the Barrandean sequence. Whether or not the base of the *cultrijugatus* beds is exactly in the same level with the top of the Zlichov stage in Bohemia is rather difficut to convince, because there may be any gap or duplication between the Zlichovian and Couvinian ages.

According to MAXIMOVA 28 out of 74 Kazakhstan trilobite species are of prime importance for the faunal connection and 11 and 17 species of them reveal affinities toward the Barrandean and the eastern North American fauna respectively, notwithstanding the fact that the Upper Silurian trilobites are not similar to North American ones.

She is of opinion that *Paciphacops saryarkensis* is the progenitor of *Paciphacops* which was presumably derived from *Phacops* (or *Ananaspis*) *fecundus* and that *Paciphacops* migrated easterly through the Mongolian geosyncline as far as Eastern North America. *Dechenellurus* and *Crassiproetus* were also Kazakhstan products which made the trans-Pacific migration through the same route in the Middle Devonian Epoch.

Weberopeltis, *Thysanopeltella* and their allies have developed not only in the Altai-Sayan area but also in the Tienshan, Ural and the Arctic areas. In Novaja Zemlya there occur *Scabriscutellum miloradovitchi* MAXIMOVA in the Coblenzian, *Scutellum alutaceum arcticum* MAXIMOVA and *Thysanopeltella* (*Arctipeltis*) *arctica* (WEBER) in the lower Eifelian and *Thysanopeltella tcherkessovae* MAXIMOVA in the upper Eifelian stage.

The Lower and Middle Devonian faunas of Northern Asia are related to the Canadian ones on the east side and the Uralian ones on the west side. In the Taimyr peninsula *Boreoscutellum boreum* (MAXIMOVA) is found in the Gedinnian and in part in the Siegenian and *Scutellum* aff. *elegans* (PEETZ) in the Middle Devonian. The former species is common in Kuznetsk, Altai and Turkestan. The latter is found in the early Lower Devonian of the New Siberian Islands, the Soviet Arctic and the Tichyi Ruchei horizon of eastern Siberia, Northeast USSR. *Dechenella verneuili* (BARRANDE) and its allies are distributed widely in the Givetian of Vaygatch in the Soviet Arctic and the Middle Devonian of the Siberian platform. In the western slope of the Urals *Dechenella tschernyshevi* RICHTER occurs in the upper Eifelian with *D. verneuili* and *Dechenella* (*Praedechenella*) cf. *markovskii* MAXIMOVA and *Phacops granulatoides* MAXIMOVA are known from the Givetian. The Eifleian fauna of eastern Siberia comprises *Thysanopletella*, "*Crotalocephalus*" and *Ganinella* (MARKOV et al., 1967, NIKOLAEV et al., 1967, KRYLOVA et al., 1967, KODIAIN et al., 1967), but *Crotalocephalina* is as yet unknown or extremely rare in North America (see Postscript 2).

Trimerus sp. in the Tiver stage of Central Kazakhstan is a solitary homalonotid in the Asiatic part of USSR. Neither the Acastavinae nor the Asteropyginae are present in the area.

VI. Devonian Trilobites of Asia

Insofar as the authors are aware, Lower and Middle Devonian trilobites of Asia belong probably to some 80 genera beside many subgenera, in 14 families in addition to some subfamilies. These families are the Pseudotrinodidae, Scutelluidae, Odontopleuridae, Lichidae, Cheiruridae, Phacopidae, Dalmanitidae, Calmonidae, Calymenidae, Homalonotidae, Proetidae, Dechenellidae, Otarionidae and Harpidae. The Pseudotrinodidae are indigenous to the Burmese-Malayan geosyncline. As shown in Fossil list 9 on page 42, the Scutelluidae are well developed in Asia, but as yet unknown from the Devonian formations in the Mongolian geosyncline and the Yangtze basin. The Odontopleuridae are unrepresented in the faunas of these two areas and also in the Burmese-Malayan geosyncline and the northern part of this continent. The Lichidae are unknown also from North Asia and the Burmese-Malayan geosyncline. The Cheiruridae are on the other hand widely distributed from Turkestan to the Kuznetsk basin and farther in the Eifelian of eastern Siberia. Baside these Soviet territories *Crotalocephalina* has thrived in Japan and Turkey.

The phacopids are spread in Asia extensively, but unknown from the Soviet Arctic. The dalmanitids are particularly well flourished from Kazakhstan to the Mongolo-Okhotsk region. The Acastavinae and the Asteropyginae of the Dalmanitidae and also the Calmonidae and the Homalonotidae are restricted to occur in Asia to the west of the Himalayas, except for an occurrence of *Trimerus* in Central Kazakhstan. While *Calymene* is distributed from Kazakhstan to Primorie, *Gravicalymene* is a leading genus in the faunas of Japan, China and Viet-Nam. It occurs probably in Burma, but unknown in South Asia except for Bithynia. *Otarion* as well as various genera of the Proetidae are found in Asia at many places. Dechenellids are common trilobites in the Soviet territories.

Among Devonian trilobites endemic genera and subgenera to part of the Asiatic continent are as follows:

Pseudotrinodidae: *Pseudotrinodus*
Scutelluidae: *Hidascutellum*, *Boreoscutellum*, *Thysanopeltella* (*Altaepeltis*, *Arctopeltis*)
Dalmanitidae
  Dalmanitinae: *Blanodalmanites*
  Acastavinae: *Pelitlina*, *Centauropyge*
  Asteropyginae: *Comura* (*Turipyge*), *Echinopyge*, *Feruminops*, *Sanidopyge*
Calmonidae or Asteropyginae: *Neocalmonia* (*Neocalmonia*)
Calmonidae: *Asteroides* (*Talus*)
Proetidae
  Lepidoproetinae ?: *Perakaspis* (*Perakaspis*, *Krohbole*)
  Eodrevermannitinae ?: *Bailielloides*
  Cyrtosymbolinae: *Langgonbole*

The Kroh fauna of Malay comprises a very unique assemblage of trilobites including *Pseudotrinodus*, *Blanodalmintes*, *Bailielloides*, *Perakaspis* and its subgenus *Krohbole* which thrived in a disphotic tranquile bottom along the axis of the Burmese-Malayan geosyncline, Southeast Asia.

Fossil list 9. Devonian trilobite genera in Asia.

Area Taxon	Arctic USSR-East Siberia	SW Siberia-Turkestan	Mongolia-Primoria	Japan	Central China-Viet-Nam	Burma-Malay	Turkey-Pakistan
Pseudotrinodidae							
Pseudotrinodus						×	
Scutelluidae							
Scutellum	×	×		×		×	×
Bojoscutellum		×					
Decoroscutellum		×					
Hidascutellum				×			
Weberopeltis	×	×					
Scabriscutellum	×	×					
Spiniscutellum							×
Metascutellum		?					
Breviscutellum		?					
Boreoscutellum	×						
Thysanopeltella	×	×		×			
(*Septimopeltis*)				+			
(*Altaepeltis*)		+					
(*Arctipeltis*)		+					
Odontopleuridae							
Primaspis				?			
Leonaspis		×					×
(*Leonaspis*)		+					
(*Ketteraspis*)		+					
Ceratocephala		×		×			
Dicranurus		×					
Isopleura		×					
Lichidae							
Lichas s. l.		×			×		
Acanthopyge		×	×				
Lobopyge		×		?			×
Radiolichas			?				
Craspedarges				×			
Cheiruridae							
Cheirurus s. l.		×					
Dideropteon		×					
Crotalocephalina	?	×		×			×
(*Crotalocephalina*)		+		+			
(*Pilletopeltis*)		+		+			
(*Crotalocephalides*)				+			
(*Geracephalina*)		+		+			
Phacopidae							
Phacopinae							

Phacops		×	×	×	×	×	×
(*Boeckops*)		+					
Reedops		×	×	×			×
Ananaspis		×					
Paciphacops		×	×				
(*Paciphacops*)		+	+				
(*Viaphacops*)		+	+				
Plagiolaria					×	×	
Trimerocephalus							×
Phacopidellinae							
Denckmannites					×		
Ductina					×		
Dalmanitidae							
Dalmanites s. l.			×				
Odontochile		×	×				
(*Odontochile*)		+					
(*Kasachstania*)		+					
(*Reussia*)		+	+				
Neoprobolium		×					
Anchiopella			×				
Blanodalmanites						×	
Acastavinae							
Pelitlina							×
Centauropyge							×
Asteropyginae							
Asteropyge							×
(*Rhenops*)							+
Comura							×
(*Turcopyge*)							+
Cryphina							×
Echinopyge							×
Feruminops							×
Metacanthina							×
Pseudocryphaeus							×
Sanidopyge							×
Calmoniidae							
Calmoniinae ?							
Neocalmonia							×
(*Neocalmonia*)							+
(*Bradocryphaeus*)							+
(*Heliopyge*)							+
Acastinae							
Asteroides							×
(*Asteroides*)							+
(*Talus*)							+
Calymenidae							
Calymene		×	×				
Gravicalymene				×	×	?	×

Homalonotidae							
Homalonotus							?
Trimerus		×					×
(*Dipleura*)							+
Burmeisteria							×
(*Digonus*)							+
Parahomalonotus							×
Proetidae							
Proetinae							
Proetus		×		×	×		×
(*Proetus*)		+					+
(*Bohemiproetus*)		+					
(*Orbitoproetus*)		?					
(*Coniproetus*)				+			
Cornuproetinae							
Cornuproetus		×					×
(*Cornuproetus*)							+
(*Buchioproetus*)		+					
(*Quadratoproetus*)		+					
(*Sculptoproetus*)							+
Lepidoproetinae							
Lepidoproetus		×					×
(*Lepidoproetus*)		+					+
(*Diadematoproetus*)		?					
Perakaspis						×	
(*Perakaspis*)						+	
(*Krohbole*)						+	
Eremiproetinae							
Eremiproetus		×					
Crassiproetinae							
Crassiproetus		×	×				
Tropidocoryphinae							
Tropidocoryphe							×
Astycoryphe		?					
Eodrevermanniinae ?							
Bailielloides						×	
Prionopeltinae							
Prionopeltis						?	
Dechenellidae							
Dechenellinae							
Dechenella	×	×	?	×	×		?
Dechenellurus		×	×				
Praedechenella		×					
Lacunoporaspis		×					
Khalfinella		×					
Monodechenella					×		
Basidechenella		×			?		?

Schizoproetinae							
Schizoproetus	×	×					
Ganinella	×	×					
Unguliproetinae							
Unguliproetus		×		×			
(*Unguliproetus*)				+			
Cyrtosymbolinae							
Waribole						×	
Typhoproetus					×		
Langgonbole						×	
Cyrtosymbolid		?					
Otarionidae							
Otarion		×		×	×		×
Cyphaspides					×		×
Harpidella							
Harpidae							
Harpes		×				×	
Reticuloharpes		×					

× : genus, + : subgenus, ?: aff., cfr., ?, etc.

Six new genera and two subgenera of the Calmoniidae and the Acastavinae and Asteropyginae of the Dalmanitidae are all South Asiatic taxa in the Tethyan zone. They as a whole show a high localization, and combined with other Rhenish trilobites, the European-Mediterranean faunal province was extended as far as Pakistan.

Arctipeltis and *Altaepeltis* of *Thysanopeltella* are two endemic subgenera of the Scutelluidae, known from the Kuznetsk basin and the Rudny Altai. The former occurs also in Novaja Zemlya and probably in the Canadian Arctic. *Boreoscutellum boreum* is a Gedinnian trilobite widely distributed in the Soviet Arctic and Eastern Siberia. While all of them have spiniferous pygidia, *Hidascutellum* of Japan has the pygidium with entire margin, notwithstanding that the cephalon is very much like *Weberopeltis.*

Finally, *Langgonbole* is an Upper Devonian cyrtosymbolid in the Langgon red beds, Malaya, which would be a product of localization in the phase of marine regression.

Many of the remainder are Eurasiatic or more widely distributed genera. Various dechenellids are well developed in Asia in the northern part. As pointed out by ORMISTON (1967), *Ganinella* and *Lacunoporaspis* are two of such genera which together with *Reticuloharpes* show the faunal connection between Siberia and Canada through Alaska. Likewise, the trans-Pacific faunal affinities from Kazakhstan to the Appalachian province through the Mongolian geosyncline are indicated by *Dechenellurus, Crassiproetus* and particularly by *Paciphacops* (*Paciphacops* and *Viaphacops*), *Odontochile* (*Odontochile, Kasachstania* and *Reussia*), *Anchiopella* and *Neoprobolium,* as emphasized by MAXIMOVA (1967, 1972). The occurrence of *Monodechenella* in North Viet-Nam suggests any relationship of the Eastern Asiatic fauna to the North American one. Nevertheless, the oriental fauna distributing in Japan, Central and South China, Indochina and Burma is quite different in the development of *Gravicalymene* which is also common and wide spread from New Zealand to the Tasman geosyncline. Like *Gravi-*

calymene, *Crotalocephalina* and *Craspedarges* are two leading members of the Fukuji fauna. The latter is known now to be indigenous to the Western Pacific province. The former is well represented in the Tasman fauna as well as in the Fukuji fauna of Japan. Thus, they are important links between these faunas on the two sides of the equator.

VII. Devonian Trilobites of Australasia

In the last quarter of the ninteenth century many Middle Palaeozoic trilobites were described from Southeastern Australia by McCoy (1876), DE KONINCK (1876-1877), RATTE (1887), FOERSTE (1888) and others. They were considered Silurian or Upper Silurian ones. As Upper Silurian of these days was used in the sense of MURCHISON, it means Silurian synonymous with Gotlandian but many of these trilobites are known now to be Lower Devonian in age. More precisely, the following Upper Silurian trilobites in *Prodromus of Palaeontology of Victoria, Dec. 3*, 1876 are revised by GILL (1939, 1948, 1951, 1962), as shown behind each species name.

Phacops (*Portlockia*) *fecundus* BARRANDE........*Phacops* sp. nov. GILL, 1951, Yeringian, i. e. Lower Devonian
Phacops (*Odontochile*) *caudatus* by McCoy (pars)........*Dalmanites wadongensis* GILL, Silurian (Melbournian)
Forbesia euryceps McCoy........*Proetus euryceps* (McCoy), Yeringian
Lichas australis McCoy........*Acanthopyge australis* (McCoy), Melbournian-Yeringian

Incidentally, the last species was later transferred to *Lobopyge* by CHATTERTON (1971).

The Palaeozoic faunas of the continent were greatly amplified by DE KONINCK through *Recherches sur les fossiles paléozoiques de la Nouvelle-Galles du Sud* (*Australie*), 1876-1877. This classical work contained 12 Silurian species of trilobites including four new species as follows:

Staurocephalus clarkei DE KONINCK
Encrinurus barrandei DE KONINCK
Cromus murchisoni DE KONINCK
Bronteus goniopeltis DE KONINCK

It is a great pity that DE KONINCK's valuable collection was destroyed by fire in 1882.

Subsequently, RATTE (1887), FOERSTE (1888), GREGORY (1900-01) and GÜRICH (1901) added the followings to the Australian fauna.

Lichas palmata var. *sinuata* RATTE, 1887........*Acanthopyge* ? *sinuata* (RATTE), Lower Devonian (*Corydocephalus* (*Trochurus*) ETHERIDGE and MITCHELL, 1917, TRIPP, 1958)
Acidaspis near *A. dormitzeri* CORDA by RATTE
Acidaspis near *A. leonhardi* BARR. by RATTE
Staurocephalus near *S. murchisoni* BARR. by RATTE........*Staurocephalus murchisoni* (Lower Tril. beds), ETHERIDGE and MITCHELL, 1917
Encrinurus bowningensis FOERSTE
Encrinurus mitchelli FOERSTE
Phacops serratus FOERSTE

Cyphaspis spryi GREGORY
Craspedarges wilcanniae GÜRICH

MITCHELL and ETHERIDGE started the description of Silurian trilobites of Australia with their papers, 1887 and 1890. In parallel to the above workers as well as CHAPMAN (1912, 1915) MITCHELL and ETHERIDGE published *The Silurian Trilobites of New South Wales with reference to those of other areas of Australia*, Parts 1-6, 1892-1917 beside several separate papers, with which the fauna was immensely clarified. MITCHELL (1919), however, noted that the Upper and Middle Trilobite Beds of Bowning and the Yass Series perhaps include Lower Devonian rocks. This opinion was recently vindicated by JAEGER (1967) and LINK (1970) with graptolites and conodonts respectively. Broadly speaking, the Lower, Middle and Upper Trilobites Beds of Yass-Bowning area, N. S. W. seem to be middle to upper Ludlovian, upper Ludlovian and lower Gedinnian or Lochkovian respectively, but not very strictly.

Following the current opinion the authors listed Silurian and Devonian trilobites of Australia and shown respectively in fossil list 4 of their Silurian trilobite monograph and Fossil List 10 in this monograph. There are, however, still much ambiguities attached to certain species as to their ages.

As shown in the list 10 the Devonian trilobite fauna of Australia probably including some Upper Silurian ones consists of the following 13 families and 24 genera.

Scutelluidae: *Scutellum*, *Dentaloscutellum*
Odontopleuridae: *Leonaspis*, *Primaspis* (*Taemaspis*), *Ceratocephala*, *Xenionurus*
Lichidae: *Acanthopyge* (*Acanthopyge*, *Mephiaspis*), *Lobopyge*, *Craspedarges*
Cheiruridae: *Crotalocephalina* (*Crotalocephalina*, *Pilletopeltis*, *Geracephalina*)
Encrinuridae: *Encrinurus*, *Staurocephalus*
Phacopidae: *Phacops*, *Denckmannites* or *Lochkovia*, *Austrocephalus*
Dalmanitidae: *Dalmanites*, *Odontochile*, *Acastella*
Calmoniidae: *Acaste*
Homalonotidae: *Trimerus*
Proetidae: *Proetus*, *Cornuproetus*
Otarionidae: *Otarion* (*Otarion*, *Tricrotarion*)
Harpidae: *Harpes*

The fossil list of the Silurian trilobites also containing probably some Lower Devonian ones, comprises 14 families. While the Illaenidae and Raphiophoridae have already dropped out of the above Devonian fauna, the family Encrinuridae is still represented in it by three species of *Encrinurus* beside one of *Staurocephalus*. Whether they have survived there until the early Devonian times is, however, a question.

In describing the stratigraphy of the Hume Series in the Yass-Bowning area, N. S. W. in detail, BROWN (1941) concluded that the series containing the three Trilobite Beds in its upper part was Upper Silurian in age, because the beds yielded *Ceratocephala*, *Encrinurus*, *Cryptonymus*, *Odontochile* and *Sphaerexochus* and because encrinurids were well represented in the Upper Trilobite Beds.

In New South Wales *Encrinurus rothwellae* ETHERIDGE and MITCHELL, 1915 and *E. incertus* MITCHELL, 1924, were described from the Upper Trilobite Beds respectively from the Bowning Series and Bounyongian Series. MITCHELL, (1924, p. 47), however, stated already that " the uppermost beds (of the Bounyongian Series) at least, are of Lower Devonian age; and in these beds *Encrinurus* is not known to occur " and that

Fossil list 10. Devonian trilobites in Australasia.

Area Trilobites	New South Wales	Victoria	Tasmania	New Zealand
Scutellum bowningensis (Etheridge & Mitchell)	u			
Scutellum crosswelli (Chapman)		Y		
Scutellum greeni (Chapman)		Y		
Scutellum calvum Chatterton	T			
Scutellum (*Scutellum*) sp. indet. by Strusz	Dlm			
Scutellum sp. by Talent		Dl		
Dentaloscutellum hudsoni Chatterton	T			
Dentaloscutellum (?) *goniopeltis* (de Koninck)	SD			
Leonaspis rattei (Etheridge & Mitchell)	←u		aff.	
"*Odontopleura*" aff. *rattei* Etheridge & Mitchell			Dl	
Leonaspis jenkinsi (Etheridge & Mitchell)	u			
Leonaspis calvus Chatterton	T			
Leonaspis sp. indet. by Strusz	Dlm			
Primaspis (*Taemaspis*) *campbelli* Chatterton	T			
Ceratocephala longispina Mitchell	u			
Ceratocephala vexilla Chatterton	T			
Xanionurus bispinosus Chatterton	T			
Odontopleurid indet. by Talent		Dl		
Odontopleurid hypostome		Y		
Trochurus sinuata (Ratte)	Dl			
Lobopyge australis (McCoy)		Y		
Acanthopyge (*Mephiarges*) *bifidus* Edgell	Dm			
Craspedarges wilcanniae Gürich	(Dlm)			
Cheirurus sternbergi (Boeck)		Y		
Cheirurus sp. s. str. by Gill (1948)			Dl	
Cheirurus sp. by Chapman (1912)		Dm		
Cheirurus (*Crotalocephalus*) *regius* Foldvary	Dl			
Cheirurus (*Crotalocephalus*) *packhami* Strusz	Dlm			
Cheirurus (*Crotalocephalus*) sp. by Talent		Dl		
Crotalocephalus ? sp. by Etheridge & Mitchell	SD			
Staurocephalus ? *clarkei* de Koninck				
"*Phacops crossleii* Etheridge & Michell" by Chapman	u	Dl		
"*Phacops serratus* Foerste"	u	Y		
Phacops sweeti Etheridge and Mitchell		Dl		
Phacops mansfieldensis Etheridge & Mitchell		Dl		
Phacops aff. *fecundus* Barrande by Gill (1949)		Y		
Phacops spedeni Chatterton	T			
Phacops (*Phacops*), n. sp. by Talent		Dl		
Phacops sp. nov. by Gill (1951)		Y		
Phacopid hypostome by Gill		Y		

Denckmannites rutherfordi Sherwin	SD			
Adastrocephalum teletypicum Mitchell	u			
Dalmanites aff. *wandongensis* Gill			Dl	
Odontochile meridianus (Etheridge & Mitchell)	←u	Y		
Odontochile loomesi (Mitchell)	←u			
Odontochile formosa Gill		Dl		
Acaste longisulcata Shergold		Yr		
Acastella frontosa Shergold		Yr		
Encrinurus aff. *silverdalensis* Etheridge & Mitchell		Y		
Encrinurus rothwellae Etheridge & Mitchell	u			
Encrinurus incertus(Mitchell)	u			
Calymene bowiei Chapman		Y		
Calymene killarensis Gill		Y		
Calymene cf. *blumenbachi* Brongniart		Y		
Calymene sp. nov. ? by Strusz	Dlm			
Gravicalymene australis (Etheridge & Mitchell)	Dlm ←u		Dl	
Gravicalymene angustior (Chapman)			Dl, Y	×
Gravicalymene quadrilobata Chatterton	T			
Homalonotus (*Burmeisteria*) *huttoni* Allan				×
Homalonotus (*Digonns*) *expansus* Hector				×
Trimerus kingalensis Gill		Dl		
Trimerus lilydalensis Gill		Y		
Trimerus zeehanensis Gill			Dl	
Proetus euryceps (McCoy)		Y	Dl	
Proetus bowningensis Mitchell	←u			
Proetus (*Proetus*) *talenti* Chatterton	T			
Proetus nemus Chatterton	T			
Cornuproetus, n. sp. by Talent		Dl		
Dechenella (*Eudechenella*) *mackayi* Allan				×
Otarion (*Otarion*) *bowningensis* (Mitchell)	←u	Y		
Otarion yassensis (Etheridge & Mitchell)		Y		
Otarion lilydalensis (Chapman)		Y		
Otarion (*Otarion*) *dabrowni* Chatterton	T			
Otarion (*Tricrotarion*) *struszi* Chatterton	T			
Otarion munroei Strusz	Dlm			
Otarion sp. by Talent		Dl		
Harpes sp. by Talent		Dl		

SD : Upper Silurian or/and Lower Devonian,
Dl : Lower Devonian, Dm : Middle Devonian,
Dlm: Lower-Middle Devonian (ex. Gara formation, NSW),
Y : Yerringian (Lower Devonian),
Yr : Lower Devonian (lower Gedinn-Siegenian, Ruddock siltstone, Victoria).
Ludlow-Gedinnian beds in the Yass-Bowning area, New South Wales
←u : Middle and Upper Trilobite Beds; upper Ludlovian to lower Gedinnian,
u : Upper Trilobite Beds; lower Gedinnian or Lochkovian,
T : Upper Emsian-lower Eifelian Taemas formation in Taemas-Cavan area near Yass, New South Wales.

"in New South Wales, and indeed in Australia, *Encrinurus* (including *Cryptonymus*) is confined to the Upper Silurian and older formation."

In the Murrumbridge river area, N. S. W. it is said that the *Encrinurus* bearing Ludlovian beds contains *Odontochile* of Devonian aspect (PEDDER, 1976). Recently PHILIP (1971) quoted that "the Silurian-Devonian boundary is to be found within the Elmside formation" of which "Upper Trilobite Beds of the older literature on the Yass sequence (containing *Encrinurus rothwellae* ETHERIDGE and MITCHELL) is a horizon.

The present authors overlooked in their preceding monograph (1974) the Siluro-Devonian fauna of Queensland which had been described by MCKELLER (1969) from the Rockhampton district. Because this fauna contains *Encrinurus* aff. *mitchelli* FOERSTE beside a scutelloid and a proetoid whose generic positions are indeterminable, its age is late Silurian rather than early Devonian.

In Western Tasmania *Encrinurus* aff. *silverdalensis* was found in association with *Cheirurus* sp. and many Lower Devonian fossils in the Eldon Group at a locality on the Lyell Highway. The cheirurid is represented only by a glabella whose trans-glabellar furrows are, however, typical of "*Crotalocephalus*" as noted by GILL (1948). Its X-connection between the posterior lateral and occipital furrows shows that it belongs to Devonian *Crotalocephalina*, instead of *Crotalocephalus* s. str. Therefore, assuming that they are exactly on the same time-lelvel, *E.* aff. *silverdalensis* which according to GILL, represents probably a new species, would be a rare relic species. In connection with this problem GILL called attention to the presence of *Calceola* on one side and *Conchidium* and *Encrinurus* on the other in the Kennett formation, California (COOPER et al., 1942, p. 1769).

BANKS (1957) stated that "From east of Queenstown, in a sandstone correlated with the Florentine quartzite, GILL (1949, 1952) has recorded *Pleurodictyum megastomum*, ···, *Cheirurus* sp., *Dalmanites* aff. *wandongensis*, *Encrinurus* aff. *silverdalensis*, *Gravicalymene australis* and *Odontopleura* aff. *rattei*." "This fauna occurs near the top of the formation and contains a number of species from Lower Devonian of Victoria, New South Wales and New Zealand." *Encrinurus* is, however, later eliminated out of the Eldon fauna by TALENT and BANKS (1967).

Staurocephalus is another genus in question which is generally known to have died out by the end of the Silurian Period. *Staurocephalus clarkei* was collected at Rock Flat Creek with *Cromus bohemicus*. *Bronteus goniopeltis* which resembled *Dentaloscutelum* closely (KOBAYASHI and HAMADA, 1974) was collected from the same locality. Because their mother rocks were somewhat different in lithology, it is probable that the *clarkei* horizon lies below the *goniopeltis* horizon in the Silurian-Devonian passage beds. This species of *Staurocephalus* may be better excluded from the Devonian fauna because of the ambiguity of occurrence.

Another question is the age of *Crotalocephalus* in the Silurian trilobite list. ETHERIDGE and MITCHELL (1917) have described the following three species in their Silurian trilobite monograph.

Crotalocephalus silverdalensis ETHERIDGE and MITCHELL
Crotalocephalus sculptus ETHERIDGE and MITCHELL
Crotalocephalus ? sp.

The last from the Molong limestone was not illustrated. The two others look typical crotalocephalinids. They were considered Upper Silurian trilobites and *C. sculptus* was procured from the Lower Trilobite Beds. STRUSZ (1964), however, included *C. sculptus* in pl. 24, fig. 11 in his new species, *Cheirurus* (*Crotalocephalus*) *packhami*, which was collected from the Lower to Middle Devonian Gara Beds, N. S. W. Later he dated the Gara formation at the Emsian (1967). *Cheirurus* (*Crotalocephalus*) *regius* FOLDVARY, 1970 is another *Crotalocephalina* collected from Central New South Wales and considered lower Mid-Devonian in age. This species belongs probably to the subgenus *Geracephalina* having two glabellar rings bisected by a median longitudinal furrow.

Cheirurus sternbergi by CHAPMAN, 1915, from the Yeringian of Lilydale, Victoria is also a *Crotalocephalina* and its age is according to GILL, (1962), Lower Devonian, instead of Silurian as suggested by CHAPMAN.

Cheirurus (*Crotalocephalus*) *silverdalensis* from the Boola Beds of Victoria (PHILIP, 1962) is probably Gedinnian or Lochkovian, because the graptolite associated with the *Baragwanathia* flora in the basal part of the Tanjil beds, the stratigraphic equivalent of the Boola beds, is *Monograptus hercynicus* rather than *M. uncinatus* as previously identified (JAEGER, 1959).

Thus, crotalocephalids recently described from Australia belong exclusively to *Crotalocephalina*. *Crotalocephalus silverdalensis*, *Cr. sculptus* and the so-called *Cr. sternbergi* are morphologically Devonian forms and part of them has already been dated at Devonian, while none was ascertained to be Silurian by recent studies.

Finally, TALENT's *Cheirurus* (*Crotalocephalus*) sp. (1963) from the Lower Devonian limestone of Walhalla, Victoria is a small cranidium having the anterior glabellar ring bisected. Therefore it is probably a juvenalium of *Crotalocephalina* (*Geracephalina*). Leaving a possible relic of *Encrinurus* in Tasmania for future investigation, there is no positive objection in Australasia to draw the Silurian-Devonian boundary between the *Encrinurus*-bearing beds below and the *Crotalocephalina*-bearing ones above.

Because *Crotalocephalina* is a Lower and Middle Devonian genus well flourished in Eurasia and North Africa, its profusion in Australia is a strong evidence showing the faunal connection between the northern and southern continents on the western side of the Pacific basin.

According to SHERWIN (1968) *Denckmannites rutherfordi* which is accompanied by *Encrinurus* sp. in the same band in Wallace shale, is either late Silurian or less probably early Devonian. *Denckmannites* as a genus has been known from the Silurian-Devonian of Europe and Devonian of Morocco. Therefore the Australian species may be connected with Eur-African ones and if it is a Devonian trilobite, *Denckmannites vietnamicus* MAXIMOVA from North Viet-Nam may be a link. CHLUPÁČ (1972) on the other hand suggested *Lochkovia* for this Australian species. Because this new genus is distributed in Silurian and Lower Devonian of Europe, North Africa and Australia, the same faunal connection is acceptable from *Lochkovia*.

SHERGOLD (1968) described *Acaste longisulcata* and *Acastella frontosa* from the Ruddock siltstone of the Lilydale district, Victoria whose age is Lower Devonian and precisely, late lower Gedinnian to Siegenian. Therefore they reveal again the faunal affinity to those of Europe and North Africa where *Acaste* and *Acastella* have most flourished.

Xanionurus WHITTINGTON and CAMPBELL, 1967, as a genus is an interesting example of easterly migration during the Silurian and Devonian periods. It comprises (1) Lower Silurian *X. boucoti* n. from Maine, (2) upper Wenlockian *Radiaspis ? formosa* PRANTL and VANĚK from Bohemia and (3) upper Emsian-Eifelian *Xanionurus bispinosus* from New South Wales.

Another example of similar migration is *Primaspis* (*Taemaspis*) CHATTERTON, 1971, to which *Odontopleura portlocki* HAWLE and CORDA (high Liteň, Bohemia) and *O. bowningensis* ETHERIDGE and MITCHELL are referred beside *O. campbelli* CHATTERTON, the type-species of the subgenus. The subgenus ranges from Silurian (upper Wenlockian) to Lower or Middle Devonian (upper Emsian or lower Eifelian).

According to CHATTERTON *Acanthopyge* (*Mephiarges*) *bifidus* EDGELL, 1955 is congeneric with *Arges consanguinea* CLARKE from the Lower Devonian of New York State. *A.* (*M.*) *mephisto* (R. & E. RICHTER) is the type-species of the subgenus *Mephiarges*. There is no link between these two species in Australia and eastern North America.

Most other genera are cosmopolitan and *Dentaloscutellum*, *Austrocephalus* and *Otarion* (*Tricrotarion*) are three endemic elements. *Craspedarges* is no more indigenus to New South Wales, because it occurs in Japan. Now it became an important link between the Western Pacific faunas on the two sides of the equator. As discussed later, the age of *C. wilcanniae* would be not much deviated from that of the Fukuji fauna.

Eight families of Devonian trilobites known in Japan are all represented in Australasia. *Scutellum*, *Ceratocephala*, *Craspedarges*, *Crotalocephalina*, *Phacops*, *Gravicalymene* and *Otarion* are common genera between Japan and Australia. *Crotalocephalina* (*Geracephalina*) is a common subgenus between the two areas.

In New Zealand HECTOR (1877) was the first to describe *Homalonotus expansus* nov. with two pygidia from Reefton. Several other trilobites were added by ALLAN and SHIRLEY respectively from the Reefton and Barton River area in South Island.

According to ALLAN (1935) the Reefton fauna comprises three species of trilobites as follows:

Dechenella (*Eudechenella*) *mackayi* ALLAN
Homalonotus (*Burmeisteria*) *huttoni* ALLAN
Homalonotus (*Digonus*) *expansus* HECTOR

He considered the fauna to be upper Siegenian to lower Emsian in age. Revising the Reefton brachiopods, he noted 1947 that the affinities of the Reefton fossils were with the North American species of the Ulsterian Series on one side and with the European ones in the range from middle Siegenian to lower Emsian. The reference of *mackayi* to *Dechenella* was doubted by RICHTERS (1950). The recent discovery of *Burmeisteria* (*Digonus*) in the Lower Devonian Horlick formation on the Ross sea coast, Antarctica on the other hand suggests the Malvinokaffric affinity of the New Zealand fauna.

SHIRLEY (1938) found another three species of Lower Devonian trilobites in the Barton River area as follows:

Goldius sp.
Calymene (*Gravicalymene*) ? *angustior* (CHAPMAN)
Homalonotus sp.

Homalonotus sp. was not illustrated, but this pygidium was said to be identical with *H. expansus*. According to him this fauna is much nearer to the Bohemian than the Rhenish facies and allied to the Yeringian fauna of Australia. *Gravicalymene* evidently shows that the fauna is allied to the *Gravicalymene* bearing ones in Southeast Asia and Japan. *Goldius*, i. e., *Scutellum* is a non-Malvinokaffric trilobite genus.

Among the families and genera of the faunas of Australia and New Zealand *Acastella* of the Dalmanitidae, *Acaste* of the Calmonidae and *Trimerus*, *Digonus* and

Fossil list 11. Devonian trilobite genera in Australasia (CHATTERTON & DAVOREN, 1974).

Age Genera and Subgenera	Lochkovian	Praguian	Zlichovian and erarly Eifelian
Scutellum PUSCH		×	×
Platyscutellum ŠNAJDR		×	
Dentaloscutellum CHATTERTON			×
Scutelloid indet.	×		
Cheirurus BEYRICH		×	
Crotalocephalus (*Crotalocephalus*) SALTER		×	
Crotalocephalina (*Crotalocephalina*) PŘIBYL		×	
Leonaspis RICHTER & RICHTER	×	×	×
Dicranurus CONRAD	×	×	
Primaspis (*Taemaspis*) CHATTERTON			×
Ceratocephala WARDER			×
Xanionurus WHITTINGTON & CAMPBELL			×
Acanthopyge (*Mephiarges*) RICHTER & RICHTER			×
Lobopyge PŘIBYL & ERBEN		×	
Phacops (*logani* group)	×	×	
Phacops EMMRICH (*cristata* group)	×		
Phacops EMMRICH (*major* group)			×
Dalmanites (*Odontochile*) HAWLE et CORDA	×	×	
Acaste GOLDFUSS		×	
Acastella REED		×	
Trimerus (*Trimerus*) GREEN		×	
Trimerus (*Dipleura*) GREEN		×	
Digonus GÜRICH	×		
Calymene BRONGNIART	×	×	
Gravicalymene SHIRLEY	×	×	×
Proetus (*Proetus*) DALMAN	×		×
Cornuproetus RICHTER & RICHTER		×	
Otarion (*Otarion*) ZENKER	×	×	×
Otarion (*Tricrotarion*) CHATTERTON			×
Harpes GOLDFUSS		×	×

Burmeisterella of the Homalonotidae are unknown, if not extremely rare, in Asia. While *Burmeisterella, Acastella* and *Acaste* are European or Eur-North American elements, *Trimerus* and *Digonus* are Rhenish-Malvinokaffric ones. The Rhenish trilobites are, however, known in Asia only in South Asia to the west of Pakistan.

CHATTERTON and DAVOREN (1972) distinguished three Devonian faunas-Lochkovian, Praguian and Zlichovian-early Eifelian ones, in Australasia. The Taemas fauna would be the best representative of these trilobites, and the rest is contained in the Yeringian and other faunas. They concluded that " throughout the early Devonian, Southeastern Australian trilobites showed great affinity to those of Western Europe and North Africa, much less to those of Kazakhstan and the Appalachian region and least of all to those of the other southern continents.

Now it is well clarified that the Australian and New Zealand faunas are intimately related to those of Southeastern and Eastern Asia including Japan as indicated by *Craspedarges, Gravicalymene, Crotalocephalina* and other genera. The fauna characterized by these three trilobite genera defines the Tasman and Oriental trilobite subprovinces in the Lower Devonian-early Middle Devonian time.

Finally, TEICHERT (1947) reported an occurrence of Upper Devonian trilobites such as *Scutellum, Cyrtosymbole, Pteroparia, Drevermannia, Chaunoproetus,* and *Harpes* in association with goniatite *Manticoceras* at Bulge Gap, West Kimberley, Western Australia.

VIII. Devonian Trilobites of North America

In the Canadian archipelago *Hemiarges biger* BOLTON, 1965 is distributed in Prince of Wales, Cornwallis and Ellesmere Islands in the uppermost Silurian or Lower Devonian strata.

ORMISTON (1967) described copious Lower and Middle Devonian faunas from the archipelago as well as the Northwest Territories, Canada. Beside some specifically indeterminable forms 34 species of trilobites from the Canadian Arctic islands indicate lower Gedinnian, Emsian, Eifelian and Givetian ages. They belong to 19 genera in the Scutelluidae, Odontopleuridae, Lichidae, Proetidae, Otarionidae, Aulacopleuridae and Harpidae.

Warburgella in the Canadian archipelago shows faunal affinity to the Gedinnian of Europe, since the genus is rare in continental North America. *Platyscutellum brevicephalus* and several species of *Leonaspis, Cornuproetus, Astycorphe, Dechenella, Otarion, Aulacopleura* (*Paraaulacopleura*) and *Harpes* in the Eids formation represent an Emsian faunule.

Dechenellids are most profused in the Eifelian or late Eifelian-Givetian Blue Fiord formation. They belong to 15 species of *Dechenella* (*Dechenella, Pedinodechenella** and *Basidechenella*), *Deltadechenella**, *Cyrtodechenella, Schizoproetoides** and *Humeia**, among which three new genera and a new subgenus are marked by asterisks. It is noteworthy that the last genus is founded on *Cyrtosymbole richteri* TOLMACHOFF, 1962, including *Dalmanites* sp. by TOLMACHOFF from Ellesmere Island, because neither the Cyrtosymbolinae nor the Phacopina are so far represented in the Devonian fauna of the Arctic Canada.

The family Scutelluidae is represented in the Middle Devonian fauna by *Ancyropyge* and *Weberopeltis*, both highly specialized. The former is an indigenous genus to North America to the north of the Great Lakes area. It is an important link between the Canadian and central lowland faunas. The latter was thought an endemic genus of the Ural-Siberian region, but recently FEIST (1974) added a species from South France. It is noted that the Canadian form is allied to *Weberopeltis arcticum* (WEBER, 1945) which occurs in the Kuznetsk basin and Novaja Zemlya and on which MAXIMOVA (1968) erected *Arctipeltis*.

Dechenella (*Dechenella*) sp. resembling *D.* (*D.*) *spaekkassensis* (TOLMACHOFF, 1926) from Ellesmereland occurs in the Middle Devonian of Mackenzie District (DEAN, 1969).

Lower Devonian trilobites described by ORMISTON (1971) from the Michelle formation of Yukon Territory bear similar aspects to the Canadian faunas. Dechenellids of this formation belong to *Lacunoporaspis* and *Schizoproetoides* where the former is typical genus of the Southwestern Siberian fauna.

Fuscipyge is a new Middle Devonian dechenellid genus including three species in Northwest Territories, Canada, beside *Schizoproetus baschkiricus* MAXIMOVA, 1966, from the Givetian of the south Urals which ORMISTON (1972) considered an Eurasiatic member of the genus. *Humeia* is another new dechenellid genus wide spread in the Eifelian of District of Mackenzie, Northwest Territories (ORMISTON, 1975).

CORGAN (1963) reported several Lower Devonian or Onesquethawan trilobites from Yukon and Northwest Territories of Canada among which three pygidia of *Terataspis* sp., *Odontocephalus* sp. and *Basidechenella* ? sp. were illustrated.

In East Central Alaska *Koneprusia* sp. (pygidium) showing Bohemian affinity was found together with *Leonaspis*, *Acanthopyge*, *Lacunoporaspis*, *Astycoryphe*, *Otarion* and *Reticuloharpes*. The age of this fauna is considered Emsian by ORMISTON (1969).

The trilobite fauna in these areas of North America is closely allied to the Siberian fauna. Like the latter the great variety of the dechenellid genera is the most striking characteristic of the Devonian trilobites in the region from the Canadian Arctic to Alaska through Western Canada. The absence, if not rarity, of the Phacopidae, Dalmanitidae, Calymenidae and Homalonotidae is another conspicuous aspect of this trilobite fauna in comparison with the rich fauna of eastern and central North America.

Devonian trilobites of the Central Lowland, North America described by COOPER and CLOUD (1939), STUMM (1953-57) and others belong to no less than 25 genera in 10 families as follows:

Scutelluidae: *Scutellum*, *Ancyropyge**
Odontopleuridae: *Acidaspis* ?
Lichidae: *Echinolichas*, *Ceratolichas**, *Terataspis**, *Acanthopyge*
Phacopidae: *Phacops*
Dalmanitidae: *Dalmanites*, *Odontocephalus**, *Cornura**, *Trypaulites**, *Anchiopsis**, *Greenops* (*Greenops*)*
Calymenidae: *Calymene*
Honalonotidae: *Dipleura*
Proetidae: *Proetus*, *Crassiproetus*, *Dechenella*, *Basidechenella*, *Monodechenella*, *Cyrtodechenella*
Otarionidae: *Otarion*
Brachymetopidae: *Cordania*, *Mystrocephala**

Compared to the Canadian fauna the Central Lowland fauna differs in the greater variety of families and genera and particularly in the presence of the Phacopidae, Dalmanitidae, Calymenidae, Homalonotidae and the Brachymetopidae, but the absence of the Aulacopleuridae. North American genera marked by asterisks occupy two-fifths of the total number of the genera.

There would be 80 or more species of trilobites among which dechenellids occupy a quarter. Phacopids, proetids and dalmanitids are represented by about 15 species, some 10 species and several species respectively. The other genera are each represented by one or a few species. In the abundance of dechenellids this fauna agrees with the Canadian one. *Crassiproetus* and MAXIMOVA's *Paciphacops* (*Viaphacops*) which includes *Phacops cristata* HALL, *Ph. pipa* HALL and CLARKE, *Ph. canadensis* STUMM and *Ph. nasutus* STUMM suggest the connection between this fauna and the Kazakhstan fauna through the Mongolian geosyncline.

Compared with the preceding, the Devonian trilobite fauna of the Appalachian mountains is distinguished by the development of the Dalmanitidae or the Synphoriidae and final radiance of the Lichinae. The dechenellids are less developed here than in the central lowland as well as the Arctic Canada. Now the authors think, however, that the difference of the Appalachian and central lowland faunas would be not sharp enough to distinguish the geosynclinal and shelf areas as two subprovinces (KOBAYASHI and HAMADA, 1975).

LESPÉRANCE (1975) promoted the Synphoriinae to the family rank. It is exclusively Devonian and almost all North America, although it is known from Mexico, Bolivia and Brazil. On the other hand it is absent in the Arctic Canada. This family was best flourished in southeastern North America or the Appohimchi subprovince by BOUCOT (1975) extending from Gaspé, Canada to Chiuhuahua, Mexico.

The anterior and middle lateral furrows are typically fused on the glabella in the Synphoriidae, although a pair of pits commonly indicate the middle laterals; pygidium multisegmented. The dorsal shield is further diversified not only by the trilobating tendency of the glabella but also by the axial and para-axial projections of the shields and their marginal indentation or deticulation. They are often accompanied by *Greenops* of the Asteropyginae and *Phacopina* of the Calmonidae, *Ceratolichas*, *Echinolichas*, *Gaspelichas* and *Terataspis*, all indigenous to the Appohimchi sea have spines on the cephalon and pygidium. In some phacopids of North America genal angles are produced or protruded into spines and axial rings bear median nodes or spines. Thus there are many spiny trilobites in the Devonian fauna of North America. The effacement of glabellar furrows and atrophy of visual organs on the other hand did not advance in American phacopids and proetids as in European ones. The Aulacopleuridae, Cheiruridae and Harpidae are rare or absent in the Appalachians and central lowland.

With marked contrast with these faunas in central and eastern North America the Lower Devonian trilobites from the Turkey Creek Inlier, Oklahoma reveals, according to ORMISTON (1968), conspicuous Hercynian aspects as below.

Much is not known of Devonian trilobites of the Cordilleran region of the United States of America. HAAS (1969) described late Helderbergian (Siegenian) and Emsian trilobites from Nevada and the Deerparkian (late Siegenian) ones from Chiuhuahua,

Turkey Creek species in Oklahoma	Hercynian species in Dalmaniten-Knollenkalk
Ceratonurus slecanus dilatus ORMISTON	*Ceratonurus slecanus slecanus* (ROEMER)
Cornuproetus pictus contractus ORMISTON	*Cornuproetus pictus pictus* (GIEBEL)
Reedops amsdeni ORMISTON	*Reedops intermedius* (BARRANDE)
Odontochile cf. *tuberculata* (ROEMER)	*Odontochile tuberculata* (ROEMER)

North Mexico. They belong to *Leonaspis*, *Koneprusia*, *Cheirurus*, *Phacops*, *Odontochile*, *Synphoroides*, *Decoroproetus* and *Cordania*. There are some species related to the Appalachian fauna closely. *Koneprusia*, on the contrary, a Bohemian genus and *Decoroproetus* an Eurasiatic one. *Cheirurus* (*Crotalocephalus*) sp. is represented only by two thoracic pleurae. Nevertheless, this is the first report of *Cheirurus* from the Devonian of Americas.

In connection with the Silurian-Devonian boundary it is of extraordinary interest that *Warburgella rugulosa eureka* ALBERTI, HAAS and ORMISTON, 1972, from the very basal part of the Devonian formation in the Robert Mountains, Central Nevada shows close affinity to the lower Gedinnian *W. rugulosa* of Germany definitely.

It is a remarkable fact that these Nevadan and Okalhoma faunas were derived from the Rhenish-Bohemian province. The latter is a colony migrated into North America from the south. The former, on the contrary, is possible to have taken the trans-Pacific route in view of the fact that *Crotalocephalina* is well flourished in Japan and the Mongolian geosyncline was a highway for Devonian trilobites to tranverse Eurasia. It is further noteworthy that *Odontochile* (*Kasachstania*) and *Ganinella* coexisting with Appalachian endemic trilobites in the Nevadan fauna (ORMISTON in BOUCOT, 1975).

IX. Devonian Trilobites of South America and the Malvinokaffric Province

Marine Devonian sediments are widely distributed in South America from northwest to southwest through the Andean geosyncline which was branched off in the south into the Argentine, Precordilleran and Patagonian troughs. The sea flooded on older rocks in the east where they are found in the Amazonas, Parniba and Paraña basins (HARRINGTON, 1967). They extend further to the Cape region of South Africa from South America through Falkland. The Bokkeveld Series of the Cape System yields Lower Devonian trilobites.

In South America the best Devonian sequence from Gedinnian to Givetian is seen in Bolivia. According to WOLFART and VOGDES (1968) the base of the Devonian System is marked there by the appearance of *Odontochile indii* (KOZLOWSKI) and *Phacopina* (*Phacopina*) *chojnacotensis* SWARTZ.

The Devonian faunas of South America, South Africa and other areas which constitute the so-called Malvinokaffric province by RICHTERS (1942) and others were described by CLARKE, KOZLOWSKI, REED and many others. The larger part of them is Lower Devonian in age and Middle Devonian in part. Trilobites typical of the Malvinokaffric fauna are as follows:

Devonian trilobite genera indigenous to the Malvinokaffric province and their distribution and type-species

- Dalmanitidae VOGDES, 1890
  - Dalmanitinae VOGDES, 1890
    - *Andinopyge* BRANISA, 1965, Bolivia. *Andinopyge spinulosa* BRANISA, 1965*
    - *Francovichia* BRANISA and VANĚK, 1973, Bolivia. *Odontochile branisi* WOLFART, 1968
  - Synphoriidae DELO, 1935
    - *Chacomurus* BRANISA and VANĚK, 1973, Bolivia. *Chacomurus confragosus* BRANISA and VANĚK, 1973
    - *Fenestraspis* BRANISA and VANĚK, 1973, Bolivia. *Fenestraspis amauta* BRANISA and VANĚK, 1973
    - *Gamonedaspis* BRANISA and VANĚK, 1973, Bolivia. *Gamonedaspis acutata* BRANISA and VANĚK, 1973
  - Asteropyginae DELO, 1935
    - *Argentopyge* BALDIS, 1974, Argentina. *Argentopyge argentina* BALDIS, 1972
    - *Australops* BALDIS, 1974, Argentina. *Australops australis* BALDIS, 1974
    - ? *Chiarumanipyge* BRANISA and VANĚK, 1973, Bolivia. *Chiarumanipyge profligata* BRANISA and VANĚK, 1973
- Calmoniidae DELO, 1935
  - Calmoniinae DELO, 1935
    - *Bainella* RENNIE, 1930 (syn. *Paradalmanites* PILLET, 1954), South Africa, ? Malvin Island, ? Brazil. *Bainella bokkeveldensis* RENNIE, 1930
    - *Bouleia* KOZLOWSKI, 1923 (syn. *Dereimsia* KOZLOWSKI, 1923), Bolivia. *Phacops dafinocourti* ULRICH, 1892
    - *Bolivianaspis* BRANISA and VANĚK, 1973, Bolivia. *Bolivianaspis scrutator* BRANISA and VANĚK, 1973
    - *Calmonia* CLARKE, 1913, Malvinokaffric province. *Calmonia signifer* VOGDES, 1917
    - *Cryphaeoides* DELO, 1935, Bolivia. *Cryphaeus rostratus* KOZLOWSKI, 1923
    - *Malvinella* WOLFART, 1968, Bolivia, ? Brazil (Paraña). *Anchiopella hanugi* KOZLOWSKI, 1923
    - *Metacryphaeus* REED, 1907, South Africa, South America (Argentina, Bolivia, Brazil, Paraguay, Urguay), Falkland Islands. *Phacops* (*Cryphaeus*) *caffer* SALTER, 1856
    - *Parabouleia* ELDREDGE, 1972, Bolivia. *Parabouleia calmonensis* ELDREDGE, 1972.
    - *Paracalmonia* STRUVE, 1958, (syn. *Proboloides* CLARKE, 1913 non VALLE, 1893; nec MORLEY, 1903), Brazil. *Proboloides cuspidatus* CLARKE, 1913
    - *Pennaia* CLARKE, 1913, Malvinokaffric Province. *Pennaia pauliana* CLARKE, 1913
    - *Probolops* DELO, 1935, Bolivia. *Proboloides glabellirostris* KOZLOWSKI, 1923
    - *Tibagya* STRUVE, 1958 (syn. *Schizopyge* CLARKE, 1913; nec HECKEL in RUSSEGGER, 1847), Brazil. *Homalonotus* (*Schizopyge*) *parana* CLARKE, 1913
    - *Schizostylus* DELO, 1935, Bolivia. *Dalmanites brevicaudatus* KOZLOWSKI, 1923
    - *Tarijactinoides* SORUCO, 1971, Bolivia. *Tarijactinoides jarcasensis* SORUCO, 1971
    - *Typhloniscus* SALTER, 1856, South Africa. *Typhloniscus bainii* SALTER, 1856
  - Acastinae DELO, 1935
    - *Kozlowskiaspis* BRANISA and VANĚK, 1973, Bolivia. *Kozlowskiaspis superna* BRANISA and VANĚK, 1973
    - *Phacopina* (*Vogesina*) WOLFART, 1968, Bolivia. *Acaste devonica* ULRICH, 1892

Incidentally, ELDREDGE (1972a) referred *Phacops dafinocourti* ULRICH, 1892, as well as " *Dereimsia* " *sphaericeps* KOZLOWSKI, 1923 to the genus *Bouleia* which he transferred to the Calmonidae from the Phacopidae and added *Parabouleia*, n. gen. (Type-species

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* BRANISA (1965) illustrated *Andinopyge spinulosa* gen. et sp. nov, but he added neither specific description nor its generic diagnosis. No mention is given of it in BRANISA and VANĚK (1973).

Parabouleia calmonensis, nov.) to the former family.

Beside these endemics, there are many genera common between the Malvinokaffric and other areas or so-called boreal-Malvinokaffric trilobite genera which are according to WOLFART (1968) *Leonaspis*, *Acanthopyge*, *Phacops*, *Dalmanites*, *Odontochile*, *Acastoides*, *Phacopina* (*Phacopina*), *Calymene*, *Dipleura*, *Burmeisteria*, *Digonus* and *Otarion*. The Scutelluidae, Cheiruridae, Proetacea exclusive of the Otarionidae and the Harpidae appear to be totally absent in the province. In other words, they are non-Malvinokaffric Devonian trilobites.

The find of *Burmeisteria* (*Digonus*) *antarcticus* SAUL, 1965, in the Horlick formation in the Ohio mountains, Antarctica shows faunal connections toward South America and South Africa on one side and on the other toward Europe-Mediterranean Province and New Zealand. Likewise, *Burmeisteria* (*Digonus*) *accraensis* SAUL, 1967, which was founded on the so-called *Trimerus* (*Dipleura*) *dekayi* from the early or middle Devonian Accraian Series of Ghana suggests any faunal connection between eastern South America and West Africa. The commingling of the Appalachian fauna with the South American one is indicated by *Anchiopella* in the Amazonas basin as well as *Trimerus* (*Diplerua*) in Bolivia.

The Malvinokaffric province may be divisible into the South African-Malvinian- ? West Antarctic subprovince and the South American subprovince (WALFART, 1968). While the former's faunal connection is traceable toward New Zealand, that of the latter is very distinct with the Appalachian geosyncline. On the basis afforded by brachiopods BOUCOT (1975) proposed "Amazon-Colombian subprovince" including Venezuela and combined it with the Appohimichi subprovince into the Eastern Americas realm, emphasizing the intimate relationship of the former's Emsian brachiopods to the Schoharie faunas of the latter. Like in the Silurian period the faunal relationship between the Asian and South American faunas was insignificant in the Devonian Period.

A further discussion on the palaeobiogeographic implication of trilobites will be found in the succeeding chapter on Trilobite Provinces in the early and middle Devonian Period.

X. On the Silurian-Devonian Boundary and Trilobite and Conodont Horizons near the Boundary in Japan and other Part of the Asia-Pacific Area

In Japan Upper Silurian and Lower Devonian rocks are found close-set in the Hikoroichi district, Kitakami mountains and the Fukuji district in the Hida plateau. In the former area the Kawauchi Series containing middle Ludlovian *Encrinurus kitakamiensis* in a limestone was said to be conformably overlain by the Takainari Series composed of reddish purple and dark green siliceous clayslates in alternation. The latter series was placed in Upper Silurian by ONUKI (1969) but in Gedinnian by HAMADA (1967). Because the Takainari is unfossiliferous except for *Cenosphaera* and indeterminable radiolarians, its age cannot be determined exactly.

The Takainari and older rocks are apparently overlained by the Ōno Series whose Lower Devonian age was determined by YABE and SUGIYAMA (1938) by the *Thamnopora* limestone in its lower part containing *Thamnopora crista* (BLUMENBACH) and other corals. This series consists of tuff and tuffaceous sandstone in main, but in the basal part occur conglomerate beds. According to ONUKI (1969) the base of the series is marked by an unconformity, because not only the conglomerate contains clayslates apparently derived from the Takainari Series, but also because of the sudden change of lithofacies and the distribution of the Ōno Series. According to MURATA and MORI (1974), however, the Takainari Series must be in part synchronous with but heteropic from the lower part of the Ōno Series, because Ludlovian *Schedohalysites kitakamiensis* (SUGIYAMA) was found in limestone lenses intercalated in its basal part.

Thus the stratigraphy of the Upper Silurian and Lower Devonian rocks is a moot question. In the Hikoroichi district the Nakazato Series yields Middle Devonian *Thysanopeltella* (*Septimopeltis*) *paucispinosa* and a few other trilobites, but none is known from either the Ōno or the Takainari Series.

In the Hida plateau *Encrinurus fimbriatus* KOBAYASHI and HAMADA was found at a locality and *Scutellum* sp. by KOBAYASHI and HAMADA, 1969 at another locality in Hitoégané hills adjacently north of Fukuji where the former is Ludlovian or probably upper Ludlovian. Whether the latter is Upper Silurian or wherther it is Devonian is a question, although it is very similar to *Hidascutellum multispiniferum*. The stratigraphic relation between these trilobite horizons is still undetermined.

Since the present authors announced a preliminary report on the Fukuji trilobites (1974), lower Gedinnian conodonts such as *Icriodus worschmidti worschmidti* ZIEGLER and *Spathognathodus remscheidensis* ZIEGLER were discovered by IGO, KOIKE and IGO (1975) in the lower part of the Fukuji Series, namely in a limestone of the F_1 zone by KAMEI. In Czechoslovakia the early Devonian conodont fauna containing the former subspecies is found associated with *Warburgella rugulosa rugulosa* (BOUČÉK). The latter ranges almost all through the lower Gedinnian from its base. This conodont horizon must be the correlative of the *I. worschmidti*-*S. remscheidensis* zone of the Elmside formation in the Yass basin, New South Wales (LINK, 1970).

This find is particularly interesting because it vindicates the authors' prediction that the lower limit of the Fukuji trilobite beds probably extends lower than the range from upper Siegenian to lower Eifelian by the reason that the Fukuji fauna containing an unnamed subgenus of *Crotalocephaus*, i.e. *Geracephalina* of *Crotalocephalina* in this monograph includes probably *Crotalocephalus expansus* MAXIMOVA, 1968, from the upper part of the Kochbaitai horizon, now referred to the basal Devonian in Kazakhstan by MAXIMOVA (1968). Unfortunately, any Silurian fossil has as yet been uncovered in the main area of the Fukuji Series to the west of Fukuji village.

In Central and South China a stratigraphic break is found widely between Upper Silurian and Lower Devonian formations. The Lienhuashan stage which is the Lockhovian equivalent yields fishes such as *Yunnanolepis* and *Kwangsilepis*. Devonian corals and brachiopods first appear in the Nakaoling stage, the middle and upper Siegenian equivalent (WANG, YÜ and WU, 1974). The limnic and paralic facies are widely distributed in the basal part of the Devonian System not only in South China, but also in Viet-Nam. In Annam the Silurian and Devonian sequences seem unbroken, but unfossiliferous near their boundary in question.

In the Burmese-Malayan geosyncline an exact boundary is expectable within the Washih-Zebingyi facies in Yunnan-Shan plateau. Upper Silurian and Lower Devonian conodonts occur in some horizons in Northwest Thailand where the system boundary lies probably between the two horizons with *Spathognathodus steinhornensis* cf. *eosteinhornensis* and *Sp. steinhornensis* cf. *remscheidensis* (BASTIN et al., 1970). *Monograptus praehercynicus* and a few younger Lower Devonian graptolites were found in the Fang-Chian Mai area (JAEGER et al., 1968, 1969).

In the Langkawi Islands, Northwest Malay IGO and KOIKE (1973) discovered in the top part of the upper Setul limestone *Spathognathodus steinhornensis eosteinhornensis* in a horizon and *Icriodus worschmidti* and *Spathognathodus remscheidensis* in another about 20 m above the preceding. Because the former represents the uppermost Ludlovian or the Pridolian of Bohemia, while the latter indicates the basal part of the Gedinnian stage, the system boundary should be drawn between these two conodont horizons. *Monograptus* cf. *uniformis* occurs in the basal part of the upper Detrital band which overlies the limestone formation conformably (JONES, 1968). IGO, KOIKE and IGO (1975) are of opinion that this form of graptolites would be different from *M. uniformis* specifically. Little is so far known of trilobites of the Gedinnian or Lockhovian age in this geosynclinal zone.

A conspicuous coincidence is found between the sequence of Malaysia and Turkey in view of the fact that the top part of the Akviran formation composed of limestone, 50 m thick in Bithynia, Northwest Turkey, also yields *Spathognathodus steinhornensis eosteinhornensis* in the lower 20 meters and *Icriodus worschmidti* and *Spathognathodus remscheidensis* in the upper 10 meters. This part of the limestone beds is considered by HAAS (1967, 1968) to be transitional from Upper Silurian to Lower Devonian. Thus the boundary drawn between these conodont horizons in Turkey and Malaya is almost exactly coeval with that of the European type-sequence, although neither *Monograptus uniformis* nor *Warburgella rugulosa* is found there.

From the view point of key-trilobites to the boundary problem most important in Asia is the Mountain Altai where it was determined recently by YOLKIN, ZHELTONOGOVA and others to be drawn between *Warburgella volkoveyana* zone below and the *W. rugulosa* zone above (GRATSIANOVA ed., 1974). *Warburgella* (*Warburgella*) *volkoveyana* BALASHOVA was primarily described by BALASHOVA (1968) from the *Acastella spinoda podolica* zone of the upper Ludlovian Skalsky horizon. *Warburgella* (*Podolites*) *rugulosa* occurs in the *Acastella herberti elsana* and *Acastella tire* zones of the Lower Devonian Borshtchovsky horizon. The *Warburgella rugulosa eureka* zone of Central Nevada must be almost exactly contemporaneous with the *W. rugulosa* zone of Eur-Asia.

Among trilobite genera or subgenera especially important for the boundary problem are probably *Encrinurus* and *Crotalocephalina* (*Geracephalina*). As noted elsewhere (KOBAYASHI and HAMADA, 1976, in this monograph, p. 34) a few species of *Cheirurus* or *Crotalocephalus* have been reported to occur in Turkestan at some localities with *Encrinurus*, but presumably in a slightly different levels at the localities, because according to MAXIMOVA (1967) *Encrinurus* is absent in the Kochbaital fauna, but *Crotalocephalus* (or *Crotalocephalina*) is present already in the Ainas beds of the Kochbaital horizon in Central Kazakhstan. The horizon or at least its lower part was previously considered Upper Silurian, but later it was concluded by MAXIMOVA (1971) on the basis of sporadical appearance of *Dicranurus*, *Odontochile* (*Kasachstania*, *Reussia* and *Odontochile* s. str.), *Crotalocephalus* (or *Crotalocephalina*) and *Paciphacops*, that the

Ainasu horizon or the lower Kochbaital horizon was relevant to be taken for the lowest Devonian sediment. This conclusion is now supported by the fact that *Crotalocephalus expansus* MAXIMOVA of the Kochbaital belongs most probably to *Crotalocephalina* (*Geracephalina*) which subgenus is proven in Japan to have appeared in the Gedinnian age.

Another area whence *Encrinurus* and *Crotalocephalus* have been described from the Upper Silurian—Lower Devonian rocks is Southeastern Australia and Tasmania. In regard to the former genus MITCHELL (1924) has already noted that its occurrence in Australia was confined to the pre-Devonian formations. Of the latter genus all Australian forms look to be Devonian crotalocephalinids rather than Silurian *Crotalocephalus* s. str. Some of them have already been ascertained their Devonian age, while none was confirmed by recent studies to be a Silurian trilobite.

A moot question is, however, attached to Lyell Highway locality high in the Florentine sandstone of the Eldron Group, Tasmania which yielded *Encrinurus* aff. *silverdalensis* ETHERIDGE and MITCHELL and *Cheirurus* sp. which appears to the authors to be referable to *Crotalocephalina.* If the Lyell Highway faunule be Lower Devonian (GILL, 1948, 1962), the above form of *Encrinurus* must be a sole relic. If it be really pre-Gedinnian (PHILIP, 1967), " *Cheirurus* " sp. would be a progenitor of *Crotalocephalina.*

Three other trilobites of the faunule are *Gravicalymene australis* (ETHERIDGE and MITCHELL), *Odontopleura* aff. *rattei* ETHERIDGE and MITCHELL and *Dalmanites* aff. *wandongensis* GILL where the first is widely ranged from middle Ludlovian to Lochkovian or even Middle Devonian. The second and third forms bear affinities respectively to *Leonaspis rattei* (upper Ludlovian-Lochkovian, N. S. W.) and Melbournian *W. wandongensis* (uppermost Wenlockian-Ludlovian, Victoria). Judging from the five species of trilobites it is probable that the faunule indicates a short time interval near or just on the system boundary.

Leaving its solution in future, it can be concluded that *Encrinurus* died out by the end of the Silurian Period and reciprocally *Crotalocephalina* appeared in the early Devonian Period. Its two subgenera, *Crotalocephalina* and *Geracephalina,* were already present in the Gedinnian Epoch.

Finally it is certain in the present state of knowledge that the Silurian-Devonian boundary must be drawn in Japan between the *Encrinurus fimbriatus* horizon and the *I. worshcmidti-S. remscheidensis* horizon in the Fukuji district. The boundary in question will be definitely determined stratigraphically, if the passage beds unbroken between these two horizons be found in future in the district.

XI. Trilobite Provinces in the Early and Middle Devonian Period

The advancement of the Devonian biostratigraphy was greatly accelerated in recent years by repeated international symposia on the Devonian System held at Prague, 1958, Bonn and Bruxelles, 1962, Calgary, Canada, 1967 and Leningrad, 1969. As the result the world picture of the Devonian Period can be drawn in a greater accuracy than before. Therefore the Devonian biogeography and provinciality were discussed successively by ERBEN, BOUCOT and many others with reference to magnifacies, brachiopods and other fossils including trilobites which the last were dealt with in articles by ORMISTON (1968), WOLFART and VODGES (1968), LESPÉRANCE and BOURQUE (1971), TALENT et al. (1972) and so forth. The present authors outlined *Devonian trilobite provinces* in an advance paper of this research project (1975).

The report of the Devonian symposium at Calgary, 1967, in two volumes was particularly helpful to get the Devonian concept, because it comprises many papers by Soviet geologists and palaeontologists which afford recent knowledge on the Devonian System in the northern and western parts of Asia to readers like the authors to whom it is difficult to absorb up-to-date data directly out of the *Devonian System* in 2 volumes, 1973, in NALIVIKIN's *U.S.S.R. Stratigraphy*. Of the Devonian of China, *Stratigraphic Tables of China*, 1956 and its supplement, 1958 and WANG and YÜ's *The Devonian System of China* were principal sources for the authors, but new results were compiled in *Advance in Devonian Biostratigraphy of South China*, 1974 by WANG, YÜ and WU. Incidentally, recent advancement in the Devonian biostratigraphy of Thailand and Malaysia is summarized by HAMADA et al. in *Geology and Palaeontology of Southeast Asia*, volume 15. 1975.

In Europe and North Africa two magnifacies, that is, the Rhenish and Hercynian magnifacies are distinguishable in the Devonian marine sediments and fossils contained. According to ERBEN (1962) the Hercynian magnifacies seems to be connected with off-shore regions, lacking or almost lacking terrigenous material, with fine grained carbonatic and/or argillaceous sediments of muddy bottom and faunas adapted to this type of environment. Of the Hercynian biofacies the characteristic of trilobites is richness in number of genera, species and individuals; taxonomically the Hercynian trilobites are represented by the Proetidae, Otarionidae, Harpidae, Scutelluidae, Odontopleuracea, Lichacea, Calymenidae, Cheiruridae, *Odontochile* and *Phacopidella* (ERBEN and ZAGORA, 1967). Thus most of these Hercynian taxa are nearly cosmopolitan.

The Rhenish magnifacies seems to be connected with near-shore regions, with high percentages of terrigenous material, with coarse and median grained sandy sea-bottoms poor in carbonatic and argillaceous material, to which a certain type of faunas has been adapted. Among them characteristic of trilobites is poorness in number of genera and individuals: typical genera are *Acaste*, *Asteropyge*, *Neometacanthus*, *Treveropyge* and related asteropygids and *Homalonotus* and its allies. Because the Rhenish trilobite faunas bear such distinct characteristics, they are much more important to define the Europe-Mediterranean province or the Rhenish-Bohemian province than the so-called Hercynian trilobites many of which are nearly cosmopolitan.

The Rhenish trilobite facies is widely distributed from North Europe to South Africa outlining the Devonian geosyncline and further around islands within the geosyncline. It is well developed in North Africa in the Anti-Atlas, Morocco (HOLLAND, 1967) and the Algerian Sahara (LEGRAND, 1967). It is known from the Middle Devonian of Poland (KIELAN, 1954) and Lower Devonian of Podolia and Eastern Roumania (BALASHOVA, 1968, PATRULIUS, 1967), but any further to the east of Eurasia except for South Asia. The Rhenish trilobites are traceable in South Asia as far as Chitral, Pakistan where they made a great endemic development yielding many new genera and subgenera in Bithynia, Turkey and Afghanistan.

With special reference to brachiopods BOUCOT, JOHNSON and TALENT (1969) distinguished three provinces beside five subprovinces in the early Devonian palaeo-

Table 7. Devonian biogeographic realms, provinces, subprovinces (S) and regions (R).

Lower Devonian Biogeography		Devonian Biogeography	
Province	Subprovince	Region or Subprovince	Realm
Old World	Rhenish-Bohemian	Rhenish-Bohemian R.	Old World
	Uralian	Uralian R.	
	undifferentiated	Mongolo-Okhotsk R.	
	Tasman	Tasman R.	
	New Zealand	New Zealand R.	
	Cordilleran	Cordilleran R.	
		Nevadan S.	Eastern Americas
Appalachian		Appohimchi S.	
		Amazon-Colombian S.	
Malvinokaffric			Malvinokaffric
Boucot, Johnson and Talent (1969)		Boucot (1974, 1975)	

geography. Subsequently Boucot (1974, 1975) modified the Devonian biogeographic division, into three realms beside several regions and subprovinces as shown in Table 7.

On the basis of trilobite faunas Wolfart and Vogdes (1968) divided the Malvinokaffric province into the South American subprovince and the South African-Malvinian-? West Antarctic subprovince, whereas Ormiston (1972) distinguished four Devonian trilobite areas in North America as below.

Arctic Islands	Uralian subprovince	Old World province
Western Canada and Alaska	Siberian-Canadian subprovince	
Great Basin	Cordilleran subprovince	
Appalachian province		

Trilobites may be neither so important as brachiopods in Devonian biostratigraphy nor so valuable as in the Cambrian biogeography. In fact, data in concern are less accumulated on trilobites than brachiopods. Nevertheless, trilobites have well fiourished in the global scale in the early and middle Devonian Period attaining acmic prominence in Emsian and early Eifelian ages. Therefore the discussion below on the Devonian trilobite provinces are inevitably related most to the part of the period.

Recently the authors attempted to clarify Devonian provinciality with reference to trilobites (1975). As the result they distinguished five provinces beside several subprovinces. This biogeographic division is here modefied and the provinciality discussed in a greater detail.

From the viewpoint of provinciality most distinctive is the Lower and Middle Devonian fauna of South America and South Africa, namely, the Malvinokaffric fauna which contains many indigeonus genera of the Phacopinae, Dalmanitinae, Synphoriinae, Acastavinae, Asteropyginae, and Calmoninae, beside some endemic species of the

Homalonotidae. This province may extend into Antarctica as well as Ghana, West Africa as suggested by the following two trilobite species.

According to SAUL (in HADLEY, ed., 1965) *Burmeisteria* (*Digonus*) *antarcticus* is nearer to the homalonotids of the southern hemisphere and Europe than those of North America and quite different from *B.* (*D.*) *expansus* from New Zealand. The Horlick fauna of the Ohio range in Antarctica which yielded this trilobite is correlated to the Tibaji fauna of Paraña, Brazil and the Bokkeveld fauna of the Cape region, South Africa (DOUMANI et al., 1967).

Burmeisteria (*Digonus*) *accraensis* was denominated by SAUL (1967) for the so-called *Trimerus* (*Dipleura*) *dekayi* from the Devonian of Ghana, West Africa. It may be a Malvinokaffric trilobite, but it is still inconvincing, if this trilobite or the Accraian fauna is most related to the Devonian fauna of North Africa, South Africa or South America (SAUL, BOUCOT and FINKS, 1963). *Digonus* is not a Malvinokaffric subgenus, but a boreal-Malvinokaffric one reported from Europe, North Africa, South America, South Africa, West Antarctica and New Zealand beside West Africa.

Now the Malvinokaffric trilobite fauna is analysed. Because there appears to be disagreements as to the Silurian or Devonian age for certain South American trilobites, the below discussion is principally referred to the Devonian trilobite genera in Table 4 in WOLFART (1968).

WOLFART divided the Malvinokaffric and the boreal-Malvinokaffric groups among the trilobite genera of the province. Here the latter group is divided again into the true boreal-Malvinokaffric subgroup and the nearly cosmopolitan subgroup where the last can be eliminated out of this discussion. For the interprovincial relationship most important is the true boreal-Malvinokaffric subgroup which includes the following genera.

Acastoides: Europe, North Africa, Bolivia, Uruguay
Phacopina (*Phacopina*): North America (Appalachian), South America (Bolivia, Amazon, Argentina)
Dipleura: Europe, Turkey, North Africa, North America (Appalachian), South America (Colombia, ? Bolivia)
Burmeisteria: North Africa (Sahara), ? Bolivia, Falkland Islands, New Zealand
Digonus: Europe, North Africa, ? North America, South America (Bolivia, Brazil, Uruguay, ? Argentina), West Africa (Ghana), South Africa, West Antarctica, New Zealand.

It is certainly a remarkable fact that *Acastoides* connects the South American fauna with the Europe-North African one and *Burmeisteria* (*Burmeisteria* and *Digonus*) reveal faunal affinities toward North Africa on one side and toward New Zealand on the other. Because they are unknown from North America, there must have been a trans-Atlantic route of migration between North Africa and South America.

Phacopina (*Phacopina*) is, on the contrary, an important link of the Appalachian fauna with the South American one. *Dipleura* may be a genus showing relationships of the Colombian fauna to the Appalachian fauna as well as the Europe-North African fauna.

Recently BOUCOT (1975) proposed to combine the Appohimchi subprovince with the Amazon-Colombian subprovince into the Eastern Americas realm. The Amazon (A) and Colombian (C) faunas comprise the following trilobites genera.

Metacryphaeus	A	
Tibagya	A	
Malvinella	A	
Dipleura		C
Digonus	A	
Dalmanites		C
Odontochile	A	
Phacopina (*Phacopina*)	A	

Thus there is no common trilobite genus between the Amazon and Colombian faunas. Neither *Dipleura* nor *Dalmanites* is a typical genus of either the Appohimchi or the Malvinokaffric fauna. Therefore it is difficult to say out of the trilobites which of the two faunas is nearer to the Colombian fauna. It is a conspicuous difference that the Malvinokaffric group is represented by three genera in the former but unrepresented in the latter. According to WOLFART Devonian trilobites of the Amazon basin consist of three Malvinokaffric genera and another three boreal-Malvinokaffric genera. As mentioned already, the occurrence of *Digonus* in North America is doubtful, but HARRINGTON (1967) pointed out the inclusion of such Appalachian genera as *Anchiopella* and *Synphoria* in the Amazon fauna. Judging from the above trilobites the Amazon basin was at the junction of the three provinces where the Appalachian, Europe-African and Malvinkaffric trilobites were coexisted. Three new genera of the Synphoriinae deseribed from Bolivia by BRANISA and VANĚK, 1973, reveal the faunal connection between the Appalachian and Andean geosynclines and at the same time the endemic development of the subfamily there occurred.

During the Devonian Period there were in North America two major biogeographic areas, namely, the Appalachian province or the Appohimchi subprovince of the Eastern Americas realm extending from Nova Scotia, Canada to Chihuahua, Mexico on the southeast side of the continent and the Siberian-Canadian subprovince of the Arcto-Pacific province on the other side, beside a minor area in the west which is called the Cordilleran or Nevadan subprovince. The two major subprovinces were separated from each other by a large Devonian land diagonally extending into the continent from Greenland, but seas on its two sides have probably become confluent intermittently near the center of the continent as suggested by the scattered occurrences of *Ancyropyge* in the Middle Devonian rocks of the Arctic archipelago, Manitoba, Michigan, and so forth.

The Appalachian fauna is well defined particularly by the development of the Synphoriidae and the final radiance of the Lichinae. In Nova Scotia, however, Rhenish acastavinids are found in the Lower Devonian Torbrook formation. In Oklahoma a colony of Hercynian trilobites is known from the Lower Devonian of Turkey Creek Inlier. There were probably four routes of the trans-Atlantic routes of migration. One was through Nova Scotia and another via Oklahoma. The remaining two routes were from the Amazon basin to North and West Africa and from Falkland to South Africa.

The Eurasian-North American route of migration in the Gedinnian age is on the other hand, indicated by the wide distribution of *Warburgella regulosa* and its subspecies from Nevada to Eurasia through Western Canada, Arctic Islands and Alaska. Little is so far known of Devonian trilobites of the Coastal Ranges (BOUCOT et al., 1973), but juding from the Lower and Middle Devonian trilobites of the Great Basin the Cordilleran fauna appears to be allied to the Appalachian fauna on the one hand and to the Eur-Asiatic one on the other (ORMISTON, 1972).

ORMISTON (1972) distinguished two Emsian-Eifelian faunas of the Arctic islands as well as Alaska-West Canada and referred the former to the Uralian subprovince and the latter to the Canadian-Siberian subprovince. Neither a barrier nor any distinct boundary is known between these two areas and the difference between the two faunas is rather gradual, like the two Appohimchi faunas of the Appalachian geosyncline and central lowland. Therefore the former pair would be two regions within the Uralian-Siberian-Canadian subprovince as the latter pair are those within the Appohimchi subprovince.

The Cordilleran faunas are allied to the Uralian-Siberian-Canadian faunas but differ from them in the inclusion of the Calymenidae, Phacopidae and the Dalmanitidae in which respect it is related to the Appohimchi faunas on the east side and the Mongolian ones on the west side of the Pacific basin.

The palaeogeographic areas on the west and north sides of North America have been referred to the Old World province by BOUCOT, ORMISTON and others. Because the so-called Old World province covers all of the Old and New Worlds except for the Malvinokaffric province and the Eastern Americas realm, how to divide this extensive palaeogeographic area into provinces and subprovinces by means of its comprehensive faunas is an important problem. For the purpose to reconsider an attempt is made to pick up some characteristic trilobites which would define such provinces and subprovinces. The most conspicuous distinction of the North American faunas from those of Eurasia, Australasia and North Africa is the total absence of *Cheirurus* except for two imperfect thoracic pleurae procured in Chihuahua and referred to *Cheirurus* (? *Crotalocephalus*) by HAAS (1969). It is not the less conspicuous that all of the dechenellids are unrepresented in either Australia or New Zealand, if *Dechenella* (*Eudechenella*) *mackayi* ALLAN from New Zealand is excluded (RICHTERS, 1950), not withstanding the fact that the Dechenellidae are widely distributed in the northern hemisphere. By means of these characteristic trilobites three areas can be distinguished as follows:

(1) Eurasia and North Africa with *Crotalocephalina* and dechenellids.
(2) Australasia with *Crotalocephalina* but no dechenellids.
(3) North America with dechenellids, but cheirurids are extremely rare.

Then the interprovincial relation should be discussed. As pointed out by MAXIMOVA (1972), *Paciphacops*, *Odontochile* (*Kasachstania* and *Reussia*), *Praedechenella* and *Dechenellurus* together with *Crassiproetus* indicate the trans-Pacific connection between Kazakhstan to North America through the Mongolian geosyncline in the west and the Great Basin in the east.

While no scutelluid is as yet known from the Mongolian-Okhotsk geosynclinal zone, *Boreoscutellum* occurs in the New Siberian Islands, and Eastern Siberia and *Arctipeltis* in Novaja Zemlja, the Kuznetsk basin and probably in Ellesmere Island. *Dechenella* is also wide spread in the Urals, the Soviet Arctic, Siberian platform and North America and various dechenellids were flourished in Canada and the Arctic Islands no less than Southwest Siberia or Eurasia. It is certain that the Uralian-Siberian-Canadian faunal connection was well maintained through Eastern Siberia and Alaska. The Phacopidae and Dalmanitidae are rare or absent in North Asia as in Alaska and Canada.

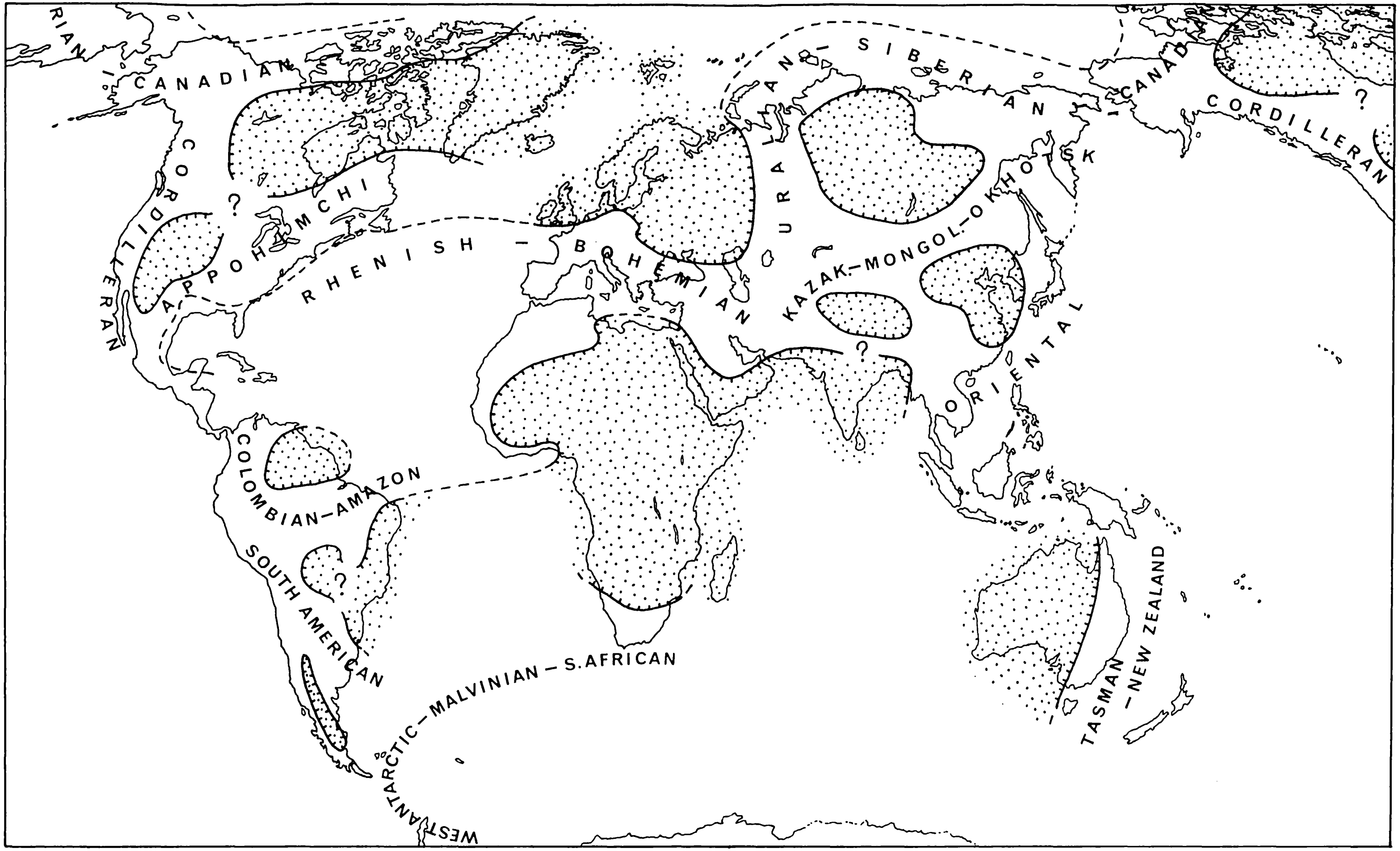
In North Asia again it is difficult to divide the Uralian-Siberian-Canadian subprovince into the Ural-Arctic and Siberian-Canadian areas. The faunal characteristic and the biogeographic boundary between this subprovince and the Mongolian-Okhotsk subprovince become not very distinct in Turkestan. At the same time it can hardly be overlooked that the Ural and Turkestan faunas reveal certain important alliances with the Hercynian or Bohemian faunas as indicated by such spiny scutelluids as *Weberopeltis* and *Thysanopeltella* (*Arctipeltis*, *Altaepeltis*) in Bohemia, the Carnic Alps and Montagne Noire, South France (ERBEN, 1969, FEIST, 1974). It is also a remarkable fact that *Aulacopleura* (*Paraaulacopleura*) cf. *beyrichi* (NOVAK) contained in the Emsian Eids Formation in Bathurst Island, Canadian Arctic indicates an isolated occurrence of a Bohemian-type trilobite in the Ural-Arctic region of the Siberian-Canadian subprovince (ORMISTON, 1967).

As pointed out already (p. 45), the Rhenish fauna is distributed in Asia any further to the east beyond Pakistan. The Praguian graptolites were recently discovered in the Liangquan Formation in South Tibet (MU et al., 1973), but no Devonian trilobite is known from the Himalayas or the Trans-Himalayas. The Oriental fauna in Eastern and Southeastern Asia is, as detailed already, quite distinct from the Rhenish fauna in Near East and Middle East. It is different also from the Mongolian fauna. With emphasis on the abundance of *Crotalocephalina* the Fukuji fauna of the Oriental province reveals affinities to the coeval faunas of Turkestan as well as Australasia and further to the Hercynian faunas of Europe and North Africa.

The Oriental fauna is intimately related to the fauna of Southeast Australia with regard to the common occurrences of *Gravicalymene*, *Crotalocephalina* (*Geracephalina*) and indigenous *Craspedarges* to the Western Pacific province. The presence of

Table 8. Early and middle Devonian trilobite realms and provinces.

Realm	Province	Subprovince	Subprovince	Province
Old World	Rhenish-Bohemian	Rhenish	Europe-Mediterranean	
	Western Pacific	Oriental	Oriental	Western Pacific
		Tasman-New Zealand	Tasman-New Zealand	
	Arcto-Pacific	Ural-Siberian-Canadian	Siberian-Canadian	Arcto-Pacific
		Kazakhstan-Mongolian-Okhotsk	Kazakhstan-Mongolian-Okhotsk	
		Cordilleran, Nevadan	Cordilleran	
New World	Eastern Americas	Appohimchi		Appalachian
		Amazon-Colombian		
	Malvinokaffric	South American		Malvinokaffric
		South African-Malvinian-West Antarctic		
KOBAYASHI and HAMADA (1976)			KOBAYASHI and HAMADA (1975)	



Text-fig. 2. Palaeogeographic map showing early and middle Devonian trilobite subprovinces.

dechenellids and absence of homalonotids are two important distinctions of the Oriental subprovince from the Tasman-New Zealand subprovince in the Western Pacific province.

In the vast terrain of Asia and other continents much remains to be explored in future. There are still many ambiguities in the Devonian biogeography. Nevertheless, it is a conspicuous fact that there were a major and a minor realm, i. e. the Old and New World Realm. The latter can be principally distinguished from the former by rarity or absence of the Cheiruridae. The Malvinokaffric fauna which is most distinctive differs not only from the Eastern Americas fauna but also all other faunas in the total absence of the Scutelluidae. The provinciality of the Old World realm is not so simple, but it may be divided into three provinces and several subprovinces as discussed already. On the basis of salient facts the proposal of the Devonian trilobite provinces in 1975 is here reconsidered and modified as shown in Table 8 and Text-fig. 2.

XII. Summary and Conclusion

In Japan there are two Devonian faunas, viz. the Fukuji and Nakazato faunas which are respectively Gedinnian-Eifelian and Middle Devonian in age. The former in the Hida plateau is a rich one comprizing 24 species in 12 genera and 7 families and the latter in the Kitakami mountains a poor one represented only by 4 species in 4 genera and 3 families. They total 28 species in 18 genera and 9 families.

The Fukuji trilobites lived with various kinds of animals in shallow sea near land which was not so quiet as the Devonian Kroh sea in Malay but not so rough as the Silurian Yokokura sea in Shikoku Island.

The Devonian fauna of Eastern Asia so far known consists of some 100 species, 38 genera and 10 families which are distributed in the Mongolian geosyncline, Yangtze basin, Chichibu geosyncline and the Burmese-Malayan geosyncline of which the latter three regions constituted the Oriental trilobite subprovince.

Devonian trilobites in Asia belong to some 80 genera in 14 families. Their assemblages in the north side, middle part and the southeastern and southwestern sides are so different from one another that the Uralian-Siberian-Canadian subprovince, Kazakhstan-Mongolian-Okhotsk subprovince, Oriental subprovince and the Asiatic part of the Rhenish-Bohemian province can be distinguished. While the Oriental subprovince is combined with the Tasman-New Zealand subprovince in the Western Pacific province, the first two subprovinces belong to the Arcto-Pacific province.

On the basis of trilobites there were two realms, five provinces and ten subprovinces in the early and middle Devonian Period as shown in Table 4 and Text-figure 2. The Cordilleran-Nevadan and Amazon-Colombian subprovinces, however, bear interprovincial aspects. Therefore their reference to either one of two neighbouring provinces must be decided after the whole faunal elements will be clarified.

Palaeontology

Introduction and Summary

The palaeontological part of this monograph is largely occupied by descriptions of twenty-five species of Devonian trilobites of Japan in sixteen genera in the Scutelluidae, Odontopleuridae, Lichidae, Cheiruridae, Phacopidae, Calymenidae, Proetidae, Dechenellidae and Otarionidae. Beside them it comprizes the following three other new trilobites, namely.

Pseudotrinodus constrictus, nov. from Thailand
Phacops machuricus, nov. and
Odontochile sp. indt. from Northeast China (North Manchuria).

Comments are given on some other Devonian trilobites and one Carboniferous trilobite from Eastern Asia as follows:

Gravicalymere maloungkaensis (MANSUY)
Dechenella indonesiensis (MANSUY)
Dechenella (?) *chengi* (SUN)
Monodechenella aff. *macrocephala* (HALL) by PATTE
Basidechenella (?) *blondeli* (PATTE)
Waribole elliptica (MANSUY)
Otarion giraudi (MANSUY)
Otarion tiaomachiensis (SUN)

One new genus and one new subgenus proposed herein are

genus *Hidascutellum* in the Scutelluidae,
subgenus *Geracephalina* of genus *Crotalocephalina*.

The Eoacidaspididae, Odontopleuridae, Lichidae, Cheiruridae, Phacopidae, Calymenidae, Proetidae and Dechenellidae are discussed in some length. The first four families were probably derived from the Corynexochidian stock. Of the Cheiruridae the oldest subfamily is the Pilekinae which in turn is intimately related to the Damesellidae as well as the Dorypygidae. The latest survivor of the same family is genus *Crotalocephalina*. Its subgenus *Geracephalina* reveals phylogerontic specialization in various ways.

Craspedarges has generally been thought the latest lichid survivor in the late Devonian Period, but the possibility of penecontemporaneity of *Craspedarges wilcanniae* with *Cr. superbus* suggests that the Lichidae or the order Lichida have totally died out before the late Devonian Period.

A review of the Phacopinae and *Phacops* shows the chaotic state of their taxonomy with regard to the generic and subgeneric concepts. The family Calymenidae exclusive of synhomalonotids is here proposed to be classified into four subfamilies. A critical review is added further on the Proetidae and Dechenellidae.

As to the trilobite morphology the trilobation of the axial lobe by means of paraxial furrows and the annulation of the glabella by transglabellar furrows are discussed and it is concluded that the former indicates a progressive specialization, whereas the latter is an example of retrogressive specialization, both in the phylogerontic stage.

The abbreviations of repositories for the specimens described and illustrated are as follows:

IGPS=Institute of Geology and Paleontology of Tohoku University, Sendai.
Kyoto Univ.=Institute of Geology and Mineralogy, Kyoto University.
T. U. E.=Institute of Geology and Mineralogy, Tokyo University of Education
Shizenkan=Hida Shizenkan Museum, Fukuji, Gifu Prefecture.
PAt=University Museum, University of Tokyo.

The Trilobation of the Axial Lobe in Miomeric and Polymeric Trilobites

One of the most conspicuous trends of specialization which can be seen among post-Cambrian trilobites is the t-trend evolution, that is, the trilobation of the axial lobe into a front-median and two lateral lobes, because it is quite rare to see in Cambrian polymeric trilobites. The trend of evolution is recognizable in the Scutelluidae not only in the glabella but also in the pygidium. The trilobation of the glabella is made by the connection of lateral furrows by paraxial furrows. It is most diagnostic of the Thysanopeltinae in this family as the authors have proposed for it the t-trend of evolution.

This kind of specialization is, however, more developed in the Lichidae and Odontopleuridae in which the glabella consists of a front-median and two lateral lobes of which the latter being coalesced so as to constitute bicomposite or tricomposite lateral lobes. The trilobation of the glabella and also the coalescence of lateral lobes have occurred in the Dalmanitidiae in such genera as *Trypaulites* and *Chasmops.* These aspects are diagnostic of the Monorakidae. Among other trilobites they are also seen in *Dionide* and *Endymionia* in the Trinucleina. In the Cheirurina paraxial furrows are seldom met with on the glabella. *Cybeloides* is a rare exception.

Among polymeric trilobites the trilobation of the axial lobe is rare to see on the pygidium. In the Scutelluidae, however, the short triangular axial lobe is commonly divided into a prominent median ridge and the two flat lateral platforms. In the Encrinuridae the polysegmented axial lobe of the pygidium is often tripartate by the interruption of the non-segmented median zone, but it is not a true trilobation, for the zone is not bounded by paraxial furrows.

Among miomeric trilobites the trilobation of the axial lobe did not take place in the Eodiscina (KOBAYASHI, 1943, 1944), but it was well advanced in the Agnostina in a different way from polymeric trilobites (KOBAYASHI, 1939). Namely, no agnostid has had any paraxial furrows on the glabella, but a median tubercle is commonly elongated into a median ridge, dividing the lobe into three parts. In the Agnostina the trilobation is more developed in the pygidium than the cephalon. It is often to see that one or a few anterior axial rings of the pygidium are trisected by paraxial furrows and that a median ridge runs across two or more anterior axial rings. In the Condylopygidae the ridge is extending through anterior rings and further into part of the posterior lobe. It extends as long as the axial lobe in Upper Cambrian

Lotagnostus and Lower Ordovician *Machairagnostus*.

As the senior author has discussed in detail (1939, 1944), the order Agnostida is a solid incipient group of trilobites which was derived from a Pre-Cambrian common ancestor. The Eodiscina and Agnostina are two suborders of the Agnostida where the latter lived longer, flourished later and more specialized morphologically than the former. The trilobation of the axial lobe is the most conspicuous trend of evolution which is seen in the Agnostina, but not in the Eodiscina. It is unknown in the Class Trilobitoidea.

The specialization first appeared in the family Condylopygidae which reveals an isolate branch from all other agnostidian families. The trilobation was far more advanced in the Upper Cambrian and later ages in the Pseudagnostinae, Agnostinae and Geragnostinae, particularly in *Lotagnostus*, *Corrugatagnostus* and *Machairagnostus*.

The t-trend of specialization which occurred in the Agnostina is similar between the Condylopyginae and other agnostidian families, but quite different from that of polymeric trilobites. Namely, the trilobation means in the former principally the trilobation by the appearance of a prominent axial ridge and it is more developed in the pygidium than the cephalon. In the polymeric trilobites, on the contrary, it has taken place mainly on the glabella through the development of paraxial furrows which defined at length the distinct T-shaped frontmedian lobe in the Lichidae and Odontopleuridae. There is, however, no comparable lobe in the Agnostida.

The median ridge of the axial lobe in the scutelluid pygidium more or less resembles the ridge of the agnostidian pygidium, but the former is not so well defined as the latter. The tripartation seen in the pygidium of the Encrinuridae is quite distinct from the typical trilobation.

The specialization of the t-trend was particularly well advanced in the Lichidae (Lower Devonian-Middle Devonian) and the Odontopleuridae (late Lower Ordovician-Upper Devonian) in conjuction with the coalescence of lateral lobes, but the mode of specialization of these two families agrees essentially with that of the Scutelluidae (Middle Ordovician-early Upper Devonian). Thus these three families are contemporaneous parallels in the t-trend of specialization.

The Monorakidae and certain dalmanitids and trinucleoids also show the similar trend of evolution.

As noted already (1974), the Scutelluidae and Illaenidae were probably derived from the corynexochidian stock. As mentioned later, the Odontopleuridae and Eoacidaspididae are another derivatives from the same stock. These two families are combined in the same order in MOORE's Treatise (1959) and *Amgaspis* of the latter family is considered a derivative from the same stock in ORLOV's Osnovy (1960).

As discussed later, it is relevant to consider that the Cheiruridae reveal a branch from the Damesellidae issued between the latter family and the Dorypygidae. The Cheiruridae and Encrinuridae are so intimately related to each other and so are the Dalmanitidae and Phacopidae that all of them are generally combined in the Phacopida. The t-trend of evolution can now be said a speciality of specialization in the Phacopida in the sense that it was most developed in the Phacopida. It was, however, not restricted to the Corynexochidian polymeric trilobites.

It is interesting to see exceptionally that the glabella is trilobed by a median depressed zone in an early meraspid of *Cloacaspis senilis* FORTEY, 1974. This mode of trilobation is quite distinct from all of those mature trilobites. Nevertheless, it is a kind of high specialization in which it agrees with them, as it is a late Arenigian olenid belonging to the Balinbariinae which reveal an isolate, highly specialized branch of the Olenidae in the late phyletic stage.

A median tube probably of the digestive system is known to have existed along the axis of the glabella and the axial lobe behind it, as it is seen in two holaspids of *Onnia ornata* (STERNBERG) (WHITTINGTON, 1940) and in an anaprotaspid, an early metaprotaspid and a few meraspids of *Redlichia chinensis* WALCOTT (KOBAYASHI and KATO, 1951). Thus there was the digestive organ below the frontmedian lobe and likewise, the musculature of appendages below the lateral lobes of the glabella and occipital lobes, as well clarified with their scars by STROMER (1939, 1942, 1951). Therefore it is presumable that the t-trend specialization or the corynxochidian evolution of the glabella and axial lobe must have been intimately related to any specialization of the internal structure, although little is as yet known how it specialized internally.

Family Pseudotrinodidae KOBAYASHI and HAMADA, 1972

Genus *Pseudotrinodus* KOBAYASHI and HAMADA, 1971

Pseudotrinodus constrictus KOBAYASHI and HAMADA, sp. nov.

Pl. 3, Fig. 8

Description:—Cephalon roundly subquadrate, well convex but with flat border on anterior and lateral sides; glabella circumscribed by deep dorsal furrows, distinctly elevated above cheeks, longer than two-thirds the cephalon, conical, rounded in front, expanded at basal lateral lobes and constricted at a little posterior to mid-length of glabella; basal lateral lobes relatively small, subtriangular, clearly isolated from main body of glabella by diagonal lateral furrow which branches off from dorsal furrow at the top of the lobe; facial suture intramarginal on cheeks; surface smooth.

Observation and comparison:—*Pseudotrinodus aenigma* KOBAYASHI and HAMADA (1971, 72) has a very similar cephalon and pygidium like the Cambro-Ordovician Agnostida. Therefore it is difficult to say which is a cephalon or a pygidium, when they are isolated. As seen in the Agnostida the articulating half-ring must be the definite evidence for the pygidium. In the specimen before hand, however, the occipital ring and posterior cheek borders are unpreserved or absent. Of *Pseudotrinodus constrictus* it is known that the cephalon has the intramarginal suture which is clearly seen also on the left cheek of this specimen and in fact it is running in the same course as in *P. aenigma*. Its frontal border is divided by a median depression which is presumably a crack secondarily produced at the longitudinal median suture of the doublure. Thus it agrees with the cephalon of *P. aenigma* in essential characteristics.

It can, however, be distinguished from *P. aenigma* primarily by the middle constriction of the glabella and its distinct expansion at the small basal lobes. Secondarily, a scar of a median tubercle and one or possibly two very narrow and shallow lateral furrows are seen on the glabella by cross light. These aspects of the glabella appear to be allied to *Geragnostus*, although the tubercle and furrows are not explicitly shown on the glabella. Although these *Geragnostus*-like aspects need further confirmation with better material, this species can readily be isolated from *P. aenigma* by the primary distinction. The resemblance of *Pseudotrinodus* to *Typhoproetus* or any other proetid must be homoeomorphic in view of the facts on the glabellar configuration and the similarity of the pygidium with the cephalon of *Pseudotrinodus*.

Occurrence:—Tuffaceous shale of the Kanchanaburi area, Western Thailand. The locality is on road-side cutting of Chong Kaep Yai ridge, *en route* to Boe Noi Lead-Zinc Mine, about 12 km to the west of Sri Sawat, Kwae Yai river tributary, Changwat Kanchanaburi, West Thailand. (RK 21, collected by HASHIMOTO, SATO and KOMALARJUN). The shale is a member of variegate schalstein, limestone and sandstone beds containing ammonoids, brachiopods, pelecypods, crinoids, ostracodes (?) and other fossils. A proetoid cheek (Pl. 3, fig. 7) is contained in the same slab. The age of the shale is probably within the limits of Coblenzian and Eifelian. It is a remarkable fact that Devonian agnostoids occur not only in Malaya but also in Thailand.

Family Scutelluidae R. and E. RICHTER, 1955

Protuberances on scutelloid cranidia

The development of various kinds of spines on the cranidium is a speciality of the morphology of the Scutelluidae. In many genera of the family the glabella bears a median tubercle or spine besides an occipital one. *Weberopeltis* is an exception having two median spines on the glabella. Its anterior spine issues from slightly behind the median point between the anterior lateral pits, while the posterior spine is found between two pairs of middle and posterior pits. The latter spine corresponds to the median glabellar spine in position in some other scutelloids.

Beside these spines and genal ones scutellid genera or species of not a small number have various spines on the fixed cheeks. Two small spines occur on the anterior and posterior sides of the palpebral lobe in *Decoroscutellum*, *Bojoscutellum*, *Microscutellum*, and *Scabriscutellum*. One small spine on the posterior side of the lobe is known in *Decoroscutellum* (*Flexiscutellum*) and *Metascutellum*.

The occipital and palpebral spines are long and stout in *Scabriscutellum* (*Cavetia*) *furciferum* (HAWLE and CORDA) and not only these spines exist, but the median spine also is well prolonged in *Cornuscutellum rhinoceros* (BARRANDE). In *Ancyropyge* the glabellar lobation is reduced in the axial part, while the occipital and palpebral spines are extraordinarily well developed. These spines are about twice the cranidium in length in *Ancyropyge*.

The palpebral spine is not so well developed in *Weberopeltis aculeatus* WEBER as in the precedings, but it is evidently larger than the small posterior one above mentioned (WEBER, 1951, pl. 2, figs. 9, 10; MAXIMOVA, 1968, text-fig. 2). The two palpebral spines are directed posterolaterally in *Decoroscutellum* (*Decoroscutellum*) *binotatum* (BARRANDE) (1872, pl. 12, figs. 24-25; ŠNAJDR, 1960, pl. 6, fig. 11). The two spines are not the less developed in *Bojoscutellum crassicostatum* ŠNAJDR (1960, pl. 14, fig. 4) and also in *Hidascutellum multispiniferum* here described.

It can be said that *Hidascutellum* best agrees with *B. crassicostatum* in the double palpebral spines, and with *Weberopeltis aculeatus* in the possession of one occipital and two median spines. It is a remarkable fact that similar spines appeared in the Scutelluinae as well as in the Thysanopeltinae, as shown by the occipital and palpebral spines in *Cornuscutellum rhinoceros* and *Scabriscutellum* (*Cavetia*) *furciferum*. In the variation of the spines the former subfamily is superior to the latter in looking through such as upper Ludlovian *Weberopeltis aculeatus* of the Urals, Lower Devonian *Hidascutellum* of Japan and Middle Devonian *Ancyropyge* of North America.

Subfamily Planiscutelluinae KOBAYASHI and HAMADA, 1974

WEBBY (1974) proposed a new genus *Heptabronteus* whose type-species was *Heptabronteus atavus*, sp. nov. This new genus is, however, a junior synonym of *Eokosovopeltis* PŘIBYL and VANĚK, 1971, which was founded on *Bronteus romanovskii* WEBER, 1948, because this species "from the Caradoc to Lower Ashgill of Kazakhstan bears very close similarities to *Heptabronteus atavus* and is undoubtedly congeneric" as WEBBY states (WEBBY, 1974, p. 221). It is probable that the Meroperixinae were derived from the Planiscutelluidae through such forms by complete effacement of lateral furrows on the glabella and bifurcation of the median rib on the pygidium.

Subfamily Scutelluinae R. and E. RICHTER, 1955

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

Type-species:—Hidascutellum multispiniferum KOBAYASHI and HAMADA, sp. nov.

Diagnosis:—Scutelloids having three lateral furrows indicated by three pairs of pits or depressions and two median and one occipital spines on the glabella and double palpebral spines of medium size produced postero-laterally on cheeks; pygidium flat and pentagonal in outline provided with seven pleural ribs on each side of the post-axial rib which is unforked.

Remarks:—This genus has the cephalon resembling *Weberopeltis* and *Bojoscutellum* in glabellar lobation and cranidial spines. It is, however, distingushed from *Weberopeltis aculeatus* (WEBER) not only by its double palpebral spines but also by the entire margin of the pygidium, although they agree with each other in the possession of a simple post-axial rib.

Bojoscutellum has the rib forked as in most Devonian scutelloids and only one median spine on the glabella, instead of two in this genus.

Distribution:—Lower and (?) early Middle Devonian; Eastern Asia.

Hidascutellum multispiniferum KOBAYASHI and HAMADA, sp. nov.

Pl. 1, Figs. 1-14, Pl. 2, Figs. 5-15; Text-fig. 3A

1974. *Scutellum* sp. OKAZAKI (pars), *Mem. Fac. Sci., Univ. Kyoto, Ser. Geol. Min., vol. 11, no. 2*, pl. 15, fig. 15, non fig. 16.

1974. *Bojoscutellum* ? n. sp. KOBAYASHI and HAMADA, *Pal. Soc. Japan, Sp. Pap. no. 18*, p. 61.

Description:—Cephalon semi-circular except for short genal spines, moderately inflated. Glabella as wide as about a half of its length in posterior but expanded almost twice broader than the basal breadth in anterior, circumscribed by dorsal furrows, elevated toward axis; anterior and middle lateral furrows indicated by pits of which the former is laterally elongate and nearer to the margin than the axis and the latter subcircutar and at about the middle between axis and margin; posterior lateral furrow represented by a larger depression extending inward and then forward from margin; anterior median tubercle or spine located a little posterior to anterior lateral pits; posterior median spine more prominent than the preceding and nearer to posterior lateral furrows than the middle lateral pits; occipital furrow straight and profound; occipital ring thickened mesially; occipital spine most prominent, produced from its posterior part backward and upward; subtriangular occipital lobe fairly well marked pits and furrows smooth on bottom, while the rest of glabella is sculptured by fine striae which are more or less parallel to glabellar margins, but become circles near the axis with the spines at the centres; a pair of such concentric striae found on frontal lobe, but neither spine nor tubercle is present at their centres; this lobe gently slant forward and its anterior margin more or less incised near the median point; frontal border there very narrow, concave and deep. Fixed cheek nearly as wide as occipital ring in posterior but no more than a third of frontal lobe of glabella and depressed in anterior; middle part of the fixed cheek inflated and produced posterolaterally into two narrow palpebral spines; paraglabellar area well defined in posterior, semi-circular and non-striated. Free cheek divided by a shallow groove into a more convex inner area and less convex outer area; marginal border narrow, depressed, and more or less concave; compound eyes in innermost part of the cheek, reniform, convex, most elevated and limited by a profound groove on the outer side; fine striae subparallel to lateral and posterior margins cover most part of free cheek, but inner area along the eye is granulate. Facial sutures nearly diagonal anterior to eyes and more widely divergent posterior to them.

Thorax unknown.

Pygidium broad, pentagonal, about 2/3 in L/W ratio; axial lobe elevated above nearly flat pleural fields, less than a quarter of pygidial breadth, well trilobed; post-axial median rib unforked; pleural ribs flat-topped, in seven pairs; pleural furrows narrower than ribs; fine striae nearly parallel to lateral and posterior margins cover ribs as well as furrows.

Two hypostomata from Oisé (YT-31, 54; Pl. 1, Figs. 9 & 8) belong most probably to this species. This form of hypostoma bears scutelloid aspects in the possession of large wings in anterior, well developed maculae in posterior and largely sinuated lateral margins as seen in certain scutelluid hypostomata in *Spiniscutellum umbelliferum* (BEYRICH), *Bojoscutellum crassicostatum* SNAJDR, and *Microscutellum gervillei* (BARRANDE) (in PILLET, 1972) for example. As in the last of these three species the general outline of this hypostoma is relatively long. It is a characteristic of this form that it is truncated in posterior, instead of well rounded or protruded into a median spine as commonly seen in scutelluids.

Observation:—There are several cranidia from 6 mm to 20 mm. in breadth. The general outline of the cephalon can be figured with the largest cranidium and free cheek from the same locality (Kanajiro-zako, KOIZUMI coll., Pl. 1, Fig. 6, 12). This cranidium shows the lobation and axial protuberances on the glabella fairly well, but they are best shown in another cranidium from the same locality (ŌNO coll., Pl. 1, Fig. 5) in addition to a pair of concentric striae on the frontal lobe. The palpebral spines are, however, poorly preserved in most cranidia except for a cranidium from Oisé (YT-11, Pl. 1, Fig. 7) on which the spines are clearly seen. It is ascertained by an Oisé specimen (YT-24, Pl. 2, Fig. 12) that such a tubercle is absent, although the median part of the lobe is prominent there. In another Oisé pygidium (YT-23, Pl. 2, Fig. 7) it is seen that the doublure extends as far as two-thirds the pleural region. The costae are obliquely striated in these two pygidia.

Sexual (?) *dimorphism:*—Besides the above free cheek (Kanajiro-zako) there are four free cheeks from Oisé two of which have granulate inner areas. Because two cranida and a free cheek from Kanajiro-zako have no granulate area, they combined with two non-granulate cheeks from Oisé consititue a form. Two cranidia (YT-11, 12; Pl. 1, Figs. 7 & 4) from Oisé, on the other hand, reveal the granualation changing from striation in the middle part of the fixed cheek which is the quite probable part of the granulate inner area of the free check. Because it is quite probable that the non-granulate and the partly granulate form belong to an identical species, they may be an example of sexual (?) dimorphism.

Axial segmentation of the pygidium:—Among some striated pygidium from Oisé, one (YT-24, Pl. 2, Fig. 12) has the axial lobe whose articulating half ring is separated from the main lobe by a very pronounced furrow. Behind this furrow a pair of narrow lateral elevations are extended from the stout median elevation in form of T and the lateral elevation is limited behind by a depression laterally eleongate. These lateral elevation and depression must be the relics of the first axial ring and furrow respectively after the axial segmentation is completely effaced on the median elevation and almost so on the lateral platforms. One can see two or three more lateral depressions, though very faint, on the lateral platform and they are probably additional relics of the ring furrows.

Immature cranidia:—In the smallest cranidium (YT-14, Pl. 1, Fig. 2) in the collection measures 4.5 mm long and 5.6 mm and 5.3 mm wide in anterior and posterior respectively. The width of its glabella is 3.6 mm in anterior and 1.7 mm. in posterior. Compared to the mature cranidia the glabella is relatively narrow, while the fixed cheeks are wider. Nevertheless, three pairs of lateral furrows are clearly shown by pits and depressions. Three axial spines or tubercles appear stouter in this than in the grown stage, insofar as they can be judged from their scars. The median sinuation of the frontal lobe of the glabella is more pronounced in the young stage. These glabellar aspects can also be seen on another cranidium in a similar stage of growth (YT-13, Pl. 1, Fig. 1), although the lateral and posterior parts of the cranidium are poorly preserved in the latter cranidium.

Occurrence:—Kanajiro-zako, KOIZUMI coll. (two cranidia, free cheek), ONO coll. (cranidium, OKAZAKI, 1974, No. 16, pl. 9, fig. 15, bed 10); Kinma-michi ?, YAMAKOSHI coll. (one pygidium).

Oisé: Three cranidia (YT-11, 12, 15), two immature cranidia (YT-13, 14) two free cheeks partly granulated (YT-19, 20), two free cheeks non-granulate (YT-21, 22), seven pygidia (YT-16, 17, 18, 23, 52, 53, 54), pygidium with ring furrow relics (YT-24).

Genus *Scutellum* PUSCH, 1833

Scutellum densigranulatum KOBAYASHI and HAMADA, sp. nov.

Pl. 2, Figs. 1-3; Text-fig. 3C

1974. *Scutellum* sp. OKAZAKI, *Mem. Fac. Sci., Univ. Kyoto, Ser. Geol. Min., vol. 11, no. 2*, pl. 19, fig. 16, non fig. 15.

Description:—Pygidium semi-elliptical in outline, gently convex in antero-axial half or two-thirds and flat or even somewhat concave in marginal part. Axial lobe subtriangular and elevated above pleural fields, divided by a deep furrow into an articulating half-ring and the main body which is trisected into a high median subconical part and two lower narrower lateral parts; the lobe limited laterally by profound furrows, but they become shallow behind the median part; post-axial median rib narrow there but broadened in posterior two-fifths as wide as more than twice the anterior breadth, but it is not forked. Surface of pygidium ornamented by granules of different sizes densely except for furrows which are smooth on bottom; articulating half-ring transversely striated. Lateral ribs seven on each side of the median rib, narrower than the latter near the margin, separated from one another by narrow furrows which terminate at a short distance from pygidial margin.

Observation:—Two imperfect pygidia collected by KOIZUMI at Kanajiro-zako are similarly ribbed and granulate as the type pygidium. One of them is distinctly slanting in the distal part, while the other is flattened in the marginal part. They show that the test is thin and the doublure very wide.

Comparison:—This pygidium is allied to *Scutellum costatum* PUSCH and its closely allied species (RICHTERS, 1956) in the general outline and convexity of the pygidium, flattopped radial ribs and granulate test, particularly in the simple median rib as it is forked in most other Devonian scutelloids. It can, however, be easily distinguished from Middle Devonian *S. costatum*, *S. altaceum* (GOLDFUSS) and its subspecies *geesense* RICHTERS in the longer axial lobe, its less distinct trilobation and much denser granules of very different sizes.

Scutellum (*Scutellum*) *pardalio* (WHIDBORNE) from the Givetian of England is allied to this species, but the pleural region of its pygidium consists of the adaxial platform and abaxial gentle slope of which the former is very horizontal (SELWOOD, 1966).

The Bohemian granulate "*Scutellum*" species are more distant from this species, precisely, "*S.*" *setosum* PRANTL has a much broader outline and *S. multiverrucatum* ŠNAJDR has much broader furrows, and the median ribs is forked.

Scutellum (*Scutellum*) sp. indet. by STRUSZ, 1964 from the Lower to Middle Devonian Garra formation of New South Wales is closely allied to this species in outline, unforked median rib expanding posteriorly, flat lateral ribs separated by narrow furrows. This Australian pygidium, however, looks almost flat and tubercles on its ribs and axial lobe are fine and not so dense as in this species.

Occurrence:—Two fragmentary pygidia were procured from Kanajiro-zako (KOIZUMI coll.); an external cast probably derived from bed 11 (YAMAKOSHI coll.).

Scutellum (?) sp. indet.

Pl. 2, Figs. 4a, b

1965. *Scutellum* (?) sp. KOBAYASHI and HAMADA, *Trans. Proc. Pal. Soc. Japan, N.S., no. 58*, p. 78, pl. 7, figs. 4a, b, text-fig. 3.

A fragmentary pygidium described by the authors in 1965 was obtained on a spur northeast of Hitoégané. If the median rib is bifurcated in posterior, as restored in text-fig. 3 at that time, this pygidium can easily be distinguished from *Hidascutellum multispiniferum*. The bifuration is, however, not clear enough to be warranted. Otherwise, it is difficult to distinguish it from that pygidium.

Recently *Encrinurus fimbriatus* was found at Hitoegane, though probably not an identical spot. Nevertheless, this discovery of a Silurian trilobite in a small area of Hitoégané casts a question, whether *Scutellum* (?) sp. indet. is really a Devonian trilobite. These questions morphological as well as stratigraphical must be solved with additional material from Hitoégané localities.

Occurrence:—On a spur of Hitoégané, Fukuji district; collected by Yoshihiro YASUÉ; stored in Institute of Earth Science, Faculty of Liberal Arts, Yokohama National University.

Subfamily Thysanopeltinae HAWLE and CORDA, 1847

To the synoptic list of the Scutelluidae, 1974, is added a new subgenus *Platyscutellum* (*Izarnia*) FEIST, 1974, whose type-species is *Bronteus gouzesi* BERGERON, 1889.

Genus *Thysanopeltella* KOBAYASHI 1957

Subgenus *Septimopeltis* PŘIBYL and VANĚK, 1971

Thysanopeltella (*Septimopeltis*) *paucispinosa* (OKUBO, 1951)

Pl. 8, Fig. 9; Text-fig. 3B

1951. *Bronteus* (*Thysanopeltis*) *paucispinosa* OKUBO, *Earth Sci., no. 4*, p. 137, pl. 1, figs. 5a-c.
1957. *Scutellum* (*Thysanopeltella*) *paucispinosa* by KOBAYASHI, *Jour. Fac. Sci., Univ. Tokyo, sec. 2, vol. 11, pt. 1*, p. 6, pl. 1, figs. 3a-b, 4.
1974. *Thysanopeltella* (*Septimopeltis*) *paucispinosa* by KOBAYASHI and HAMADA, *Pal. Soc. Japan, Sp. pap. no. 18*, p. 73.

This species can be said briefly a *Septimopeltis* having a pentagonal pygidium. MINATO's suggestion (1962), to consider this species a primitive form of *Weberopeltis* is by no means tenable, because it is so distinct from *Weberopeltis* of the Scutelluinae that MAXIMOVA (1968) has excluded it from her genus and because it is well specialized, instead of primitive, as indicated by its pentagonal ouline of the pygidium.

Occurrence:—Nakazato series; middle part of a valley between Ōmori and Higuchizawa, Sakari district, Ofunato city, Iwaté Prefecture.

Family Eoacidaspididae POLETAYEVA, 1956

In 1932 RICHTER included the Odontopleuridae in his Zacanthoididea, but no Cambrian ancestor of the family had been known until LERMONTOVA established *Acidaspides* for an Upper Cambrian odontopleuroid from Kazakhstan in 1951. Subsequently POLETAYEVA (1955) added *Belovia* and *Eoacidaspis* to the family, but sooner or later (1956) she erected the Eoacidaspididae for these Cambrian genera. TSCHERNYSHEVA (1955), on the other hand, erected *Amgaspis* for a Middle Cambrian trilobite of Southern Siberia which somewhat resembled the Dolichometopidae. In Osnovy (1960) she proposed the Amgaspidae as a new family of the Corynexochoidea, while MAXIMOVA placed the Eoacidaspidae in the Corynexochoidea. One year before this WHITTINGTON erected in Treatise the Odontopleurida to include the Odontopleurida and Eoacidaspididae, saying primitive odontopleurids for the latter.

As discussed already (KOBAYASHI 1961, 1962) it is quite probable that the Eoacidaspididae were derived from the Corynexochian stock near the Jakutidae through *Amgaspis*, because *Amgaspis* is allied to *Acidaspides* on one side and to *Judaiella* of the Jakutidae on the other and because *Acidaspides* is a link between *Amgaspis* and *Eoacidaspis*. Then, missing links between the pre-Ordovician odnotopleuroids and post-Cambrian ododntopleurids are in the Tremadocian age, because *Eoacidaspis* occurs in Siberia in the high Upper Cambrian with *Plethopeltis* and *Cyclognathina* (TCHERNYSHEVA, 1961), whereas *Boedaspis* and *Miraspis* appeared in the Baltic in the Arenigian and *Selenopeltis* in the lower Arenigian in Sweden and probably in England (WHITTINGTON and BOHLIN, 1958).

Like in the Odontopleuridae the Eoacidaspididae have well developed eye-ridges and the glabella nearly as long as the cranidium. The forward tapering of the glabellar outline was reduced from *Amgaspis* to later genera. The anterior branches of facial sutures are, however, invariably divergent in this family, but convergent in the Odontopleuridae.

Finally, *Bestjubella* IVSHIN, 1962 may be an off-shoot issued from the Eoacidaspidae, but it reveals an isolated family on account of the anterior expansion of the glabellar outline and the effacement of eye-ridges and the anterior and middle lateral furrows on the glabella. In the wide divergence of the facial sutures it agrees with the Odontopleuridae and the Zacanthoididae, but disagrees with the Dorypygidae, Dolichometopidae and Corynexochidae.

The family Eoacidaspididae is here divided into two subfamilies, because *Amgaspis* agrees with *Acidaspides* best, although eye-ridges are well developed and a median occipital tubercle is present in the latter. Their cranidia are closely allied to that of *Judaiella*, but the glabellae are more tapering forward in them than in *Judaiella*.

Subfamily Eoacidaspidinae POLETAYEVA, 1956

The following five or six genera belong to this subfamily.

Acidaspides LERMONTOVA, 1951. (*Acidaspides precurrens* LERMONTOVA, 1951). Late Middle Cambrian of Siberia and early Upper Cambrian of Kazakhstan.

Belovia POLETAYEVA, 1956. (*Belovia clava* TCHERNYSHEVA, 1956). Upper Cambrian of Siberia.

Eoacidaspis POLETAYEVA, 1956. (*Eoacidaspis salairensis* POLETAYEVA, 1956). Upper Cambrian of Siberia.

Paracidaspis POLETAYEVA, 1956. (*Paracidaspis hunanica* JEGOROVA, 1963). Upper Cambrian of Siberia and Central China (Paishanian, Hunan).

?*Acidaspidina* LAZARENKO, 1960. (*Acidaspidina plana* LAZARENKO, 1960). Upper Cambrian of Siberia (Northwestern Siberian platform).

Acidaspidella POKROVSKAYA in ROSOVA, 1963. (*Acidaspidella limbata* POKROVSKAYA in ROSOVA, 1963). Upper Cambrian of Siberia (Northwest Siberian platform).

It is known that *Acidaspides* has three pairs of strong posterior spines on the pygidium. In *Acidaspidina plana* the lateral margin of the pygidium is entire, although its posterior margin is unknown.

Subfamily Amgaspidinae N. TSCHERNYSHEVA, 1960

Amgaspis TSCHERNYSHEVA, 1956. (*Amgaspis medius* TSCHERNYSHEVA, 1956). Middle Cambrian, rarely late Lower Cambrian; Siberia and Altai.

Family Bestjubellidae IVSHIN, 1962

Bestjubella IVSHIN, 1962. (*Bestjubella munificus* IVSHIN, 1962). Upper Cambrian (Kujandinian); Kazakhstan.

Family Odontopleuridae BURMEISTER, 1843

In 1949 PRANTL and PŘIBYL classified their Odontopleuracea into three families (Odontopleuridae, Selenopeltidae and Ceratocephalidae) and five subfamilies. Their tripartation of the post-Cambrian Odontopleuracea was accepted by HUPÉ (1955) and MAXIMOVA (1960). WHITTINGTON (1959) made their superfamily a family of his Odontopleurida and their three families three subfamilies in his order to which his subfamily Apianurinae was added. In this procedure he replaced the Ceratocephalidae RICHTERS, 1925, em. by the Miraspinae RICHTERS, 1917.

The following 12 genera and subgenera are supplemented to those of this family in Treatise, 1959 to make its composition more complete.

Boedaspis WHITTINGTON and BOHLIN, 1958. (*Boedaspis ensifer* WHITTINGTON and BOHLIN, 1958). Lower Ordovician (? *Expansus* limestone, *Raniceps* limestone, Sweden) .... Apianurinae

Primaspis (*Chlustinia*) PŘIBYL and VANĚK, 1965. (*Odontopleura keyserlingi* BARRANDE, 1846). Caradocian (Zahorany), Bohemia ....Odontopleurinae

Primaspis (*Meadowtownella*) PŘIBYL and VANĚK, 1965. (*Primaspis whitei* WHITTARD, 1961). Anglo-Scandinavia and North America ....Odontopleurinae

Periallaspis BRUTON, 1966. (*Periallaspis uncinus* BRUTON, 1966). Lower Ordovician (Basal Oeland Series), Sweden........Subfamily uncertain

Isoprusia BRUTON, 1966. (*Isoprusia mydlakia* BRUTON, 1966). Lower and Middle Devonian, Bohemia, Germany, Poland and Kazakhstan ....Miraspidinae

Anacaenaspis BRUTON, 1967. ("*Acidaspis emarginata* SCHMIDT, 1885). Llandovery to Ludlow, Gotland, Esthonia........Odontopleuridae

Xanionurus WHITTINGTON and CAMPBELL, 1967. (*Xanionurus boucoti* WHITTINGTON and CAMPBELL, 1967). Upper Wenlock-Ludlow; North America........Odontopleurinae

Primaspis (*Taemaspis*) CHATTERTON, 1971. [*Primaspis* (*Taemaspis*) *campbelli* CHATTERTON, 1971]. Upper Wenlockian to Lower or Middle Devonian; Australia and (?) Bohemia .. .. Odontopleurinae

Elbaspis BALDIS y BLASCO, 1973. (*Elbaspis pintadensis* BALDIS y BLASCO, 1973). Middle and Upper ? Ordovician; Argentine (Mendoza)..........................Odontopleurinae

Leonaspis (*Eoleonaspis*) SHENG, 1974. (*Acidaspis shanensis* REED, 1915). Upper Ordovician: Eurasia..Odontopleurinae

Ningnanaspis SHENG, 1974. (*Ningnanaspis ningnanensis* SHENG, 1974, monotypic). Middle Ordovician, Central China (Szechuan), presumably ancestral to *Eoleonaspis* .... Odontopleurinae

Gaotania CHANG, 1974. (*Gaotania ovata* CHANG, 1974). Lower to (?) Middle Silurian; South China (Kweichou, Hupei, Yunnan) ....Odontopleurinae ?

PŘIBYL and VANĚK (1973) pointed out that *Anacaenaspis* BRUTON, 1967 and *Primaspis* (*Taemaspis*) CHATTERTON, 1971 are junior synonyms of *Primaspis* (*Measdowtownella*) PŘIBYL and VANĚK, 1965 and that *Solenopeltis* PRANTL and PŘIBYL, 1949 and *Leonaspis* (*Acanthalomina*) PRANTL and PRIBYL, 1949 are respecitively a valid genus and subgenus. BRUTON (1968) on the other hand, considered that the co-authors have overestimated the taxonomic importance of the differences between the two subgenera, *Primaspis* (*Primaspis* and *Meadowtownella*).

The Ceratocephalidae emended by PRANTL and PŘIBYL, 1949 consisted of the Ceratocephalinae, Dicranurinae and Miraspinae. This tripartation was upheld by ERBEN (1952), HUPÉ (1955), and MAXIMOVA (1960). This family by PRANTL and PŘIBYL is the Miraspidinae by WHITTINGTON (1959).

According to WHITTINGTON (1956) *Ceratocephala* indicates the trunk of his family from which *Miraspis* and *Dicranurus* were issued on two sides. Thus their subfamily-tripartation was also accepted by WHITTINGTON.

The generic grouping of the Ceratocephalidae by PRANTL and PŘIBYL was later modified. Among 11 genera of their family they distributed only five to the three subfamilies and others remained in the Ceratocephalidae or incertae subfamiliae. Subsequently ERBEN (1952) located *Orphanaspis, Koneprusia* and *Selenopeltoides* in the Dicranurinae. WHITTINGTON (1959) considered *Whittingtonia* an independent off-shoot from the *Ceratocephala* trunk. Furthermore, *Drummuckaspis* and *Onychaspis* were found to be two synonyma of *Proceratocephala* and *Ceratocephala* respectively. *Orphanaspis* PRANTL and PŘIBYL, 1949, as well as *Selenopeltoides* PRANTL and PŘIBYL, 1948, were synonymized with *Dicranurus* CONRAD, 1841, and *Ceratocephalina* was promoted to the generic rank by BRUTON (1968).

Now the three groups of the Miraspidinae comprise the following genera.

I. *Ceratocephala* group: *Ceratocephala, Ceratocephalina, Proceratocephala, Whittingtonia*
II. *Dicranurus* group: *Dicranurus, Koneprusia,* ? *Ceratonurus,* ? *Isopleura*
III. *Miraspis* group: *Miraspis*

PŘIBYL and VANĚK (1973) have already revived the Dicranurinae PRANTL and PŘIBYL, 1949.

Distribution of odontopleurids in Asia

While *Paraacidaspis hunanica* JEGOROVA was described from the Upper Cambrian of Hunan, Central China (JEGOROVA et al., 1963), little has been known of Ordovician odontopleurids in Eastern Asia. *Acidaspis huangi* SUN, 1931 is the type-species of *Omeipsis* KOBAYASHI, 1951, of the Taihungshanidae SUN, 1931. PATTE (1926) reported that a fragmentary thoracic segment presumably of an ascidaspid was found in *les schistes de Nam mo*, east Tonkin, Viet-Nam which contained *Ceraurienella* cf. *mitis* (SALTER), *Vietnamia douvillei* (MANSUY) and other Middle Ordovician trilobites (KOBAYASHI, 1960), but the thoracic fragment in question was neither illustrated nor precisely described. A possible odontopleurid contained in the Upper Ordovician Tambak faunule of Malay is an obscure right cheek with short spines on the lateral margin (KOBAYASHI and HAMADA, 1970).

Recently two new species of Ordovician odnontopleurids were described by LU and CHANG (1974) from Central China. One is *Dicranurus oviformis* from Middle Ordovician of Kweichou. It is the oldest species of *Dicranurus*, since the genus has been known from Lower and Middle Devonian. The other is *Diacanthaspis laokuangshanensis* from Upper Ordovician of Szechuan. This is the latest species of the genus, because it is known from Middle Ordovician.

Some Silurian ones are, however, well known from the Sino-Burmese borderland. REED (1915) was the first to describe *Acidaspis shanensis* from the Llandoverian Panshapyge trilobite band in the Northern Shan States, Burma. Later CHEN (1948) described the following three from the basal part of the lower Jenhochiao Series in West Yunnan.

Leonaspis yunnanensis CHEN
Leonaspis cf. *shanensis* (REED)
Primaspis suni CHEN

Because this *Leonaspis* shale lies below the *Monograptus cyphus* zone or the *M. modestus* zone (SUN and SZETU, 1947, MU, 1964), the age of these odnotopleurids is probably early Llandovery. In Central China *Acidaspis octaspinus* GRABAU, 1925, (nom. nud.) and *Acidaspis* sp. were reported to occur in the Middle Silurian Lojoping Series in west Hupeh, but they remain undescribed. Recently CHANG (1974) described two Lower Silurian species of *Leonaspis* from Kweichou. They are *Leonaspis sinensis* and *L. pusillus*. Another two Lower Silurian odontopleurids from Kweichou are named by him *Gaotania ovata* and *G. pulchella* (See Postscrikt 6).

In South Asia none is known from the Himalayas. SEILACHER (1963) reported an occurrence of *Selenopeltis buchi* (BARRANDE) in the Sinat shale of Iran and suggested Caradocian for its age. In further west HAAS (1968) described the following four species from Bithynia, near Istanbul, Northwest Turkey.

Leonaspis panoptes HAAS (Siegenian, Praguian)
Leonaspis belisatius HAAS (upper Emsian)
Leonaspis leucothea HAAS (Eifelian)
Leonaspis sp. ex aff. *hoernesi* (BARRANDE) (Lowest upper Emsian)

On the other side of the Asiatic continent WEBER (1948) described *Acidaspis* (*Leonaspis*) sp. aff. *A. parvissimus* ETHERIDGE and MITCHELL and *Acidaspis* sp. indet.

from the Upper Ordovician of Western Siberia and Kazakhstan respectively, and compared the latter to *Primaspis* (*Meadowtownella*) *evoluta* (TÖRNQUIST). In addition he described *Acidaspis* sp. indet. from the lower Ludlovian of the Urals and Pri-Balkhash, East Kazakhstan (1951) and *Acidaspis cornuta* WEBER, 1932, from the Middle Devonian of Turkestan. According to BRUTON (1966) this species belongs to *Isoprusia* closely allied to *Isoprusia ursula* (BARRANDE).

Lately several odontopleurids were added by MAXIMOVA as follows:

1. *Acanthaloma emarginata* (SCHMIDT) (i.e. *Acanthaloma pectinata* by MAXIMOVA, 1955) from the Llandovery of the Siberian platform (MAXIMOVA, 1962).
2. *Acanthaloma* (*Acanthaloma*) *tenella* MAXIMOVA, 1960 from the Eifelian of the Rudi Altai.
3. *Acanthaloma* (*Acanthaloma*) *longispina* BALASHOVA from Upper Silurian; *Ceratocephala* sp. and *Dicranurus* sp. aff. *Dicranurus hamatus* CONRAD from the Gedinnian; *Acanthaloma* (*Ketteraspis*) aff. *pigra* (BARRANDE) from the Coblenzian; *Acanthaloma* (*Ketteraspis*) cf. *derelicta* (BARRANDE) from the Eifelian. All from Central Kazakhstan.

Incidentally, *Acanthaloma* CONRAD, 1840 was surpressed by *Leonaspis* R. and E. RICHTER, 1917.

The odontopleurids from Fukuji, Central Japan belong to two species and no other Devonian species is known from Eastern Asia.

Subfamily Odontopleurinae BURMEISTER, 1843

Genus *Primaspis* R. & E. RICHTER, 1917

Primaspis (?) *tanakai* KOBAYASHI and HAMADA, sp. nov.

Pl. 3, Figs. 1a-e; Text-fig. 3E

Description:—Glabella strongly inflated, very broad and most expanded between genal angles where its breadth is much broader than twice its length; these angles located at about one-third the cephalic length; anterior and lateral margins broadly rounded and seemingly a little protruded at frontal margin; posterior cheek margin angulated at about the middle breadth; genal spines present. Glabella subovate, convex, composed of a median lobe and two pairs of lateral lobes which are separated from one another by deep furrows and outlined as a whole by circum-glabellar furrows; median lobe subcylindrical, only a little expanded laterally in anterior; anterior and posterior lateral lobes respectively subtriangular and subquadrate; occipital furrow very profound; occipital ring thickened mesially; median tubercle, instead of a spine, present; paired occipital lobes separated from median part by shallow furrows; frontal border depressed; frontal margin straight and non-spinose; palpebral ridges arcuate, divergent from the antero-lateral sides of median lobe, narrow but distinct. Fixed cheeks inside the ridges broadened posteroirly to some extent, but anterior to the ridges very minute. Eyes small, located far back at the terminal of the ridges. Free cheek moderate in size; lateral border provided with ten marginal spines; genal spine of medium length, curved with convexity on antero-lateral side and extending more or less downward; intergenal angle obtuse; free cheek inside of marginal border decorated with irregular fine ridges which are more or less cancellate in anterior portion, but radial elements predominate the others in posterior position. Cranidium ornamented by coarse granulation.

Comparison:—This species is repesented by a small cephalon, 3.7 mm long. It resembles *Primaspis* (*Taemaspis*) *bowningensis* (ETHERIDGE and MITCHELL, 1896), particularly a paratype of that species in fig. 7, pl. 23 in CAMPBELL, 1971, most closely. It, however, disagrees with that species in that the lateral lobe is bisected, that border spines are countable no more than ten and that the cephalon appears more inflated in this than in that species. Because of the bilobation, instead of trilobation in *Primaspis*, a better specimen is required to warrant its taxonomic position. Nevertheless, the two species look so similar in most other characteristics that the differences depend possibly upon the poor state of preservation of the cephalon at hand.

Occurrence:—Kanajiro-zako with a pygidium of *Gravicalymene yamakoshii* in the same slab. Y. TANAKA coll.

Subfamily Miraspidinae R. and E. RICHTER, 1917

Genus *Ceratocephala* WARDER, 1847

The generic characteristics of *Ceratocephala* in comparison with allied odontopleurids were greatly clarified by WHITTINGTON (1956) and others. Recently many European species of the Odontopleuridae including this genus were thoroughly restudied by BRUTON (1966, 1968). This genus typical of the *Ceratocephala* group has the cephalon in inverted trapezoidal outline, while it is normal trapezoid in *Miraspis* and somewhat tetragonal in *Dicranurus*. In this genus paired occipital spines are not twisted and the facial sutures not so distinct as in *Dicranurus*. The eyes are set more anteriorly and their stalks, if present, not so prolonged as in *Miraspis*. There are of course other distinctions in thorax and pygidium, but omitted here for only the cephalon is known of *Ceratocephala nipponica*.

Of the three other genera in the same group *Ceratocephala* can easily be distinguished from *Ceratocephalina* by the absence of the prominent median occipital spine and from *Whittingtonia* by the strong inflated cephalon, well developed median lobe and small lateral lobes of the glabella and two pairs of stout spines on the cephalon of that genus. Eyes are obscure and a median glabellar lobe defined by profound furrows is narrower in *Proceratocephala*, if compared with that of *Ceratocephalina*. These three allied genera are all Ordovician in age.

Ceratocephala is long ranged from Middle Ordovician to Middle Devonian and widely distributed not only in the northern continents but in Australia also. ETHERIDGE and MITCHELL (1897) described four species (*jackii*, *vogdesi*, *impedita* and *longispina*) of the genus from the Silurian Bowning Series in New South Wales. According to GILL (1947) *Bounyongia*, subgenus of *Ceratocephala* founded on *Bounyongia bowningensis* by ETHERIDGE and MITCHELL (1917), is invalid.

Ceratocephala nipponica KOBAYASHI and HAMADA, sp. nov.

Pl. 3, Figs. 5,6; Text-fig. 3D

Description:—Internal and external moulds of a cranidium and a latex-cast taken from the latter are before hand. As this cephalon is contained in a shale, its convexity is reduced. As it is deformed diagonally, its original form is provisionally restored for a comparative study.

The outline of the cephalon exclusive of two pairs of spines is trapezoidal or more or less pentagonal, a little expanded forward and rounded at angles, its length being about twice its breadth; anterior margin gently arcuate and a little protruded in front of the glabella. The glabella is subtrapezoidal in outline, most expanded laterally at the basal lateral lobes; median lobe parallel-sided, nearly one-third as wide as the glabella, but laterally expanded at the frontal lobe half as wide as the glabellar breadth. A small anterior lateral lobe is present behind the expansion of the frontal lobe. The middle lateral lobe is not much smaller than the basal lobe. The dorsal, lateral, para-axial and occipital furrows are smooth, or minute granules are very sparse. While such granules are densely distributed on the lobes of the grabella, occipital ring and cheeks, larger tubercles look more or less regularly disposed on the glabella. A median protuberance is much larger than these tubercles. It looks similar to occipital lobes behind the basal lobes in size and prominence; occipital ring provided, in addition, with a pair of spines which are directed postero-laterally and upward; posterior depressed band is thinning out laterally behind the occipital lobe. The free and fixed cheeks are so well fused that the facial sutures become very obscure, but their posterior branches are traceable behind the eye-lobes to cut the posterior border just inside of the genal spines. Eyes are unpreserved, but their scars are seen to be opposed at about the middle lateral lobes of the glabella. The anterior part of the cephalon is so crudely deformed that no distinct eye-ridge can be assured. The genal spine issues upward and toward a little lateral to the posterior from the junction between lateral and posterior rims, but inside of a narrow depressed band at the genal angle. The narrow raised marginal rim is limited by a relatively narrow furrow on the inner side, while on the other side it is provided with small spines on the anterior and antero-lateral side of the cephalon.

A hypostom procured by ONO at Sorayama is very similar to the hypostomata of Middle Ordovician *Ceratocephala laciniata* and *C. triacantheis* (WHITTINGTON and EVITT, 1954), although the posterior margin is fairly well sinuated in this hypostoma as in Silurian *Ceratocephala verneuili* (BARRANDE). This Devonian hypostoma is quite distinct from them in the possession of an elliptical anterior elevation laterally elongated and a large shallow depression behind it and further a pair of circular pit on the former.

Comparison:—This species is most closely allied to *Ceratocephala vesiculosa* (BEYRICH), 1864 and *C. verneuili* (BARRANDE) 1864 both of which are so intimately related to each other, particularly in the cephalon, as BARRANDE combined them in *Acidaspis vesiculosa.* In the presence of small spines along the anterior margin, the median protuberance located at the centre of the occipital ring and coarser granulation of the test (PRANTL and PŘIBYL, 1949), it agrees better with *C. vesiculosa.* According to BRUTON (1968) the presence of the anterior lateral lobe of the glabella is a distinction of *C. verneuili* from *C. vesiculosa.* This species possesses the lobe, but it is a very small elevation within a relatively broad and deep lateral furrow, which is set close to the frontal lobe at its lateral expansion. An important distinction of this species from these two European species is the absence or improminence of the eye-ridges. Additional differences from *C. vesiculosa* are the mode of coarse granulation and the median tubercle of the occipital ring which is pointed at the top but not produced into a spine as noted by BRUTON in *C. vesiculosa*.

Among the Asiatic odontopleurids the nearest to this species is *Ceratocephala* sp. described by MAXIMOVA (1968) from the Lower Devonian Pribalkhash horizon of Central Kazakhstan. It is represented by an imperfect cephalon. As it is compared with *C. verneuili*, it belongs to the same species group of *Ceratocephala*, but probably not so close to this as these Bohemian species. While the Bohemian ones have the cephala subtrapezoidal in outline, distinctly expanded anteriorly, it is longer and well rounded in the anterior half in the Kazakhstan form. In the outline it may be nearer to *C. vesiculosa* by ERBEN (1952) from the Coblenzian of the Lower Harz. This is another impferfect cephalon whose anterior margin is seemingly more arcuate than the two above mentioned Bohemian forms.

The cephalon of *Ceratocephala vogdesi* ETHERIDGE and MITCHEL in fig. 3 of their plate 51 resembles this cephalon, but the anterior margin is straight, anterior lateral lobe of the glabella absent and eye-ridges are very prominent in that species.

Occurrence:—Fukuji. Incidentally, *Ceratocephala verneuili* occurs in the Kopanina formation of the Budňany and *C. vesiculosa* ranges from the Pridoli formation of the Budňany to the lower Eifelian in Bohemia according to BRUTON (1968).

Family Lichidae HAWLE and CORDA, 1847

In *Silurian Trilobites of Japan*, 1974 the authors summarized Asiatic species of lichids which they can gather out of accessible references to them at that time. Recently CHANG (1974) instituted a new genus *Tsunyilichas* on *Tsunyilichas pustulosus*, nov. from Lower Silurian of Kweichou. Of Devonian species there were 13 species including specifically indeterminable ones which are now referred to *Acanthopyge* s. l. and *Lobopyge*. Here one of *Radiolichas* (?) and another of *Craspedarges* are added to them, as shown in Fossil list 12.

It is a remarkable fact that these four genera belong all to the Ceratargiinae and *Acanthopyge altirhachis* (TSCHERNYSHEVA) from the Upper Silurian of the Kuznetsk basin is the forerunner. "*Acanthopyge*" sp. indet. from Ferghana is the next oldest in Asia.

In Australia are known four lichids as follows:

Acanthopyge australis (McCOY)
Acanthopyge (?) *sinuata* (RATTE)
Acanthopyge (*Mephiarges*) *bifidus* EDGELL
Craspedarges wilcanniae GÜRICH

According to TRIPP (1958) the first and second species are Lower Devonian, the third species is Middle Devonian and the last one Upper Devonian. CHATTERTON (1971) referred the first species to *Lobopyge* and dated the third species at Emsian. GÜRICH's dating of the last species at late Upper Devonian is an important question, since it is, if so, the latest survivor of the Lichidae or Lichacea. The conspicuous

Fossil list 12. Devonian lichids in Asia and Australia.

Trilobite Species / Area	1	2	3	4	5	6	7	8	9
Acanthopyge planus (WEBER)	MD								
Acanthopyge haueri (BARRANDE)	LDf			Daff.					
Acanthopyge, n. sp. (*A. planus* ?)	LDf								
Acanthopyge sp. (WEBER, 1932)	MDf								
" *Acanthopyge* " sp. indet. (WEBER, 1932)	USLDf								
Acanthopyge sibiricus (TSCHERNYSHEVA)		MD							
Acanthopyge parvulus convexus (TSCHERNYSHEVA)		LD							
Lobopyge limbata MAXIMOVA			D_1^{1-2}						
Lobopyge brevis MAXIMOVA			D_1^2 ?						
Lobopyge longiaxis MAXIMOVA			D_1^2						
Lobpoyge sp. (MAXIMOVA, 1968)			D_1^1						
Radiolichas (?) *asiaticus* MAXIMOVA					MD				
Lobopyge erinacea HASS						lEm			
Lobopyge (?) *pulex* HASS						uEm			
Lichas aff. *declieni* HOLZAPEL							MD		
Lobopyge (?) sp. indet.								LD	
Craspedarges superbus KOBAYASHI and HAMADA								Cb-Ef	
Acanthopyge australis (MCCOY)									LD
Acanthopyge (?) *sinuata* (RATTE)									LD
Craspedarges wilcanniae GÜRICH									(Cb-Ef)
Acanthopyge (*Mephiarges*) *bifidus* EDGELL									Em

Area 1 Turkestan, WEBER (1932); f: Ferghana
2 Kuznetsk basin, TSCHERNYSHEVA (1932)
3 Central Kazakhstan, MAXIMOVA (1968)
4 Upper Amur, MODZALEVSKAYA (1969)
5 Mongolian Altai, MAXIMOVA (1974)
6 Bithynia, Turkey, HAAS (1968)
7 Viet-Nam
8 Japan, KOBAYASHI and HAMADA (1977, in this paper)
9 Australia
Age S: Silurian, D: Devonian, Cb: Coblenzian, Em: Emsian, Ef: Eifelian,
L, l: lower, M: middle, U, u: upper

alliance of *Craspedarges superbus* to *C. wilcanniae* suggests that the age of the latter in question may not be much deviated from the former species.

These Australian lichids are also members of the Ceratargiinae. While the Lichinae have flourished in North America in the Devonian period, *Acanthopyge*, *Lobopyge*, *Craspedarges*, *Radiolichas*, *Mephiarges*, and allied genera and subgenera of the Ceratargiinae made a wide radiance in Eurasia and Australia in the same period, although *Acanthopyge* including some of these allies (TRIPP, 1959, in Treatise) is a cosmopolitan genus. *Craspedarges* is on the other hand, restricted to the Western Pacific area. The Lichidae were died out probably by the end of the Middle Devonian period.

Genus *Craspedarges* GÜRICH, 1901

Type-species:—Craspedarges wilcanniae GÜRICH, 1901.

Diagnosis:—In cephalon antero-median, bicomposite lateral and basal lateral lobes completely circumscribed; preoccipital depression profound; occipital ring and posterior cheek border well marked; frontal border depressed, very well developed for lichids; facial sutures divergent from large eyes on two sides. Pygidium having multisegmented cylindrical axial lobe from which post-axial ridge and then a median spine issue; pleural lobes with five pairs of lateral spines issuing from pleural ribs of different strength through marginal rim. Test granulate.

Remarks:—In the lobation of the glabella this genus agrees nicely with

(1) *Acanthopyge* HAWLE and CORDA, 1847, i. e. *Eurages* GÜRICH,

(2) *Perunaspis* PRIBYL, 1949, i. e. *Lobopyge* (*Nitidulopyge*) PŘIBYL and ERBEN, 1952, and

(3) *Lobopyge* PŘIBYL and ERBEN, 1952.

The anterior lobe of the glabella and the anterior marginal border are, however, incomparably well developed in this genus. Furthermore they are quite distinct in the pygidium. Namely, *Acanthopyge* has a similar axial lobe. Only two anterior axial rings are distinct; two pairs of pleural ribs prominent above pleural fields and ending long slender spines; third pair of spines issuing from posterior border. The pygidium of *Lobopyge* is not essentially different from that of *Acanthopyge*, but the axial lobe is very stout, while the post-axial ridge is small. Two anterior pleurae are well developed, each divided into two bands by a pleural furrow; marginal border undefined. *Perunaspis* has a pygidium similar to *Lobopyge*, bur the axial lobe is conical and provided with three or more rings well defined; four pairs of spines present (VANEK, 1959).

The median spine is absent in these three genera, but present in *Radiolichas* REED, 1923, in which, however, the post-axial ridge is absent and three pairs of long pleural spines are mesially furrowed. *Eifliarges* RICHTERS, 1917, has spines as many as six pairs in addition to four short spines behind the axial lobe. *Radiolichas* and *Eifliarges* have cephala quite distinct from *Craspedarges*.

This genus is allied to *Trochurus* BEYRICH, 1845 and *Dicranogmus* HAWLE and CORDA, 1847, both having the posterior median depression and distinct occipital ring, but the cranidium is strongly convex in these genera. The anterior glabellar lobe is not widely exapanded laterally in *Trochurus* and the longitudinal furrows of the glabella are effaced in anterior so completely that the anterior lobe is undefined in *Dicranogmus*.

Among the older lichid genera *Hemiarges* reveals the same kind of lobation and the isolation of the occipital ring, but the anterior and posterior lateral furrows happen to become obsolete. The preglabellar portion of the median lobe is separated from the main part which becomes in *Acanthopyge*, a depressed zone with a pair of tubercles.

The hypostoma of *Hemiarges* is closely allied to that of *Acanthopyge*. The hypostomata of *Lobopyge* and *Perunaspis* are allied to them but differ from them in the lateral auriculation and posterior sinuation. The hypostoma of *Craspedarges* so far known appears nearer to the *Hemiarges-Acanthopyge* form than the *Lobopyge-Perunaspis* form, but the main body is completely bisected by a transversal furrow. The development of the marginal border is the most distinctive speciality for the cephalon of this genus.

In conclusion *Craspedarges* may be said a terminal branch of the Ceratargiiae near *Acanthopyge* derived from Silurian *Hemiarges* stock.

Distribution:—Craspedarges was instituted by GÜRICH in 1901 on *Craspedarges wilcanniae*, nov. which was found among sandstone boulders at White Cliffs, Idar, Wilcannia district, New South Wales, Australia. He concluded the age of the sandstone boulders derived from the opal-bearing formation of White Cliffs at late Upper Devonian on the basis of brachiopods and other fossils in the boulders. Since then the range of the family was generally considered from Ordovician to Upper Devonian as in ZITTEL-BROILI's Grundzüge (1928). It was accepted as the solitary survivor of the superfamily Lichidacea in the late Devonian age by TRIPP (1958, 59).

PHLEGAR (1937), on the contrary, cited the range of the genus from Middle Silurian to Lower Devonian. This range was accepted by HUPÉ (1953, 55), citing " Gothlandien: Europe et Dévonien: Australie." The Silurian species of Europe which PHLEGER referred to *Craspedarges* are

C. acutalis (REED) from Dudley, England
C. ambigua (BARRANDE) and
C. hetericylta (BARRANDE) both from E-e2, Bohemia

which are now all placed in *Hemiarges* (TRIPP, 1958, VANĚK, 1959, HORNÝ and BASTL 1970). Thersfore these three species must be excluded from the genus. Then the age of *Craspedarges wilcanniae* remains as the matter of discussion.

DUN (1896) was the first to examine the fossiliferous boulders in the Cretaceous beds in the White Cliffs Opal-fields. He distinguished 10 forms of brachiopods, 9 of pelecypods and 3 of gastropods besides *Orthoceras*, *Goniatites* and *Tentaculites*, and placed the boulder fauna at the top of Middle Devonian, if not Upper Devonian. *Schizophoria*, *Spirifer jaqueti*, *Aviculopteria australis*, *Loxonema*, and *Tentaculites* are common members between the two collections examined by DUN and GÜRICH. Emphasizing the inclusion of *Rhynohonella duni* GÜRICH, i. e. *R.* cf. *pleurodon* by DUN, GÜRICH concluded the late Upper Devonian age of the opal-bearing formation of White Cliffs.

In *The Geology of New South Wales* (PACHMAN, ed. 1969, p. 148) *Spirifer jaqueti* is referred to *Howellella* (Silurian to Lower Devonian) and it is quoted that "The fauna from the Amphitheatre group apparently Early Devonian in age." Incidentally, the range of *Howellella* is upper Llandovery to Gedinnian in MOORE's Treatise, H, p. 334, 1965, but the genus ranges up as high as Emsian in Australia (TALENT, 1963, p. 28) and some other areas (HAMADA, 1971). The group is disconformably or unconformably overlain by the Middle and Upper Devonian Mulga Downs Group in the Cobar basin, N. S. W. (CAMPBELL, 1972). Therefore the Amphitheatre group must be pre-Eifelian. Is there any possibility for the boulder fauna to be a composite one derived from the two groups ?

Under this cirumstance the dating of *Craspedarges wilcanniae* either at Lower Devonian or at Upper Devonian seems to be indefinite. On the other hand it is fairly certain that *Craspedarges superbus* here described is Coblenzian-Eifelian in age. In view of the remarkable affinity of this species to *C. wilcanniae* it is presumable that the generic range will not expand so long as the whole Devonian period.

Craspedarges superbus KOBAYASHI and HAMADA, sp. nov.

Pl. 4, Figs. 3-15; Text-fig. 5A

1974. ? *Craspedarges* sp. OKAZAKI, pl. 9, figs. 12-14.

Description:—Cranidium provided with well inflated glabella, highest near its center and with relatively wide, flat frontal border; glabella clearly divided by profound furrows into a mushroom-shaped antero-median lobe, bicomposite lobes and basal lateral lobes; antero-median lobe composed of lunate anterior lobe and cylindrical median lobe where the latter is extending further back than bicomposite lobes; longitudinal furrow straight, suddenly bent at anterior end laterally and posteriorly and running into arcuate anterior lateral furrow; bicomposite lobe subtrigonally ovate whereas basal lateral lobe is roundly quadrate; posterior lateral furrow dividing these lobes diagonally divergent from profound preoccipital depression behind the median lobe; occipital ring nearly straight, bent upward along its posterior margin and slanting toward the preoccipital depression where three protuberances are generally present but no median tubercle on the ring; occipital furrow connected with posterior border furrow, but basal lateral lobe invaded between the ring and posterior border of fixed cheek; circum-glabellar furrow deep, continuous in its whole length; fixed cheek narrow and depressed below glabellar lobes; palpebral ridge and band extending from bicomposite lobe postero-laterally, but abruptly turning back- and inward and terminating near middle point of lateral margin of posterior lateral lobe; frontal border nearly as long as anterior lunate lobe of glabella, well rounded, flat, depressed below glabella; facial sutures divergent from palpebral lobe more widely backward than forward; glabellar lobes, occipital ring and posterior border coarsely and densely granulate, but glabellar furrows smooth; frontal border and fixed cheek also granulate, but not so densely as glabellar lobes.

Pygidium exclusive of spines parabolic in outline, about 2/3 in L/W proportion and moderately inflated; marginal spines composed of five pairs of lateral spines beside a short median spine and long and short lateral ones disposed alternately; axial lobe slightly elevated above pleural fields, as wide as a quarter of pygidium, teretconical, but abruptly rounded near three-fifths the pygidial length; thence a narrow and low post-axial ridge issues, but it terminates just inside the posterior rim and then a posterior spine extends backward; axial lobe divided into no less than eleven rings by ring furrows; first ring large, provided with a small articulating half-ring; first ring furrow more pronounced than succeeding ones; two or three rings behind the first better marked than succeeding ones; pleural lobes gently inflated adaxially; first pleuron divided into a narrow anterior band and a broad posterior band by a narrow interpleural furrow which is, however, interrupted by a narrow lateral rim; then two bands united and produced postero-laterally into a spine; second pleuron composed of a wide flat anterior depression and a low posterior rib which are issuing from the second axial ring; third pleuron consists of a prominent rib and a narrow furrow in front both of which are extending from the third or fourth axial ring; fourth and fifth ribs very weak, the former of which exends from near the fourth ring posteriorly and a little laterally, while the latter is nearly parallel to the lateral margin of axial lobe; these pleural ribs once interrupted at marginal rim, extended into spins; granules distributed all over the pygidium.

Observation:—OKAZAKI illustrated in his paper (1974) two cranidia and a pygidium collected by KITO from Sorayama, Fukuji, under the name of (?) *Craspedarges.* The authors spent considerable times with not only KITO's specimens but also many others collected by ONO, TANAKA and YAMAKOSHI for cleaning, observation and comparison. As the result a nearly complete concept can now be figured out of the cranidium and pygidium and something is known of the fixed cheek and hypostoma, although nothing is known of the thorax. Thus, this species supplements a great deal to the type-species to grasp the generic concept.

The cranidia at hand are 7 mm to 19 mm in breadth. The right palpebral lobe is clearly seen in a cranidium (no. 22; KITO coll., Pl. 4, Fig. 8). An imperfect hypostoma (Pl. 4, Fig. 16) and a free cheek (Pl. 4, Fig. 10) were found in a same slab with a small cranidium (no. 14, KITO coll.). They belong most probably to an identical cephalon insofar as can be judged from their size, outline and convexity. The internal and external moulds of a cranidium (625, ONO, coll. Pl. 4, Fig. 9) show the difference of the mode of granulation and sculpture of glabellar furrows between the two sides of the test.

A free cheek whose posterior part is imperfect, is fairly broad. It fits the cranidium along the diagonal anterior branch of the facial suture and the large eye behind it. The cheek has a flat lateral border which is evidently the extention of the frontal border.

The hypostoma is presumed from its middle and posterior parts to be subquadrate and broader than long. The median body is divided by a transverse furrow into a large anterior part and a posterior band. The body is embraced on the posterior and lateral sides by a well developed border, but they are separated from each other by a broad furrow.

Six pygidia in hand are all represented by internal and external moulds. Three of them show the outline which is evidently broader (Figs. 12, 14, 15) than others (Figs. 11, 13), but the narrower ones may be laterally compressed secondarliy, causing deformation of the axial lobe and other part. Because the marginal spines are imperfectly preserved, how far the spines are actually different in length and also their interval. It is, however, certain that long and short ones were alined alternately on the two sides of the short median spine.

Comparison:—GÜRICH (1901) instituted *Craspedarges wilcanniae* gen. et sp. nov. with an imperfect cranidium and three very fragmentary pygidia. The palpebral lobe and the postero-lateral limb of the fixed cheek are unpreserved in the cranidium, but it is evident that the cranidium, glabella and its antero-median lobe are all longer in the Australian species, if compared with this species. In that species the bicomposite lobe is larger as well as longer in comparison with the basal lateral lobe and a median tubercle is present on the occipital ring. In the lateral view the convexity of the glabella attains the maximum near the junction of the anterior lobe with the median lobe whereas the glabella becomes most convex at about the mid-length of the median lobe in this species. The anterior lobe is more developed and the anterior branches of the facial sutures are not so widely divergent in that species.

REED (1923) quoted that " Pygidium (incompletely known) composed of seven (?) pairs of pleural ending in freely projecting marginal spines on each side." It is difficult to restore the pygidium out of the three pygidia. GÜRICH'S pygidium in fig. 7, pl. 18 appears to be broad subtriangular and truncated in posterior. There a median spine is present and five spines are countable on its right side.

The glabellar lobation, developed anterior border of the cranidium and the possession of five pairs of pygidial spines beside the median spine are essential characteristics showing the congeniality of this species with *C. wilcanniae*, but it is readily distinguishable from that species as mentioned above.

Among the lichids of Asia *Lobopyge limbata* MAXIMOVA, 1968, from the Lower Devonian of Central Kazakhstan has the nearest cranidium to this species, particularly in regard to the developed frontal border, although the frontal lobe of the glabella is less developed than that of this species and the median lobe is expanded in middle-posterior. The pygidium of the Kazakhstan species is typical of *Lobopyge*.

Occurrence:—All specimens except one shown in Fig. 15, which was found in shaly bed, were collected by OHNO from a sandy bed at Sorayama.

Genus *Acanthopyge* HAWLE and CORDA, 1847

Acanthopyge (*Lobopyge* ?) sp. indet.

Pl. 4, Fig. 2; Text-fig. 5B

A small cranidium, 4.7 mm broad, from Sorayama is quite different from *Craspedarges* in the narrow convex anterior rim which is separated from the glabella by a narrow deep marginal furrow. The anterior-median lobe is mushroom shaped, like that of *Craspedarges superbus*, but more quickly narrowing laterally. Its median posterior part is cylindrical and separated by straight longitudinal furrows from the bicomposite lateral lobes which are subovate in outline.

In the cranidium before hand its posterior part is unpreserved, but it belongs most probably to either *Lobopyge* or *Acanthopyge*, the two genera having similar cephala, but their pygidia are quite different from each other.

Occurrence:—From a sandy bed at Sorayama, KOIZUMI coll.

Family Cheiruridae HAWLE and CORDA, 1847

This family has been classified and reclassified repeatedly by several authors since HAWLE and CORDA'S proposal on *Cheirurides*, the latest being LANE'S classification, 1971. In his revision he divided the family into seven subfamilies the oldest of which is the Pilekinae ranging from late Upper Cambrian to early Arenigian. All other subfamilies appeared during the Ordovician period, but after Tremadocian and most flourished in the period. Almost all genera of the family disappeared by the end of the Silurian period leaving *Youngia* until Siegenian and *Crotalocephalus* until Givetian.

The subfamily Cheirurinae is the trunk of the family and its terminal genus is *Crotalocephalus*. Because Devonian crotalocephalids reveal unique aspects in phyletic senility, the morphology, taxonnmy and distribution of *Crotalocephalus* are here described and discussed in detail. On this occasion the Pilekinae are discussed with special reference to Upper Cambrian genera, as the subfamily is the stock of the Cheiruridae. As the result of comparison of Upper Cambrian cheirurids with older trilobites it is concluded that the Pilekiinae were probably derived from near the Damesellidae.

Subfamily Pilekiinae SDZUY, 1955

SIVOV (1955) was the first to describe a late Upper Cambrian cheirurid, *Emsurina*, nov. from Salair, Kuznetsk basin, Siberia and to refer the genus to the Cheiruridae in comparing it with *Pilekia*. HARRINGTON (1959), however, stated that it "may be L. Ord. (Tremadoc)" in MOORE's Treatise. Subsequently ROSOVA (1960) instituted *Eocheirurus* and *Emsurella* also on late Upper Cambrian trilobites of Salair. These three cheirurid genera occur together with *Pseudagnostus*, *Arctokephalus* SIVOV, *Portentosus* SIVOV et JEGOROVA, *Parakoldinia* SIVOV, *Pedinocephalina* SIVOV and some other genera. They constitute the Tolstochikhohinsky fauna which is quite distinct from the Tremadocian Zapadnayah fauna of Mt. Shorie, Kuznetsk basin which contains *Apatokephalus*. Furthermore it is now ascertained in the northwestern Siberian platform that *Parakoldinia* and *Apatokephalus* occur in the Upper Cambrian and Tremadocian respectively (ROSOVA, 1963, 1969). Therefore SIVOV and ROSOVA are correct to determine the age of these three cheirurid genera at late Upper Cambrian.

Among these three genera *Eocheirurus* differs from the two others in the broader cephalon and cheeks relative to the glabella and the possession of genel spines of moderate length. In *Emsurella* the glabella tapers forward more distinctly and more rounded in front than in the two other genera. Nevertheless, all of them have the glabella nearly parallel-sided or teretely tapering forward and provided with three pairs of lateral furrows as typical of the Pilekiinae. Small eyes are located in anterior near the glabella; eye-ridge short; facial sutures proparian, their two branches being a little convergent anteriorly and extending laterally but slightly posteriorly on the two sides of the eyes.

When SDZUY (1955) instituted the Pilekiinae in the Cheiruridae, he combined *Pilekia* BARTON, 1915, *Parapilekia* KOBAYASHI, 1934 and *Anacheirurus* REED, 1896 in the subfamily. HARRINGTON (1959) transferred it to the Pliomeridae and added *Metapilekia* HARRINGTON, 1938, *Metapliomerops* KOBAYASHI, 1934, *Emsurina* SIVOV, *Seisonia* KOBAYASHI, 1934 and *Tesselacauda* ROSS, 1951 to the family, but he retained some doubt on the reference of the last three genera.

Recently LANE (1971) replaced the subfamily to the Cheiruridae and included *Pilekia*, *Anacheirurus*, *Koraipsis* KOBAYASHI, 1934, *Metapilekia*, ? *Emsurella*, ? *Emsurina*, ? *Eocheirurus* and ? *Tesselacauda* in it. The authors agree with LANE to consider the subfamily to be the ancestral stock of the Cheiruridae. At the same time it is probable that the family Pliomeridae was derived from the same stock, in view of the close similarity between *Tesselacauda* and *Rossaspis* with regard to the elliptical glabella, short lateral genal spines and so forth which LANE has pointed out.

Among the three Upper Cambrian cheirurid genera *Eocheirurus* is particular intimately related to *Damesella* in the broad cephalon and broad cheeks with genal spines, although the eyes are larger and located near the centers of the cheeks and facial sutures are opisthoparian in *Damesella*. In the outline of the cephalon *Eocheirurus* agrees better with *Damesella brevicaudata* (WALCOTT) than *D. paronai* (AIRAGHI). The latter having intergenal angles is on the contrary comparable with *Tesselacauda* and *Rossaspis*.

In 1905 *Damesella* was founded by WALCOTT on *Damesella blackwelderi*, nov. which was later found to be identical with *Cheirurus paronai* AIRAGHI, 1902, as pointed out already by the senior author (1941). It is an interesting fact indeed that the type-species of *Damesella* was originally a Cambrian species of opisthoparian *Cheirurus*.

Emsurina on the other hand agrees better with the Dorypygidae than the Damesellidae in the narrower cheeks and the greater convexity of the glabella. Its outline is more or less elliptical in *Dorypyge richthofeni* DAMES as in *Tesselacauda* and *Rossaspis*, but parallel-sided and rounded in front in *Basocephalus normalis* IVSHIN as in *Emsurina* and tapering forward and well rounded in anterior in *Paraolenoides kasini* IVSHIN as in *Emsurella* (vide fig. 1 in KOBAYASHI, 1960). *Emsurina* and *Emsurella*, however, differ from the Dorypygidae and Damesellidae not only in the biocharacters of eyes and facial sutures, but also in the lack of genal spines.

Nothing is known of the thorax and pygidium of these cheirurid genera of the Pilekiinae, but it may be admitted to assume that they were like those of the Tremadocian genera of the same subfamily. Their pleuron is generally divided into two bands by pleural furrows like in *Damesella* and *Stephanocare*. *Metapliomerops* has 6 pairs of spines on the pygidium, although the last two pairs are diminitive.

Morphologically it is certain that *Mississquoia* SHAW, 1951 is a relic of the Damesellidae which was introduced by the effacement of the eye-ridge and forward migration of facial sutures, although there are some missing links between the Kushanian Damesellidae and Tremadocian *Mississquoia*. The facial suture is gonatoparian in *Mississquoia*, while it is further migrated causing the forward migration of the eye in the Upper Cambrian cheirurids. In the cephalon *Mississquoia* is not far apart from Canadian *Wutingia* ENDO, 1935 of the Kaolishaniidae, although its pygidium is multispinose, while the pygidium of the Kaolishaniidae has only a pair of spines.

The extension of the lineage of the Damesellidae as far as Tremadocian and of the Cheiruridae as far as late Upper Cambrian, namely, the finds of a relic genus of the former and three progenitors of the latter, and their morphological alliances suggest as a whole that the family Cheiruridae was derived from the Damesellidae probably between the latter and the Dorypygidae (See Postscript 7).

Subfamily Cheirurinae HAWLE and CORDA, 1847

Phylogerontic specializations of the glabella in Silurian and Devonian crotalocephalids

It is of great interest to see unusual aspects of the glabella in *Crotalocephalus*, because it is the latest survivor of the Cheiruridae and the suborder Cheirurina.

Among such aspects are *transglabellar furrows* and *glabellar rings*, nom. nov. defined by them. These furrows indicate the original cephalic segmentation. Therefore they are rather common among Lower Cambrian trilobites, but rare to see among post-Cambrian polymeric trilobites.

Three transglabellar furrows are often explicitly represented in *Redlichia*, a few other redlichids, certain olenellids and *Bathynotus*. They are generally subparallel to one another and gently arcuate backward. Combined with the occipital furrow they define three glabellar rings. It is a general tendency for effacement of such furrows to start from the distal side, as seen in *Paradoxides-Centropleura*, for example. Therefore the posterior glabellar ring i. e., the preoccipital ring is not so rare even among post-Cambrian trilobites. On the other hand two or three transglabellar furrows are exceedingly rare to see even among Middle and Upper Cambrian trilobites, although they are seen in komaspids and ptychaspids for example. Two such furrows in Lower Ordovician *Curiospis* are really exceptional among post-Cambrian trilobites.

In comparison with mature forms, the transglabellar furrows are met with more commonly in immature stages. They are known of *Paradoxides*, *Sao*, *Olenus*, *Leptoplastus*, *Triarthrus*, *Proetus* and so forth, and in Eastern Asia of *Redlichia chinensis*, *Amphoton deois*, *Blackwelderia quadrata* and others. At the same time it can be said that many of them are Cambrian trilobites. Therefore transglabellar furrows and glabellar rings in *Crotalocephalus* are quite rare recurrences of primitive biocharacters known only either in archaeic trilobites or in the early stages of growth.

Lateral furrows are often bifurcated adaxially on the glabella. The bifurcation is met with more commonly on the posterior lateral furrows than the others. In *Crotalocephalus articulatus* posterior branches extend rectangularly from the preoccipital transglabellar furrow, dividing the preoccipital ring into a median and two lateral lobes. This kind of tripartation is similar to that of *Delaria* and *Ditomopyge*, although the median and lateral furrows of the two latters are not identical with the transglabellar furrows and their posterior branches of *C. articulatus*.

In Devonian crotalocephalids the posterior transglabellar furrow and the occipital furrow take respectively V-shape and reversed V-shape as much as they are connected to each other in form of X. As the result the preoccipital ring is bisected into two triangular basal lobes. Such a X-connection is seen also in *Cheirurus* and *Pseudocheirurus*, whereas in *Cerauroides* subquadrate basal lobes are intervened by a broad median area like in *Crotalocephalus articulatus*. *Ceraurinella* represents an intermediate form whose basal lobes are triangular and separated by a median area. These cheirurids, however, have no transglabellar furrows except for *Crotalocephalus*. Thus the appearance of transglabellar furrows is a recurrence of a primitive biocharacter, but the X-connection is a speciality unknown in Cambrian trilobites.

Finally, a median longitudinal or sagittal furrow which bisects the anterior glabellar ring in certain Devonian crotalocephalids is so unusual that PRANTL (1947) considered it to be an abnormal modification in senility. Prior to this three varieties were distinguished by the discrepancy of the ring, namely, *Cheirurus gibbus* var. *interruptus* BARRANDE, 1852, *Cheirurus sternbergi* var. *interrupta* KAYSER, 1878 and *Ch. myops* var. *interrupta* WEBER, 1932 where BARRANDE's is now considered an independent species of *Cheirurus* (*Crotalocephalina*) (HORNÝ and BASTL, 1970). As pointed out already

(KOBAYASHI and IGO, 1956) the latter variety may not be a gerontic form of *Ch. myops*, because it is smaller than *Ch. myops* s. str. not with standing the fact that they were procured from the same locality in Kazakhstan.

Insofar as the authors are aware with accessible literatures, such a discrepant glabellar ring is very uncommon among Eur-African crotalocephalids. In the Fukuchi collection, however, it is so common and so varies in size and form that it can be evaluated a supra-specific distinction.

The median longitudinal furrow on the glabella is really rare in polymeric trilobites. An exception which the authors are aware is Silurian *Langgonia* in Malay in which the furrow cuts into the frontal lobe of the glabella. *Encrinuroides* REED and its related group is another exception having an anterior median furrow on the glabella. Likewise, the furrow cuts the frontal lobe in *Pleuroctenium* and *Tomagnostus*, completely dividing it into two lobes. In *Neoagnostus* the anterior glabellar ring is bisected by such a furrow just like in some Devonian crotalocephalids. Because the suborder Agnostina represents a highly specialized group of trilobites, it may be said a pattern of high specialization. It is also noteworthy that the bisection of the frontal lobe by a median longitudinal furrowdis also well represented on the glabella of certain *Paradoxides* in immature stages. *Paradoxides* is again a highly specialized Middle Cambrian genus derived from the redlichian stock. Therefore it is reasonable to consider that the median longitudinal furrow of Devonian crotalocephalids reveal also a mode of specialization which occurred in a very terminal branch.

In summarizing the above discussion the specializations which occurred in Devonian crotalocephalids may be classified as follows:

1. Glabellar rings defined by transglabellar furrows
   ············Phylogerontic reccurrence of retrogressive biocharacter
2. X-connection between occipital and preoccipital furrows
   ············Phylogerontic spesialization of progressive biocharacter
3. Bisection of anterior or/and middle glabellar rings by a median longitudinal furrow
   ············{ Phylogerontic specialization of progressive (3a) biocharacter
   Pathologic or teratologic modification occurring in some individuals by accidental or spontaneous (3b) injury

These specializations (1, 2, 3a) are all found in subgenus *Geracephalina*, but only two of them (1 and 2) in other subgenera of genus *Crotalocephalina*, here defined.

Genus *Crotalocephalus* SALTER 1853

Type-species:—Calymene articulata MÜNSTER, 1840 (known only of cranidium), monotypic (?).

Remarks:—In 1853 SALTER proposed *Crotalocephalus* as one of four subgenera of *Cheirurus*, in describing *Cheirurus articulatus* ? However, as he was uncertain in the specific identification, he suggested *Crotalocephalus pengelli* for this British form in case of misidentification. This suggestion was later accepted by WHIDBORNE (1889) when he described *Cheirurus pengelli*. *Crotalocephalus* in SALTER's mind was probably such a form as *Crotalocephalus pengelli* and *C. sternbergi*, but *C. articulata* (MÜNSTER) beared " Glabella oblong, broadest in front, with furrows continuous across " as in SALTER's diagnosis.

Calymene articulata MÜNSTER, 1840 was cited as the type-species of *Crotalocephalus* by BARTON (1915), HENNINGSMOEN (in MOORE's Treatise, 1959), ALBERTI (1969) and PILLET (1972), although PRANTL and PŘIBYL (1947) choosed *Cheirurus gibbus* BEYRICH, 1945 for the type-species and the selection was accepted by HUPÉ (1955), BALASHOVA (in Osnovy, 1960), and MAXIMOVA (1968). Therefore PŘIBYL and VANĚK (1964) are correct to propose *Crotalocephalina* nov. for *Cheirurus gibbus*. This was accepted by ALBERTI (1969) and PILLET (1972).

As a result of a restudy on the MÜNSTER's, LÜTKE (1965) who retained a question on the acceptance of *Cheirurus gibbus* as the lectogenotype, pointed out that the *articulata* group should be isolated from most other species of *Crotalocephalus*. The principal distinction of the group is quadrate basal lobes of the glabella, instead of triangular ones, and the rectangular posterior branches of the preoccipital transglabellar furrow which isolate the median lobe from the basal ones. Its age is Middle-early Upper Silurian, if ignored dubious reference of upper Eifelian *C. cordai* BARRANDE, 1846.

Thus, *Crotalocephalus* includes two kinds of cephala, but there is no link. There is a time gap between the two groups at upper Ludlovian. As discussed already, the tripartation of the preoccipital ring and the X-connection of the occipital and preoccipital furrows indicate two distinct trends of evolution. Therefore the authors are of opinion that Devonian crotalocephalids should be distinguished from the *articulate* group generically.

As pointed out by PRANTL and PŘIBYL (1947) and PŘIBYL and VANĚK (1964), Devonian crotalocephalids may be classified into two groups, namely

(1) the *sternbergi* group having a broad and fairly flat dorsal shield, relatively broad cheeks and thoracic pleurae and two or three pairs of long spines of pygidium, and

(2) the *gibbus* group having an elongate convex dorsal shield, broad glabella and thoracic axis and three (or four) pairs of broad spines on the pygidium which is typically mucronate in posterior.

Incidentally, ALBERTI (1971) noted that *Ch.* (*Cr.*) cf. *paupera* BARRANDE is dimorphic, having a mucronate pygidium in one and a non-mucronate pygidium in another form.

In the congrees of A. F. A. S. at Rennes, 1963, PILLET presented a note in which he proposed a tripartation of *Crotalocephalus* into *Crotalocephalus* s. str., *Gibbocephalus* nov. and *Boeckia* nov. where the type-species of the respective subgenus were *Calymene articulata*, *Cheirurus gibbus* and *Trilobites sternbergi*. This article was printed in 1965. In consequence *Gibbocephalus* became a junior subjective synonym of *Crotalocephalina*. *Boeckia*, on the contrary, was a homonym of *Boeckia* MALM, 1870, BRÖGGER and BRADY, 1874. Therefore PŘIBYL suggested *Pilletopeltis* for PILLET's *Boeckia* in his letter to PILLET, 1969 and PŘIBYL's new name was published in PILLET's article, 1972.

Beside these ALBERTI (1969) proposed *Crotalocephalides* for *Cheirurus* (*Crotalocephalus*) *gaertneri* ALBERTI, 1962 as its type-species. It has four pairs of long spines on the pygidium; frontal lobe of glabella well developed and drooping in anterior; pregenal spine present in early post-larval stage reduced in length in mature stage.

Here *Crotalocephalina* is promoted to the generic rank. The above mantioned X-connection is the essential distinction from *Crotalocephalus.* This genus includes four subgenera, viz. *Crotalocephalina* s. str., *Pilletopeltis*, *Crotalocephalides* and *Geracephalina*, nov. The last subgenus, *Geracephalina* here proposed, differs from the precedings in the bisection of the anterior glabellar ring by the median longitudinal furrow. Its type-species is *Geracephalina secta*, nov.

In summarizing the above discussion the so-called *Crotalocephalus* is classified as follows:

Genus *Crotalocephalus* Salter, 1853
Genus *Crotalocephalina* Přibyl and Vaněk, 1964
    Subgenus *Crotalocephalina* Přibyl and Vaněk, 1964
    Subgenus *Crotalocephalides* Alberti, 1967
    Subgenus *Pilletopeltis* Pribyl in Pillet, 1972
    Subgenus *Geracephalina* Kobayashi and Hamada, subgen. nov.

Distribution of "*Crotalocephalus*" in Asia and the Ural Mountains

This genus is widely distributed from Japan to Asia Minor. It has most flourished in Ferghana, Turkestan as reported by Weber in 1932 the following species.

1. *Cheirurus myops* Roemer and *Ch. myops interrupta* Barrande. Mushketov and Nalivikin's collection, loc. 53, Upper Silurian.
2. *Cheirurus myops* Roemer. J. Rheinwald's collection, loc. 20, Upper Silurian.
3. *Cheirurus sternbergi* Boeck (?). Hypostoma. Weber's collection, loc. 1300, Lower Devonian.
4. *Cheirurus sternbergi* Boeck. Hypostoma. Nalivikin's collection, lower Middle Devonian.
5. *Cheirurus uratubensis* Weber (nov.). Pygidium. Mushketov's collection, loc. 81, Uratiube, Upper Silurian.

In 1951 Weber redescribed *Crotalocephalus myops* and proposed a new name, var. *scissa* for *Cr. myops interrupta.* In addition he described *Crotalocephalus sternbergi* Boeck var. *bitumulata* nov. from the Urals, and *Cheirurus* (?) *longiaxiatus* nov. from Middle Asia. The last is founded on a mucronate pygidium with three pairs of long spines apparently intermediate between *Crotalocephalina* and *Pilletopeltis.* They were considered upper Ludlovian in age.

In the same year Tschernysheva described the following species from the Kuznetsk basin, West Siberia.

Cheirurus (*Crotalocephalus*) *myops* Roemer (S_2, D_1^1)
Cheirurus (*Crotalocephalus*) *yavorskyi* Tschernysheva (D_1^1)
Cheirurus (*Crotalocephalus*) *parvus* Tschernysheva (D_2^1)

A further development of the genus in the stretch from the Urals to Kazakhstan was shown successively by Maximova in her papers as below.

(1) Givetian: *Agoniatites* and *Stringocephalus burtoni* zone in the Urals and Northern Mugodzhar (Maximova, 1955).

Cheirurus (*Crotalocephalus*) *sternbergi* ROEMER
Cheirurus (*Crotalocephalus*) *tardus* MAXIMOVA (nov.)

(2) Lower and Middle Devonian of Rudĭ-Altai (MAXIMOVA, 1960).

Crotalocephalus myops ROEMER (D_1^2-D_2^1)
Crotalocephalus aff. *uratubensis* (WEBER) (D_2^1)
Crotalocephalus sp. Hypostoma (D_2^1)

(3) Coblenzian, Kazakhstan (MAXIMOVA, 1960).

Crotalocephalus gibbus hexaspinus MAXIMOVA (nov.)

(4) Upper Silurian and Lower Devonian, Central Kazakhstan (MAXIMOVA, 1968).

Crotalocephalus expansus BALASHOVA (S_2)
Crotalocephalus gemmatus WEBER (S_2)
Crotalocephalus cf. *sternbergi* BOECK (S_2)
Crotalocephalus hexaspinus MAXIMOVA (D_1^2)
Crotalocephalus sp. Hypostoma (D_1^2)

Assuming that the specific identification is correct, the above species may be referred to subgenera of *Crotalocephalina* as below:

(1) *Crotalocephalina* (*Crotalocephalina*): *hexaspinus* MAXIMOVA, *uratubensis* WEBER, (?) *yaborskyi* TSCHERNYSHEVA, (?) *longiaxiatus* WEBER
(2) *Crotalocephalina* (*Pilletopeltis*): *bitumulatus* WEBER, *myops* ROEMER, *parvus* TSCHERNYSHEVA, *sternbergi* ROECK, *tardus* MAXIMOVA.
(3) *Crotalocephalina* (*Geracephalina*): *expansus* BALASHOVA, *myops interrupta* BARRANDE.

Incidentally, *Cheirurus myops* BEYRICH, 1845 is according to LÜTKE (1965) a junior objective synonym of *Cheirurus* (*Cheirurus*) *propinquus* (MÜNSTER, 1840) and *Cheirurus myops* ROEMER, 1850 is a junior primary homonym of *Cheirurus myops* BEYRICH. Therefore he proposed a new name *Cheirurus* (*Crotalocephalus*) *affinis neomyops* for the latter. LANE (1971) referred *Crotalocephalus gammatus* together with *Cheirurus quenstedti orientalis* MAXIMOVA to his *Didrepanon*. *Cheirurus* (*Crotalocephalus*) *yavorskyi* is a peculiar species having the middle glabellar ring, instead of the anterior ring, bisected.

In Japan two subgenera, *Pilletopeltis* and *Crotalocephalina* of *Crotalocephalina* were represented respectively by *Cheirurus* (*Crotalocephalus*) *japonicus* KOBAYASHI and IGO, 1956 and *Cheirurus* (*Crotalocephalus*) sp. indet.

Now the following species are known in Japan:

Crotalocephalina (*Crotalocephalina*) sp. nov.
Crotalocephalina (*Pilletopeltis*) *japonica* KOBAYASHI and IGO
Cr. (*P.*) *japonica granulata* KOBAYASHI and HAMADA, subsp. nov.
Cr. (*P.*) *kameii* KOBAYASHI and HAMADA, sp. nov.
Crotalocephalina (*Crotalocephalides*) sp.
Crotalocephalina (*Crotalocephalides* ?) sp.
Crotalocephalina(*Geracephalina*) *secta* KOBAYASHI and HAMADA, sp. nov.
Cr. (*G.*) *secta projecta* KOBAYASHI and HAMADA, subsp. nov.
Cr. (*G.*) *convexa* KOBAYASHI and HAMADA, sp. nov.
Crotalocephalina (*Geracephalina*) *euryrachis* KOBAYASHI and HAMADA, sp. nov.
Crotalocephalina subg. et spp. indet.

The Devonian of Bithynia, Northwest Turkey yields the following two species (HAAS, 1968).

Cheirurus (*Crotalocephalus*) *copiosus* HAAS, Praguian, probably high Siegenian.
Cheirurus (*Crotalocephalus*) *sternbergi sternbergi* (BOECK), highest Emsian.

They are two members of *Crotalocephalina* (*Pilletopeltis*), but the latter species appears to include *Geracephalina*.

Finally, *Crotalocephalus* is reported to occur in the Eifelian of Northeastern USSR (NIKOLAEV and RZHONSNITSKAYA, 1967).

Distribution of "*Crotalocephalus*" in Australia and Tasmania

"*Crotalocephalus*" has thrived in Australia and Tasmania in the Middle Palaeozoic times as represented by the following occurrences:

Crotalocephalus silverdalensis ETHERIDGE and MITCHELL, 1917. Yass-Hume beds, New South Wales, Upper Silurian; Boola beds, Victoria (PHILIP, 1962)
Crotalocephalus sculptus ETHERIDGE and MITCHELL, 1917. Lower Trilobite beds, N.S.W.; Upper Silurian.
Crotalocephalus (?) sp. by ETHERIDGE and MITCHELL, 1917. Molong limestone, N.S.W.
Cheirurus sternbergi BOECK by CHAPMAN, 1915. Yeringian, Victoria.
Cheirurus (*Crotalocephalus*) sp. by GILL, 1948. Yeringian Eldron Group, Tasmania.
Cheirurus (*Crotalocephalus*) sp. by TALENT, 1963. Lower Devonian limestone, Victoria.
Cheirurus (*Crotalocephalus*) *packhami* STRUSZ, 1964. Lower to Middle Devonian, N.S.W.
Cheirurus (*Crotalocephalus*) *regius* FOLDVARY, 1970. Lower Devonian, N.S.W.

C. silverdalensis and *C. sculptus* belong to *Crotalocephalina* (*Pilletopeltis*) and *C. packhami* and probably *C. regius* to *Crotalocephalina* (*Crotalocephalina*). *C. regius* is probably referable to *Crotalocephalina* (*Geracephalina*) because its illustration shows its median longitudinal furrow clearly bisecting the anterior and middle glabellar rings. TALENT's *Cheirurus* (*Crotalocephalus*) sp. seems to be an immature form of *Crotalocephalina* (*Geracephalina*). It is a question whether *Crotalocephalina* appeared already in late Silurian in Australia, Turkestan, western Siberia and the Urals. These are mostly older records and more recent records are all from the Devonian except for in Central Kazakhstan where it occurs at the Silurian-Devonian transition.

Genus *Crotalocephalina* PŘIBYL and VANĚK, 1964

Type-species:—*Cheirurus gibbus* BEYRICH, 1845.

Distribution:—Lower and Middle Devonian: Europe, North Africa, Asia and Australia, possibly uppermost Silurian in Kazakhstan. Upper Silurian in the Urals, North and Central Asia, and Australia in older records of occurrences.

Subgenus *Crotalocephalina* PŘIBYL and VANĚK, 1964

This subgenus is represented in Europe and North Africa by the following species:

? *africanus* ALBERTI, 1967
brevispsnosus ERBEN, 1952
chlupaci PŘIBYL and VANĚK, 1962

gibbus auster ALBERTI, 1970
globifrons HAWLE and CORDA, 1847
intermedius PILLET, 1965
? *maurus* ALBERTI, 1966
trigonalis PILLET, 1972

They are distribued in the range from Lochkovian to Eifelian in Europe and North Africa. See pages 100 and 102 for Asian and Australasian species respectively.

Crotalocephalina (*Crotalocephalina*) sp. indet.

Pl. 8, Fig. 2; Text-fig. 3E

1956. *Cheirurus* (*Crotalocephalus*) sp. indet. KOBAYASHI and IGO, *Japan. Jour. Geol. Geogr., vol. 27*, p. 152, pl. 10, figs. 5a-b, text-fig. 2.

Though imperfect, this species agrees with *Crotalocephalina* s. str. in the strongly inflated cephalon, forwardly expanded glabella, strongly convex large frontal lobe and narrow cheek. The transglabellar furrows are distinctly oblique to the axis; eye relatively small but prominent and located near the anterior glabellar ring. The anterior branch of the facial suture is somewhat arcuate and cuts the frontal border diagonally; its posterior branch nearly straight and transversal. The test is coarsely granulate. The anterior outline of the cephalon conspicuously protruded at the part of the cranidium and the more or less arcuate anterior and middle furrows on the glabella are two characteristics of this species to show its being a new species.

Occurrence:—On the southern slope of Sorayama, Fukuji, Kamitakara village, Yoshiki County, Gifu Prefecture.

Genus *Pilletopeltis* PRIBYL in PILLET, 1971

Type-species:—Trilobites sternbergi BOECK, 1827.

Distribution:—The following species and subspecies are known from Devonian strata from Praguian to Givetian in Europe and Nortn Africa.

affinis affinitis HAWLE and CORDA, 1847
affinis meridionalis ALBERTI, 1969
affinis neomyops LÜTKE, 1965
? *cordai* BARRANDE, 1852
insularis LÜTKE, 1961
? *lenoiri* BERGERON, 1887
maurus ALBERTI, 1966
pauper pauper BARRANDE, 1852
pauper zagorai ALBERTI, 1967
pengelli WILDBORNE, 1889
sternbergi racemifer PŘIBYL and VANĚK, 1968
sternbergi couffoni PILLET, 1971
transiens BOUCEK, 1935

See pages 101 and 102 for Asian and Australasian species respectively.

Crotalocephalina (Pilletopeltis) japonica (KOBAYASHI and IGO, 1956)

Pl. 5, Figs. 1, 2, 3, 5-8; Pl. 8, Figs. 3-6; Text-fig. 3F

1955. *Cheirurus sternbergi* BOECK by KAMEI and IGO, *Jour. Geol. Soc. Japan*, p. 557, text-fig.
1956. *Cheirurus (Crotalocephalus) japonicus* KOBAYASHI and IGO, *Japan. Jour. Geol. Geogr., vol. 27, nos. 2-4*, p. 150, pl. 10, figs. 1-4.
1970. *Crotalocephalus* sp. by KOIZUMI and KAKEGAWA, *Earth Sci., vol. 24, no. 5*, p. 184, pl. 1, fig. 5, only.
1974. *Crotalocephalus japonicus* by OKAZAKI et al. *Jour. Geol. Soc. Japan, vol. 80, no. 11*, pl. 1, figs. 1-2.
1974. *Crotalocephalus (Pilletopeltis) japonicus* KOBAYASHI and HAMADA, *Proc. Japan Acad., vol. 50, no. 9*, p. 761.

Description:—Dorsal shield fairly broad and not much inflated; axial lobe relatively narrow in comparison to pleural lobe and tapering gradually backward. Cephalon semicircular in outline, large and moderately inflated. Glabella clearly outlined by profound dorsal furrows, more or less pentagonal, but well rounded in front, slightly elevated above cheeks, a half longer than broad, occupying about one-third cephalic breadth at the base, expanding forward very slowly but rather abruptly in anterior; transglabellar furrows deep; anterior and middle ones in form of two obtuse Vs, and more or less recurved near lateral ends; posterior one more oblique than the precedings and joins with occipital furrow on axis where it is bent up; at this point occipital ring strongly expanded and a little so the middle glabellar ring; median tubercle absent on these rings; posterior glabellar ring divided there into two triangular basal lobes; middle ring almost as large as anterior one, but somewhat thicker near axis; frontal lobe much larger than these rings, more or less triangular, expanded laterally near base and well rounded in anterior. Eyes moderate sized, close-set to anterior glabellar ring and elevated above cheeks. Marginal border convex, defined by marginal furrow on inner side and produced into a short spine. Facial sutures anterior to eyes running nearly parallel to axial furrow, but somewhat laterally and swinging adaxially on anterior marginal furrow and border; posterior branch of the suture running laterally from posterior end of eye, but suddenly turning postero-laterally at junction with marginal furrow, forming an angle and crossing lateral border diagonally. Glabella densely granulate; cheeks pitted and in part granulated; all furrows smooth; marginal border almost smooth, but minute tubercles sparcely scattered.

Thorax composed of no less than 10 segments, gradually narrowing backward; axial ring narrower than pleuron and divided into three parts by a pair of buttons; pleuron divided into two bands by diagonal pleural furrow and falcate near the end; anterior band provided with two prominent buttons and posterior band with a prominent button near adaxial end.

Pygidium with three rings and a terminal lobe; axial ring provided with paired buttons; post-axial spine absent. Pleural region divided into three parts by interpleural furrows and free in abaxial half; anterior pleuron extending laterally, falcate terminaly, divided into two bands by diagonal pleural furrow; anterior band furnished with two buttons and posterior one with one button; middle pleuron also divided into two bands, but buttons not so prominent and more largely falcate in free part; last pleural part extending from third axial ring and a terminal lobe, produced posteriorly and bisected by a furrow; buttons there insignificant.

Observation:—The holotype shield is composed of a cephalon and seven thoracic segments, but the anterior right side of the cephalon is broken off. The paratype specimen is an imperfect pygidium which, however, shows paired buttons on the axial rings clearly.

Another shield from Kinma-michi (No. 125, Shizenkan; Pl. 5, Fig. 1) consists of a cephalon, ten or eleven thoracic segments and a part of a pygidium, but these segments are not so well preserved as their number is exactly countable. Due to secondary deformation pits on the right cheek are elongated, but those on the left cheek are normal. The eyes and facial sutures are clearly observable on the right cheek, but genal angles are ill-preserved.

Genal spines can be well seen on a nearly complete cranidium from Oisé-dani (YT-1; Pl. 5, Fig. 3).

Two detached thoracic segments from Oisé show narrow axial rings and broad falcate pleurae which are divided into two bands. A pygidium on the same slab has falcate free parts of the pleurae which are twice or more broader than the axial lobe.

A pygidium KITO collected at Ichinotani (Pl. 5, figs. 7a, b) enables one to grasp the general concept, being supplemented by another from Kinma-michi (Pl. 5, Fig. 4; OKAZAKI, Pl. 8, Fig. 9).

Comparison:—This species is typical of *Pilletopeltis* in the broad outline and low convexity of the dorsal shield, narrowness of the glabella and axial lobes of the thorax and pygidium which is non-macronate. As noted by KAMEI and IGO (1955) already, it is allied to *Crotalocephalus sternbergi* and *Cr. silverdalensis*, particularly to the latter in the arcuate transglabellar furrows. Most distinctive of this species is two rows of prominent buttons through the axial rings of the thorax and pygidium by which it can readily be distinguished from other species of *Pilletopeltis*.

Occurrence:—The holotype and paratype specimens were collected near Kinma-michi on the eastern slope of the upstream of Ichinotani about 300 m from its junction with Osobu-dani to the South of Fukuji village. Other specimens are from Kinma-michi (No. 125, Shizenkan); Oisé-dani (YT-1, YT-19, YT-45); Kinma-michi (OKAZAKI coll., Pl. 8, fig. 9).

Crotalocephalina (*Pilletopeltis*) *japonica granulata*
KOBAYASHI and HAMADA, subsp. nov.

Pl. 5, Figs. 9a-d

1974. *Crotalocephalus* (*Crotalocephalus*) *japonicus* by OKAZAKI, *Mem. Fac. Sci., Univ. Kyoto, Ser. Geol. Min., vol. 11, no. 2*, pl. figs. 4a-b.

Compared with the typical form the transglabellar furrows, particularly the anterior one, are more distinctly V-shaped in this subspecies. It differs from the succeeding species principally in the dense granulation on the glabella. The transglabellar furrows are somewhat slender. At a glance the anterior glabellar ring seems to be bisected mesially, but it is entire and only accidentally cracked. The occipital ring bears paired tubercles.

Occurrence:—Boulder in western area (Kanajiro-zako), Fukuji distinct.

Crotalocephalina (*Pilletopeltis*) *kameii* KOBAYASHI and HAMADA, sp. nov.

Pl. 5, Figs. 10a-d, 11; Text-fig. 3G

1970. *Crotalocephalus* sp. α, KOIZUMI and KAKEGAWA, *Earth Sci.*, *vol. 24*, *no. 5*, p. 180, pl. 1, fig. 4, only.

1974. *Crotalocephalus* (*Crotalocephalus*) *japonicus* by OKAZAKI, *Mem. Fac. Sci.*, *Univ. Kyoto*, *Ser. Geol. Min.*, *vol. 11*, *no. 2*, p. 8, pl. 8, fig. 6, only.

Description:—Cranidium gently convex toward middle and posterior parts of the axis which indicate top-level. Glabella circumscribed by deep dorsal furrows subcylindrical or slightly tapering backward; anterior and middle transglabellar furrows gently arcuate; posterior one distinctly V-shaped and connected with occipital furrow in form of X; basal lobes triangular; occipital ring narrowing laterally; frontal lobe of glabella moderate in size, subrhomboidal or more or less triangularly ovate, gently slanting as far as frontal border; surface of glabella smooth except for sparse fine granules. Fixed cheeks nearly as wide as glabella or a little narrower than the latter, gently sloping toward lateral border; eyes close-set anterior glabellar ring; marginal furrow deep; border narrow and convex; short spine issuing from genal angle diagonally; anterior branches of facial sutures subparallel to each other as far as they reach anterior lateral border; their posterior branches extending laterally and then diagonally crossing a half of posterior lateral border; cheeks strongly pitted but borders and spines are smooth.

Observation:—Four cranidia before hand are somewhat different particularly in the outline of the frontal lobe of the glabella, but they bear common biocharacters. The holotype collected by TATEMATSU at Kanajiro-zako is a nearly complete cranidium. Compared with it the frontal lobe is somewhat larger and more or less triangularly ovate in another cranidium from the same locality (YT-0; Pl. 5, Fig. 11). The two transglabellar furrows are nearly straight in still another cranidium (KOIZUMI and KAKEGAWA, Pl. 1, fig. 4). They are, however, similar to one another in outline and texture of the glabella.

Comparison:—This species differs from the preceding in the nearly parallel-sided and relatively broad glabella, small granules very sparse there and transglabellar furrows not so V-shaped as in that species.

In the relatively narrow cheeks it resembles subgenus *Crotalocephalina*, but the cheeks are by no means so narrow as in *C.* (*C.*) *gibbus*. The cranidium is not so inflated and the frontal lobe of the glabella not much drooping as in that subgenus.

Occurrence:—Bed 10, TATEMATSU collection (OKAZAKI, Pl. 8, fig. 6); Kanajiro-zako, TANAKA coll. (YT-0); Takahara-gawa float (KOIZUMI and KAKEGAWA, pl. 1, fig. 4).

Subgenus *Crotalocephalides* ALBERTI, 1967

Type-species:—*Cheirurus* (*Crotalocephalus*) *gaertneri* ALBERTI, 1962.

Remarks and Distribution:—It is more likely that this subgenus was derived from an early form of *Crotalocephalina* s. str. by addition of a segment to the pygidium and associated modification rather than from Wenlockian *Cheirurus* (*Cheirurus*) *bifuracatus* BARRANDE, 1852 from the Liteň high in Bohemia.

Praguian; Germany (Oberfranken-Ostthüringen), and Sardinia. It is unexpected that two Fukuji specimens bear pregenal spines unknown in other subgenera of crotalocephalids.

Crotalocephalina (*Crotalocephalides*) sp. indet.

Pl. 7, Fig. 8.

A fixed cheek before hand has a genal and a pregenal spine which the latter issues just behind the junction of the posterior branch of the facial suture with the lateral margin of the cheek. The margin between the two spines is distinctly concave, while the anterior lateral margin of the free cheek is regularly convex outward. The genal spine is a little longer than the pregenal spine.

In *Crotalocephalina* the pregenal spine is known to appear only in subgenus *Crotalocephalides* in its immature stage. The cheek in hand is already in an early mature stage insofar as can be judged from its size.

Occurrence:—At the top of a water fall of Ichinotani, Fukuji district.

Crotalocephalina (*Crotalocephalides* ?) sp. indet.

Pl. 7, Fig. 7; Text-fig. 3D.

1974. *Crotalocephalus* (*Crotalocephalus*) *japonicus* by OKAZAKI, *Mem. Fac. Sci., Univ. Kyoto, Ser. Geol. Min., vol. 11, no. 2*, pl. 8, fig. 5, only.

A full grown cranidium at hand has a rudimentary pregenal spine in front of a relatively long genal spine. Judging from the changing breadth of the posterior lateral border the pregenal spine is located just behind the lateral end of the facial suture as it is in the preceding species.

The two species reveal probably two growth stages of two different species in the same subgenus.

This species resembles *Crotalocephalina* (*Geracephalina*) *secta*, but the median longitudinal furrow appears absent whereas the rudimentary pregenal spine is present.

Occurrence:—The crotalocephalid bed of Sorayama; Shizenkan no. 3.

Subgenus *Geracephalina* KOBAYASHI and HAMADA, subgen. nov.

Type-species:—Crotalocephalina (*Geracephalina*) *secta* KOBAYASHI and HAMADA, sp. nov.

Diagnosis:—Crotalocephlina nearest to *Pilletopeltis*, but different from all existing subgenera in the presence of the median longitudinal furrow which bisects the anterior glabellar ring and occasionally the middle one; a pair of tubercles commonly present on occipital ring.

Remarks:—The anterior glabellar ring is exceptionally bisected by a sagittal furrow on a Steinkern of a cranidium from Upper Emsian (?) of Bohemia which was identified by LÜTKE (1965) with *Crotalocephalus sternbergi sternbergi* a form (pl. 21, fig. 2). The sagittal furrow is seen, but not quite distinctly, on an immature cranidium from the Praguian of Morocco which ALBERTI (1969) referred to *Cheirurus* (*Crotalocephalina*) *gibbus.* Beside these the discrepant rings have been known of *Crotalocephalus sternbergi interruptus* KAYSER, 1878, *Cheirurus myops interruptus* WEBER and a few other Coblenzian and Eifelian crotalocephalids (HOLZAPFEL, 1885, KAYSER, 1896, HERMANN, 1911, 1912, RICHTERS, 1917, 1921). They may be attributable to an abnormal degenerating modification occurred accidentally in gerontic individuals.

In the case of the Fukuji trilobites, on the contrary, such forms are no less common than others of known subgenera of *Crotalocephalina.* On the other hand there is none having teratological injuries which are asymmetrical as demonstrated by PRANTL (1946). This subgenus is represented by three species and one subspecies, each represented by more than two individuals which are in different growth stages. They constitute as a whole a terminal highly specialized group which appeared in the phylogerontic stage.

Crotalocephalus expansus BALASHOVA in MAXIMOVA, 1868 from Central Kazakhstan belongs most probably to this subgenus.

Distribution:—Gedinnian to Eifelian in Japan; Gedinnian in Kazakhstan; Lower and Middle Devonian in Australia and ? Eur-Africa.

Crotalocephalina (*Geracephalina*) *secta*
KOBAYASHI and HAMADA, sp. nov.

Pl. 6, Fig. 1; Text-fig. 3A.

1974. *Crotalocephalus* (*Crotalocephalus*) *japonicus* by OKAZAKI, *Mem. Fac. Sci., Univ. Kyoto, Ser. Good. Min., vol. 11, no. 2*, p. 85, pl. 6, figs. 1, 3, only.

Description:—Cephalon exclusive of genal spines semicircular and moderately inflated. Glabella subcylindrical, well rounded in front and behind, circumscribed by pronounced dorsal furrows, strongly convex, slightly elevated above cheeks; three transglabellar furrows all arcuate; anterior and middle furrows nearly parallel to each other, but the former is apparently a little more arcuate than the latter; posterior one strongly bent in obtsue V-shape and confluent with occipital furrow in form of X to separate triangular basal lobes on two lateral sides; middle glabellar ring expanding adaxially, while anterior one is very slightly narrowing in the same direction and bisected by a median longitudinal furrow; anterior margin of middle ring sometimes notched at median point; frontal lobe subrhombic, much wider than long; occipital ring rhomboidal, nearly as long as middle ring in sagittal length and provided with a pair of tubercles; posterior margin of the ring less arcuate than its anterior one. Cheek a little broader and less convex than glabella; eyes set close to anterior glabellar ring. Marginal borders and furrows visible all around cephalon in dorsal view. Facial sutures subparallel to axial furrows in anterior to eyes and extending from their posterior ends almost due laterally, but forming angles at the junction with lateral marginal furrows, they cross lateral borders diagonally. Glabella granulate; cheeks pitted.

Associated pygidium subtriangular, provided with three pairs of lateral spines of similar length; axial lobe occupying one-third the triangle, composed of three rings and a terminal lobe; pleural lobe divided into three parts by interpleural furrows; three pleurae each provided with a long spine which is extending more posteriorly than lateral; no post-axial spine.

Comparison:—This species can be distinguished from *Crotalocephalina* (*Pilletopeltis*) *japonica* essentially by the discrepant anterior glabellar ring by a median longitudinal furrow. The glabella is nearly parallel-sided in this species.

Occurrence:—Crotalocephid bed at Sorayama, Fukuji district.

Crotalocephalina (*Geracephalina*) *secta projecta*, KOBAYASHI and HAMADA, subsp. nov.

Pl. 6, Figs. 2-4; Pl. 7, Fig. 13; Text-fig. 3B.

1974. *Crotalocephalus* (*Crotalocephalus*) *japonicus* by OKAZAKI, *Mem. Fac. Sci., Univ. Kyoto, Ser. Geol. Min., vol. 11, no. 2*, pl. 8, fig. 2 only.

This subspecies agrees with the typical form in most characteristics, but the anterior outline of the cephalon is distinctly protruded at the front of the glabella. Two cephala in black shales show such projection partly emphasized by secondary deformation. The projection is, however, considered probably an original aspect because two cephala procured from two separate localities have the same kind of projection.

The type cephalon from Ichinotani reveals a complete left cheek and glebella. A pair of tubercles are distinct on the occipital ring. The second cephalon is imperfect, but the median furrow is more clearly seen. The third specimen also from Ichinotani contains an imperfect cranidium and a nearly complete hypostoma which the latter is long elliptical in outline, but provided with a pair of small anterior wings. The central body is divided into a main part and a posterior lunate area by insertion of a pair of lateral furrows.

Occurrence:—The type specimen collected by OHNO from bed 8 at Ichinotani; the second specimen by KOIZUMI at Kanajiro-zako, the third specimen by OKAZAKI from bed 10 at Ichinotani.

Crotalocephalina (*Geracephalina*) *convexa* KOBAYASHI and HAMADA, sp. nov.

Pl. 6, Figs. 5-10; Pl. 7, Figs. 10-12; Text-fig. 3C.

This is the more convex form than the preceedings. The glabella is robust, strongly inflated and steeply slanting at frontal lobe. The dorsal and transglabellar furrows are all strengthened. The middle glabellar ring is distinctly notched at the median point of its anterior margin.

Hypostomata from Sorayama (TATEMATSU coll.), Kanajiro-zako (KOIZUMI coll.) and Takanosu (ONO coll.) are elongate oval in outline, but auriculate antero-laterally; anterior wings moderate in size and depressed; main body strongly convex, separated from posterior lobe by maculae-incisions; test sparsely tuberculate.

Two thoracic segments in the collection are, though fragmentary, invaluable to supplement the specific concept. They are each divided into two convex bands by a pleural furrow and falcate in the abaxial quarter or so. Near the other end the anterior band bears two buttons. The adaxial one is large and elongate laterally, while the other is small and circular. The pleural ridge extending therefrom bears a row of minute tubercles on the top. The posterior band has a triangular button near the axial furrow.

Two pygidia also from Kanajiro-zako bear buttons on the two bands of the pleura. Paired spines on the axial rings are well preserved. They reveal a very distinctive characteristic of this species. The free falcate part of the pleuron is, however, unpreserved in the specimens at hand.

Occurrence:—Kanajiro-zako (KOIZUMI collection).

Crotalocephalina (*Geracephalina*) *euryrachis* KOBAYASHI and HAMADA, sp. nov.

Pl. 7, Figs. 1-6; Text-fig. 4H.

1974. *Crotalocephalus* (*Crotalocephalus*) *japonicus* by OKAZAKI, *Mem. Fac. Sci., Univ. Kyoto, Ser. Gool. Min., vol. 11, no. 2*, pl. 8, figs. 7 and 8.

This species differs from the precedings in the relatively broad glabella in comparison with free cheeks. It is forwardly protruded so much that the anterior border lies concealed below the frontal lobe in the dorsal view, but the anterior outline of the cephalon is not particularly protruded in front of the glabella. The genal spines are unusually undeveloped in this, while they are moderate in length in the preceedings.

The Sorayama specimen (Pl. 7, Fig. 3) shows the general shape of the cephalon, but the test is somewhat eroded. The cephalon from Ichinotani (TATEMATSU coll., Pl. 7, Fig. 6) is imperfect, but one can see the eye, facial suture, genal point and surface sculptures on the glabella and cheek more clearly. The cephala found at Kinma-michi (Pl. 7, Figs. 4, 5) are so strongly compressed laterally that they became longer than broad. At the same time the convexity is much emphasized. The Ichinotani specimen is the type of this species.

Crotalocephalus expansus BALASHOVA in MAXIMOVA, 1968 is a *Geracephalina* without genal spines like this species. In that species, however, the frontal lobe of the glabella is much larger in comparison with the remainder of the glabella and in this species the transglabellar furrows are more strongly V-shaped.

Occurrence:—Type specimen collected by TATEMATSU at Ichinotani; two other specimens from Sorayama (YAMAKOSHI coll., 72, 4, 5) and Kinma-michi.

Subgenus indet.

Crotalocephalina, subgen. et spp. indet.

1970. *Crotalocephalus* sp. α, (fragmentary pygidia) KOIZUMI and KAKEGAWA, *Earth Sci., vol. 24, no. 5*, pl. 1, figs. 6 and 7.

1970. *Crotalocephalus* sp. β, (fragmentary glabella) KOIZUMI and KAKEGAWA, *Ibid.*, pl. 1, fig. 8.

Occurrence:—Floats on the Takahara-gawa.

Family Phacopidae HAWLE and CORDA, 1847

R. and E. RICHTER and STRUVE's classification of this family into three subfamilies, Phacopinae, Bouleiinae HUPÉ, 1955 and the Phacopidellinae DELO, 1935 is here accepted.

Devonian phacopids in Asia

Phacopids are not well represented in Eastern and Southern Asia, but a large number of *Phacops* s. l. have been described from the Asiatic part of the U.S.S.R. and Mongolia as below. Assuming the original identification to be correct, recent generic references are noted of certain species behind them.

[Abbreviations]
Ph: *Phacops*
P. (P.) : *Paciphacops* (*Paciphacops*)
P. (V.) : *Paciphacops* (*Viaphacops*)
m. : monotypic

From Turkestan (WEBER, 1932).

Phacops cf. *sternbergi* CORDA (Low. Devon.) .... *Reedops* ?
Phacops *turanicus* WEBER, nov. (ditto)
Phacops *zorgensis* KAYSER (ditto) .... *Ph.* (*Boeckops*)
Phacops sp. I (ditto)
Phacops sp. indet. II (ditto)
Phacops cf. *batracheus* WHIDB. (Mid. Dev.)
Phacops sp. indet. III (Low. Dev.)
Phacops sp. IV (Up. Silur.—Low. Dev.)
Phacops sp. V (hypostoma) (Low. Dev.)

From Western Mongolia (TSCHERNYSHEVA, 1937).

Phacops sp. (Low. Dev.)

From Kuznetsk basin (TSCHERNYSHEVA, 1951).

Phacops *rana* GREEN (D_2^2-D_3) .... *Ph.* (*Ph.*)
Phacops *fecundus* BARRANDE (D_1^1-D_2^2) .... *Ananaspis*
Phacops *sublatifrons* TSCHERNYSHEVA (nov.) (D_2^1)
Phacops aff. *shanensis* REED (S_2)

Altai Range (KHALFIN, 1955).

Phacops *altaicus* (TCHERNYSHEV, 1892) (Coblenzian) .... *Ph.* (*Ph.*) or *P.* (*V.*)
Phacops *subcristata* KHALFIN (Coblenzian)

From Rudi Altai (MAXIMOVA, 1960).

Phacops *altaicus* TCHERNYSHEV (D_2^1) .... *Ph.* (*Ph.*) or *P.* (*V.*)
Phacops *sternbergi* HAWLE and CORDA (D_2^1) .... *Reedops* (*Reedops*)
Phacops *portieri ulbensis* MAXIMOVA (D_2^1)
Phacops *oculeus* MAXIMOVA (D_2^1)
Phacops *postaltaicus* MAXIMOVA (D_2^1-D_3^1)
Phacops *loganops* MAXIMOVA (D_1-D_2^1)
Phacops cf. *cristata* var. *pipa* HALL and CLARKE (D_1-D_2^1) .... ? *P.* (*P.*)
Phacops cf. *altaicus* TCHERN. (D_2^1) .... ? *Ph.* (*Ph.*) or *P.* (*V.*)
Phacops aff. *loganops* MAXIMOVA (D_1-D_2^1)

Phacops aff. *pronini* MAXIMOVA (D_2^1)
Phacops sp. (D_2^1)
Phacopidella primitiva MAXIMOVA (D_2^1)
Phacopidella sp. (D_2^1)

Central Kazakhstan (MAXIMOVA, 1968).

Phacops fecundus orientalis MAXIMOVA (S_2)
Phacops ainasuensis BALASHOVA (S_2)
Phacops kasachstanicus MAXIMOVA (S_2)
Phacops logani balchaschensis MAXIMOVA (D_1^1) .... *P.* (*P.*)
Phacops kotanbulakensis BALASHOVA (D_1^1)
Phacops saryarkensis MAXIMOVA (D_1^1) .... *P.* (*P.*)
Phacops aff. *boecki* HAWLE and CORDA (D_1^1) .... *Ph.* (*Boeckops*) ?
Phacops praepipa MAXIMOVA (D_1^2) .... *P.* (*V.*)
Phacops dentatus MAXIMOVA (D_1^2) .... *P.* (*V.*)
Phacops ex. gr. *cristata* HALL (D_2^1)........................... *P.* (*V.*) ?, *Ph.* (*Ph.*)
Phacops pustulatus MAXIMOVA (D_2^1) .... *P.* (*V.*)
Phacops acutus MAXIMOVA (D_2^1-D_2^2)
Phacops angulatus MAXIMOVA (D_1^2)
Phacops aff. *fecundus degener* BARR. (D_2^1) .... *Ph.* (*Ph.*) ?
Phacops rhinoceros MAXIMOVA (D_2)
Phacops aff. *pustulatus* MAXIMOVA (D_2^1) .... *P.* (*V.*)
Phacops sp. α (S_2)
Phacops sp. β (S_2)
Reedops cephalotes (HAWLE and CORDA) (D_1^2)............................ *Reedops* (*Reedops*)
Reedops aff. *sternbergi* (HAWLE and CORDA) (D_1^1-D_2^2) .... *Reedops* ?

Kazakhstan (K) and Tadjikstan (T) (BALASHOVA, 1968).

Phacops ainasuensis BALASHOVA (Up. Ludlow, Ainasu), K
Phacops kasakhstanicus BALASHOVA (Up. Ludlow), K
Phacops schischkathensis BALASHOVA (Up. Ludlow), T
Reedopsis serratus spiniferus BALASHOVA (Up. Ludlow), K

See "Silurian Trilobites of Japan, 1964" for other Silurian species.

From the Far East (Upper Amur), U.S.S.R. (MAXIMOVA in MODZALEVSKAYA, 1969).

Paciphacops (*Viaphacops*) *pipa* (HALL and CLARKE) Givetian
Phacops rana var. *milleri* STEWART Eifelian
Phacops (*Paciphacops*) *logani asiaticus* MAXIMOVA Low. Devon.
? *Paciphacops* (*Paciphacops*) *urushensis* (MAXIMOVA) Low Devon.
Phacops guranensis MAXIMOVA Eifelian

Mongolian Altai (MAXIMOVA, 1974).

Paciphacops (*Viaphacops*) *mongolicus* MAXIMOVA (early Middle Devonian)

As noted above, CHLUPÁČ (1972) found a Turkestan species and a Turkish species in his *Phacops* (*Boeckops*), whereas PŘIBYL and VANĚK (1970) considered another Turkish species to be a *Reedops* (*Nephranomma*).

Phacops manchuricus KOBAYASHI and HAMADA, nov. is described here from the Lower Devonian of Northeast China (North Manchuria).

In Japan two phacopids are described from the Middle Devonian Nakazato Series of the Kitakami mountains as follows:

Phacops okanoi Sugiyama
Reedops nonakai (Okubo)

Some species are known of phacopids in South China (Lu et al., 1965). *Phacops* cf. *shanensis* Reed is reported from the Silurian Kaochiapien shales at Lunshan, Nanking hill with *Cerauroides lunshanensis* (Grabau) and other trilobites and *Phacops granulatus* Münster is listed as a member of the late Upper Devonian fauna of the Hsik'uangshan stage in Central Hunan. Recently *Phacops guangxiensis* Chang and *Phacops luofuensis* Chang from the Eifelian Tanghsiang formation at Luofu, Nantan, Kwangsi are illustrated and *Plagiolaria nandanensis* listed with the latter species in a paper by Wang, Yü and Qi (1974).

In Southeast Asia phacopids are wide spread and particularly in the *Tentaculites* shale facies, *Phacops* in the *Tentaculites elegans* zone of the Washih Series in the Paoshan area in West Yunnan for example (Sun and Szetu, 1947).

Phacopids are found in the *Tentaculites* facies in North Viet-Nam and precisely, the following three species were described by Maximova (1965) and considered to be Eifelian in age.

Plagiolaria (?) *orientalis* Maximova
Ductina vietnamensis Maximova
Denckmannites vietnamicus Maximova

In East Burma the following three species of *Phacops* are Devonian rather than Silurian in age.

Phacops shanensis Reed from Zebingyi (loc. 2), Northern Shan States
Phacops ponensis Reed from Pon, Southern Shan State
Phacops cf. *sternbergi* Barrande, ditto..*Reedops* ?

They were found associated with *Tentaculites* and *Styliolina*.

In Thailand the Devonian sediments were first documented with Emsio-Eifelian *Plagiolaria poothaii* Kobayashi and Hamada (1968) in the peninsular part. Subsequently the *poothaii* horizon was found in Perak, Malaya (Kobayashi and Hamada, 1971).

Recently many phacopids were found by Tint and Wai (1970) at Taungtalong peak in the east Medan area, Maymyo district, Northern Shan States in the lower part of the Lower Plateau Limestone as follows:

Phacops giganteus Tint and Wai
Phacops taungtalonensis Tint and Wai
Phacops thahlai Tint and Wai
Phacops minutus Tint and Wai

They contend the age of these phacopids to be Lower Devonian or Siegenian, because the horizon is located above the Zebingyi beds and far below the Eifelian Padaukpin reef limestone containing *Phacops latifrons* Bronn and the Wetwin shale. *Phacops* sp. occurs also in the Middle Devonian at Kay Twinge, southeast of Maymyo (Müller, 1967).

In the Himalayas Reed (1922) reported *Phacops* aff. *latifrons* Bronn from Chitral.

In Afghanistan the following phacopids were described by Pillet and de Lapparent (1969).

Phacops sp. from Fransnian	
Phacops accipitrinus (PHILLIPS) and its new subsp. from Famennian	*Ph.* (*Ph.*)

R. and E. RICHTER (1939) described the following phacopids from the Bosporus region.

Phacops (*Phacops*) *turico* RICHTERS	Uppermost Low. Dev. or lowest Mid. Dev.
Phacops (*Phacops*) *corallinus* RICHTERS.	Age indet.
Phacops (*Phacops*) *confluense* RICHTERS.	Upper Coblenzian
Phacops (*Trimerocephalus*) *mastophthalmus* (Rhein. RICHTER)	Up. Dev.
Phacops spp.	

According to HAAS (1968) different phacopids occur in Bithynia, Turkey from upper Emsian to Upper Devonian as follows:

Phacops (*Phacops*) *corallinus corallinus* RICHTERS	Up. Ems.
Phacops (*Phacops*) *corallinus successor* HAAS	Ditto
Phacops (*Phacops*) *pantichionensis* HAAS	Uppermost Ems.
Phacops (*Phacops*) *proponticus* HAAS	Ditto, *Ph.* (*Boeckops*)
Phacops (*Reedops*) *sternbergi filius* HAAS	Ditto
Phacops (*Reedops*) *seleniomma* HAAS	Ditto, *Reedops* (*Nephranomma*)
Phacops (*Phacops*) *turico praecedens* HAAS	Eifel.
Phacops (*Phacops*) *turico turico* RICHTERS	Up. Eifiel.
Phacops (*Trimerocephalus*) *mastophthalmus* (RICHTERS)	Up. Devon.

While CAMPBELL (1967) retained *Phacops altaicus* TSCHERNYSHEV in *Phacops* typified by *Calymene latifrons* BRONN, MAXIMOVA (1972) included the same species in her *Paciphacops* (*Viaphacops*) whose type-species is *Phacops pipa* HALL and CLARKE, 1888.

In adding some Silurian species omitted in the above statement, there are more than fifty species of phacopids in Asia among which *Phacops* (*Phacops, Boeckops*), *Acernaspis*, *Paciphacops* (*Paciphacops, Viaphacops*), *Plagiolaria*, *Ductina*, *Denckmannites*, *Trimerocephalus*, *Reedops*, *Eophacops* and *Phacopidella* are probably represented. *Phacops rana*, *Phacops pipa* and some other species reveal affinities toward the North American faunas whereas some others are related to European faunas. Beside these there are endemic species which constitute specific groups, if intensive studies be made in future.

Phacopids in Australia

Since the descriptions of *Phacops* (*Portlockia*) *fecundus* BARRANDE by MCCOY, 1876 and *Phacops serratus* FOERSTE, 1888 many other species were described from Victoria and New South Wales and the older identification was revised by palaeontologists, as done by ETHERIDGE and MITCHELL, 1896, CHAPMAN, 1915, GILL, 1949, 51, 62, ÖPIK, 1953, TALENT, 1963, SHERGOLD, 1968, SHERWIN, 1970 and others. The subfamily Phacopinae is well represented in Australia by the following species.

"*Phacops*" *serratus* FOERSTE, 1888.	Silurian-Devonian boundary, Vict. and NSW.
"*Phacops*" *crossleii* ETHERIDGE and MITCHELL, 1896	Ditto
Phacops latigenalis ETHERIDGE and MITCHELL, 1896	Ludlow-Downtonian, NSW.
Phacops sweeti ETHERIDGE and MITCHELL, 1896.	Lower Devon., Vict.
Phacops mansfieldensis ETHERIDGE and MITCHELL, 1896.	Lower Devon., Vict.

Phacops aff. *fecundus* by GILL, 1949.	Yeringian, Vict.
Phacops (*Portlockia*) *fecundus* BARRANDE by McCOY, 1876, i. e. *Phacops* sp. nov. by GILL, 1951.	Lower Devon., Vict.
Phacops n. sp. by TALENT, 1963.	Ems.-Eifelian, Vict.
Acernaspis typhangonus (ÖPIK, 1953).	Llandovery, Vict.
Acernaspis ? *macdonaldi* (FLETCHER, 1950).	Llandovery, NSW.
Acernaspis ? *oblatus* SHERWIN, 1970.	Ditto
Denckmannites rutherfordi SHERWIN, 1968.	Up. Silur.-Low. Devon., NSW.
Phacopid hypostomata, by GILL, 1949.	Yeringian, Vict.

According to CHLUPÁC (1972) *Denckmannites rutherfordi* is referrable to his new genus *Lochkovella*.

Subfamily Phacopinae HAWLE and CORDA, 1847

In MOORE's Treatise RICHTER and STRUVE (1959) referred ten genera of phacopids to this subfamily. Six additional genera with two subgenera in *Paciphacops* were instituted by STRUVE, CAMPBELL, LESPÉRENCE, MAXIMOVA and CHLUPÁČ since then. They are *Volkops*, *Acernaspis*, *Ananaspis*, *Murphycops*, *Paciphacops* (*Paciphacops* & *Viaphacops*) and *Lochkovella*.

Genera and subgenera, their type-species and distribution

Phacops EMMRICH, 1839.	*Calymene latifrons* BRONGNIART, 1925	Ems.-Up. Dev.; Eur-Asia, N. Afr., N. Am., Australia
Trimerocephalus McCOY, 1849.	*Phacops mastophthalmus* Rhein. RICHTER, 1859	Up. Dev., Eur., Australia
Dereimsia KOZLOWSKI, 1923.	*Phacops* (*Dereimsia*) *shaericeps* KOZLOWSKI, 1923	Dev., Bolivia
Dianops R. & E. RICHTER, 1923.	*Phacops limbatus* Rhein. RICHTER, 1848	Up. Dev., Europe
Reedops R. & E. RICHTER, 1925.	*Phacops bronni* BARRANDE, 1846	Sil.-Up. Dev. (Low. Dev.-Eifel.), Eurasia, N. Am.
Cryphops R. & E. RICHTER, 1926.	*Phacops cryptophthalmus* EMMRICH, 1844	Up. Dev., Eur.
Nephranops R. & E. RICHTER, 1926.	*Phacops* (*Trimerocephalus*) *insisus* ROEMER, 1886	Up. Dev., Eur.
Eocryphops R. & E. RICHTER, 1931.	*Phacops kayseri* HERRMANN, 1909	Early Mid. Dev., Eur., Afr.
Eophacops DELO, 1935.	*Phacops handwerki* WELLER, 1907	Mid. Sil., N. Am., NW. Eur.
Plagiolaria KEGEL, 1952.	*Phacops plagiophthalmus* Rhein. RICHTER, 1865	Up. Mid. Dev.; Germ., SE. Asia
Volkops STRUVE, 1959.	*Volkops volki* STRUVE, 1959 (m.)	Ord., Germany
Ananaspis CAMPBELL, 1967.	*Phacops fecundus communis* BARRANDE, 1852	Wenlock, Ludlow, ? Up. Llandovery, Eur-Am., Asia.
Acernaspis CAMPBELL, 1967.	*Phacops orestes* BILLINGS, 1860	Uppermost Ord.-lowest Wenlock, East Canada, Britain, Norway, Esthonia, Siberia, Australia
Murphycops LESPÉRANCE, 1968.	*Murphycops skidmorei* LESPÉRANCE, 1968, (m.)	Llandovery, East Canada (Quebec).
Paciphacops (*Paciphacops*) MAXIMOVA, 1971.	*Phacops logani* HALL, 1861	Low Dev.-early Mid. Dev. North Asia-N. Am.
Paciphacops (*Viaphacops*) MAXIMOVA, 1971.	*Phacops cristata* var. *pipa* HALL and CLARKE, 1888	Late low. Dev.-Mid. Dev. (Givet.), N. Asia-N. Am.
Lochkovella CHLUPÁČ, 1972.	*Phacops miser* BARRANDE, 1852	Low. Dev. (Lochkov), Barrandian area, Australia

Volkops volki, monotypic of *Volkops* was found in boulders of upper clayslate ($S_{1\beta}$, "Lederschiefer") of Thuringian Upper Ordovician. It must be an early offshoot, intead of the stock, because it is well specialized in the elongate glabella, genal and pleural thoracic spines and the truncated terminus of the axial lobe on the relatively long pygidium.

According to CAMPBELL (1967) *Eophacops* as the substitute of *Portlockia* (MCLEARN, 1924) should be transferred to the Phacopidellinae from this subfamily. While CAMPBELL (1967) and CHLUPÁČ (1972) considered to be relevant the generic separation of *P. logani* and some other species, ELDREDGE (1973) is negative for the erection of *Paciphacops* and its bipartation.

According to ELDREDGE (1972, 1973) *Phacops logani* HALL consists of five subspecies, whereas *Phacops cristata* HALL is an extremely variable species comprising seven subspecies. *Ph. cristata* var. *pipa* HALL and CLARKE, 1888 which has once been accepted as an independent species by STUMM (1954, 1964) is synonymized with *Ph. cristata bombifrons* HALL, 1861. Incidentally, BURTON and ELDREDGE (1974) erected two new subspecies, *africanus* and *tindoufensis*, of *Phacops rana* for Middle Devonian phacopids from Northwest Africa (Spanish Sahara and Morocco), because they are especially close to subspecies *milleri* STEWART and *crassituberculata* STUMM among five subspecies of *Phacops rana* (GREEN) (ELDREDGE, 1972).

Finally, it is noteworthy that Praguian *Phacops zinkeri* ROEMER has genal spines in the young stage like mature *Paciphacops*, but later the genal angle becomes simply pointed and then rounded in full maturity (JAHNKE, 1969).

Genus *Phacops* EMMRICH, 1839

While G. ALBERTI (1970) accepted *Ananaspis*, *Reedops* and *Plagiolaria* as three subgenera of *Phacops*, CHLUPÁČ (1971, 1972) and STRUVE (1972) regarded *Phacops* (*Phacops*) in a more restricted sense. As the result *Phacops* as a genus was splitted into nine subgenera with two groups in each of two subgenera, *Phacops* and *Pedinopariops* as follows:

Phacops EMMRICH, 1839. *Calymene latifrons* BRONN, 1925
(*Phacops*) EMMRICH, 1839. *Calymene latifrons* BRONN, 1925
latifrons-Gruppe. ....Eifel: lowest Givet.
werneri-Gruppe. ....Up. Ems: lowest Eifel.
(*Prokops*) CHLUPÁČ, 1971. *Phacops* (*Prokops*) *prokopi* CHLUPÁČ, 1971, (m.) ....Low. Dev., Praguian; Barrandian area.
(*Chotecops*) CHLUPÁČ, 1971. *Phacops* (*Chotecops*) *auspex* CHLUPÁČ, 1971 .... Mid.-Up. Dev; ? late Low. Dev.
(*Boeckops*) CHLUPÁČ, 1972. *Phacops boecki* HAWLE and CORDA, 1847....Low. Dev.
(*Arduennops*) STRUVE, 1972. *Phacops* (*Phacops*) *michelsi* STRUVE, 1970, (m.)..Ems.
(*Nyterops*) STRUVE, 1972. *Phacops* (*Phacops*) *nyter* STRUVE, 1970 .... Up. Ems.-Low. Givet.
(*Geesops*) STRUVE, 1972. *Calymene schlotheimi* BRONN, 1825 ....Eifel.
(*Pedonopariops*) STRUVE, 1972. *Phacops* (*Phacops*) *lentigifer* STRUVE, 1970

lentigifer-Gruppe. .... Up. Ems.-Givet.
eurycaulus-Gruppe. .... Up. Ems.-lowest Givet.
(*Liolophops*) STRUVE, 1972. *Phacops* (*Phacops*) *sublevatus* STRUVE, 1970
.... Up. Ems.-up. Eifel.

In the present knowledge the species referred to these new subgenera are mostly endemic to the Barrandian area or the Hercynian zone from Poland to Luxemburg through Germany except for *Chotecops* and *Boeckops*. The former is widely distributed in Eur-Africa or Germany, Bohemia, Urals, North Africa and ? England. The latter's distribution is more extensive in Eurasia namely in Bohemia, Germany, Asia Minor, Middle and East Asia and possibly in North America. In Asia *P.* (*B.*) *zorgensis* KAYSER is reported from Turkestan and *P.* (*B.*) *prononticus* HAAS from Turkey. This subgenus resembles the *Phacops logani* group. i. e. *Paciphacops* (*Paciphacops*), but CHLUPÁČ considers the resmblance to be analogy (See Postscript 8).

Of the distribution of *Paciphacops* it is noted that BURTON and ELDREDGE (1974) found two new subspecies of *Phacops rana*, namely *africanus* and *tindoufensis* in the Middle Devonian of Northwest Africa which were close to *P. rana milleri* STEWART and *P. rana crassituberculata* STUMM of North America.

Thus *Phacops* has recently examined in a geat precision with the results it was found that various forms were classified from different altitutudes, and that several new genera were erected on the basis of *Phacops* species and added to the Phacopinae in one way, while in another way many subgenera were distinguished within genus *Phacops* and in a still another way certain *Phacops* species complexes were subdivided into many subspecies, or such a specific complex was eliminated from *Phacops* as a separate genus or subgenus. This chaotic status of taxonomy reveals the great difficulty of the natural classification of *Phacops* s. l. and the Phacopinae.

Phacops (subgen. nov. ?) *manchuricus* KOBAYASHI and HAMADA, sp. nov.

Pl. 8, Figs. 1a-d, Pl. 9, Figs. 2-4; Text-fig. 5E.

1960. *Phacops* aff. *subcristata* KHALFIN by HAMADA, *Japan. Jour. Geol. Geogr., vol. 31*, p. 180 (listed).
1971. *Phacops altaicus* TSCHERNYSHEV by HAMADA, *Pal. Soc. Japan., Sp. Pap. no. 15*, p. 6 (listed).

Description:—Cephalon strongly convex, becoming highest at anterior glabellar projection, semi-parabolic in outline, broadest through posterior of palpebral lobes, its width being more than twice its length; genal angle roundly angulate. The cephalic margin anterior to eyes distinctly inclined backward, if the margin behind the eyes is placed horizontal. Glabella highly elevated, projected beyond cheek margins and overhanging; its outline in dorsal view subpentagonal, strongly expanded forward from occipital margin, as wide as a half of cephalic breadth; anterior outline well rounded; frontal wall subvertical, but with slight convexity; two lateral furrows faintly marked in posterior of glabella internally, but almost indiscernible externally; intercalating ring trisected; its median part broad, cresentic, outlined by narrow preoccipital furrow anteriorly and by very pronounced occipital furrow posteriorly; lateral pieces of the ring button-like, on the two sides of the pronounced occipital furrow and circumscribed by narrow furrows; occipital ring sublenticular, and depressed on the two sides behind the pair of lateral pieces of the intercalating ring; neither a median turbercle nor an axial spine present on the occipital ring; glabella inclusive of the occipital ring coarsely granulate. Cheeks strongly inflated and separated from glabella by pronounced axial furrows; eyes fairly large; palpebral lobe semicircular, moderately convex, slanting toward axial furrow and smooth; facial suture extending from posterior end of the lobe laterally and somewhat anteriorly, crossing stout lateral border and broad and shallow lateral furrow. In anterior view vincular furrow well developed, defined by a sharp ridge on each side; upper ridge separated from glabella by a narrow frontal furrow; lower ridge divides doublure into vincular depression and crescentic depressed area behind it.

Pygidium sublenticular with anterior margin more broadly rounded than the other; axial lobe one-fourth as wide as pygidium, composed of seven axial rings and a terminal piece; pleural area seven ribbed.

Test smooth except for granulate glabella.

Observation:—The holotype is an internal mould of a cephalon whose glabella inclusive of the neck ring is 13.5 mm long and 9 mm wide at the ring, but it expands as wide as 17.5 mm in the anterior part. The straight posterior border of the cheek is 14 mm broad. It is bent therefrom antero-laterally for a short distance forming a rounded genal angle.

In the paratype cephalon, like in the holotype, the glabella is well expanded forward from the neck ring. It is strongly convex, ascending forward, but it becomes suddenly subvertical. The occipital and dorsal furrows are very strong and the latter abruptly broadened in front of the eye. There the palpebral band is bent forward and steeply slant adaxially. A latex cast taken from the external mould of this cranidium shows that the occipital ring bears neither a median tubercle nor an axial spine. The median lobe of the intercalating ring, crescentic in outline, is completely isolated from the rest of the glabella by a preoccipital furrow which is confluent with the well developed occipital furrow on the two sides of the lobe. A pair of button-like subcircular lobes are on the lateral sides of the occipital furrow. This cranidium coincides with the holotype in the frontal view in regard to the narrow frontal furrow and rim and the well developed vincular depression which is not indented.

Neither one of these cephala is so well preserved to show the disposition of ocular lenses clearly.

A thoracic segment along with the latter cephalon has an axial ring 9.3 mm wide and a pleuron 12.5 mm wide. This pleuron is divided into a narrow anterior rib and a broad posterior one by a deep pleural furrow; axial ring apparently simple. It bears no axial spine as seen in *Phacops cristata* HALL, but its articulating half-ring is fairly well developed. The pleuron is obtusely bent at its middle point and the pleural furrow narrows out there.

An internal mould of a pygidium, lenticular in outline, whose length and beadth measure 7.3 mm and 15.2 mm respectively. It is trilobed by a pair of broad axial furrow and abruptly slant near the posterior margin.

Three axial rings in addition to an articulating half-ring are seen in the anterior half and the fourth ring is partly exposed behind, but the more posterior segmentation is inobsevable on this specimen. The pleural lobe is almost as wide as the axial one and 5 or 6 ribs are separated from one another by broad furrows. These pleural ribs are simple and undivided. The marginal border is narrow.

Another pygidium shows the segmentation on the axial and pleural lobes so clearly that their numbers are countable as in the description.

Comparison:—The specimens before hand are neither numerous nor well preserved. Therefore the specific concept obtained out of them is inevitably imperfect. Nevertheless, this species bears very distinctive characteristics which would be after all evaluated more than specific criteria. One of them is the mode of tripartation of the intercalating ring. Namely, the median lobe well developed and completely circumscribed by furrows, is distinctly anterior to the posterior margin of lateral lobes. Therefore it engraves forward into the main part of the glabella and the occipital furrow is quite unusually excavated behind this lobe.

Another consipicuous characteristic is the doublure which is divided into the vincular depression and the post-vincular depression where the former is larger than the latter. These two crescentic concave depressions are separated by a sharp post-vincular ridge and the doublure is separated from the narrow and shallow frontal furrow by a sharp pre-vincular ridge.

The third characteristic is the marginal border and furrow of subequal breadth which run continuously along the lateral and posterior margins of the cheek forming a small well rounded genal angle between the two margins.

The absence of the projections on the occipital ring as well as the axial rings of the thorax and the improminence of the articulating facet of the pleural lobe of the relatively broad pygidium are additional distinctions. The combination of these biocharacters shows high possibility of its being an unnamed genus in the generic level of modern phacopid taxonomy, although the proposal of a new name is left for any paleontologist who will find a better material having beautiful eyes. The ignorance of the details of the eye and hypostoma is the principal defect for the proposal.

This species does not exactly fit in the diagnosis of *Phacops*, *Acernaspis*, *Ananaspis*, *Reedops*, *Paciphacops*, or the *logani* and *cristata* complexes, or any other genus or subgenus of *Phacops*. This species can easily be distinguished from these specific complexes as they bear commonly genal spines and the genal angle produced even when genal and axial spines are absent. On this account it is rather comparable to the *rana* and *iowensis* complexes among the North American species of *Phacops*, but the intercalating ring is rarely so discrepant in them.

Among the Rhenish species of *Phacops* the tripartation of the intercalating ring is common as seen in *Phacops* (*Liolophops*) *sublevatus* STRUVE, *Ph.* (*Nyterops*) *nyter* STRUVE, *Ph.* (*Peinopariops*) *lentigifer* STRUVE and some others of *Phacops* but this species is incomparable with them in the pronounced median part of the occipital furrow. This distinction applies also to *Phacops* (*Phacops*) *regius* CHLUPÁČ, although such a trilobed ring is seen and the vincular furrow well developed in this Barrandian species. The furrow is, however, by far larger in this species.

Among the Asiatic species it resembles MAXIMOVA's *Paciphacops* (*Viaphacops*) *pipa* from the Emsio-Eifelian of the Urmisky region, Far East, USSR (MODZALEVSKY, 1969), but the latter has two pairs of lateral lobes of the occipital and preoccipital rings. The occipital furrow is quite pronounced in the median part as in this species, but the preoccipital furrow is interrupeted at the top of the median lobe of the intercalating ring.

TSCHERNYSHEVA's *Phacops fecundus* from the Kuznetsk basin (1951) appears to have a similar cephalon, but the aspect around the occipital furrow is fairly different from this species.

Phacops subcristata KHALFIN (1955) from the Coblenzian of the Gornogo Altai is an allied species, but the cephalon and glabella are broader in this species in proportion to their lengthes. The axial part of the glabella is simply protruded posteriorly in that species and it is not so large as the median preoccipital lobe in this species.

Another close ally is *Phacops altaicus* TSCHERNYSHEV from the Eifelian of the Rudi Altai (MAXIMOVA, 1960) which differs, however, from this species in the longer and more triangular cephalic outline in the dorsal view, coarser tuberculation on the glabella, longer pygidium and so forth. The pygidium of *Phacops* sp. from the Khangai highland, Mongolia (TSCHERNYSHEVA, 1937) is more similar to the pygidium of *Ph. manchuricus* in the borad outline and mode of ribbing. It is noteworthy that the vincular and post-vincular concavities are well developed on the doublure of the *Ph. altaicus*, but the former is evidently narrower than the latter depression.

Among the Kazakhstan and Mongolian species of *Phacops* which MAXIMOVA (1968, 1974) described none looks very close to this species. The Japanese and Burmese species of *Phacops* are also dissimilar to this species.

Occurrence:—Lower Emsian Houlungmen Formation: East of Chinshuei (Kinsui) station of the Kakkolu lines, Nünkiang-hsien of the Lesser Khingan district (vide HAMADA, 1971 for Devonian barchiopods).

Phacops okanoi SUGIYAMA, 1944

Pl. 9, Fig. 8.

1941. *Phacops* (s. str.) sp. SUGIYAMA and OKANO, *Jour. Geol. Soc. Japan, vol. 48*, p. 359, text-fig. 1-3a.

1944. *Phacops okanoi* SUGIYAMA, *Studies from Geol. Miner. Inst. Tokyo Bunrika Daigaku, no. 1*, p. 24.

A fragmentary cephalon comprising antero-lateral part of the glabella and a large left eye was compared with *Phacops latifrons* BRONGNIART by SUGIYAMA and OKANO. Eye-lenses are aligned in 17 rows and 5 to 11 lenses in each row. As they total as numerous as 157, SUGIYAMA proposed a new name for it.

Occurrence:—Upper part of Nakazato Series, at the southeastern foot of Takainari-yama, Ōfunato district, Iwaté Prefecture. Reg. no. IGPS 64549, Institute of Geology and Palaeontology, Tohoku University, Sendai.

Phacops cf. *okanoi* SUGIYAMA

Pl. 8, Figs. 7a-d; Text-fig. 5F.

1956. *Phacops nakanoi* OKUBO (pars), *Japan. Jour. Geol. Geogr., vol. 27, no. 1*, pl. 3, fig. 11b, non. fig. 11a.

Two cephala contained in a slab are strongly campressed laterally, but restoration is made of a better one of them and shown in Text-fig. 5F. In the greater eyes it reveals better agreement with *P. okanoi* than with *Reedops nonakai*, although specific identification with *P. okanoi* cannot be definite as SUGIYAMA based on his species on such a poor fragment of a cephalon as illustrated in fig. 8 pl. 9.

Occurrence:—The upper part of the Nakazato Series in the middle part of Higuchizawa, Ofunato district, Iwaté Prefecture.

Genus *Reedops* R. & E. RICHTER, 1925

This genus is accepted as a subgenus of *Phacops* by HAAS (1968) and G. ALBERTI (1970), but an independent genus in MOORE's Treatise and ORLOV's Osnovy. PŘIBYL and VANĚK (1970) distinguished three subgenera in this genus. One is their new subgenus *Signatops*. Another is *Nephranomma* which was primarily proposed as a subgenus of *Phacopidella*. Their type-species are as follows:

R. (*Reedops*) R. & E. RICHTER, 1915. *Phacops bronni* BARRANDE, 1846
R. (*Signatops*) PŘIBYL & VANĚK, 1970. *Phacops signatus* HAWLE & CORDA, 1847
R. (*Nephranomma*) ERBEN, 1952. *Phacopidella* (*Nephranomma*) *drepanomma* ERBEN, 1952

Reedops nonakai (OKUBO, 1956)

Pl. 9, Figs. 1a-e; Text-fig. 5D.

1956. *Phacops nonakai* OKUBO (pars), *Japan. Jour. Geol. Geogr, vol. 27*, p. 43, pl. 3, figs. 11a, non. 11b.

Description:—Cephalon subtriangular but developed toward well rounded genal angles; marginal border narrow. Glabella large, subpentagonal, elevated above cheeks and tuberculate; median lobe isolated by preoccipital and occipital furrows; posterior and middle lateral furrows narrow and die out in the axial part; anterior lateral furrows obsolete; occipital ring and furrow distinct. Eyes large, semicircular, prominent and composed of about 160 corneal lenses. Thorax composed of more than nine segments; lateral margin subparallel; axial ring convex; its median half prominently elevated above lateral sides; axial furrows profound; pleurae wider than axial rings, nearly horizontal in the inner half but declined in the outer; pleural furrows broad and deep; pleural end rounded.

Observation:—The holotype which is composed of a cephalon and nine thoracic segments is eroded to some degrees. Its glabella is somewhat depressed secondarily in the anterior part, though it is highly elevated above cheeks.

In eyes on two paratype cephala eleven lenses are countable at the maximum in a row in the middle part. Only the median preoccipital lobe is present in the paratype cephala.

Comparison:—This species is tentatively referred to *Reedops*, because the vincular furrow is clearly impressed on the external mould of the holotype specimen on its postero-lateral sides which, however, die out in front of the cephalon. The genal angle is produced postero-laterally like in *Reedops* (*Reedops*) *cephalotes*, but its glabella appears less produced like *Reedops* (*Signatops*) *signata* (HAWLE and CORDA). The lateral preoccipital lobes, present in these two species are, however, absent, if not unpreserved, in this species.

Occurrence:—The upper part of the Nakazato Series in the middle part of Higuchizawa, Ōfunato district, Iwaté Prefecture.

Family Dalmanitidae VOGDES, 1890

Subfamily Dalmanitinae VOGDES, 1890

Genus *Odontochile* HAWLE and CORDA, 1847

Recently VANĚK (1970) and MAXIMOVA (1971) proposed three new subgenera in this genus as follows:

Odontochile (*Zlichovaspis*) VANĚK
  Type-species:—Odontochile rugosum HAWLE and CORDA, 1847
Odontochile (*Kasachstania*) MAXIMOVA
  Type-species:—Dalmanites saryarkensis MAXIMOVA, 1960
Odontochile (*Reussia*) MAXIMOVA
  Type-species:—Dalmanites reussi BARRANDE, 1864

Odontochile sp. indet.

Pl. 9, Figs. 5, 6.

1960. Dalmanitid by HAMADA, *Japan. Jour. Geol. Geogr. vol. 31*, p. 180.
1971. *Probolium altaicum* (KHALFIN) by HAMADA, *Pal. Soc. Japan Sp. Pap. no. 15*, p. 6 (listed).

An imperfect pygidium at hand is flat and subtriangular in outline; lateral margin nearly straight, but anterior margin is well arcuate; axial lobe probably about one-sixth as wide as pygidium; pleural field large, having 11 or more ribs as far as can be judged from narrow ribs on the preserved part; pleural ribs look imbricated, since their anterior slopes are gentle, while their posterior side is overhanging; ribs sharply angulated at the top and separated from one another by pleural furrows with relatively broad flat bottom; interpleural furrow faintly seen on the anterior slope near the angulation; ribs somewhat swinging forward near the proximal end and backward near the narrow and flat lateral border with which the ribs are connected; pleural furrows terminate just inside the border; axial furrow narrow and straight; 7 anterior pleural ribs and 6 interpleural furrows nearly corresponding to anterior axial rings and ring furrows preserved in the specimen. Two genal spines in the collection from the same locality are both flat. In one of them inner ridges of lateral and posterior borders are confluent with each other and run into a median rib on the spine.

The pygidium combined with these genal spines suggests that the dalmanitid before hand belongs to either *Odontochile* or *Neoprobolium*. This species agrees better with *Odontochile hausmanni* (BRONGNIART) than *Neoprobolium nastus* (CONRAD).

A few kinds of dalmanitid pygidia have long been known to occur in Western Mongolia, but none of them which TSCHERNYSHEVA (1939) has described from the Bairim ridge agrees with this species nicely. Among the Kazakhstan species of *Dalmanites* and *Odontochile* or subgenera of the latter *Odontochile arcuata* MAXIMOVA from D_1^2 is somewhat allied to this species in the arcuate anterior outline and the mode of pleural ribs. This species is nearer to *Neoprobolium altaicum* (KHALFIN), 1955, from the Coblenzian of the Gorny Altai and so in the lessened degree to *Odontochile* aff. *ulrichi* DELO and *Dalmanites urakanensis* MAXIMOVA from the Coblenzian in the Far East of the USSR (MODZALEVSKAYA, 1967). *Odontochile* (*Zlichovaspis*) *maccoyi* (BARRANDE, 1852) from the Emsian of Bohemia also has the arcuate anterior margin of the pygidium. Its lateral margin is also more or less arcuate where the margin is nearly straight in this species.

Occurrence:—Houlungmen formation; Chinshuei, Heilungchiang, Northeast China (formerly Manchuria).

Family Calymenidae BRONGNIART, 1843

In 1894 SCHMIDT has distinguished *Ptychometopus* and *Pharostoma* from *Calymene* s. str. As the result or an extensive survey of the Calymenidae (s. l.) POMPECKJ (1898) traced the lingeage of *Calymene* s. l. and its allies as follows:

(1) The *Calymene* group has developed from *Bavarilla* through *Pharostoma*. *Calymene* restricted by SCHMIDT was divided into the *C. senaria—C. declinata* series and the *C. callicephala—C. tuberculosa* series.

(2) Two derivatives from *Neseuretus* are (a) *Homalonotus* and (b) the *Synhomalonotus* group which the latter comprises the *Synhomalonotus tristani* and *S. arago* subgroups beside *Ptychometopus*.

Later NOVAK (1918) proposed *Colpocoryphe* for *Calymene arago*.

SHIRLEY (1931, 1933, 1936) carried out a thorough study on the British and other species of the *Calymene* group. In adding KEGEL's two subgenera and his five new genera to *Calymene*, he distinguished calymenids into two groups with and without papillate glabellar lobes or genal buttresses beside *Synhomalonotus* which is well isolated from them. The former group includes *Calymene*, *Diacalymene* and *Papillicalymene* whereas the latter contains *Flexicalymene*, *Reacalymene*, *Gravicalymene*, *Metacalymene* and *Platycalymene*. Incidentally, STUMM and KAUFMANN (1958) suggested that the term "papillate" should be abandoned owing to its inadiquacy and that "conjugate second glabellar lobes" was proposed as its substitute.

In 1937 the senior author has given a brief review of the Calymenidae and pointed out that *Synhomalonotus* is a characteristic genus of the European-meridional province extending from the Andes to Eastern Asia through Europe and South Asia. Not only because of this distribution but also because *Synhomalonotus* does not fit in either the Calymenidae or the Homalonotidae morphologically, he proposed the Synhomalonotidae to combine it with *Vietnamia*, *Calymenesun* and *Reedocalymene* (1960). He, however, had to replace the family name by the Neseuretidae, nov. (1969), because WHITTARD (1959) has already pointed out that *Synhomalonotus* POMPECKJ, 1898 is a junior synonym of *Neseuretus* HICKS, 1872. The synonymy was accepted by WHITTINGTON (1966), HENRY (1970) and others. DEAN (1967) erected *Neseuretinus* as a South Asiatic subgenus of *Neseuretus* occurring in Turkey and Burma.

Bavarilla which POMPECKJ has considered the ancestor of the Calymenidae was transferred by SDZUY (1955) and WHITTINGTON (1966) into the Homalonotidae together with *Colpocoryphe*. *Calymenidius* RASETTI (1944) is an Upper Cambrian genus found in the Levis conglomerate, Quebec whose author stated that its superficial resemblance to *Calymene* may indicate any real affinity. SDZUY (1954) on the other hand emphasized that Tremadocian *Pharostomina* of Germany was closely allied to *Calymene*. This genus as well as *Pharostoma*, however, can be distinguished from gonatoparian *Calymene* or the Calymenidae by the opisthoparian facial suture and the possession of genal spines. WHITTINGTON (1966) presumed that *Calymenidius* and *Pharostomina* would be ancestral to the family. *Protocalymene* ROSS, 1967 is an additional early genus which bears alliance to calymenids on one side and to hystricuroids on the other. Its facial sutures proparian in juvenalium but gonatoparian in maturity.

In the past fifteen years *Spathacalymene*, *Onnicalymene*, *Thulincola*, *Protocalymene*, *Calymene* (*Paracalymene*) and *Thelecalymene* were successively instituted respectively by TILLMAN, DEAN, TRIPP, ROSS, PILLET, and WHITTINGTON as calymenid genera and a subgenus. In adding *Bathycheillus* and *Endocrania* to them, but excluding the Neseuretidae, the family Calymenidae is here tentatively classified into four subfamilies and 21 genera as shown in a synoptic list below. Accepting the papillate and non-papillate series of the Calymeninae (s. l.), WHITTINGTON suggested recently that short-ranged local genera have branched off from two long-ranged (Ordovician-Devonian) stems from time to time. He adopted the Flexicalymeninae for the latter series.

Four subfamilies of the Calymenidae

I. Calymeninae BURMEISTER, 1843

Calymene BRONGNIART, 1882. (*Calymene blumenbachi* BRONGNIART, 1822). *L. Sil.-M. Dev.*, Eur-Asia-N. Am. Australia

Diacalymene KEGEL, 1927. (*Calymene diademata* BARRANDE, 1864) *M. Sil.-U. Sil.*, Bohemia

Papillicalymene SHIRLEY, 1936. (*Calymene papillata* LINDSTRÖM, 1855) *Sil.*, Sweden

Calymene (*Paracalymene*) PILLET, 1936. (*Calymene* (*Paracalymene*) *bureaui* PÉNEAU, 1928) *Late L. Dev.*, Eu.

Spathacalymene TILLMAN, 1960. (*Calymene nasuta* ULRICH, 1879) *M. Sil.-U. Sil.*, USA-Eu-Poland

Thelecalymene WHITTINGTON, 1971. (*Calymene mammillata* HALL, 1861) *U. Ord.*, USA

II. Flexicalymeninae SHIRLEY (1936) in WHITTINGTON, 1971

? *Liocalymene* RAYMOND, 1916. (*Hemicrypturus clintoni* VANUXEM, 1842) *L. Sil.-M. Sil.*, east. N. Am.

? *Metacalymene* KEGEL, 1927. (*Calymene baylei* BARRANDE, 1846) *U. Sil.*, Bohemia

Flexicalymene SHIRLEY, 1936. (*Calymene caractaci* SALTER, 1865) *M. Ord.-M. Sil.*, Eur-Asia-N. Am.

? *Reacalymene* SHIRLEY, 1936. (*Reacalymene limba* SHIRLEY, 1936) *M. Ord.-U. Ord.*, Eu. (Eng.), ? N. Am.

Gravicalymene SHIRLEY, 1936. (*Gravicalymene convolva* SHIRLEY, 1936) *U. Ord.-L. Dev.*, ? *early M. Dev.*, Wales-S. and E. Asia-Australia, N. Z.

Platycalymene SHIRLEY, 1936. (*Asaphus duplicatus* MURCHISON, 1839) *M. Ord.*, Br. Is.-Swed.

Onnicalymene DEAN, 1962. (*Calymene onniensis* SHIRLEY, 1936) *U. Ord.* (*Caradoc*), Engl. Wales, Swed., Norway

Orimops RAFINESQUE, 1832. (*Calymene callicephala* GREEN, 1832) *M. Ord.*, N. Am.

FISCHER (1957) suggested that *Orimops* RAFINESQUE may be synonymous with *Flexicalymene* but DEAN (1962) states that *Orimops* is a nomen dubium.

III. Pharostominae HUPÉ, 1953

Pharostoma HAWLE and CORDA, 1847 (i. e. *Prionocheilus* ROUAULT, 1847) (*Calymene pulchra* BARRANDE, 1840) *M. Ord.-Up. Ord.*, Eu., Qu., Asia

Bathycheilus HOLUB, 1908. (*Dalmanites perplexus* BARRANDE, 1872) *M. Ord.* (*Llanvirn*), Bohemia

Calymenidius RASETTI, 1944. (*Calymenidius tuberculatus* RASETTI, 1944) *Up. Camb.*, Quebec

Pharostomina SDZUY, 1955. (i. e. *Colpocorphoides* HARRINGTON and LEANZA, 1957) (*Pharostomina opiki* SDZUY, 1955) *L. Ord.*, Germ.-S. Am.

Thulincola TRIPP, 1962. (*Thulincola barbarus* TRIPP, 1962) *Mid. Ord.*, Scotland.

IV. Ptychometopinae BALASHOVA, 1960.

Ptychometopus SCHMIDT, 1894. (*Calymene* (*Ptychometopus*) *volborthi* SCHMIDT, 1894) *L. Ord.*, USSR (Balt.)

Endocrania KOBAYASHI, 1956. (*Hystricurus convexus* ENDO, 1935) *L. Ord.-M. Ord.*, E. Asia (Manchuria)-N. Asia (Central Siberia)

? *Protocalymene* ROSS, 1967. (*Protocalymene macallisteri* ROSS, 1967) *Ord.* (*Arenig-Llanvirn*), N. Am.

The Calymenidae, s. str. in Asia and Australasia

As noted elsewhere, the Neseuretidae, i. e. Synhomalonotidae have greatly flourished in Southern and Eastern Asia in the Ordovician Period, but less so the Calymenidae, although the latter family distributed more widely than the former in the world. It is represented in west Pamir by

Flexicalymene arshachensis BALASHOVA, 1966,

in the Shan States, Burma by

Calymene (*Pharostoma*) *liluensis* REED
Calymene oldhami REED,

in South China by

Pharostoma parapulchra KOBAYASHI in Kueichow
Flexicalymene conica KOBAYASHI in Szechuan
Calymene (?) sp. by REED, 1917, in Yunnan,

and in North China by

Endocrania convexa (ENDO) in Liaoning.

As noted already (1960, 62), *Tollaspis quartus* BALASHOVA, 1955, from the Tremadocian Ustuktsky stage of the Siberian platform reveals marvellous resemblance with *Endocrania convexa* that the two species look congeneric, although the three pairs of lateral furrows are more pronounced and the frontal border is thicker in the former.

In the Middle Palaeozoic periods the distribution of the family was widely expanded in North and Central Asia. *Calymene taimyrica* BALASHOVA (1960) is described from the Lower Silurian far north in the Taimyr peninsula. *Calymene blumenbachi* BRONGNIART was reported from the Llandovery of the Siberian platform (MAXIMOVA, in NIKIFOROVA, 1955) and the Silurian of Tuva (TSCHERNYSHEVA, 1937). The same species was reported by Kazansky from the Silurian of the upper Amur valley already in 1910-15 (MODZALEVSKAYA, 1968). Furthermore *Calymene* spp. *α* and *β* were reported from the Llandovery and Wenlock of the Siberian platform by MAXIMOVA (1962).

In Turkestan *Calymene* sp. indet. was discovered in the Devonian in association with *Thysanopeltella tarak* (WEBER), 1932. Later WEBER (1951) described *Calymene blumenbachi* BRONGNIART and its variety *asiatica* nov. from the Wenlockian and Ludlovian of Ferghana and Pribalkhash and *Calymene blumenbachi* var. *producta* (nov.) from the Turkestan range of Baribak. According to MAXIMOVA (1960), *Calymene* ex. gr. *blumenbachi* BRONGNIART occurs in the early Middle Devonian (D$_2^1$) in the Rudi Altai. In Kazakhstan she described the following species from the Upper Silurian and basal Devonian.

Calymene kokbaitalensis MAXIMOVA (D$_1^1$)
Calymene weberi MAXIMOVA (S$_2$, D$_1^1$)
Calymene aff. *weberi* MAXIMOVA (S$_2$)
Calymene sp. (S$_2$)

Incidentally, *Calymene* (*Calymene*) *beyeri* R. & E. RICHTER, *C.* (*C.*) *conspicua* SCHMIDT subsp. *podolica* (nov.) and *C.* (*C.*) *ohhesaarensis* SCHMIDT subsp. *dnestroviana* (nov.) occur in the Ludlovian of Podolia (BALASHOVA, 1968).

In Central Manchuria *Calymene* cf. *blumenbachi* BRONGNIART is described by KUO (1962) from Xiap-sui-ho, near Ertaogou, about 15 km to the west of Yong-ji (Kirin) city. It was found together with *Otarion diffractum conveximarginatum* KUO and *O. sphaerium* KUO in coralline limestone with shale intercalations. *Encrinurus sinicus* KUO occurs with these species of *Otarion* in a higher trilobite horizon in dark grey sandstone and shale beds. The age of these trilobite horizons are considered by him to belong to Silurian and probably late Wenlockian or early Ludlovian.

In West Primoria, Far East of USSR *Calymene* ex. gr. *blumenbachi* BRONGNIART and *Calymene* sp. were found in terrigenous strata on the left bank of the Kordonk river, southwest of Grodekow peninsula in association with *Aviculopecten* and *Pseudomonotis* (?). The former is represented by pygidia resembling *Calymene macrocephala* MAXIMOVA in the Lower Devonian of northwestern Pribalkhash. The latter shown by an imperfect specimen of a cephalon and thorax is closely allied to *Calymene platys* HALL and CLARKE from the early Middle Devonian of North America. According to MAXIMOVA and ORGANOVA (1959) these fossils are Lower Devonian in age.

In Japan KOIZUMI and KAKEGAWA (1970) are the first to report their discovery of *Gravicalymene* (?) sp. from the Devonian of Fukuji, Gifu Prefecture. This species is closely examined in this study.

In Central China *Calymene changyangensis* CHANG, 1974 was described from the early (?) Middle Silurian of Changyang, Hupeh.

In Southeast Asia *Calymene blumenbachi* BRONGNIART var. was reported by REED, (1906, 15) from the Lower and Upper Namshim formation the age of which is Wenlockian or Wenlock-Ludlovian. *Calymene scrivenori* KOBAYASHI and HAMADA is another Silurian species so far restricted to the Langkawi islands, west Malaysia. *Gravicalymene maloungkaensis* MANSUY is widely distributed in the *Calceola sandalina* stage in Tonkin, North Viet-Nam (MANSUY, 1908, 16, 21, PATTE, 1926), in the Lower Devonian Pochiao shale in Yunnan (LU et al., 1956), and possibly in the Plateau Limestone of Burma (SAHNI in HERON, 1936). In addition *Calymene* spp. are reported to occur in the Devonian of Tonkin and the Devonian or Silurian in Laos (PATTE, 1926, 29).

Recently *Calymene kashmirica* GUPTA (1969) was described from the Upper Silurian Nauburg beds in Kashmir. What the present authors could dug out from the literatures on the Asiatic fauna is completed with the following three species from Bithynia, Asia Minor, Northwest Turkey (HAAS, 1968).

Calymene arotia HAAS, Upper Ludlow
Flexicalymene (*Flexicalymene*) ex. gr. *onniensis* SHIRLEY,
  Upper Llandovery to lower Wenlock
Gravicalymene eunoa HAAS, Praguian, probably lower Emsian.

Finally, the Calymenidae are well represented in Australasia by the following species:

Calymene cf. *blumenbachi* BRONGNIART, (CHAPMAN, 1915), Low. Dev. (Yeringian), Victoria.
Calymene bowiei GILL, 1945. Low. Dev. (Yeringian), Victoria.
Calymene duni ETHERIDGE and MITCHELL, 1917. Up. Silur. (?), N.S.W.
Calymene killarensis GILL, 1945. Low. Dev. (Yeringian), Victoria.
Calymene sp. nov. (?) STRUSZ, 1964. Low. to Mid. Dev., N.S.W.
Flexicalymene sp. (GILL, 1945). Silurian, Victoria.
Gravicalymene australis (ETH. & MITCH.), 1917. Up. Silur. Low.—Dev. (Low. Mid. & Up. Trilobite beds), N.S.W., Low. to Mid. Dev., N.S.W. (STRUSZ, 1964), Low. Dev., Vict. (PHILIP, 1962, TALENT, 1963), Low. Dev., Tasmania (GILL, 1948).
Gravicalymene angustior (CHAPMAN), 1915. Low. Dev., Victoria, New Zealand.
Gravicalymene cootamundrensis GILL, 1942. Up. Silur. N.S.W.
Gravicalymene hetera GILL, 1945. Silurian, Victoria.
Gravicalymene kilmorensis GILL, 1945. Silurian, Victoria.

Subfamily Flexicalymeninae SHIRLEY

Genus *Gravicalymene* SHIRLEY, 1926

Gravicalymene yamakoshii KOBAYASHI and HAMADA, sp. nov.

Pl. 10, Figs. 1-14, Pl. 11, Figs. 1-15; Text-fig. 5C.

1970. *Gravicalymene* ? sp. KOIZUMI and KAKEGAWA, *Earth Sci., vol. 24, no. 5*, p. 183, pl. 1, figs. 1-3.
1974. *Gravicalymene* sp. OKAZAKI, *Mem. Fac. Sci., Univ. Kyoto, Ser. Geol. Min., vol. 11, no. 2*, p. 88, figs. 1-5.
1974. ? *Gravicalymene* sp. OKAZAKI et al., *Jour. Geol. Soc. Japan, vol. 80, no. 11*, pl. 1, figs. 3-4.

Description:—Cephalon nearly straight in anterior, but well rounded laterally as far as genal angles. Cranidium strongly inflated, its breadth being about one and a half of its length. Glabella strongly convex, expanding in posterior, more or less rounded in front, provided with three pairs of distinct lateral furrows, or more precisely with four pairs of furrows internally, but most anterior ones are rudimentary and indiscernible externally; anterior lateral furrows indicated by minor incisions; middle ones being greater sinuses, but cutting into glabella less than a quarter of its breadth; posterior lateral furrows incomparably developed than the precedings, diagonal, expanding inward and divided by an intermediate lobe; posterior lateral lobe roundly triangular, strongly swelling and internally almost isolated from the rest of glabella by posterior lateral furrow; occipital furrow deep and more or less arcuate; occipital ring transversal, stout and narrowing near lateral extremities; dorsal furrows wide and very profound on lateral as well as anterior sides of glabella; sagittal section of glabella fairly well convex, suddenly becoming subvertical near deep anterior marginal furrow: frontal border nearly straight or only a little arcuate, highly raised and rounded on top. Fixed cheeks well convex; anterior part narrow and crossed obliquely by an obtuse eye-ridge; palpebral lobes opposed at about middle lateral lobes of glabella; postero-lateral limb large; posterior border thick; border furrow fairly deep. Free cheek fairly broad, elevating toward eyes of medium size; marginal border occupying one-third or one-fourth the free cheek's breadth, distinctly limited by narrow marginal furrow. Facial sutures gonatoparian; their anterior branches subparallel to each other and somewhat convergent on marginal border; pcsterior branch diagonal with weak convexity on antero-lateral side: Hypostoma broadly arcuate along anterior and posterior margins and largely sinuate between two pairs of anterior and posterior projections; median body divided by an intermediate furrow into large ovate main part and crescentic posterior lobe; anterior marginal furrow long and persistent; lateral furrows terminating at pits in anterior and posteriorly confluent with each other to form an intermediate furrow; this and posterior marginal furrow outline posterior lobe.

Pygidium subrhomboidal in outline with rounded antero-lateral margin and nearly straight postero-lateral margin, widest near mid-length of pygidium, about one and a half as wide as long and strongly inflated; axial lobe prominent above pleural lobes, about one-third or less the breadth of pygidium, conical, but rounded very near the posterior end whence a very short post-axial ridge issues, composed of six rings and a terminal lobe which are separated from one another by strong ring furrows; axial furrows deep; pleural lobes gently convex on axial side but convexity is very emphasized on the other side; pleural ribs flattopped, countable five, four of which are each divided into two bands by a shallow pleural furrow, but the fifth rib is ill-defined; interpleural furrows profound; posterior margin slightly arched behind post-axial ridge.

Test granulate externally and minutely punctate internally.

Observation:—The holotype (Pl. 10, Fig. 2) and paratype (1) (Pl. 10, Fig. 4) cranidia reveal all aspects of the cephalon internal and external, combined with two type free cheeks (paratypes 2 and 3) (Pl. 11, Figs. 2, 4). One can grasp the concept of the cephalon almost completely with them. All furrows are wider and deeper internally than externally. An antennal pit is unsually well shown on the right axial furrow near the fourth lateral furrow on the holotype cranidium, but it is generally indisitinct. The fourth lateral glabellar furrow counted from posterior can be better seen on the internal mould but not on the external cast of the same cranidium (paratype 1). There are several other cranidia, but no trace of a papilla is seen in the cranidia at hand. Due to secondary deformation the outlines of the cranidium and glabella vary not to a small extent. For example, the anterior border looks somewhat convex backward in a cranidium (paratypes, W-5) and straight in another (W-2). Compared to the type cranidia the glabella is expanded in posterior more in the cranidia (KOIZUMI and KAKEGAWA, pl. 1, fig. 1, OKAZAKI, pl. 9, fig. 1) and less in the cranidium (OKAZAKI, pl. 2, fig. 2). The glabella of the last cranidium is longiconic rather bell-shaped.

Two hypostomata from Oisé (YT-43, 67-68) are tentatively referred to this species. This form bears two pairs of lateral wings where the posterior ones are larger, rhombic in outline, elongated longitudinally, depressed, flat and separated from each other by a deep posterior sinuation. The anterior wings are not so large, but moderate in size, triangular and extended behind at the two terminal parts of the anterior marginal rim. The central body is long, well convex, contracted in the middle part and a little incised on the two sides at the posterior end of the contraction.

This form of hypostome agrees with that of *Flexicalymene senaria* (CONRAD) in EVITT and WHITTINGTON (1953), but it quite disagrees with those of *Calymene blumenbachi* as well as *Thelecalymene mammillata* (HALL) in WHITTINGTON (1971) in the deep posterior sinuation between a pair of large wings.

Little is known of the thorax of this species. Pygidia are not rare in Fukuji and Oisé area, but they are deformed in different degrees. The paratype (5) pygidium would be least deformed and its partial exfoliation enables one to compare the inner and outer sides of the test.

The largest cranidium (Pl. 10, Fig. 1) attains about 40 mm in width and the smallest one (TY-26, Pl. 10, Fig. 8) in the collection is about 12 mm wide. The largest pygidium (paratype, W-3, Pl. 11, Fig. 11) is 23.8 mm wide and the smallest one from Kanajirozako (Pl. 11, Fig. 8) 3.5 mm wide and the one from Oisé (YT-7, Pl. 11, Fig. 12) 6.6 mm wide. Among these holaspids no significant growth change is recognizable.

Comparison:—This species has the generic characters common with *Gravicalymene convolva* SHIRLEY, 1936 from Upper Bala, the type-species of the genus. In that species the posterior lateral lobe has quadrangular shape and the lateral glabellar furrows are more developed, but the "supplementary" glabellar furrow is compeletely effaced. In the profile of the cephalon the glabella is more convex in this species whereas it is less so in larger part, but steeply slanting in very anterior part. The frontal marginal furrow is a deep trench between this part and the high anterior border. The pygidium of the British species is said sub-semicircular in outline.

Calymene maloungkaensis MANSUY, 1921, which was referred to *Gravicalymene* by GILL (1942) and LU et al. (1965) is a close ally to this species. In MANSUY's species, however, the middle and anterior lateral lobes of the glabella are comparatively larger and the anterior border is thicker and more arcuate. In *G. convolva* the middle and anterior lateral lobes are still more developed and the frontal border is much thicker than these two Asiatic species.

Gravicalymene asperula VANĚK, 1965, from the Ashgillian Kraluv Dvur beds of Bohemia is another resembling species in Europe, but it has a subquadrate glabella, almost circular posterior lateral lobes, a tiny median tubercle on the occipital ring and a roof-shaped frontal rim on the cranidium. Its pygidium is widely subpentagonal in outline.

In his paper on the Baton River fauna of New Zealand SHIRLEY (1918) referred *Calymene angustior* CHAPMAN, 1915, from the Yeringian and *Calymene australis* ETHERIDGE and MITCHELL, 1917, from the Lower Middle and Upper Trilobite Beds of New South Wales to *Gravicalymene*. These two species were later synonymized by GILL (1945). In this Australian species the fourth incipient lobe is discernible on the glabella. In the profile of the cranidium the glabella is more strongly curved in anterior than in the Japanese species, but it is nearly horizontal in the middle and posterior parts (GILL, 1945, text-fig. 1c). Eyes are located relatively anteriorly. The pygidium is nearly semicircular in outline.

Calymene interjecta HAWLE and CORDA, 1847, from the Praguian of Bohemia to which *G. maloungkaensis* and *G. angustior* were compared respectively by MANSUY and GILL is still retained in *Calymene* (HORNÝ and BASTL, 1970).

GILL (1940) described *Calymene* (*Gravicalymene*) *cootamundrensis*, nov. from the Upper Silurian of New South Wales. It has the frontal margin of the cranidium nearly straight like in the Japanese species. The cephalic profile is also similar to the latter, though less convex. The outline of the cephalon is, however, subquadrilateral. The free cheek is extraordinarily narrow and has the nearly straight lateral margin. The eyes are located anterior to the middle lateral lobe of the glabella. The pygidium is triangular in outline and the pleural furrows are very strong.

Occurrence:—Most common in the *Gravicalymene* bed of of Sorayama, Fukuji, but common also at Oisé.

Gravicalymene maloungkaensis (MANSUY, 1916)

1908. *Calymene blumenbachi* MANSUY (non BRONGNIART) *Contr. de la carte géol. de l'Indochine, Paléont.*, p. 49, pl. 12, fig. 23.
1916. *Calymene maloungkaensis* MANSUY, *Mém. Serv. géol. l'Indochine., vol. 5, fasc. 4*, p. 21, pl. 4, figs. 4a-b.
1921. *Calymene maloungkaensis* MANSUY, *Ibid., vol. 8, fasc. 1*, p. 22, pl. 2, figs. 14a-b; pl. 3, figs. 1a-b.
1938. *Calymene maloungkaensis*, YIN, *Bull. Geol. Soc. China., vol. 18, no. 1*, p. 52, pl. 4, figs. 4a-b, figs. 6.
1945. *Gravicalymene maloungkaensis*, GILL, *Proc. Royal Soc. Victoria, vol. 65, (N. S.), pt. 2*, p. 176.
1957. *Calymene maloungkaensis* LU, Index Fossils of China, Invertebrates, *vol. 3*, pl. 28, pls. 154, figs. 5, 6.
1965. *Gravicalymene maloungkaensis*, LU et al., Chinese Trilobites, *vol. 2*, Each group of fossils of China, p. 288, pl. 154, figs. 5, 6.
1974. *Gravicalymene maloungkaensis*, CHANG, *Handbook of stratigr. & paleont. Southwest China*, p. 236, pl. 117, fig. 10, 11.
1974. *Gravicalymene maloungkaensis*, YÜ et al., *Mem. Nanking Inst. of Geol. and Pal., Acad. Sinica, no. 6*, pl. 19, figs. 5, 6, 7, 8.

This MANSUY's species in Indochina and China was transferred from *Calymene* to *Gravicalymene* independently by GILL (1945) and LU et al. (1965). Because the known geological range of *Gravicalymene* is *U. Ord.-L. Dev.* according to WHITTINGTON (in MOORE's Treatise, 1959), it may be a survivor of the genus until the early Eifelian age.

In Central Tonkin the Coblenzian in the Song-cau basin contains *Calymene* cf. *maloungkaensis*. In Indochina the Emsian *Chonetes* shale is tightly combined with the *Spirifer speciosus* bearing shale in a suite which often comprises also coralline reef limestones. *Calymene maloungkaensis*, *Proetus indonesiensis* and *Otarion giraudi* are typical trilobites of its fauna (SAURIN, 1935). The *speciosus* shale and limestone are generally considered Eifelian or lowest Middle Devonian (FONTAINE, 1968).

Calceola sandalina, *Spirifer cultrijugatus*, and *S. speciosus* are well known to be typical members of the Couvinian fauna of Ardenne. The *cultrijugatus* beds are considered in Europe either the lowest Eifelian (GIGNOUX, 1955) or the transition from Coblenzian top to Eifelian base (BRINKMANN, 1960).

In China YIN (1938) was the first to describe this species from the Pochiao shale or the *Spirifer tonkinensis* shale near Kuangnan, East Yunnan which was considered the equivalent of the *cultrijugatus* zone in the transitional beds from the Lower to Middle Devonian in Central Europe. The Pochiao shale was later placed in the early Middle Devonian (WANG and YÜ, 1964), but the Pingipu group yielding *Calymene maloungkaensis* in the *Calceola sandalina elongata* zone and the *Euryspirifer paradoxus lungmenshanensis* zones of the Kanhsi stage in its upper part in Northwestern Szechuan is located late Lower Devonian according to YOH (Stratigraphic Tables, 1956, WANG and YÜ, 1964). In the description of the species the age of the Pochiao shale is cited early Middle Devonian (LU, 1957) and Lower Devonian (LU et al., 1965). Recently *Gravicalymene maloungkaensis* was reported to occur in the lower part of the Tangting stage at Nantan, Kwangsi and the stage was correlated to the Zlichkov stage of the Barrandian sequence (WANG et al., 1974).

As reviewed above, the age of the *maloungkaensis* horizon must be in the range from upper Emsian to lower Eifelian. The species is widely distributed in South China and North Viet-Nam and possibly in East Burma where *Calymene* cf. *maloungkaensis* is reported from the Plateau Limestone (SAHNI in HERON, 1936).

Flexicalymenid, gen. et sp. indet.

Pl. 8, Fig. 7; Pl. 10, Fig. 15.

1956. Gen. et sp. indet. (Pygidium) KOBAYASHI and IGO, *Japan. Jour. Geol. Geogr.*, *vol. 27*, *nos. 2-4*, pl. 10, fig. 6.

An internal cast of an imperfect cranidium has a less convex glabella in comparison with *Gravicalymene yamakoshii*. The posterior lateral lobe occupies one-third the breadth of the glabella. Like that species the posterior lateral furrow is bipartate by an intermediate lobe, but the furrow is as a whole not so strong as in that species. The middle and posterior lobes are isolated from the axial part by longitudinal furrows as commonly seen in *Calymene*. The occipital ring is narrowing laterally. The inner margin of the fixed cheeks are distinctly protruded toward the middle lateral lobes of the glabella to form genal buttresses, although they are disconnected by the axial furrow in this cast.

A pygidium illustrated by KOBAYASHI and IGO (1956) (Pl. 8, Fig. 7 of this paper) differs from that species in the more rounded outline, the subcylindrical axial lobe, fairly well depressed pleural lobes and simple ribs. Seven axial rings and five pleural ribs are countable on this pygidium.

This form disagrees with *Gravicalymene yamakoshii* in several aspects on the cephalon and pygidium. Although the anterior part is largely gone out of the cranidium at hand, the tendency to conjugate the fixed cheek margin with the lateral lobe of the glabella suggests the approach of this species to *Calymene*.

Occurrence:—A cranidium (Pl. 10, Fig. 15) was procured from sandy limestone bed at Kinma-michi (HAMADA coll.); a pygidium (Pl. 8, Fig. 9) also collected by IGO at Kinma-michi, both in the Takaharagawa formation, Fukuji district.

Family Proetidae SALTER, 1864

This family may be the largest of the Trilobita, insofar as the number of subfamilies is concerned. Beside five subfamilies of the Phillipsidae which would be transferred into this family according to some authors, twenty-three subfamilies were proposed in this family, as already listed elsewhere (KOBAYASHI and HAMADA, 1973) except for the Warburgellinae OWEN, 1973. YOLKIN (1968) has already combined the Dechenellinae and the Schizoproetinae in the Dechenellidae. Then PILLET added the Lacunoporaspinae to this family and proposed the Tropidocoryphidae in order to include the Tropidocoryphinae, Astycoryphinae and Denemarkiinae in it.

As in many other trilobites, the concept of proetoid family and genus is greatly different among palaeontologists. *Cornuproetus* of the Cornuproetinae, for example, comprises, according to ALBERTI (1969) 16 subgenera including *Lepidoproetus* and *Piriproetus* for which PILLET proposed the Lepidoproetinae and Piriproetinae in the same year. Another example is *Lacunoporaspis* which was primarily erected by YOLKIN (1966) as a genus of the Dechenellinae, and PILLET (1972) proposed the Lacunoporaspinae in the Dechenellidae. OWEN (1973) on the other hand accepted *Lacunoporaspis* as a valid subgenus of *Proetus*, instead of dechenellidgenus. These two examples show how far specialists' opinions are divergent and how difficult to schematize proetoids in the scheme of natural classification (see Postscript 9).

Subfamily Proetinae SALTER, 1864

Genus *Proetus* STEININGER, 1831

In 1972 PILLET modified this genus in his classification of the Proetidae, 1969 as below. Type-species is cited behind each genus or subgenus.

Genus *Proetus* STEININGER, 1831. *Calymene concinna* DALMAN, 1827
    Subgenus *Proetus* (*Proetus*) STEININGER. Ditto
    Subgenus *Proetus* (*Longiproetus*) CAVET et PILLET, 1958
        Proetus tenuimargo RICHTER, 1909
    Subgenus *Proetus* (*Coniproetus*) ALBERTI, 1966
        Proetus (*Proetus*) *condensus* PŘIBYL, 1965
Genus *Gerastos* GOLDFUSS, 1843. *Proetus cuvieri* STEININGER, 1831
    Subgenus *Gerastos* (*Gerastos*) GOLDFUSS, 1843. Ditto
    Subgenus *Gerastos* (*Bohemiproetus*) PILLET, 1969
        Proetus bohemicus HAWLE et CORDA, 1847
    Subgenus *Gerastos* (*Orbitoproetus*) PILLET, 1969
        Proetus orbitatus BARRANDE, 1864
    Subgenus *Gerastos* (*Oehlertaspis*) PILLET et VANĚK, 1973
        Proetus rondeaui D. et P. OEHLERT, 1890
    Subgenus *Gerastos* ? (*Erbenites*) PŘIBYL, 1964
        Proetus fallax BARRANDE, 1846

Gerastos (*Oehlertaspis*) nom. nov. PILLET et VANĚK, 1973, is the substitute of *G.* (*Oehlertia*) PILLET, 1972, non PERNER, 1907. According to PILLET *Oehlertaspis* has the strongly convex cephalon and glabella and allied to *Orbitoproetus* particularly in small eyes, course of facial sutures and the lack of genal spines, but its pygidium is short and paucisegmented like that of *Quadratoproetus*.

As mentioned already (1974), three subgenera, *Longiproetus*, *Bohemiproetus* and *Orbitoproetus* approxeimately correspond respectively to the *tenuimargo*, *bohemicus* and *orbitatus* groups of *Proetus* (*Proetus*) by ERBEN (1951). OWEN (1973) accepted *Coniproetus* and *Gerastos* as two subgenera of *Proetus*, but he considered that *Bohemiproetus* is synonymous with *Coniproetus* and so are *Orbitoproetus* and *Longiproetus* with *Gerastos*, because their subgeneric boundary is obscure. On the other hand he brought *Lacunoporaspis* from the Dechenellinae to *Proetus* as its additional subgenus, and accepted *Proetus* (*Rudoproetus*) HESSLER, 1963 as an early Carboniferous descent of *Proetus* (*Gerastos*).

Subgenus *Coniproetus* ALBERTI, 1966

Proetus (*Coniproetus*) *fukujiensis* KOBAYASHI and HAMADA, sp. nov.

Pl. 13, Figs. 2-14; Text-fig. 3 I.

Description:—Cephalon semicircular except for a pair of short genal spines. Glabella subtriangular but rounded in front, rapidly and regularly expanding backward, circumscribed by strong dorsal furrows, convex, distinctly elevated above cheeks; lateral furrows obsolete; occipital furrows very pronounced, gently arcuate in wide median part and bent anterolaterally in both lateral quarters; shallow furrow extending from the bending point diagonally, limiting an occipital lobe from the main part of neck ring where a median tubercle is present; frontal border convex; frontal furrow confluent with dorsal furrow; preglabellar area very narrow but present there.

Fixed cheek narrow whereas free cheek is fairly broad; eyes large, opposed in a little posterior to the middle of the glabella. Facial sutures anterior to eyes a little divergent, but nearly lateral for some distance in posterior to eyes and suddenly running across posterior cheek border.

Pygidium sublenticular, broadly arcuate anteriorly and well rounded posteriorly, about two-thirds as long as wide and widest at about one-fifth or one-fourth the length from anterior end; axial lobe one-third as wide as pygidium in anterior, defined laterally by deep axial furrows, longiconic, prominent above pleural sides, divided into about ten rings and rounded off at posterior end; pleural region horizontal in adaxial half, but gently sloping down in the other half, divided into six or seven ribs, anterior ones of which are subdivided into two bands; median fulcrum and lateral facet distinct on first anterior band; marginal border convex, limited inside by shallow furrow.

Observation:—The holotype craidium (Pl. 13, Fig. 9) from the *Gravicalymene* bed (YAMAKOSHI coll.) is represented by an external and internal mould, the former of which shows fine rather irregular tuberculation on the glabella, while the latter as well as most other glabellae at hand look smooth. The median tubercle is seen on the neck ring.

Four pygidia contained in platy limestone beneath the *Gravicalymene* bed have invariably pleural regions geniculate and the axial lobe is very prominent, high up the horizontal part of the region.

The paratype pygidium (W-6, Pl. 13, Fig. 5) shows many typical aspects clearly, but the outline is somewhat modified by lateral compression as seen by its asymmetrical lateral view. The sublenticular shape of the pygidium is better shown by other pygidia (W-7, Pl. 13, Fig. 6; OKAZAKI, No. 11-1, Pl. 13, Fig. 2).

Comparison:—Compared with *Proetus* (*Coniproetus*) *glandifrons* NOVÁK, 1890, this species has a more conical glabella surrounded by the very pronounced dorsal furrow which is in direct contact with the frontal border. In other words, the narrow space between the border and glabella is occupied by the furrow. The pygidium is longer and the axial lobe is narrower in this than in that species.

Occurrence:—The *Gravicalymene* bed and the underlying platy limestone bed at Sorayama in the Fukuji district.

Subfamily Unguliproetinae PILLET, 1969

Genus *Unguliproetus* ERBEN, 1951

ERBEN founded *Proetus* (*Unguliproetus*) on *Proetus unguloides* BARRANDE, 1846 and referred three other Devonian species of *Proetus* to this subgenus. According to him it was possibly derived from Silurian *Proetus ryckholti* BARRANDE which is intermediate between *Proetus* s. str. and *Unguliproetus*, or it was branched off from the *bohemicus* group of the long-ranged *Proetus* (*Proetus*). RICHTERS and STRUVE (in MOORE's Treatise, 1959) placed genus *Unguliproetus* tentatively in the Proetinae. ALBERTI (1969) accepted it as a genus of the subfamily, while he referred *P. ryckholti* to *Proetus* (*Coniproetus*). PILLET (1969) on the other hand isolated the genus in a separate subfamily, proposing Unguliproetinae for it. The most distinctive characteristic of this monotypic genus lies in the presence of the relatively large preglabellar field in front of the conical glabella. The pygidial segmentation is typical of *Gerastos*, but only the first pair of pleural furrows are very distinctive.

Thus, the intimate relation of *Unguliproetus* with the *Proetus-Coniproetus-Gerastos* group is generally accepted and the separation of the genus from the group either in the subfamily level, or generic level would be a matter of opinion. In regard to this problem it is noted that *Unguliproetus oisensis* here described would be a very near species of *Unguliproetus* to *Proetus* (*Coniproetus*). The taxonomic position of *Unguliproetus* bears particular importance, if considered that it is a possible link between the Proetinae and Cyrtosymbolinae.

Unguliproetus oisensis KOBAYASHI and HAMADA, sp. nov.

Pl. 12, Figs. 1-25; Pl. 13, Fig. 1; Text-fig. 3H.

1974. ? *Cyrtosymbole* sp. OKAZAKI et al., *Jour. Geol. Soc. Japan, val. 80*, pl. 1, figs. 5-7.

Description:—Cephalon semicircular in outline, but provided with a pair of genal spine of moderate length. Glabella longiconic, convex, and rounded in front; lateral furrows weak or obsolete; occipital furrow narrow but deep, broadly arcuate and bent forward near lateral ends; occipital ring provided with triangular occipital lobes on lateral sides from the bending points of the occipital furrow; fronfal border nearly as long as preglabellar area in sagittal length where the former is convex and the latter nearly flat and depressed. Cheeks relatively wide, gently convex, and inclined from eyes to marginal furrows; lateral and posterior borders meeting at genal angle and thence extended into a genal spine; lateral and posterior marginal furrows forming an acute angle and extending into spine; fixed cheek narrow in comparison with free cheek; eyes fairly large, close-set to glabella near its mid-length; palpebral lobe slanting toward axial furrow. Anterior branches of facial sutures diverging from eyes as far as parallels through eyes and curving inward on marginal border; their posterior branches cutting posterior margin at about its median point.

Pygidium broad, well inflated, and nearly semicircular, but posterior margin is more or less transversal; axial lobe about one-third as wide as pygidium, elevated above pleural slopes, composed of eight or more rings, slowly tapering back, rounded behind and in contact with marginal furrow; anterior band of the first pleural segment facetted from median point to lateral end; pleural and interpleural furrows both distinct on anterior four pleurae; marginal border well defined.

Observation:—The holotype cranidium (YT-30, Pl. 12, Fig. 3) contained in limestone shows relieves better than three other cranidia. Two short lateral furrows emerged secondarily on the glabella of a cranidium (YT-27, Pl. 12, Fig. 5) by dorso-ventral depression. In an imperfect cephalon collected by IMAI the cranidium and left free cheek are still fused. The doublure is distinctly cut by a rostral suture diagonally in the paratype free cheek (YT-33, Pl. 12, Fig. 14). It has a large prominent eye. In a right free cheek from the same locality (YT-5, Pl. 12, Fig. 13) the striated doublure is raised in form of a narrow rim along the lateral border, probably due to secondary deformation.

Test is half exfoliated in the paratype pygidium (YT-32, Pl. 13, Fig. 1) where it is clearly seen that deep pleural furrows and linear interpleural furrows are alternating in anterior pleurae.

Comparison:—This species can be easily distinguished from the preceding by (1) the glabella longiconic, instead of breviconic in that species, (2) the possession of a larger preglabellar area and (3) the greater forward divergence of the facial sutures in the cephalon and (4) the more transversal anterior and posterior margins of the pygidium, and (5) the absence of geniculation on its pleural region.

The preglabellar field appears relatively short, if compared to the glabellar length, but it is nearly as long as the frontal border as in *Unguliproetus ungulatus.* The pleural segmentation is not so distinct in typical *Unguliproetus* as in this species. These differences show that it is near *Proetus* (*Coniproetus*), but still within *Unguliproetus.*

Occurrence:—TY (TANAKA coll.) and IMAI coll. (Pl. 12, Fig. 12) from Oisé-dani, Fukui Prefecture.

Proetid, gen. et sp. indet. (a)

Pl. 13, Figs. 15, 16.

Two small pygidia in the collection have unusuallly narrow axial lobes. In one from the *Gravicalymene* bed of Sorayama the lobe is much more strongly convex and highly elevated above the pleural lobes, if compared with the other pygidium. However, they are, otherwise, similar to each other in many other aspects. One specimen from the *Gravicalymene* bed of Sorayama (Pl. 13, Fig. 16) and the other from Oisé-dani (YT-49, Pl. 13, Fig. 15).

Proetid, gen. et sp. indet. (b)

Pl. 13, Fig. 17.

A pygidium contained together with a cranidium of *Proetus* (*Coniproetus*) *fukujiensis* in a slab from the *Gravicalymene* bed of Sorayama is quite strange. Its triangular outline is too different to consider a deformed *fukujiensis* pygidium. At the same time it is quite aberrant among the pygidia of the Fukuji fauna.

Proetoid, gen. et sp. indet.

Pl. 13, Fig. 18.

A pygidium from Ichinotani which is an internal mould is, compared with the pygidium of *Unguliproetus oisensis*, evidently longer and nearer to the pygidium of *Proetus* (*Coniproetus*) *fukujiensis*. The lateral and posterior margins are, however, more well rounded in this than these two pygidia. The axial lobe is conical, stout and prominent above very gently inflated pleural fields. Four rings and three furrows are countable in the anterior two-thirds of the axial lobe. Only two anterior pleural segments are marked on the mould. Striated doublure is exposed along the margin by exfoliation.

Occurrence:—Ichinotani, Fukuji, Kamitakara-village, Yoshiki-county, Gifu Prefecture. YASUE collection.

Family Dechenellidae PŘIBYL, 1946

In 1946 PŘYBIL proposed subfamily Dechenellinae in the Proetidae to include *Dechenella*, *Schizoproetus* and *Proetina*. Its diagnosis was as follows:

> Proetidae with 3-4 pairs of glabellar furrows. Glabella conical or of clover-leaf form (Kleeblattförming according to R. RICHTER, 1912), i. e. with a broad base and a pair of very markedly projecting basal lobes, the frontal lobe being considerably narrowed. The anterior border is often bent inwards with a rounded-off rim. Facial sutures opisthoparoid. Thorax consists of ten segments. Pygidia are large and broad, considerably drawn-out lengthwise. The rhachis is formed of a large number of axial segments (12-20). The lateral lobes display up to 16 ribs. The margin of the pygidium shows a broad well marked border.

He is of opinion that the Dechenellinae differ from the Phillipsinae in the form of the cephalic shield and the larger number of thoracic segments, the apparent resemblance between their pygidia being probably due to homoeomorphic convergence.

Later MAXIMOVA (1955) referred to the subfamily such cyrtosymbolids as *Cyrtosymbole* (*Calybole*, *Waribole*, *Cyrtodechenella*), *Typhoproetus*, *Drevermannia* (*Carnicia*), etc., while HUPÉ (1955) erected the Cyrtosymbolidae. Later the elimination of cyrtosymbolids from the Dechenellinae was accepted by RICHTERS and STRUVE (1959) and MAXIMOVA (1960). In MOORE's Treatise RICHTERS and STRUVE classified the Dechenellinae into 3 genera in addition to 3 subgenera, namely *Dechenella* (*Basidechenella*, *Monodechenella*, *Praedechenella*), *Paradechenella*, and *Schizoproetus*, and *Proetina* was transferred to the Proetidellinae.

HUPÉ (1955) promoted the Dechenellinae to family rank. YOLKIN (1968) distinguished the family into two subfamilies, viz. Dechenellinae and Schizoproetinae (nov.) The distinctly keeled fixed cheeks are most characteristic of the latter, but its additional differences from the former are as follows:

	Dechenellinae s. str.	Schizoproetinae
Glabella	pear-shaped or subcylindrical	elongately subtrapezoidal or concial
Frontal limb	medium to narrow	absent or undeveloped
Neck lobes	not always marked	usually well marked
Axial lobe of pygidium	8-12 rings	9-15 rings
Pleural lobes of pygidium	3-16 ribs	4-9 ribs

The Schizoproetinae include *Schizoproetus* and *Ganinella*. These two subfamilies are, however. closely linked with each other through *Dechenella burmeisteri* RICHTER and *D. granulata* RICHTER which are according to RICHTER two species of *Dechenella* s. str., i. e., *Eudechenella* with angulate keels on their free cheeks.

Among the four Carboniferous genera *Linguaphillipsia* and *Palaeophillipsia* were referred to the Dechenellinae by OSMOLSKA (1970). G. and H. HAHN (1967), on the contrary, are of opinion that the two genera are members of the Phillipsinae in which they constitute an Upper Devonian—Permian branch from *Archegonus* (*Pseudowaribole*). Incidentally *Palaeophillipsia japonica* is considered now lowest Carboniferous, instead of Upper Devonian in age (ENDO and MATSUMOTO, 1962).

Because the Dechenellinae have declined in the late Devonian Period, whether these genera reveal the phyletic rejuvenescenee of the subfamily, or whether their morphic resemblances to the Dechenellinae are homoeomorphic is a question.

ORMISTON (1967) erected three new subgenera, *Pedinodechenella*, *Deltadechenella* and *Schizoproetoides* in *Dechenella* and traced the origin of the Dechenellinae back to *Proetus* (*Longiproetus*). Subsequently he (1972) accepted the Dechenellidae and the Schizoproetinae when he instituted a new genus *Fascipyge* in this subfamily. In the same year PILLET added three more genera to the Dechenellidae and classified the family into four subfamilies as follows:

Subfamily Dechenellinae PŘIBYL, 1946

Dechenella, *Basidechenella*, *Praedechenella*, *Pedinodechenella*, ? *Dechenelloides*

Subfamily Monodechenellinae PILLET, 1972. Glabella globular; preglabellar field absent; palpebral lobe small; post-ocular facial suture with a long parasagittal segment.

Monodechenella

Subfamily Lacunoporaspinae PILLET, 1972

Lacunoporaspis, Khalfinella, Eocyrtosymbole, Deltadechenella, Benesovella

Subfamily Schizoproetinae YOLKIN, 1968. Glabella scarcely piriform; three pairs of lateral furrows faintly marked; preglabellar field narrow or absent; eyes large; pygidium short, witn a dozen axial rings and 4 to 9 pleural ribs.

Schizoproetus, Ganiella, ? Paradechenella, Schizoproetoides, ? Chauffouraspis

There are some 25 genera or subgenera which were referred to this family a fifth of which is, however, provisional. Of the subfamily reference some genera are very tentative. The promotion of the Dechenellinae to a family and its subdivision would require more time before their general acceptance.

Synopsis of genera and subgenera of the Dechenellidae with type-species behind them

Late Silurian (?) to middle Devonian genera and subgenera

Dechenella KAYSER, 1880. (*Phillipsia verneuili* BARRANDE, 1852)
Basidechenella R. RICHTER, 1912. Subgenus of *Dechenella*. (*Dechenella kayseri* RICHTER, 1909)
Paradechenella R. RICHTER, 1912. Subgenus of *Dechenella*. (*Dechenella tschernyschewi* RICHTER, 1909)
Schizoproetus R. RICHTER, 1912. (*Proetus celechovicensis* SMYČKA, 1895)
(?) *Cyrtodechenella* R. & E. RICHTER, 1950. *Cyrtosymbole* (*Cyrtodechenella*) *cyrto* R. & E. RICHTER, 1950
Praedechenella MAXIMOVA, 1952. Subgenus of *Dechenella*. (*Dechenella* (*Praedechenella*) *liniclivosa* MAXIMOVA, 1952)
Monodechenella STUMM, 1953. Subgenus of *Dechenella*. (*Proetus*) *macrocephalus* HALL, 1861)
(?) *Crassiproetus* STUMM, 1953. *Proetus* (*Crassiproetus*) *traversensis* STUMM, 1953
Dechenellurus MAXIMOVA, 1960. (*Dechenellurus ursus* MAXIMOVA, 1960)
Lacunoporaspis YOLKIN, 1966. (*Lacunoporaspis contermina* YOLKIN, 1966)
Pedinodechenella ORMISTON, 1967. (*Dechenella* (*Dechenella*) *melvillensis* ORMISTON, 1967)
Deltadechenella ORMISTON, 1967. (*Deltadechenella bathurstensis* ORMISTON, 1967)
Schizoproetoides ORMISTON, 1967. (*Cyrtosymbole richteri* TOLMACHOFF, 1962)
Khalfinella YOLKIN, 1968. (*Proetus carinatus* KHALFIN, 1948)
Ganinella YOLKIN, 1968. (*Dechenella batchatensis* TSCHERNYSHEVA, 1951)
Benesovella CHLUPÁČ, 1969. (*Benesovella strandi* CHLUPÁČ, 1969)
Pseudodechenella PILLET, 1972. (*Calymene rowi* GREEN, 1838)
Eocyrtosymbole PILLET, 1972. (*Eocyrtosymbole magnifica* PILLET, 1972)
Chauffouraspis PILLET, 1972. (*Chauffouraspis andegavensis* PILLET, 1972)
Fuscipyge ORMISTON, 1972. (*Fuscipyge yolkini* ORMISTON, 1972)
Humeia ORMISTON, 1975. (*Humeia merga* ORMISTON, 1975)

Post-Devonian genera

(?) *Palaeophillipsia* SUGIYAMA and OKANO, 1944. (*Palaeophillipsia japonica* SUGIYAMA and OKANO, 1944)
(?) *Linguaphillipsia* STUBBLEFIELD, 1948. (*Linguaphillipsia terapaiensis* STUBBLEFIELD, 1948)
Dechenelloides GRANDL, 1968. (*Proetus angustigenatus* LEYH, 1897)
Bitumulina OSMOLSKA, 1970. (*Phillipsia bitumula* WEBER, 1932)

Notes on some Devonian dechenellid genera

The principal distinctions of *Dechenella* from *Monodechenella* and *Basidechenella* are in the outline of the glabella and effacement of lateral lobes. Three pairs of glabellar furrows are all distinct in the first; only posterior pair pronounced in the second and all pairs faint in the third genus. The occipital lobe is not isolated in *Basidechenella* as in the two others. The glabellar outline is pear-shaped in *Dechenella* s. str., semioval in *Monodechenella* and roundly triangular or suboval in *Basidechenella*.

According to ORMISTON (1967) *Dechenella* (*Pedinodechenella*) can be distinguished from *Dechenella* (*Dechenella*) by its remarkably depressed glabella which is wider than long and rapidly tapering in anterior and anterior nodes in place of antennulus pits in the axial furrows. In *Pseudodechenella* lateral furrows of the glabella are not so distinct as in *Pedinodechenella*. It can easily be distinguished from *Basidechenella* by the possession of the marginal border. *Deltadechenella* is another genus resembling *Dechenella*, but having a triangular pygidium like *Chaunoproetus*, although the axis is shorter and paucisegmented, if compared with the pygidium of *Chaunoproetus*.

In *Paradechenella* the glabella is long, slender, and provided with three lateral furrows; neck lobes present; facial suture sigmoidal in front of the eye; pygidium with a caudal spine. *Praedechenella* is similar to *Paradechenella* but having median spines on the occipital ring and axial rings of the pygidium, but lacks the caudal spine. The pygidium is less segmented than in *Paradechenella* and the anterior branch of the facial suture is largely convex laterally and not sigmoidal.

In *Dechenellurus* the facial sutures are diagonal anterior to eyes and form angles with the frontal border. The glabella is cylindro-conical, non-constricted, and reaching the frontal border which is often ill-defined; occipital lobes present; eyes medium sized and located posteriorly; tenth thoracic segment may be macropleural. The absence of axial projections on the neck ring and succeeding axial rings and at the posterior border of the pygidium is an important distinction of *Dechenellurus* from *Paradechenella* as well as *Praedechenella*. The pygidium is more segmented in this genus than in *Praedechenella*, and numbering 12-17 rings on the axis and 8-15 ribs on the pleural lobe.

Lacunoporaspis, *Khalfinella* and *Benesovella* are similar to one another and resemble *Praedechenella* and *Basidechenella* in some or other biocharacters of the cephalon. The occipital lobes are well developed in *Lacunoporaspis* and *Khalfinella*, small but distinct in *Praedechenella* and indistinct or undifferentiated in *Benesovella* and *Basidechenella*. The glabella is roundly conical in *Lacunoporaspis*, but less so and even pear-shaped in *Khalfinella*. The most conspicuous characteristics of *Benesovella* are the broad subtrapezoidal outline of the pygidium and its posterior sinuation. The below tabulated segmentation of the pygidium provides additional distinctions.

	Axial rings	Pleural ribs
Khalfinella	8	2-5
Benesovella	7-9	4-6
Praedechenella	5-11	5-7
Lacunoporaspis	9-12	5-8
Basidechenella	12-13	about 8

Schizoproetus and *Ganinella* are fairly well isolated from the precedings as they were grouped into the Schizoproetinae by YOLKIN. *Ganinella* differs from *Schizoproetus* in the regular tapering of the glabella and less segmented pygidium. The axial rings number less than 12 in *Ganinella* whereas they are 13 or 14 in *Schizoproetus*.

Eocyrtosymbole resembles *Lacunoporaspis, Khalfinella* and *Benesovella*, but it differs from them in obsolete lateral furrows, absent preglabellar field, widely divergent preocular facial sutures or/and the mode of segmentation of the pygidium. *Chauffouraspis* is different from *Bensovella* as well as *Ganinella* in the more conical glabella, obsolete lateral furrows, lack of the preglabellar field or/and keeled free cheek. The distinct glabellar lobation, deep axial furrows and prominent preglabellar ridge are chief distinctions of *Schizoproetoides* from *Schizoproetus*. Finally, *Fuscipyge* is an aberrant schizoproetid having three or more marginal spines on the pygidium.

The above distinctions are not always very sharp. For example, *Proetus latimarginatus* MEEK, 1871 was referred to *Dechenella* (*Dechenella*) by STUMM (1953), but to *Dechenellurus* by MAXIMOVA (1960).

Dechenellids are so far splitted that it is difficult to locate poorly preserved materials of Eastern Asia at proper taxonomic position. As written later, *Proetus blondeli* and *Proetus indosinensis* of Tho-phung appear two dechenellids notwithstanding that their thoracic segments number only 9. Whether one more segments lie concealed beneath the cephalon must be carefully examined with the type specimens and fresh materials.

Finally, *Dechenella* (*Dechenella*) *setosa* WHIDBORNE, 1889 is according to SELWOOD (1965) dimorphic and the dimorphism is probably sexual.

Distribution of dechenellids and dechenelloid genera

Dechenellids are widely distributed in the northern hemisphere, but unknown from Australasia and South America, if *Dechenella* (*Dechenella*) *mackayi* ALLAN from New Zealand is excluded (R. & E. RICHTER, 1950). *Praedechenella* appeared probably in the late Silurian age. Dechenellids were flourished during the early and middle Devonian Period when schizoproetids where branched off, but suddenly all disappeared in the entrance into the late Devonian age. Therefore it is a question whether Lower Carboniferous dechenelloids are really their descendants.

1. Late Silurian (?) and early and middle Devonian dechenellids in the northern hemisphere.
   - *Dechenella*: Middle Devonian, chiefly Givetian; Europe, North Africa, Asia, Canada and United States.
   - *Lacunoporaspis*: Lower Devonian and Eifelian; Salair and Altai Mountains.
   - *Khalfinella*: Lower Devonian and Eifelian; Salair and Altai mountains and Western Europe.
   - *Praedechenella*: Upper Silurian of Baltic and Asia (?); Lower and Middle Devonian, chiefly Eifelian; Kuznetsk coal-field, Minussinsk basin, Mountain Altai, Central Kazakhstan and North America (?).
   - *Basidechenella*: Coblenzian and Middle Devonian; Mountain Altai, Western Europe and North Africa, N. America.
   - *Monodechenella*: Middle Devonian; North America and (?) Eastern Asia.
   - *Dechenellurus*: Lower and Middle Devonian: Kazakhstan, Ruddy Altai (?), Far East of USSR (very rare) and North America (Alaska ?, Michigan, Indiana, Ohio and New York).
   - *Benesovella*: Early Middle Devonian (upper Eifelian): Barrandian, Northern Moravia.

Pseudodechenella: Lower-Middle Devonian; Europe, N. America.
Eocyrtosymbole: Emsian; France.
Pedinodechenella: Middle Devonian; Canadian Arctic.
Deltadechenella: Middle Devonian; Canadian Arctic.

2. Schizoproetids: Early and Middle Devonian; Asia and Europe.
Schizoproetus: Middle Devonian; Europe and Asia (Salair).
Ganinella: Lower Devonian and Eifelian; Salair, Mountain Altai and Podolia.
Paradechenella: Middle Devonian (Givetian); USSR (Urals).
Schizoproetoides: Middle Devonian; Canadian Arctic.
Chauffouraspis: Upper Emsian; France.
Fuscipyge: Middle Devonian; Urals, Siberia, Alaska, Canada.

3. Carboniferous Dechenelloid genera.
Dechenelloides: Lower Carboniferous; Germany (Frankenwald).
Bitumulina: Tournaisian of the Mugodzhars, the Urals, Kazakhstan, (?) Visean of Great Britain.
Linguaphillipsia: Dinantian of Great Britain, Germany; Tournaisian of Australia; Visean of Poland, U.S.S.R. (Moscow basin), Malaysia, Laos; (?) Middle Permian of Timor.
(?) *Palaeophillipsia*: Lowest Carboniferous; Northeast Japan.

Dechenellid species in Asia and North America

Dechenellids have flourished in Western Siberia and Kazakhstan no less than in North and Central Europe. Many species of *Dechenella* described by TSCHERNYSHEVA (1951) and MAXIMOVA (1955, 68) are listed here as they have not been included in the previous list (KOBAYASHI, 1957).

1. Kuznetsk basin, Siberia (TSCHERNYSHEVA, 1951)
Dechenella salairica TSCHERNYSHEVA, 1951. Age D_1^2-D_2^1
Dechenella batchatnesis TSCHERNYSHEVA, 1951. D_2^1
Dechenella cf. *dombrowiensis* GÜRICH, 1909. (*Basidechenella* ?) D_2^1-D_2^2
Dechenella cf. *onyx* RICHTER, 1912. (*Basidechenella* ?) D_2^1-D_2^2
According to YOLKIN (1968) the first species belongs to *Schizoproetus* and the second to *Ganinella*.

2. The Urals and Northern Mugodzhar (MAXIMOVA, 1955)
Dechenella (*Dechenella*) cf. *verneuili* (BARRANDE), 1952. Givetian
Dechenella (*Dechenella*) *polonica* GÜRICH, 1896. Givetian
Dechenella (*Dechenella*) *romanovski* TSCHERNYSCHEVA, 1887. Givetian
Dechenella (*Dechenella*) *arschensis* MAXIMOVA, 1955. Givetian
Dechenella (*Dechenella*) *longimedia* MAXIMOVA, 1955. Givetian
Dechenella (*Dechenella*) *lata* MAXIMOVA, 1955. Givetian
Dechenella (*Dechenella*) aff. *rittbergensis* ZIMMERMANN, 1892. Givetian
Dechenella (*Dechenella*) aff. *romanovski* ZIMMERMANN, 1892. Givetian
Dechenella (*Dechenella*) aff. *polonica* GÜRICH, 1896. Givetian
Dechenella (?) *platycaudata* MAXIMOVA, 1955. Frasnian (*Manticoceras* zone)

3. Central Kazakhstan (MAXIMOVA, 1968)
Dechenella (?) aff. *planimarginatus*, MEEK, 1871. D_1^2

In the Amur region, Far East, U.S.S.R. *Dechenella* (?) *bejensis* MAXIMOVA is reported from the Givetian Oldoiskaja suite (MODZALEVSKAYA, 1967). Furthermore, *Dechenella* aff. *verneuili* is widely distributed in the Middle Devonian (Eifelian and Givetian) in the Siberian platform and the Soviet Arctic (KRYLOVA et al., 1967, MARKOV et al., 1967).

In North America the following species were reported by COOPER and CLOUD

(1938), STUMM (1953, 67) and FAGERSTROM (1961) from the Middle Devonian areas around the Great Lakes.

Dechenella elevata COOPER and CLOUD, 1938. Illinois
Dechenella (*Dechenella*) *alpensis* STUMM, 1953. Ohio, Michigan, Ontario
Dechenella (*Dechenella*) sp. A. Michigan
Dechenella (*Dechenella*) *valentini* STUMM, 1953. Michigan
Dechenella (*Dechenella*) *planimarginata* (MEEK), 1873. Ohio, Michigan
Dechenella (*Dechenella*) *welleri* (STAUFFER), 1909. Ohio
Dechenella (*Dechenella*) *delphinula* (HALL and CLARKE), 1888. Ontario
Dechenella (*Dechenella* ?) *angustifrons* (HALL), 1861. New York
Dechenella (*Dechenella* ?) *halli* STUMM, 1953. New York, Ontario

The Lower Devonian of Northwest Territory, Canada yielded *Basidechenella* (?) n. sp. sharing characteristics of *Dechenella* and *Basidechenella* (CORGAN, 1963). This pygidium is, however, unusually broad in outline for these genera. Recently a pygidium of *Dechenella* (*Dechenella*) sp. was described by DEAN (1969) from Mackenzie in association with Eifelian *Rutoceras* (?) *eifelense* (d'ARCHIAC and de VERNEUILI). McLAREN (1961) pointed out that *Dechenella* sp. is one of the most characteristic fossils of the Devonian Bird Fiord formation in Bathurst Island in further east. Later a large number of dechenellid species were described by ORMISTON (1967) from the Eifelian Blue Fiord formation and the Givetian Bird Fiord formation in the Canadian Arctic islands as follows:

Dechenella (*Dechenella*) *bathurstensis* ORMISTON
Dechenella (*Dechenella*) *algida* ORMISTON
Dechenella (*Dechenella*) *osborni* ORMISTON
Dechenella (*Dechenella*) *crista* ORMISTON
Dechenella (*Dechenella*) *neotesca* ORMISTON
Dechenella (*Dechenella*) *crepuscula* ORMISTON
Dechenella (*Dechenella*) *maclareni* ORMISTON
Dechenella (*Dechenella*) *paragranulata* ORMISTON
Dechenella (*Dechenella*) *tesca* ORMISTON
Dechenella (*Dechenella*) cf. *planimarginata* (MEEK, 1871)
Dechenella (*Dechenella*) *franklini* ORMISTON
Dechenella (*Dechenella*) *spaekkassensis* (TOLMACHOFF, 1926)
Dechenella (*Dechenella*) n. sp., aff. *struvei* R. & E. RICHTER, 1950
Dechenella (*Pedinodechenella*) *melvillensis* ORMISTON
Dechenella (*Basidechenella*) *laticauda* ORMISTON
Deltadechenella bathurstensis ORMISTON
Cyrtodechenella macnairi ORMISTON
Humeia retusa (ORMISTON)
Schizoproetoides richteri (TOLMACHOFF, 1926)
Schizoproetoides ellesmerensis ORMISTON
Dechenellids spp. indet.

Recently the Canadian fauna was further amplified by ORMISTON (1972) with

Fuscipyge yolkini ORMISTON
Fuscipyge apllanata ORMISTON
Fuscipyge inflata ORMISTON
Humeia merga ORMISTON

from the Middle Devonian of the Mackenzie district, Northwest Territory. He noted that *Schizoproetus baschkiricus* MAXIMOVA, 1955 from the Givetian of the Southern

Urals is assignable with query to *Fuscipyge*. Combined with the Siberian forms they reveal the extensive distribution of dechenellids in the circum-Arctic region.

Finally, *Dechenella* (*Dechenella*) *minima* OKUBO occurs in Japan in the Middle Devonian Nakazato Series in the Southern Kitakami mountains. In South China *Dechenella* (?) *chengi* (SUN) occurs in the Frasnian Yütienchiao formation in Hunan and *Dechenella* (*Monodechenella* ?) aff. *macrocephala* (HALL) by PATTE in the Middle Devonian at Kaiyuan, Yunnan. *Dechenella* cf. *kuhuaensis* YOH is reported from the late Upper Devonian Motzuling shale in the upper part of the Kuhua limestone formation in North Kuantung (Stratigraphic Tables of China, Supplement, 1958), but the authors cannot have access to YOH's description of *D. kuhuaensis*.

Proetus indosinensis MANSUY is reported to occur at some localities in Indochina and Yunnan in the Eifelian *Spirifer tonkinensis* horizon in common association with *Calceola sandalina* and *Calymene maloungkaensis*. The one from Mia-ré, Dong quan, North Tonkin, Viet-Nam is typical of *Dechenella* (*Dechenella*). In addition, *Proetus blondeli* PATTE from Hohai belongs probably to *Dechenella* (*Basidechenella*). Thus *Dechenella* was wide spread in the northern hemisphere in the middle Devonian time and especially well flourished in the Givetian, but it declined abruptly in the Fransnian.

Subfamily Dechenellinae PŘIBYL, 1946

Genus *Dechenella* KAYSER, 1880

Subgenus *Dechenella* KAYSER, 1880

Dechenella (*Dechenella*) *minima* OKUBO, 1950

Pl. 8, Fig. 8; Text-fig. 3F.

1950. *Dechenella minima* OKUBO, *Chikyu-Kagaku*, *No. 4*, p. 28, pl. 1, figs. 6a-c.
1957. *Dechenella* (*Dechenella*) *minima* by KOBAYASHI, *Jour. Fac. Sci. Univ. Tokyo*, *sec. 2*, *vol. 11*, *pt. 1*, p. 7, pl. 1, figs. 1a-b, 2a-b.

Because an occipital ring is unpreserved in the cranidium, paired lateral lobes are not delineated by furrows in the restoration.

Occurrence:—Middle Devonian (Givetian ?), Higuchi-zawa, Hikoroichi village, Ōfunato district, Iwaté Prefecture, Japan.

Dechenella (*Dechenella*) *indosinensis* (MANSUY, 1916)

Text-fig. 3G.

1916. *Proetus indosinensis* MANSUY, *Mém. Serv. géol. l'Indochine*, *vol. 5*, *fasc. 4*, p. 23, pl. 3, figs. 16b-c, (?) figs. 16a, d, pl. 4, figs. 2b-e, non, fig. 3a.
1920. (?) *Proetus indosinensis* MANSUY, *Ibid.*, *vol. 7*, *fasc. 1*, p. 16, pl. 2, fig. 11.
1926. (?) *Proetus* cf. *indosinensis* by PATTE, *Bull. Serv. géol. l'Indochine*, *vol. 15*, *fasc. 1*, p. 86.
1938. (?) *Proetus indosinensis* by YIN, *Bull. Geol. Soc. China*, *vol. 18*, *no. 1*, p. 55, pl. 4, figs. 7-11, pl. 5, figs. 3b.
1948. *Linguaphillipsia* (?) *indosinensis* by STUBBLEFIELD, in MUIR-WOOD'S *Malayan Lower Carboniferous Fossils etc.*, p. 99.
1965. (?) *Proetus* (?) *indosinensis* by LU et al., *Chinese Trilobites*, *vol. 2*, p. 573, pl. 121, figs. 10-13.

Among MANSUY's three cranidia of this species from the Eifelian of Miaré the cranidium in fig. 16, pl. 3, 1916 which fits best with his description must be the lectotype. The expanded posterior of its glabella, three pairs of distinct lateral furrows, isolated basal lobes, large eyes located posteriorly and close to the glabella and the aspects of the preglabellar area and facial sutures are all typical of *Dechenella* s. str. Paired lateral lobes on the occipital ring are omitted in restoration as they are neither mentioned in description nor clearly seen in illustration. The glabella is pear-shaped as in *Dechenella verneuili* and not so long and slender as in *Linguaphillipsia*. *Dechenella* (*Dechenella*) *minima* can easily be distinguished from this species by the broader cranidium and glabella which the latter is not so abruptly expanded in posterior in *D. indosinensis*. The pygidium of *indosinensis* in fig. 16c having a parabolic outline, 12 axial rings and 7 or 8 pleural ribs would be combined with the cranidium in *Dechenella* (*Dechenella*) *indosinensis*.

In the cranidium in fig. 3a, pl. 4, 1916, however, the glabella is not so distinctly expanded in posterior. Its lateral furrows are obsolete as in *Basidechenella*. It somewhat resembles the cephalon of *Proetus namanensis* MANSUY, 1920, fig. 9a, pl. 8.

Proetus indosinensis MANSUY, 1916 from Tho-phung near Thanh-hoa is represented by a nearly complete dorsal shield, although its cephalon is poorly preserved. Its thorax is composed of 9 segments, instead of 10 in the Dechenellinae. In this number this form agrees better with the Phillipsidae. The pygidium of this form appears broader and less segmented for *Dechenella* as well as *Linguaphillipsia*. Thus two or more species may be distinguished among the specimens referred to *Proetus indosinensis*. *Proetus* cf. *indosinensis* by PATTE, 1926, from Van Linh is neither illustrated nor precisely described, but this species can be said to be very variable.

YIN's *Proetus indosinensis* from Pochiao shale, Yunnan is represented by parabolic multisegmented pygidia similar to MANSUY's. A thorax attached to a pygidium is composed 8 or more segments.

Occurrence:—Mia-ré, Dong quan region, North Tonkin, Viet-Nam in association with *Calceola sandalina* and *Calymene maloungkaensis*. Possibly in the Pochiao shale near Kuangnan and Tichi, East Yunnan with *Calymene maloungkaensis*. The Ho-phung and Van Linh forms are also Eifelian in age insofar as can be juedged from their associated fossils.

Dechenella (?) *chengi* (SUN, 1937)

1937. *Proetus chengi* SUN, *Bull. Geol. Soc. China*, *vol. 17*, p. 350, pl. 1, figs. 2a-c.
1965. *Dechenella* (?) *chengi* by LU et al., *Chinese Trilobites*, *vol. 2*, p. 575, pl. 122, figs. 4-6.

This species is founded on a pygidium which is subtriangular in outline and very convex in comparison with the preceding. The axial lobe is relatively breviconic and composed of 13 segments and the pleural lobe narrower than the axial lobe and consists of 12 segments; marginal furrow distinct and marginal border flat; test pustulate.

As compared by SUN, it resembles the pygidium named *Proetus chitralensis* by REED, 1911, but REED's has 10-11 axial rings and 8-9 pleurae and the ring has lateral nodes. The reference of this species to *Dechenella* is inconvincing.

Occurrence:—According to WANG and YÜ (1964), the specimen were procured in

Chaling district, Hunan, probably from the Frasnian Yütienchiao formation, instead of the Famennian Hsikuangshan formation s. str. from which *Phacops granulatus* was obtained.

Subgenus *Monodechenella* STUMM, 1953

Dechenella (*Monodechenella* ?) aff. *macrocephala* (HALL)

1929. *Dechenella* sp. aff. *D. macrocephala* HALL, by PATTE, *Bull. Serv. géol. l'Indochine, vol. 18, fasc. 1*, p. 25, pl. 2, fig. 2.
1959. *Dechenella* (*Dechenella*) sp. aff. *D. macrocephala* by PATTE, RICHTERS, *Senckenbergiana, Bd. 31, Nr. 3-4*, p. 174.
1965. *Monodechenella* sp. aff. *M. macrocephala* by PATTE, LU et al., *Chinese Trilobites, vol. 2*, p. 576, pl. 122, fig. 7.

RICHTERS (1950) suggested that PATTE's *Dechenella* sp. is a member of *Dechenella* (*Dechenella*), while LU et al. transferred the form to *Monodechenella* probably because of its affinity to *Proetus macrocephala* HALL, 1861 which is the type-species of the genus *Monodechenella* STUMM, 1953.

The PATTE's form is represented by a deformed pygidium from Yunnan. Its axial lobe appears narrower than HALL's and well pointed at the end. Some rings may be bent to form broad Vs, but this is possibly a secondary aspect by lateral compression judging from the outline of the pygidium.

This pygidium belongs probably to *Dechenella* s. l., but its subgeneric position is difficult to determine. It shows the Hamilton affinity, if it be a *Monodechenella*.

Occurrence:—Middle Devonian at Kaiyüan, (Tche-Ts'ouen, environs d'Ami-cheoú, PATTE, 1929), Yunnan.

Subgenus *Basidechenella* RICHTER, 1912

Dechenella (*Basidechenella* ?) *blondeli* (PATTE, 1929)

1929. *Proetus blondeli* PATTE, *Bull. Serv. géol. l'Indochine, vol. 18, fasc. 1*, p. 7, 14, 54, pl. 6, fig. 4.
1950. *Dechenella* (*Basidechenella* ?) *blondeli* by RICHTERS, *Senckenbergiana, Bd. 31, Nr. 3-4*, p. 174.

This species is represented by a nearly complete dorsal shield which is, however, strongly deformed by lateral compression, causing the trilobation of the glabella by two longitudinal furrows and the effacement of the lateral furrows.

PATTE compared it with *Proetus rowi* in HALL and CLARKE, 1888, pl. 21, fig. 5 from the Hamilton of New York. This GREEN's species was referred to *Dechenella* by RICHTERS (1926) and to *Dechenella* (*Basidechenella*) by STUMM (1953). The hesitance of this reference lies in the number of the thoracic segments which is said 9, instead of 10.

This species is, however, not closely related to either *Proetus decorus* BARRANDE, 1852, pl. 17, figs. 13 and 21 or *Proetus astyanax* in BARRANDE, 1852, pl. 22-23. These two species are tropidocorphyids where the former is the type-species of *Decoroproetus* PŘIBYL and the latter is synonymous with *Astycoryphe gracilis* (BARRANDE).

Occurrence:—Eifelian schistes de Ho-tai, Van Yen region, Tonkin, Viet-Nam, associated with *Spirifer speciosus.*

Subfamily Cyrtosymbolinae HUPÉ, 1955

The Cyrtosymbolinae differ from the Dechenellinae in the posterior expansion of the glabella, pronounced lateral furrows, adaxial bifurcation of the posterior lateral furrows, common occipital lobes, uncommon median tubercle on neck ring, well developed eyes, narrow fixed cheeks and sometimes mesially keeled free cheeks, widely divergent anterior facial sutures, thick convex marginal border, usual possession of genal spines, 10 segments in thorax, and large, long and multisegmented pygidium with distinct border of the latter subfamily.

A lengthy note of the subfamily was given by the authors in a recent paper (1973). These subfamilies indicate two independent branches of the Proetidae issued respectively in the early and middle Devonian times.

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

Waribole elliptica (MANSUY, 1912)

Text-fig. 3J.

1912. *Proetus ellipticus* MANSUY, *Mém. Serv. géol. de l'Indochine, vol. 1, fasc. 2,* p. 85-86, pl. 16, figs. 2a-c.

A nearly complete dorsal shield in figs. 2a-b is the lecto-holotype and a cranidium and pygidium in fig. 2c on the same plate are paratypes.

Cephalon semicircular, nearly as long as one-third the shield. Glabella inclusive of neck ring, outlined by deep dorsal furrows, slightly convex, a little longer than two-thirds the cephalon and about one-fourth as wide as the cephalon, but narrowing gradually forward and subangulated in front; posterior lateral furrows very oblique and apparently continuing to strong occipital furrow to limit posterior lateral furrow; other lateral furrows of the glabella obsolete; neither median tubercle nor occipital lobes visible on neck ring. Palpebral lobes semicircular and close-set the glabella, its diameter being equal to a half of glabellar length; frontal border as long as preglabellar field, convex and continuing narrower lateral border which is produced into strong genal spine. Facial suture is seen in the holotype illustration. Its anterior branch diagonal in front of eye, but curved inward on marginal border; posterior branch more or less sigmoidal and cutting posterior cheek margin a little outside its middle point. Hypostoma unknown.

Thoracic segments probably 9 in number, instead of 10; axial lobe a little narrower than a quarter of segment in anterior and nearly a fifth in posterior; pleural furrow distinct.

Pygidium broader than twice its length, almost semicircular, but posterior margin nearly transversal; axial lobe a little narrower than a quarter of pygidial breadth, compose of 10 rings, terminating at blunt end; 6 or more ribs on pleural lobe, flattopped, separated by deep pleural furrows and each divided into two bands by a weak interpleural furrow; marginal border narrow, depressed and somewhat broadened in posterior.

MANSUY's description is here a little emended by the authors' observation of his illustration. The preglabellar field of moderate size and lack of occipital lobes exclude this species from the Proetinae. The pygidium is evidently too broad and less segmented for the Dechenellinae. Any posterior expansion of the glabella as seen in *Dechenella* cannot be seen in this species. In these two subfamilies the thorax has ten segments, but the segments countable on the holotype illustration are 9 in number.

This species agrees better with the Cyrtosymbolinae than these two subfamilies and best with *Waribole*. Compared to this species *Waribole perlisensis* KOBAYASHI and HAMADA, 1966 has the larger cephalon, relatively long glabella reaching the depressed frontal border, smaller eyes which are not semicircular, but rather lunate, broad axial lobe of the thorax, and marginal border of the pygidium ill-defined and slanting, instead of depressed.

Occurrence:—Lower Carboniferous shale beds containing *Spirifer subconicus* at a locality between Tao-Kao and Yiliang, East Yunnan. The known range of *Waribole* suggests Tournaisian for the age of the shale beds.

Family Otarionidae R. and E. RICHTER, 1926

Subfamily Otarioninae R. and E. RICHTER, 1926

PILLET (1972) included the following genera and subgenera in the Otarioninae.

Otarion ZENKER, 1833 (*Otarion diffractum* ZENKER, 1833)
Coignouinia REED, 1943 (*Cyphaspis acanthina* COIGNOU, 1890)
Otarionella WEYER, 1965 (*Cyphaspis davidsoni* BARRANDE, 1852)
Rhinotarion WHITTINGTON and CAMPBELL, 1967 (*Rhinotarion sentosum* WHITTINGTON and CAMPBELL, 1967)
Otarion (*Maurotarion* ALBERTI, 1969) (*Harpidella mauri* ALBERTI, 1967)
Otarion (*Otarionides* ALBERTI, 1969) (*Otarion* (*Otarionides*) *franconicum* ALBERTI, 1969)

He, however, transferred *Tschernyschewiella* TOLL to the Brachymetopidae from this family. *Namuropyge* R. and E. RICHTER, 1939, provisionally located in the Brachymetopidae in MOORE's Treatise was on the other hand added to them by GANDL (1973).

Songkania CHANG, 1974 whose type-species is *Songkania haijiadianensis* CHANG, 1974 from the Lower Silurian of Hupei and Kweichou would be an additional member of this subfamily.

In describing two new species of *Scharyia*, i. e. *S. heoteissa* from the Ashgillian of Sweden and *S. siceripotrix* from the Ludlow of British Isles OWENS (1974) claimed that this genus reveals closer affinities with the Otarionidae than the Proetidae.

Genus *Otarion* ZENKER, 1833

Otarion in Asia and Australasia

Early in 1886 SCHMIDT has described *Cyphaspis sibirica*, nov. from the "Devonian" limestone at Torgoshino near Krasnoyarsk on the Yenissei river, Central Siberia together with *Proetus* (*Phaeton*) *slatkowski* nov. Later two Cambrian genera, *Erbia* and *Kooteniella* were founded by LERMANTOVA (1940) respectively on the latter and former species.

There are, however, several species of *Otarion* in the Asiatic part of the Soviet Union. Namely, WEBER (1932) described the followings from Turkestan.

Cyphaspis ocellata WHIDBORNE, 1889 by WEBER. Middle Devonian
Cyphaspis sp. I and *Cyphaspis* (?) sp. II. Silurian

Subsequently TSCHERNYSHEVA (1951) added *Cyphaspis convexa* CORDA and *C. convexa* (?) from the Devonian (D_{1-2}, D_{2-2}) from the Kuznetsk basin, West Siberia.

In China KUO (1962) has recently described two Silurian species from near Kirin, Central-eastern Manchuria as follows:

Otarion diffrectum conveximarginatum KUO, 1962
Otarion sphaericum KUO, 1962

In addition, *Cyphaspis tiaomachienensis* SUN, 1937, is described from the Middle Devonian of Hunan, South China (See Postscript 10.)

In further south *Cyphaspis giraudi* MANSUY, 1918, occurs in the Eiferian série, schist-calcaire de Naca, Tonkin, Viet-Nam in association with *Proetus vietnamensis* KOBAYASHI and HAMADA, 1974.

In Burma REED (1923) reported the occurrence of *Cyphaspis* cf. *convexa* CORDA from the Southern Shan State, but it was neither described nor illustrated.

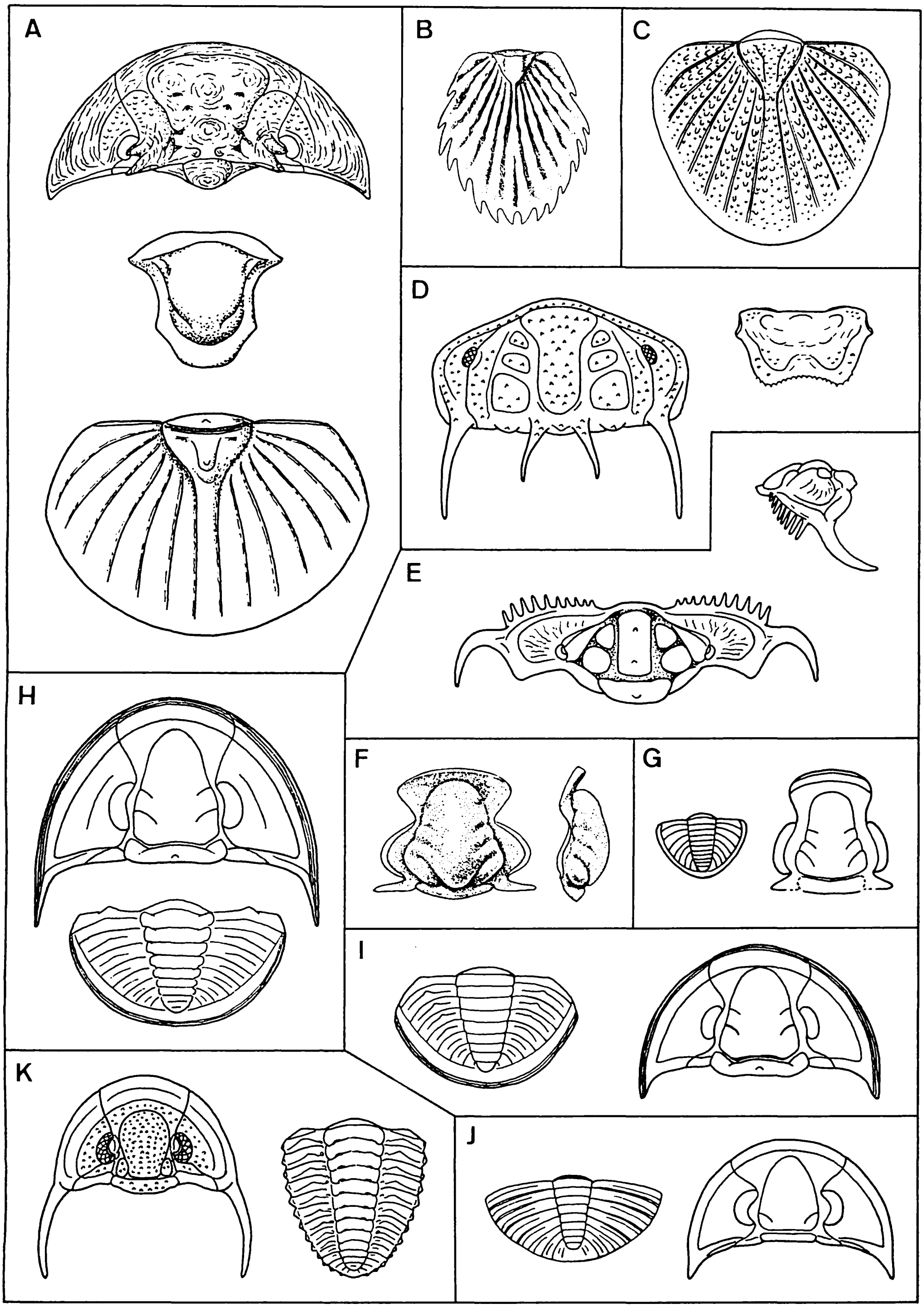
They belong to genus *Otarion* and most of them, if not all to *Otarion* (*Otarion*). The Otarionidae are furthermore represented in Bithynia, Turkey by four species in two genera as follows:

Otarion (*Otarion*) *hystrix* HAAS, 1968. Siegen-lower Emsian
Otarion (*Otarion*) *hydrocephalum hydrocephalum* (ROEMER). Upper Emsian
Otarion (*Otarion*) *goerlichi* HAAS, 1968. Eifelian
Harpidella cimex HAAS, 1968. Upper Emsian

None of the Asiatic species is known to be referable to *Otarion* (*Maurotarion*) ALBERTI, 1969, *Otarion* (*Otarinoides*) ALBERTI, 1969, *Coignouinia* REED, 1943, *Otarionella* WEYER, 1965, or *Rhinotarion* WHITTINGTON and CAMPBELL, 1967 in the Otarioninae or *Cyphaspides* NOVAK, 1890 in the Cyphaspidinae, PŘIBYL, 1947. Of *Tschernyschewiella* TOLL, 1899, which was proposed for *Schmidtella uralica* TSCHERNYSHEV, 1893 from the

Text-fig. 3. Restoration of the Scutelluidae, Odontopleuridae, Proetidae, Dechenellidae and Otarionidae.

A *Hidascutellum multispiniferum*, gen. et sp. nov. ×2
B *Thysanopeltella* (*Septimopeltis*) *paucispinosa* (OKUBO) ×1.2
C *Scutellum densigranulatum*, sp. nov. ×1.5
D *Ceratocephala nipponica*, sp. nov. ×1.5
E *Primaspis* (?) *tanakai*, sp. nov. ×6
F *Dechenella* (*Dechenella*) *minima* OKUBO ×3.2
G *Dechenella* (*Dechenella*) *indosinensis* (MANSUY) ×0.6, ×1.3 (cranidium)
H *Unguliproetus oisensis*, sp. nov. ×4
I *Proetus* (*Coniproetus*) *fukujiensis*, sp. nov. ×2.5
J *Waribole elliptica* (MANSUY) ×2.8
K *Otarion megalops*, sp. nov. ×5


A
B
C
D
E
F
G
H
I
J
K

Lower Devonian of the Urals, the reference of the genus to the Otarionidae or the Brachymetopidae is a question (ERBEN, 1966).

Otarion has flourished in Australia and Tasmania in the Devonian and possibly in the late Silurian times as represented by some ten species as follows:

Cyphaspis bowningensis MITCHELL, 1888. Upper and Middle Trilobite beds, N. S. W.; Yeringian, Vict. (CHAPMAN, 1915)
Cyphaspis yassensis ETHERIDGE & MITCHELL, 1894. Lower Trilobite beds, N. S. W.; Yeringian, Vict. (CHAPMAN, 1915)
Cyphaspis hormi ETHERIDGE & MITCHELL, 1894. Lower Trilobite beds, N. S. W.
Cyphaspis rotunda ETHERIDGE & MITCHELL, 1894. Lower Trilobite beds, N. S. W.
Cyphaspis lilydalensis CHAPMAN, 1915. Yeringian, Vict.
Cyphaspis filmeri, MITCHELL, 1919. Lower Trilobite beds, N. S. W.
Otarion sp. TALENT, 1963. Lower Devonian limestone, Vict.
Otarion munroei STRUSZ, 1964. Lower to Middle Devonian Garra formation, N. S. W.
Otarion (*Otarion*) *dabrowni* CHATTERTON, 1971. Warrow limestone, N. S. W.
Otarion (*Tricrotarion*) *struszi* CHATTERTON, 1971. *Receptaculites* limestone & Warrow limestone, N. S. W.

According to CHATTERTON *Cyphaspis filmeri* is probably synonymous with *Cyphaspis horni.*

Otarion megalops KOBAYASHI and HAMADA, sp. nov.

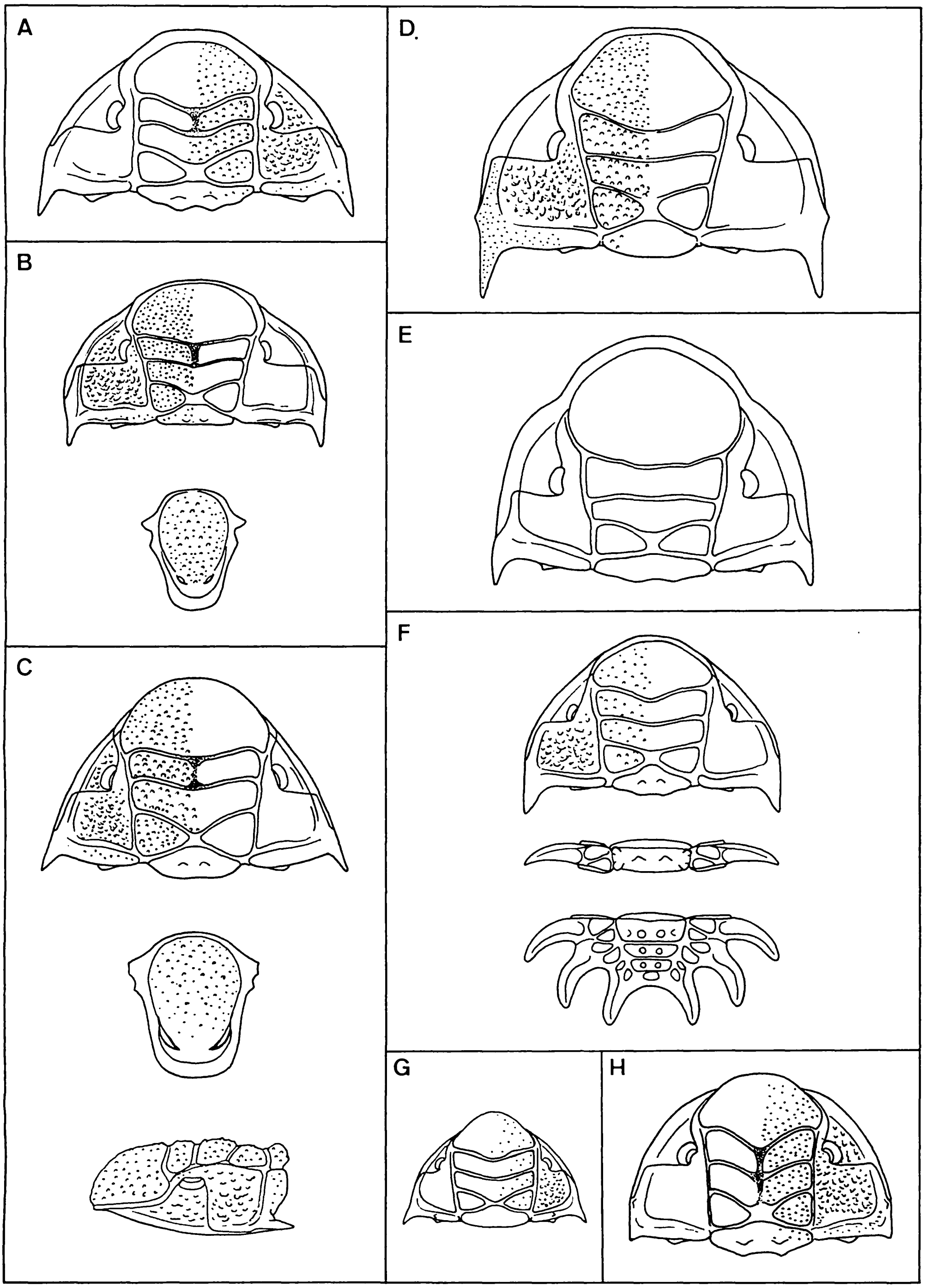
Pl. 3, Figs. 2-4; Text-fig. 3K.

1974. *Otarion* sp. OKAZAKI, *Mem. Fac. Sci. Kyoto Univ. Ser. Geol. Min., vol. 40, no. 2,* pl. 9, figs. 10-11.

Description:—Cephalon exclusive of genal spines nearly semicircular, its maximum breadth a little anterior to the posterior end, since posterior margin is bent anterolaterally near lateral ends; cephalic length about two-thirds of its breadth. Glabella inclusive of neck-ring about two-thirds the cephalic length, pyriform, strongly vaulted, and outlined by deep dorsal furrows; basal lobes longer than wide, triangularly ovoid, medium in size, and completely circumscribed by furrows; no other furrow discernible on glabella; occipital furrow very profound; occipital ring expanding mesially as its posterior margin more arcuate than the other; granules aligned more or less longitudinally on glabella and somewhat alternately on neck ring; a few mesial ones on the ring a little larger than lateral ones, but no median tubercle is present. Cheeks and preglabellar area strongly convex on the inner side and concave on the outer side; marginal border flat and nearly as wide as the concave outer zone of cheek;

Text-fig. 4. Restoration of *Crotalocephalina.*

A *Crotalocephalina* (*Geracephalina*) *secta*, subgen. et sp. nov. ×1
B *Crotalocephalina* (*Geracephalina*) *secta projecta*, subsp. nov. ×1
C *Crotalocephalina* (*Geracephalina*) *convexa*, sp. nov. ×1
D *Crotalocephalina* (*Crotalocephalides* ?) sp. indet. ×1
E *Crotalocephalina* (*Crotalocephalina*) sp. indet. ×1.5
F *Crotalocephalina* (*Pilletopeltis*) *japonica* (KOBAYASHI & IGO) ×1.5
G *Crotalocephalina* (*Pilletopeltis*) *kameii*, sp. nov. ×2
H *Crotalocephalina* (*Geracephalina*) *euryrachis*, sp. nov. ×1.5


A
B
C
D
E
F
G
H

posterior border bent somewhat antero-laterally at intergenal angle; genal spine nearly as long as cephalon extending from genal angle more laterally than lateral margin of the cheek and gently falcate; granules distributed only on convex inner roll. Eyes reniform, close-set to glabella just anterior to basal lobes, very large and prominent, highly elevated above glabella; palpebral lobe semicircular, slanting toward axial furrow. Facial sutures divergent forward from eyes as far as their lateral ends, recurving axially on frontal border, and posteriorly diverging from eyes so as to cut posterior margin at intergenal angle.

Thorax composed of ten or more segments, nearly parallel-sided in anterior but narrowing regularly in posterior; axial lobe wider than pleural one; pleural furrow running a little anterior of mid-length of pleuron; falcral process distinct at about mid-point of anterior margin; lateral end of pleura pointed postero-laterally.

Pygidium small, sublenticular, twice wider than long; posterior margin more convex than the other; axial and pleural lobes trisegmented lateral and posterior margins serrated.

Observation:—The holotype cephalon is represented by an external and internal mould. As seen on the rubber replica out of the former the convex part of the cephalon is conspicuously granulated, but on the latter which is partly coated by foreign material secondarily the granulation is obscure. The eyes are probably densely facetted, although it is not clearly observable.

The paratype is composed of ten thoracic segments and a pygidium. As it is quite reasonable to consider that two thoracic segments on the antero-lateral side of the specimen belong to the same thorax, this species must have had twelve or more segments in thorax. Because a thoracic segment is still attached to the type cephalon and because all of these segments belong to an identical carapace, judging from their size and disposition in the same slab, the segments number no less than thirteen in total. The breadth of the first thoracic segment corresponds to that of the posterior border of the cephalon between the intergenal angles. None of the axial rings of these segments bears an axial spine.

A deformed cranidium shows the anterior margin clearly. This and the type cephalon warrants that the cephalic margin is entire, except for the projection of long genal spines. Nothing is known of the hypostoma and rostral plate.

Comparison:—Compared to *Otarion diffrectum* and its close allies this species differs in the well developed prominent eyes, relatively broad axial lobe and the small paucisegmented pygidium.

Otarion tiaomachiensis (SUN) and *Otarion giraudi* (MANSUY) are two Devonian species in Eastern Asia. The former is known of the cranidium having a distinct

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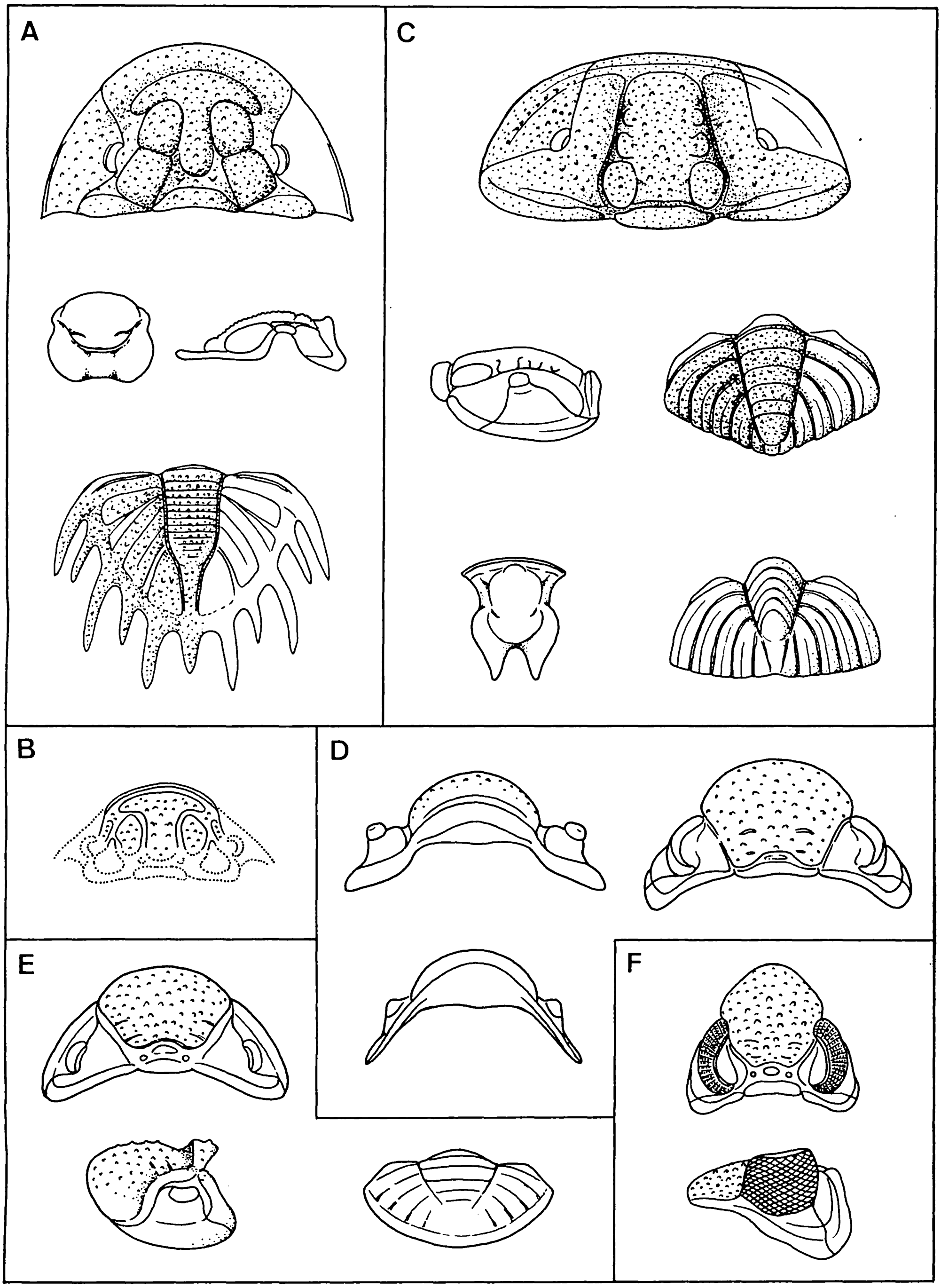
Text-fig. 5. Restoration of the Lichidae, Phacopidae and Calymenidae.

A *Craspedarges superbus*, sp. nov. ×2
B *Acanthopyge* (*Lobopyge* ?) sp. indet. ×4
C *Gravicalymene yamakoshii*, sp. nov. ×2
D *Reedops nonakai* (OKUBO) ×1.2
E *Phacops* (subgen. nov. ?) *manchuricus*, sp. nov. ×1.5
F *Phacops* cf. *okanoi* SUGIYAMA ×2


A
C
B
D
E
F

median foramen just in front of the glabella by which it can easily be distinguished from this species. The latter has an oval glabella distinctly narrowing forward, smaller eyes on the larger cheeks which are detached from the glabella, and the shorter genal spine issuing in the regular extension of the lateral margin of the cheek. The intergenal angle is absent and the thorax is composed of fourteen segments in that species.

Among other Asiatic species *Otarion ocellata* WHILDBORNE by WEBER, 1932, from the Devonian of Ferghana has prominent eyes, like this species, but the eyes are much smaller in that species. The cephalon and the glabella in particular are much more vaulted in WEBER's species as well as in *Otarion convexa* CORDA by TSCHERNYSHEVA, 1951 from the Devonian of the Kuznetsk basin.

Among the Australian species this species resembles *Otarion bowningensis* (MITCHELL), in the large prominent eyes and some other characteristics but the glabella is larger and the frontal limb narrower in that species. Furthermore this species has no lateral ridge crossing the free cheek, but it has a concave zone along the flat marginal border which is absent in that species.

Finally, the marginal serration of the pygidium distinguishes this species from many similar ones.

Occurrence:—Common in a shaly bed below the *Gravicalymene*-Orthocerid bed at Sorayama, Fukuji district.

Otarion giraudi (MANSUY, 1918)

1918. *Cyphaspis giraudi* MANSUY, *Bull. Serv. géol. l'Indochine, vol. 5, fasc. 2*, pl. 11, pl. 2, figs. 9a-b, e-f, ? 9c-d.

Isolated basal lobes of the glabella and other aspects of the cephalon are clearly shown in figs. 9e-f, except for the genal spine which is, however, preserved in the dorsal shield in figs. 9a-b. This shield is nearly complete, but the glabella is ill-preserved. It has 14 segments in thorax and its pygidium is small and broad.

Among three specimens from Naca one in figs. 9c-d appears different from the two others in the outline of the glabella, size of the eyes and the thickness and convexity of the frontal limb and rim. This specimen is laterally compressed, but the difference looks more than simple deformation.

Occurrence:—Naca, Pho-binh-gia region, Northeast Tonkin, Viet-Nam.

Otarion tiaomachienensis (SUN, 1937)

1937. *Cyphaspis tiaomachienensis* SUN, *Bull. Geol. Soc. China, vol. 17*, p. 349, pl. 1, figs. 1a-b.
1957. *Otarion tiaomachienensis* by LU, *Index Fossils of China, Invertebrates, vol. 3*, p. 287, pl. 153, figs. 1-2.
1965. *Otarion tiaomachienensis* by LU et al., *Chinese Trilobites, vol. 2*, p. 583, pl. 123, figs. 2-3.

This species differs from *O. giraudi* in the oval strongly vaulted glabella provided with a pair of button-like basal side-lobes, a median pit at the glabellar front, posteriorly located eyes and laterally extended postero-lateral limb of the fixed cheek.

Occurrence:—Middle Devonian Tiaomachien formation at Tiaomachien, Changsha district, Hunan, China.

Bibliography

See Bibliography in KOBAYASHI and HAMADA (1974a) for Silurian trilobites.

ADIE, R. J. et al. (1972): Antarctic Geology and Geophysics. *IUGS, Ser. B, No. 1, Oslo.*

ALBERTI, G. K. B. (1960): Trilobiten aus dem Tentaculitenschiefern (Devon) von Schaderthal (Ostthüringen). *Mitt. Geol. Staatsinst, Hamburg, Hft. 29.*

——— (1961): Ueber *Proetus* (*Piriproetus*) ERBEN im Mitteldevon des Oberharzes. *N. Jb. Geol. Paläont., Mh. 105.*

——— (1962): Unterdevonische Trilobiten aus dem Frankenwald und Rheinischen Schiefergebirge (Ebbe-Remscheider Sattel). *Geol. Jahrb., 81.*

——— (1963): Zur Kenntnis rheinisch-herzynischer Mischfaunen (Trilobiten) im Unterdevon. *Mitt. Geol. Staatsinst. Hamburg, Hft. 32.*

——— (1964): Neue Trilobiten aus dem marokkanischen und deutschen Unter- und Mitteldevon. *Senckenberg. Leth., Bd. 45, Hft. 1-4.*

——— (1966a): Ueber einige neue Trilobiten aus dem Silurium und Devon, besonders von Morokko. *Ibid., Bd. 47, Hft. 2.*

——— (1966b): Zur Taxonomie und Verbreitung der Trilobiten-Gattung *Kolichapeltis* PRANTL und PŘIBYL, 1947, im Unter-Devon. *Palaeont. Zeitschr., Bd. 40, Hft. 3-4.*

——— (1966c): Note prêliminaire sur quelques trilobites (en paticulier des Proetides) du Silurien, du Devonien inférieur et du Devonien moyen du Maroc. *Notes et Mém. Serv. géol. Maroc., 26* (188), Rabat.

——— (1967a): Neue obersilurische sowie unter- und mitteldevonische Trilobiten aus Marokko, Deutschland und einigen anderen europäischen Gebieten. 1 und 2. *Senckenberg. Leth., Bd. 48, Hfte. 5 und 6.*

——— (1967b): Silurian and Devonian in Northwest Morocco and faunal relationship with Central Europe. *Abst. Proc. Intern. Symp. Dev. System, Calgary, 5-6.*

——— (1969, 1970): Trilobiten des jüngeren Siluriums sowie des Unterdevons, 1-2. *Abh. Senckenberg. Naturf. Gesell., 520, 525.*

——— (1970): Zur Augenreduktion bei devonischen Trilobiten mit Beschreibung von *Nephranops franconicus* n. sp. aus dem Oberdevon I von Oberfranken. *Palaeont. Zeitschr., Bd. 44.*

——— (1971): Sexual-Dimorphismus (?) bei *Cheirurus* (*Crotalocephalus*) cf. *pauper* BARRANDE 1852 (Trilobita, Devonian). *Ibid., Bd. 45, Nr. 3/4.*

———, HAAS, W. and ORMISTON, A. R. (1971): Discovery of the trilobite *Warburgella regulosa* (ALTH, 1874) in Gedinnian strata of central Nevada. *N. Jb. Geol. Pal., Monatschr., No. 4.*

——— and ——— (1972): *Warburgella regulosa eureka* n. sp. (Trilobita, Proetidae) aus dem unter-Gedinnium von Zentral Nevada (USA). *Senckenberg. Lethaea, Bd. 53, Nr. 1.*

ALBERTI, H. (1968): Trilobiten (Proetidae, Otarionidae, Phacopidae) aus dem Devon des Harzes und die Rheinischen Schiefergebirges (Beitrag 1). *Beihefte zum Geol. Jahrb., Hft. 73.*

——— und RUCHHOLZ, K. (1964): *Cornuproetus* (*Linguaproetus* n. subg.) *fornix* n. sp. und *Drevermannia* (*Eodervermannia*) *tegula* n. sp. aus dem Devon des Harzes. *N. Jb. Geol. Paläont., Abh. 119 (1).*

ALLAN, R. S. (1935): The Fauna of the Reefton Beds (Devonian) New Zealand with Notes on Lower Devonian Animal communities in relation to the base of the Devonian System. *Geol. Surv. N. Z., Pal. Bull., No. 14.*

——— (1947): A revision of the Brachiopoda of the Lower Devenian strata of Reefton, New Zealand. *Jour. Pal., Vol. 21.*

AMMON, L. V. (1893): Devonische Vensteinerungen von Lagoinna in Mato Grosso (Brasilien). *Zeitschr. Gesell. für Erdkunde zu Berlin, Bd. 28.*

Anderson, M. M., Boucot, A. J. and Johnson, J. G. (1969). Eifelian brachiopods from Padaukpin, Northern Shan States, Burma. *Bull. Brit. Mus. (Nat. Hist.), Geol., Vol. 18, No. 4.*

Angelin, N. P. (1954) : Palaeontologica Scandinavica.

Avnov, D. P., Popov, V. E., Gratsianova, R. T., Yolkin, E. A., Lapin, B. N. and Kalugin, A. S. (1967) : Devonian of Intermontane Depressions in the Altai-Sayan region. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1.*

Balashova, E. A. (1960) : Trilobites of the Middle and Upper Ordovician and Lower Silurian of Eastern Taimyr. *Leningrad Univ.*

——— (1966) : Trilobtes from the Ordovician and Silurian Sediments of Pamir. *Trudi Geol. Bureau, Cabinet of Tudjikstan, USSR. Pal. & Stratigr., Fasc. 2.*

——— (1968) : Skalian and Bolshov Horizon Trilobites of Podolia. *Silurian-Devonian fauna of Podolia.*

———, Kramarenko, N. N. and Maximova, Z. A. (1960) : Proetidea, Scutelloidea, Lichoidea, Odontopleuroidea, Calymenoidea, Phacopoidea, Cheiruroidea. Orlov's *Osnovy Paleont., Vol. 8.*

Baldis, B. A. J. (1967) : Some Devonian trilobites of the Argentine Precordillera. *Intern. Symp. Dev. System, Calgary, 1967, Vol. 2.*

——— (1974) : Trilobites devonicos de la Sierra de Santa Barbara (provincia de Jujuy). *Ameghiniana, Vol. 9, No. 1.*

——— and Blasco, G. (1973) : Trilobites ordovicicos de Ponon Trehue, Sierra Pintada de San Rafael, Provincia Mendoza. *Ibid., Vol. 10, No. 1.*

Banks, W. R. (1961) : Age and relationship of Tasmanian fossil faunas and floras. *Proc. Ninth Pacif. Sci. Congr., Vol. 12.*

Barrande, J. (1852, 1972) : Système Silurien du centre de la Bohême. *Vol. 1 et Suppl. au Vol. 1.*

Barrouquère, G. et Pillet, J. (1969) : Trilobites Dévoniens du massif de l' Arize (Ariège). *Bull. Soc. d'Hist. Natur. de Toulonse, t. 105, fasc. 3-4.*

Barton, D. C. (1915) : A revision of the Cheirurinae with notes on their evolution. *Washington Univ. Studies, Vol. 3, Pt. 1, No. 1.*

Bastin, H., Braun, E. von, Hess, A., Koch, K.-E., Stein, V., Stoppel, D. and Wolfart, R. (1970) : Silurian and early Devonian biostratigraphy in Northwest Thailand. *Newsl. Stratigr., Vol. 1, No. 2.* Leiden.

Berry, W. B. N. and Boucot, A. J. (1927) : Correlation of the Southeast Asian and Near Eastern Silurian rocks. *Geol. Soc. America, Sp. Pap. 137.*

Blagonoravov, V. A., Zonenshayn, L. P. Filippova, I. B. et al. (1973) : The Middle Paleozoic of Northeastern Mongolia. *Sov. Geol., No. 8.* (not seen).

Bolton, TE. (1965) : Trilobites from Upper Silurian rocks of the Canadian Arctic archipelago : *Encrinurus (Frammia)* and *Hemiarges. Geol. Surv. Canada, Bull. 134.*

Boucot, A. (1971) : Malvinokaffric Devonian marine community distribution and implications for Gondwana. *An. Acad. Brasil. Cienc., Vol. 43, (Supplemento).*

——— (1974) : Silurian and Devonian biogeography. In Ross, C. A. (ed.) *Paleogoegraphic provinces and provinciality. Soc. Econ. Paleont. & Mineralogists., Sp. Publ. No. 21.*

——— et al. (1965) : Early Devonian Brachiopod Zoogeography. *Geol. Soc. Am., Spec. Pap. 87.*

———, Caster, K. E., Ives, D. and Talent, J. A. (1963) : Relationships of a new Lower Devonian terebratuloid (Brachiopoda) from Antarctica. *Bull. Am. Paleont., Vol. 46 (207).*

———, Dean, W. T., Potter, A. et al. (1973) : Biogeographic Relations of the Pre-late Middle Devonian of Eastern Klamath Belt, Northern California. (abstr.) *Cordilleran Section, 69th Annual Meeting, Geol. Soc. Am., Abstr. 5, No. 1.*

———, ——— and Martinsson, A. et al. (1973) : Pre-Late Middle Devonian Biostratigraphy of the Eastern Klamath Belt, Northern California. (Abstr.) *Ibid. 5, No. 1.*

———, Doumani, G. A., Johnson, J. G. and Webers, G. F. (1967) : Devonian of Antarctica. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1.*

———, Johnson, J. G. and Talent, J. A. (1969) : Early Devonian brachiopod zoogeography. *Geol. Soc. Am., Spec. Pap. 119.*

Branisa, L. (1965) : Los Fosiles Guias de Bolivia. *Servicio Geologico de Bolivia, Boletin No. 6.*

——— and Vaněk, J. (1973) : Several new trilobite genera of the Dalmanitacea Vogdes, 1890 in the Devonian of Bolivia. *Czech Ústered. Ústak Geol. Věstn., Vol. 28, No. 2.*

Breivel, M. G., Eroschevskaya, R. I., Nestoyanova O. A. and Khodalevich (1967) : Devonian of the Eastern Slope of the Urals. *Intern. Symp. Dev. System, Calgary, 1967, Vol. 1.*

Brezhnev, V. D., Gorianov, V. N., Klishevitch, V. L., Martyshev, V. R., Nasybulin, N. N. and Zubtsov, E. I. (1967) : Devonian of Tien Shan. *Ibid., Vol. 1.*

Brinkmann, R. (1960) : Geologic evolution of Europe. (J. E. Sanders's translation).

Brown, I. A. (1941) : The stratigraphy and structure of the Silurian and Devonian rocks of the Yass Bowning district, N. S. W. *Jour. Proc. Roy. Soc. N. S. W., Vol. 74.*

Bruton, D. L. (1965) : The Middle Ordovician of the Oslo region, Norway, 19. The trilobite family Odontopleuridae. *Norsk Geol. Tidsskr., 45.*

——— (1966a) : A new odontopleurid trilobite genus from the Devonian of Bohemia. *Palaeont., Vol. 9.*

——— (1966b) : A revision of the Swedish Ordovician Odontopleuridae (Trilobita). *Bull. Geol. Inst. Univ. Uppsala, Vol. 43.*

——— (1967) : Silurian odontopleurid trilobites from Sweden, Estonia, and Latovia. *Palaeont., Vol. 10.*

——— (1968) : A revision of the Odontopleuridae (Trilobita) from the Palaeozoic of Bohemia. *Norsk Vidensk.-Akad. i Oslo, 1. Mat. Naturv. Kl., Ny Ser., No. 25.*

Bublichenko, N. (1967) : The history of development of the Devonian in Kazakhstan. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 2.*

Burton, C. J. (1972) : Provincial affinities of Eifelian phacopids (Trilobita) of Southwest England and Brittany. *Proc. Ussher Soc. Vol. 2, Pt. 5,* pp. 458-463.

——— and Eldredge, N. (1974) : Two new subspecies of *Phacos rana* (Trilobita) from the Middle Devonian of Northwest Africa. *Palaeont., Vol. 17, Pt. 2.*

Campbell, K. S. W. (1967) : Henryhouse trilobites. *Okla. Geol. Surv., Bull. 115.*

——— (1973) : A species of the trilobite *Dalmanitina* (*Dalmanitina*) from Australia. *Geol. Foren. i Stockholm Forhandl., Vol. 95, Pt. 1.*

Campbell, K. S. W. (convener) (1972) : The Devonian System in Australia;
D. L. Strusz : Correlation of Lower Devonian rocks,
J. W. Pickett : Correlation of the Middle Devonian formations of Australia,
J. Richards et al. : Correlation of the Upper Devonian racks of Australia.
Jour. Geol. Soc. Australia, V. 18. Pt. 4.

Carrington da Costa, J. (1942) : Notas sobre a Familia Calymenidae. *Bol. Soc. Geol. Portugal, 1, Fc. 3.* (not seen).

Caster, K. E. (1939) : A Devonian fauna from Columbia. *Bull. Am. Paleont,, Vol 24, No. 83.*

Castro, Judith de Souza (1968) : Trilobitas da formação Pimenteiras, devoniano do estado de Piaui. (Trilobites of the Pimenteiras formation, Devonian Piaui) *Acad. Brasil Cienc. An., Vol. 40, No. 4.* (not seen.)

Cavet, P. and Pillet, J. (1958) : Les Trilobites des calcaires à Polypiers siliceux (Eifelian) du synclinal de Villafranche-de-Conflent (Pyrénées-Orientales) *Bull. Soc. géol. Fr., (6) 8, 1.*

Chang, An-Chi (1958) : Stratigraphy, palaeontology, and palaeogeography of the ammonite fauna of the Clymenienkalk from Great Khingan with special reference to the post-Devonian break (hiatus) of South China. *Acta Pal. Sinica. Vol 6, No. 1.*

——— (1960) : New late Upper Devonian ammonite-fauna of the Great Khingan and its biological classification. *Ibid., Vol. 8, No. 2.*

Chang, W. T. (1955) : Note on a new proetid from Upper Devonian of Kwangsi. *Acta Pal. Sinica, Vol. 3, No. 3.*

——— (1974) : Devonian trilobites. Hand-book of stratigraphy and palaeontology of Southwest China. Compiled by Nanking Institute of Geology and Palaeontology, Academia Sinica.

Chapman, F. (1914) : Australian fossils.

——— (1915) : New or little known Victorian fossils in the National Museum, part 18. Some

Yeringian trilobites. *Proc. Roy. Soc. Vict., Vol. 28,* (*N.S.*), *Pt. 1.*

Chaterji, G.C. (1967): Devonian of India. *Proc. Intern. Symp. Dev. System, 1967, Calgary, Vol. 1.*

Chatterton, B.D.E. (1971): Taxonomy and ontogeny of Siluro-Devonian trilobites from near Yass, New South Wales. *Palaeontogr., Bd. 137. Abt. A.*

——— (1973): Brachiopods of the Murrumbridgee Group, Taemas, New South Wales. *Austr. Bur. Miner. Res. Geol. Geophy., Bull. 137.*

Chauvei, J., Drot, J., Pillet, J. et Tamain, G. (1969): Precisions sur l'Ordovicien moyen et supérieur de la "Série-Type" du Centenillo (Sierra Morena Orientale Espagne). *Bull. Soc. géol. France, 7e Ser. Pt. 11.*

Chen, Kuang-yuan (1958): On the occurrence of the odontopleurid fauna in West Yunnan. *Nation. Peking Univ., 50th Ann. Papers., Geol. Ser.* (not seen).

Chlupáč, I. (1961): Prelimnary report on some new Upper Devonian trilobites from the Moravian Karst. *Věstník ÚÚG, Roč. 34.*

——— (1966): The Upper Devonian and Lower Carboniferous Trilobites of the Moravian Karst. *Sbor. Geol. Věd, Rada P. svazek 7.*

——— (1967): Devonian of Czechoslovakia. *Proc. Intern. Symp. Dev. System., Calgary, 1967, Vol. 1.*

——— (1969): Revision of the Middle Devonian trilobites from Horni Benešov in the Nízky Jeseník Mts. (Moravia). *Sborník Geolog. Věd. paleont. řada P, sv. 10.*

——— (1971): New phacopid trilobites from the Devonian of Czeckoslovakia. *Časopis pro min. a geol. roč 16, č. 3.*

——— (1972): New Silurian and Lower Devonian phacopid trilobites from the Barrandian area (Czechoslovakia). *Ibid., roč. 17, č. 4.*

———, Jaeger, H. and Zikmundova, J. (1972): The Silurian-Devonian boundary in the Barrandian. *Bull. Canad. Petrol. Geol., Vol. 20, No. 1.*

——— and Vaněk, J. (1965): Einige neue Arten von Trilobiten aus dem mittelböhmischen Devon. *Acta Univer. Carolinae, Geol. No. 1.*

Churkin, M. jr. (1961): Silurian trilobites from the Khamath mountains, California. *Jour. Pal., Vol. 35.*

——— and Brabb, E.E. (1965): Ordovician, Silurian and Devonian biostratigraphy of East Central Alaska. *Bull. Am. Assoc. Petrol. Geol., Vol. 49. No. 2.*

Clarke, J.M. (1892): Notes on the genus *Acidaspis. N. Y. State Mus., 44th Ann. Rep.*

——— (1913): Fosseis Devoniano do Parana. *Serv. Geol. Min. Monogr., No. 1.* Rio de Janeiro.

Clarke, M.J. (1968): Trilobites from the north bank of the Que river, Murchison highway, Tasmania. *Dep. Mines, Tech. Rep. No. 12* (1967). (not seen).

Clarkson, E.N.K. (1967): Fine structure of the eye in two species of *Phacops* (Trilobita). *Palaeont., Vol. 10, Pt. 4.*

Compilation Comm. of Geol. of China and Geol. Inst. Acad. Sinica (1956, 58), Areal stratigraphic tables of China and its supplement.

Cooper, C.A. et al. (1942): Correlation of the Devonian sedimentary formation of North America. *Bull. Geol. Soc. Am., Vol. 52.*

——— and Cloud, P. E. jr. (1938): New Devonian fossils from Calhoun County, Illinois. *Jour. Pal., Vol. 12.*

Corgan, J.X. (1963): Lower Devonian (Onesquethawan) marine faunule of Yukon and Northwest Territories Canada. *Bull. Am. Ass. Petrol. Geol., Vol. 47.*

Cuerda, A.J. and Baldis, B.A. (1971): Silurico-Devonico de la Argentina. *Ameghiniana, Vol. 8, No. 2.*

Davila, J. and Rodriguez, E. (1967): The Devonian System in Bolivia and the problem of its base. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 2.*

Dean, W.T. (1962): The trilobites of the Caradoc Series in the Cross Faull Inlier of northern England. *British Mus. Nat. Hist. Bull. Geol., Vol. 7. no. 3.*

——— (1967): The correlation and trilobite fauna of the Bedinan formation (Ordovician) in Southeastern Turkey. *Ibid., Vol. 15, Pt. 2.*

——— (1969): An Occurrence of the trilobite *Dechenella* (*Dechenella*) in the Middle Devonian Landry Formation, western district of Mackenzie. *Geol. Surv. Canada, Bull. 182.*

DELO, D.M. (1935a): A revision of the phacopid trilobites. *Jour. Pal., Vol. 9. no. 5.*

——— (1935b): New Phacopinae from the Devonian of Oklahoma and Iowa, *Ibid., Vol. 9, no. 5.*

——— (1940): Phacopid trilobites of North America. *Geol. Soc. Am., Sp. Pap. no. 29.*

DESTOMBES, J. (1966): Quelques Calymenina (Trilobitae) de l'Ordovicien moyen et supérieur de l'Anti-Atlas (Maroc). *Notes Serv. géol. Maroc, Pt. 26, No. 188.*

DOUMANI, G.A. et al. (1965): Lower Devonian fauna of the Horlick Formation, Ohio Range, Antarctica. HADLEY, J.B. (ed.) Geology and Paleontology of the Antarctica. *Publ. Am. Geophy. Union.*

DUN, W.S. (1898): Notes on the fauna of the Devonian boulders occurring at the White Cliffs Opal-fields. *Rec. Geol. Surv. N.S.W., 5.*

DURKOOP, A., MENINSK, H. and PLODOWSKIM, G. (1967): Central and Western Afghanistan and Southern Iran. *Proc. Intern. Symp. Devon. System, Calgary, 1967, Vol. 1.*

EDGELL, H.S. (1955): A Middle Devonian lichid trilobite from South-Eastern Australia. *Paläont. Zeitschr., Bd. 29.*

ELDREDGE, N. (1971): Patterns of cephalic musculature in the Phacopina (Trilobita) and their phylogenetic significance. *Jour. Pal., Vol. 45, No. 1.*

——— (1972a): Morphology and Relationships of *Bouleia* KOZLOWSKI, 1923 (Trilobita, Calmoniidae). *Ibid., Vol. 46, No. 1.*

——— (1972b): Systematics and evolution of *Phacops rana* (GREEN, 1932) and *Phacops iowensis* DELO, 1935 (Trilobita) from the Middle Devonian of North America. *Bull. Am. Mus. Nat. Hist., Vol. 147, Art. 2.*

——— (1973): Systematics of Lower and lower Middle Devonian species of the trilobite *Phacops* EMMRICH in North America. *Ibid., Vol. 151, Art. 4.*

——— (1974): Stability, diversity and separation in Paleozoic epiric seas. *Jour. Pal., Vol. 48, No. 3.*

ENDO, R. (1935): Additional fossils from the Canadian and Ordovician rocks of the Southern part of Manchoukuo. *Sci. Rep. Tohoku Imp. Univ., 2d. ser. (Geol.), Vol. 16, no. 4.*

——— (1944): Description of *Blackwelderia quadrata*, n. sp. and its post-embryonic development. *Bull. Cent. Nat. Mus. Manchoukuo, No. 1.*

——— and MATSUMOTO, E. (1962): Permo-Carboniferous trilobites from Japan. *Sci. Rep. Saitama Univ., Ser. B, Vol. 4, No. 2.*

ERBEN, H.K. (1951): Beitrag zur Gliederung der Gattung *Proetus* STEIN., 1831 (Trilobitae). *N. Jb. Geol. u. Palaent. Abh., Bd. 94, Hft. 1.*

——— (1952a): Trilobiten aus dem älteren Hercyn (Unterdevon). *Ibid., Bd. 94, Hft. 2/3.*

——— (1952b): Zur Gliederung der Ceratocephalidae Rud. und E. RICHTER, 1925, emend. PRANTL and PŘIBYL, 1949 (Tril.). *N. Jb. Geol. Paläont., Mh. 7.*

——— (1953): Ueber einige Otarionidae (Tril.) aus dem Mitteldevon der Eifel. *Senckenbergiana, Bd. 34, (1/3).*

——— (1961): Blinding and extinction of certain Proetidae (Tril.). *Jour. Palaeont. Soc. India, Vol. 2* (1958).

——— (1962): Zur Analyse und Interpretation der rheinischen und hercynischen Magnafazies des Devons. *2 Intern. Arbeitstagung über die Silur/Devon-Grenze und die Stratigraphie von Silur und Devon, Bonn-Bruxelle 1960.* Simposium-Band.

——— (1966): Ueber die Tropidocoryphinae (Tril.)-Lief. 1. *N. Jb. Geol. Paläontol., Abh. Bd. 125.*

——— (1969): Faunenprovinzielle Beziehungen zwischen unterdevonischen Trilobiten der Karnischen Alpen und Zentralasien. *Symposium ueber Palaeontologie und Stratigraphie der Karnischen Alpen. Carinthia II. Sonderh., No. 27.*

——— and ZAGORA, K. (1967): Devonian of Germany. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1.*

ETHERIDGE, R. jr. and MITCHELL, J. (1892): The Silurian trilobtes of New South Wales with reference to those of other parts of Australia. Pt. 1. *Proc. Linn. Soc. New South Wales,* *ser. 2, Vol. 6, pt. 3.*

——— and ——— (1894): The Silurian trilobites of N.S.W. etc. pt. 2. *Ibid., Ser. 2, Vol. 8, Pt. 6.*

——— and ——— (1896): The Silurian trilobites of N.S.W. etc. pt. 3. *Ibid., Ser. 2, Vol. 10.*

——— and ——— (1897): The Silurian trilobites of N.S.W. etc. pt. 4. *Ibid., Vol. 21.*

——— and ——— (1915): The Silurian trilobites of N.S.W. etc. pt. 5. *Ibid., Vol. 40, Pt. 4.*

——— and ——— (1917): The Silurian trilobites of N.S.W. etc. pt. 6. The Calymenidae, Cheiruridae, Harpidae, Bronteidae, with an appendix. *Ibid., Vol. 42, Pt. 3.*

EVITT, W.R. and WHITTINGTON, H.B. (1953): The Exoskeleton of *Flexicalymene* (Trilobita). *Jour. Pal., Vol. 27, no. 1.*

FAGERSTROM, J.A. (1961): The fauna of the Middle Devonian Formosa reef limestone of Southwestern Ontario. *Ibid., Vol. 35, No. 1.*

FEIST, R. (1970): *Breviscutellum* (*Meridioscutellum*) n. sg. (Trilobite) et son developement larvaire. *Geobios, Vol. 3, fasc. 4.*

——— (1974): Devonische Scutelluidae (Trilobitae) aus der ostlichen Montagne Noire (Südfrankreich). *Palaeontogr. Abt. A, Bd. 147.*

FISCHER, D.W. (1957): Mohawkian (Middle Ordovician) biostratigraphy of the Welles Outlier, Hamilton County, New York. *Bull. N. Y. State Mus, Albany, 359.*

FLETCHER, H.O. (1950): Trilobites from the Silurian of New South Wales. *Rec. Aust. Mus., Vol. 22.*

FOERSTE, A.F. (1920): The generic relations of the American Ordovician Lichadidae. *Am. Jour. Sci., Ser. 4, Vol. 49.*

FOLDVARY, G.Z. (1970): A new species of trilobite, *Cheirurus* (*Crotalocephalus*) *regius* n. sp. from the early Devonian of Trundale district, Central N.S.W. *Jour. & Proc. Roy. Soc. NSW., Vol. 103.*

FONTAINE, H. (1968): Cambodge du Laos et du VietNam. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1.*

FORTY, R.A. (1974): The Ordovician trilobites of Spitzbergen. *Norsk Polarinst. Skrif., Nr. 160.*

FREYER, G. (1963): Trilobiten aus dem tiefen Mitteldevon des Vogtlandes. *Geologie, Jahrg. 12, Hft. 8.*

FUJIMOTO, H., KANUMA, M. and MIDORIKAWA, Y. (1953): On the Gotlandian deposits newly discovered from Kiyomi-mura, Gifu Prefecture. *Studies from Geol. Miner. Inst. Tokyo Univ. Educ., No. 2.*

GAETANI, M. (1967): Northern and Eastern Iran, Northern Afghanistan and Northern Pakistan. *Proc. Intern. Symp. Devon. System, Calgary, 1967. Vol. 1.*

GANDL, J. (1972): Die Acastavinae und Asteropyginae (Trilobita) kelbiheriens (NE-Spanien). *Senck. Naturf. Ges. Abh., Nr. 530.*

——— (1973): Die Trilobiten der Vegamian-Schichten (Ober-Trounai). Die Karbon-Trilobiten des Kantabrischen Gebirge (N.W. Spanien) 1. *Senckenberg. Leth., Bd. 54, Nr. 1.*

GERTH, H. (1932): Geologie Südakmerikas. Erster Teil. *Geologie der Erde.*

GIGNOUX, M. (1955): Stratigraphic Geology. (G.G. WOODFORD's translation).

GIGOUT, M. (1951): Etudes géologiques sur la Méséta Marocaine Occidentale (arrierre-pays de Casablanca, Mazagan et Safi). *Trav. l'Inst. Scient. Chérifien. No. 3, Pt. 2.*

GILL, E.D. (1938): Yeringian trilobites. *Vict. Nat., Vol. 45.*

——— (1939): The Silurian trilobite *Lichas australis*. *Mem. Nat. Mus. Melb., Vol. 11.*

——— (1940a): A new trilobite from Cootamunda, N.S.W. *Proc. Roy. Soc. Vict., Vol. 52.*

——— (1940b): The Silurian rocks of Melbourne and Lilydale—a discussion of the Melbournian-Yeringian boundary and associated problems. *Ibid., Vol. 52.*

——— (1945): Trilobita of the Family Calymenidae from the Palaeozoic rocks of Victoria. *Ibid., Vol. 56, Pt. 2.*

——— (1947): A new trilobite from the Yeringian (Lower Devonian) rocks of Kinglake, *Ibid., Vol. 59, Pt. 1.*

——— (1948a): Eldron Group fossils. *Rec. Queen Vict. Mus. Launceston, Vol. 2.*

——— (1948b): A Gens of dalmanitid trilobites. *Jour. & Proc. Roy. Soc. N. S. W., Vol. 82.*

——— (1949a): Description and interpretation of some Victorian trilobite hypostomes. *Proc. Roy. Soc. Vict., Vol. 61.*

——— (1949b): Palaeozoology and taxonomy of some Australian homalonotid trilobites. *Ibid., Vol. 61.*

——— (1951): Revision of McCoy's *Prodromus* type from Lilydale and Killarn districts of Victoria. *Proc. Roy. Soc. Vict., Vol. 63.*

——— (1962): Catalogue of Middle Palaeozoic types and figured specimens in the National Museum of Victoria, Part 1. *Mem. Nat. Mus. Melbourne, Vict., No. 25.*

——— (1965): Palaeontology of Victoria: A description of fossils found in Victoria, Australia. *Victorian Year Book, No. 79.*

Gobbett, D. J. and Hutchison, C. S. (eb. 1973): Geology of the Malay Peninsula.

Grabau, A. W. (1925): Summary of the faunas from the Silurian shale. *Bull. Geol. Soc. China, Vol. 7.*

Grabert, H. (1967): Devonian strata in the central part of the Rhenish massif (Rheinisches Schiefergebirge, North Rheine-Westphalia), Germany. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 2.*

Gratsianova, R. T. (ed.) (1974): The most ancient dechenellids (trilobites) and Silurian stratigraphy of the Mountain Altai. *Trudi Inst. Geol. Geol. Geoph. Siberian branch, Akad. Sci. U. S. S. R., Issue 130.*

Gregory, J. W. (1901): *Cyphaspis spryi*, a new species of trilobite from the Silurian of Melbourne. *Proc. Roy. Soc. Vict., Vol. 13, (N. S.) Pt. 2.*

Gürich, G. (1901): Jura- und Devon-Fossilien von White Cliffs, Australien. *N. Jb. B.-B., 14.*

——— (1901): Ueber eine neue *Lichas*-Art aus dem Devon von Neu-Süd-Wales und uber die Gattung *Lichas* überhaupt. *N. Jb. für Min. nsw. Beil.-Bd., 14.*

Haas, W. (1967): The Devonian of Bithynia, Northwest Turkey. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 2.*

——— (1968a): Die Alt-Palaeozoikum von Bithynien (Nordwest-Türkei). *N. Jb. Geol. Palaeoat. Abhandl., Bd. 131, Hft. 2.*

——— (1968b): Trilobiten aus dem Silur und Devon von Bithynien (NW-Türkei). *Palaeontogr. A., Bd. 130, Lfg. 1-6.*

——— (1969): Lower Devonian trilobites from Central Nevada and Northern Mexico. *Jour. Pal., Vol. 43, No. 3.*

——— and Mensink, H. (1970): Asteropyginae aus Afganistan (Trilobita). *Akad. Wiss. Lit. Mainz, Math.-Naturw. Kl. Abh., No. 6, (1969).*

Hahn, G. und R. (1967): Zur Phylogenie der Proetidae (Trilobita) des Karbons und Perms. *Zool. Beitr., N. F., Bd. 13, 2/3 Hft.*

Hall, J. and Clarke, J. M. (1888): Trilobites and other Crustacea of the Oriskany, Upper Heldeberg, Hamilton, Portage, Chumung, and Catskill Groups. *Palaeont. 7, Natural History of New York.*

Hamada, T. (1959a): Discovery of a Devonian ostracod in the Fukuji district, Gifu Prefecture, West Japan. *Japan. Jour. Geol. Geogr., Vol. 30, Nos. 2-4.*

——— (1959b): On the Taxonomic position of *Favosites hidensis* and its Devonian age. *Ibid., Vol. 30, Nos. 2-4.*

——— (1960a): Gotlandian-Devonian System in Korea and Northeastern China. *Jour. Geol. Soc. Japan., Vol. 65, No. 775.*

——— (1960b); The Middle Palaeozoic formations in China and Korea, I. Korea and Northeastern China. *Japan. Jour. Geol. Geogr. Vol. 31, Nos. 2-4.*

——— (1960c): Ditto. II. Northeast and South China. *Ibid., Vol. 31, Nos. 2-4.*

——— (1961); The Middle Palaeozoic Group of Japan and its bearing on her geological history. *Jour. Fac. Sci. Univ. Tokyo, sec. 2, Vol. 13, Pt. 1.*

——— (1963); The Silurian and Devonian. In Takai, F. et al. (ed.), *Geology of Japan.* Univ. Tokyo Press.

——— (1968): Devonian of East Asia. *Proc. Intern Symp. Dev. System, Calgary, 1967,* *Vol. 1.*

——— (1971a); Early Devonian brachiopods from the Lesser Khingan district of Northeast China. *Pal. Soc. Japan, Sp. Pap. 15.*

——— (1971b): Discovery of *Calceola* from the Fukuji Series, Gifu Prefecture, Japan. *Sci. Pap. Coll. General Education, Univ. Tokyo, Vol. 21.*

———, Igo, H., Kobayashi, T. and Koike, T. (1975): Older and Middle Palaeozoic formations and fossils of Thailand and Malaysia. *Geol. Pal. SE Asia, Vol. 15.*

Harbort, E. (1903): Ueber mitteldevonische Trilobiten-Arten im Iberger Kalk bei Grund im Harz. *Zeitschr. deutsch. geol. Gesellsch., Bd. 55.*

Harrington, H. J. (1950): Geologia del Paraguay oriental. *Universidad de Buenos Aires, Facultad de Ciencias Exactas, Fisicas y Naturales, Contr. Cientificas, Serie E: Geologia, Tomo 1.*

——— (1967): Devonian of South America. *Proc. Intern. Symp. Dev. Syst., Calgary, 1967, Vol. 1.*

——— and Leanza, A. F. (1957): Ordovician trilobites of Argentina. *Depart. Geol. Univ. Kansas, Sp. Publ. 1.*

Hawle, I. and Corda, A. J. C. (1847): Prodrom einer Monographie böhmischen Trilobiten. *Abhandl. königl. böhm. Ges. Wiss., (5), 5.*

Hayasaka, I. and Minato, M. (1954): A *Sinospirifer*-faunule from the Abukuma plateau, Northeast Japan in comparison with the so-called Upper Devonian brachiopod faunule of the Kitakami mountains. *Trans. Proc. Palaeont. Soc. Japan, N. S., No. 16.*

Hector, J. (1877): On a new trilobite (*Homalonotus expansus*). *Trans. Roy. Soc. N. Z. Wellington, Trans. & Proc. N. Z. Inst., Vol. 9.*

Heller, Th. (1926): Die Fauna des obersilurischen Orthocerenkalkes von Elbersreuth. *Geogn. Jh., 38 Jahrg.*

Henry, J.-L. (1970): Quelques Calymenacea (Trilobites) de l'Ordovicien de Bretagne. *Ann. de Paléont. Invert., Pt. 56, fasc. 1.*

Heron, A. M. (1936): General report of the Geological Survey of India for the year 1935. *Rec. Geol. Surv. India,. Vol. 71.*

Hessler, R. R. (1963): Lower Mississipian trilobites of the family Proetidae in the United States. Part 1. *Jour. Pal., Vol. 37, (3).*

Hill, D. (1956): Palaeozoic corals from New Zealand. Part 1, The Devonian corals of Reefteon, New Zealand. *N. Z. Geol. Surv., Pal. Bull. 25.*

——— (1967): Devonian of Eastern Australia. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1.*

Hintze, L. F. (1953): Lower Ordovician trilobites from Western Utah and Eastern Nevada. *Utah Geol. and Min. Surv. Bull., 48.*

Hirata, M. (1966): On the Upper Devonian Ohira Formation in the Outer Zone of Shikoku, Japan. *Chigaku-Kenkyu, Vol. 17, No. 4.*

Hollard, H. (1967): Le Dévonien du Maroc et du Sahara Nord-Occidental. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1.*

Holub, K. (1908): Beitrag sur Kenntnis der Bed $D_{d1\gamma}$ des mittelböhmischen Untersilurs. *České Akad. Rozpravy, Vol. 17, No. 10.*

Holzapfel, E. (1895): Das Obere Mitteldevon (Schichten mit *Stringocephalus burtoni* und *Maeneceras terebratum*) im Rheinischen Gebirge. *Abhandl. Preuss. Geol. Landesanst., N. F. 16.*

Horný, R. and Bastl, F. (1970): Type specimens of fossils in the National Museum Prag. *Vol. 1*, Trilobita.

——— and Chlupáč (1968): The recently proposed standard Siluro-Devonian (Budnanian-Lochkovian) boundary in the Barrandian (Czechoslovakia). *Intern. Geol. Congr. Rep. of XXIII session, Czechoslovakia, 1968, Proc. Sec. 9.*

Hou, Houng-fei (1959): Devonian brachiopods from Northeast China. *Acta Pal. Sinica, Vol. 7, No. 2.*

House, M. R. (1971): Devonian faunal distributions. In Midlemis, F. A., Ranson, P. F. and Newall, G. (ed.) *Faunal Provinces in Space and Time. Geological Journal, Special Issue, No. 4.*

HU, Chung-hung (1974): Ontogenies of a few Ordovician Trilobites from the Edinburg Formation of Virginia, U.S.A. *Bull. Geol. Surv. Taiwan, No. 24.*

HUCKRIEDE, R., KURSTEN, M. and VENZIAFF, H. (1962): Zur Geologie des Gebietes zwischen Kerman und Sagand (Iran). *Beihefte zum Geol. Jahrb., Hft. 51.*

HUPÉ, P. (1953, 55): Classification des trilobites. *Ann. Paléont., Vols. 39, 41.*

IGO, H. and KOIKE, T. (1973): Upper Silurian and Lower Devonian conodonts from the Langkawi Islands, Malaysia with note on conodont fauna of the Thung Song limestone, Southern Thailand and the Setul limestone, Perlis, Malaysia. *Geol. Pal. SE Asia, Vol. 13.*

IGO, H., KOIKE, T. and H. IGO (1975): On the base of the Devonian System in Japan. *Proc. Japan Acad., Vol. 51.*

ILINYCH, G.G., BALASHOVA, E.A. and MAXIMOVA, Z. (1968): Trilobita. B.P. MARKOVSKY ed. *New species of ancient plants and invertebrates, Vol. 2, No. 2.* Moscow.

ISHIOKA, K. and KAMEI, S. (1950): A Discovery of Gotlandian Formation in the upper part of Kuzuryu River, Fukui Prefecture (Preliminary Report). *Jour. Geol. Soc. Japan, Vol. 56.*

IVSHIN, N.K. (1962): Upper Cambrian trilobites of Kazakhstan, Part 2. *Acad. Sci. Kazakhstan SSR., Inst. Geol. Sci.*

JAEGER, H. (1967): Preliminary stratigraphical results from graptolite studies in the Upper Silurian and Lower Devonion of Southeastern Australia. *Jour. Geol. Soc. Austral., Vol. 14.*

————, NAKINBODEE, V., MAHAKAPONG, V., BRAUN, E.v., HESS, A., KOCH, K.E. and STEIN, V. (1968): Graptolites of the Lower Devonian from Thailand (Preliminary results). *N. Jb. Geol. Paläont., Mh. 1968, 12.*

————, STEIN, V. and WOLFART, R. (1969): Fauna (Graptoliten, Brachiopoden) der unterdevonischen Schwarzschiefer Nordthailands mit einem Beitrag von D. STOPPEL. *N. Jb. Geol. Paläont., Abh. 133.*

JAHNKE, H. (1969): *Phacops zinkeni* F.A. ROEMER, 1843-ein Beispiel für eine ontogenetische Entwicklung bei Phacopiden (Trilobiae, Unterdevon). *N. Jb. Geol. Paläont., Abh. 133, (3).*

JEGOROVA, L.L., HSIANG, L.W., LEE, S.C., NAN, J.S. and KUO, C.M. (1963): The Cambrian trilobite faunas of Kueichou and Western Hunan. *Bull. Geol. Inst. Geol. Surv., Sec. B. Strat. and Palaeont., Vol. 3, No. 1.*

JOHNSON, J.G. and BOUCOT, A.J. (1973): Devonian brachiopods. In HALLAM, A. (ed.) *Atlas of Palaeobiogeography.*

JOHNSTON, M.R. (1974): Geology of the Mount Arthur district, North-West Nelson. *N.Z. Jour. Geol. Geophys., Vol. 17, No. 1.*

JONES, C.R. (1968): Lower Paleozoic rocks of Malay peninsula. *Bull. Am. Ass. Petrol. Geol., Vol. 52, No. 7.*

———— (1973): The Silurian-Devonian graptolite faunas of the Malay peninsula. *Overseas Geol. & Min. Res., No. 44.*

KAMEI, T. (1952): The stratigraphy of the Paleozoic rocks of the Fukuji district, southern part of the Hida mountainland. *Jour Fac. Lib. Arts, Shinshu Univ., Vol. 2.*

———— (1955): Classification of the Fukuji formation (Silurian) on the basis of *Favosites* with description of some *Favosites. Ibid., Vol. 5.*

———— (1961): Notes on Japanese Middle Devonian. *Earth Sci., No. 56.*

———— (1962): On the Devonian formation in the Hida mountainland. *Geological Studies of the Hida Mountainland.*

———— et al. (1973): On the occurrence of *Rhizophyllum* (Rugosa) from the Devonian Fukuji formation, Central Japan. *Jour. Geol. Soc. Japan, Vol. 97.*

———— and IGO, H. (1955): On a discovery of *Cheirurus sternbergi* BOECK from the Gotlandian Fukuji Group. *Ibid., Vol. 61.*

KANUMA, M. (1958): Stratigraphical and palaeontological studies of the southern part of the Hida plateau and the northeastern part of Mino mountainland. *Jubilee Pub. in comm. Prof. H. FUJIMOTO.*

KAPLUN, L.I. (1967): Lower and Middle Devonian marine deposits of Central Kazakhstan. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 2.*

KATO, M. (1972): Devonian of Korea. *Jour. Geol. Soc. Japan, Vol. 78, No. 10.*

KEGEL, W. (1926): Unterdevon von böhmischer Fazies (Steinberger Kalk) in der Lindener Mark bei Giessen. *Abhandl. d. Preuss. geol. Landesanst., N.F. 100.*

——— (1972): Die obersilurische Trilobiten aus dem Harz und dem rheinischen Schiefergebirge. *Jahrb. d. Preuss. geol. Landesanst., Bd. 48.*

——— (1953): Contribuição nara o estudo do Devoniano da bacia do Parnaíba. *Div. Geol. Min. Bol. No. 141.* Rio de Janeiro.

KHALFINA, L.L. (1955): Atlas of important forms of the characteristic fauna and flora of West Siberia.

KIELAN, Z. (1954): Les trilobites mésodévoniens des Monts de Sainte-Croix. *Palaeont. Polonica, No. 6.*

KOBAYASHI, T. (1933): Cambrian faunas of South Chosen with a special study on the Cambrian trilobite genera and families. The Cambro-Ordovician formations and faunas of South Chosen, palaeontology, part 3. *Jour. Fac. Sci. Imp. Univ. Tokyo, sec. 2, Vol. 4, Pt. 2.*

——— (1937): The Cambro-Ordovician shelly faunas of South America. *Ibid., Vol. 4, Pt. 4.*

——— (1939): On the Agnostida. *Ibid., Vol. 5, Pt. 5.*

——— (1941-1942): Studies on Cambrian trilobite genera and families. *Japan. Jour. Geol. Geogr., Vol. 18, Nos. 1-4.*

——— (1942): The Akiyoshi orogenic cycle in the Mongolian geosyncline. *Proc. Imp. Acad., Vol. 18 (6).*

——— (1943): Brief notes on the eodiscids, 1-2. *Iibid., Vol. 19.*

——— (1944): On the eodiscids. *Jour. Fac. Sci. Imp. Univ. Tokyo, Sec. 2, Vol. 7, Pt. 1.*

——— (1951a): On the Ordovician trilobites in Central China. *Ibid., Sec. 2, Vol. 8, Pt. 1.*

——— (1951b): Geology around Hakusan volcano with special reference to the Tetori Series. Ishikawa Pref. Offic.

——— (1953): Geology of South Korea with special reference to the Limestone Plateau of Kogendo. The Cambro-Ordovician formation and the faunas of South Chosen, Pt. 4. *Jour. Fac. Sci. Univ. Tokyo, sec. 2, Vol. 8, Pt. 4.*

——— (1956): On the Kaolishaniinae. *Japan. Jour. Geol. Geogr., Vol. 27, No. 1.*

——— (1957): Notes on two Devonian trilobites from the Kitakami mountains in Japan. *Jour. Fac. Sci. Univ. Tokyo, sec. 2, Vol. 11, Pt. 1.*

——— (1958): A Gotlandian nautiloid from the Hida plateau in Japan. *Trans. Proc. Pal. Soc. Japan, N.S., No. 31.*

——— (1960a): Some Ordovician fossils from East Tonkin, Viet Nam. *Japan. Jour. Geol. Geogr., Vol. 31, No. 1.*

——— (1960b): Supplement to the Cambrian faunas of the Tsuibon zone with notes on some trilobites genera and families. The Cambro-Ordovician formations and faunas of South Korea, Pt. VII, Palaeont. VI. *Jour. Fac. Sci. Univ. Tokyo, Sec. 2, Vol. 12, Pt. 2.*

——— (1961): Cambrian Faunas of the Mun'gyong (Bunkei) district and the Samposan formation of the Yoengweol (Neiestsu) district. The Cambro-Ordovician formations and faunas of South Korea, Pt. 7, Pal. 8. *Ibid., Vol. 13, Pt. 2.*

——— (1962): The Machari fauna. The Cambro-Ordovician formations and faunas of South Korea, Pt. 9, Pal. 8. *Ibid., Vol. 14, Pt. 1.*

——— (1967): The Cambrian of Eastern Asia and other parts of the continent. *Ibid., Vol. 16, Pt. 3.*

——— (1969): The Ordovician of Eastern Asia and other parts of the continent. *Ibid., Vol. 17, Pt. 2.*

——— (1971a): The Cambro-Ordovician faunal provinces and the interprovincial correlation. *Ibid., Vol. 18, No. 1.*

——— (1971b): Eurasiatic faunal connection in the Ordovician Period. Colloque Ordovicien-Silurien. *Mém. du B.R.G.M., No. 73, 1971.*

——— (1971c): The Manmo Group of the Mongolian geosyncline in Manchuria and adjacent areas. *Geology and Mineral Resources of the Far East, Vol. 3.* Univ. of Tokyo Press.

——— (1972): Three faunal provinces in the early Cambrian Period. *Proc. Japan Acad., Vol. 48, No. 4.*

——— (1973a): The Early and Middle Palaeozoic history of the Burmese-Malayan geosyncline. *Geol. Pal. SE. Asia, Vol. 11.*

——— (1973b): The early stage of the Burmese-Malayan geosyncline. *Geol. Soc. Malaysia, Bull. 6.*

——— and BURTON, C.K. (1971): Discovery of ellesmereoceroid cephalopods in West Irian, New Guinea. *Proc. Japan. Acad., Vol. 47, No. 7.*

——— and HAMADA, T. (1965): An occurrence of a new *Scutellum* in the Silurian of Shikoku Island. *Trans. Proc. Pal. Soc. Japan, N.S., No. 58.*

——— and ——— (1966): A Devonian proetoid from Malaysia (Malaya). *Japan. Jour. Geol. Geogr., Vol. 37, Nos. 2-4, Pt. 2.*

——— and ——— (1968): A Devonian phacopid recently discovered by Mr. Charan POOTHAI in Peninsular Thailand. *Geol. Pal. SE. Asia, Vol. 4.*

——— and ——— (1971): Agnostoid trilobites in a Devonian formation in West Malaysia. *Proc. Japan Acad., Vol. 47, No. 4.*

——— and ——— (1972): A unique trilobite assemblage of the Devonian Kroh fauna in West Malaysia, with notes on the Tentaculites facies and the Older Palaeozoic faunal sequence in Thailand Malaya. *Geol. Pal. SE. Asia., Vol. 10.*

——— and ——— (1973a): Cyrtosymbolids (Trilobita) from the Langgon red beds in Northwest Malaya, Malaysia. *Ibid., Vol. 12.*

——— and ——— (1973b): Brief note on Silurian trilobites from Mt. Yokokura, Shikoku Island. *Proc. Japan. Acad., Vol. 49, No. 7.*

——— and ——— (1974a): Silurian trilobites of Japan in comparison with Asian, Pacific and other faunas. *Pal. Soc. Japan, Sp. Pap., No. 18.*

——— and ——— (1974b): On the time-relation between the graptolite zones and *Dalmanitina* beds near the Ordovician-Silurian boundary in Eurasia. *Proc. Japan. Acad., Vol. 50. No. 7.*

——— and ——— (1974c): On the geological age of the Fukuji formation in the Hida plateau. *Ibid., Vol. 50, No. 9.*

——— and ——— (1975): Devonian trilobite provinces. *Ibid., Vol. 51, No. 6.*

——— and IGO, H. (1956): On the occurrence of *Cratalocephalus*, Devonian trilobites, in Hida, West Japan. *Japan. Jour. Geol. Geogr., Vol. 27.*

——— and KATO, F. (1951): On the ontogeny and the ventral morphology of *Redlichia chinensis* with description of *Alutella nakamurai*, new gen. and sp. *Jour. Fac. Sci., Univ. Tokyo, sec. 2, Vol. 8, Pt. 3.*

——— and NONAKA, J. (1942): On the Manmo Group. *Jour. Geogr. Tokyo, Vol. 54, No. 643.*

KOCH, K.K. (1973): Geology of the Region Sri-Sawat-Thong Pha Phum-Sangkhaburi (Kanchanaburi Province-Thailand). *Geol. Soc. Malaysia, Bull. 6.*

KOIZUMI, H. and KAKEGAWA, S. (1970): New occurrence of Devonian trilobites from Fukuji, Gifu Prefecture, Central Japan. *Earth Science, Vol. 24, No. 5.*

KONDIAIN, A.G., KONDIAIN, O.A., KULIKOVA, V.F. and TYAZHEVA, A.P. (1967): Devonian of the western slope of the Urals. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1.*

KONINCK, L.G. de (1876): Recherches sur les fossiles paléozoiques de la Nouvelle-Galles du Sud Australie. *Mém. Soc. Sci. Liège, 2me sér., Vol. 6.* English translation by T.W.E. DAVID, et al. *Mem. Geol. Surv. N.S.W., Palaeont. Vol. 6*, 1876.

KOZLOWSKI, R. (1923): Faune dévonnienne de Bolivie. *Ann. Paléont., V. 12.*

KOZU, S. (1911): On the geology of the volcano Norikura. *Rep. Imp. Earthquake Invest. Comm., No. 71.*

KRYLOVA, A.K., MALITCH, N.S., MENNER, V.V., OBRUTCHEV, D.V. and FRADKIN, G.S. (1967): Devonian of the Siberian platform. *Proc. Intern. Symp. Dev. Syst., Calgary, 1967, Vol. 1.*

KRYSKOV, L.N., LAZARENKO, N.P., OGIENKO, L.V. and TSCHERNYSHEVA, N.E. (1960): New early Palaeozoic trilobites of East Siberia and Kazakhstan. *New species of prehistoric plants and invertebrates of the U.S.S.R., Pt. 2. VSEGEI, Moscow.*

KUO, Hong-tsun (1962): Some Silurian trilobites from the Ertaogou Group of Jilin. *Acta Pal. Sinica, Vol. 10, No. 3.*

LAKE, P. (1896): The British Silurian species of *Acidaspis*. *Quart. Jour. Geol. Soc. London,* *Vol. 52.*

——— (1906) : Trilobites from Bolivia. *Quart. Jour. Geol. Soc. London, Vol. 62.*

LANES, F.D. (1971) : British Cheiruridae (Trilobita). Palaeotogr. Soc.

LAPPARENT, A.F. de and PILLET, J. (1969) : Description de Trilobites ordoviciens, siluriens et dévoniens d'Afghanistan. *Ann. Soc. géol. Nord, Pt. 89.*

LAZARENKO, N.P. (1960) : Some new Upper Cambrian trilobites from Northwest Siberian platform. *Short Pap. Palaeont. and Biostrat., Vol. 20.*

LEGRAND, Ph. (1967) : Le Dévonien du Sahara Algerien. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1.*

LERMONTOVA, E.V. (1940) : Trilobita in VOLOGDINE's Atlas of leading forms of fossil faunas of the U.S.S.R., Vol. 1, Cambrian.

LESPÉRANCE, P.J. (1968) : Ordovician and Silurian trilobite faunas of the White Head formation, Percé region, Quebec. *Jour. Pal., Vol. 42, No. 3.*

——— (1975) : Stratigraphy and paleontology of the Synphoriidae (Lower and Middle Devonian dalmaniticean trilobites). *Ibid., Vol. 49, No. 1.*

——— and BOURQUA, P.-A. (1973) : The Synphoriinae and evolutionary pattern of Lower and Middle Devonian trilobites-Corrigendia. *Ibid., Vol. 47, No. 2.*

LINK, A.G. (1970) : Age and correlation of the Siluro-Devonian strata in the Yass basin, New South Wales. *Jour. Geol. Soc. Austral., Vol. 16.*

LU, Yen-ho (1957) : Trilobita. *Index fossils of China, Invertebrates, Vol. 3.*

———, CHANG, Wen-tang, CHU, Chao-ling, CHIEN, Yi-yuan and HSIANG, Lee-wen (1956) : Trilobites of China, 2 vols. *Each group of fossils of China.*

——— et al. (1974) : Bio-environmental control hyposhesis and its application to the Cambrian biostratigraphy and palaeozoogeography. *Mem. Nanking Inst. Geol. Palaeont., No. 5.*

LÜTKE, F. (1965) : Zur Kenntnis hercynischer Trilobiten aus dem Unter- und Mitteldevon des Harzes. *Palaeontogr., Bd. 124. Abt A.*

MAXIMOVA, Z.A. (1955a) : Trilobita. In O.I. NIKIFOROVA's Field atlas of the Ordovician and Silurian faunas of the Siberian platform.

——— (1955b) : Trilobites of the Middle and Upper Devonian of the Urals and northern Mudodzhar. *Trudi, VSEGEI, Moscow, (ns) 3.*

——— (1960a) : New Middle Paleozoic trilobites of Central Kazakhstan, Ruddy Altai and Arctics. *New species of prehistoric plants and invertebrates of the U.S.S.R., Pt. 2, VSEGEI. Moscow.*

——— (1960b) : Devonian and Carboniferous trilobites from the Rudi Altai. *Palaeontological basis of stratigraphy of the Paleozoic of the Rudi-Altai, Vol. 7.*

——— (1962) : Trilobites from the Ordovician and Silurian of the Siberian platform. *Trudi, VSEGEI. n.s., tom. 76.*

——— (1965) : New Devonian trilobites from North Viet-Nam. *Ann. All Soviet Union, N.S., tom. 165.*

——— (1967) : Late Silurian and early Devonian trilobites of Central Kazakhstan. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 2.*

——— (1968a) : Middle Palaeozoic trilobites from Central Kazakhstan. *Trudi, VSEGEI, N.S., tom. 165.*

——— (1968b) : Devonian scutelloids of Arctic Soviet and some problems on phylogeny of Family Scutelluidae. *Ann. Rep. VSEGEI, Palaeont. Dep., Tom. 18.*

——— (1969) : Trilobita in MODZALEVSKAYA's Field atlas of Silurian Devonian and Lower Carboniferous faunas of the Far East.

——— (1971) : The importance of trilobites for Silurian of the solution of the problem of the Silurian-Devonian boundary in Kazakhstan. The Silurian-Devonian boundary and the Silurian stratigraphy. *Proc. 3rd Intern. Symp. Leningrad, 1968, Vol. 1, VSEGEI.*

——— (1972) : New Devonian trilobites of the superfamily Phacopoidea. *Paleont. Zh., 1972, No. 1.*

——— (1974a) : Devonian trilobites from Mongolian Altai. *Trudi, VSEGEI, N.S., tom. 182.*

——— (1974b) : Important discovery of Devonian trilobites in Mongolian Altai and new data on complicate phacopids. *Ibid.*, *tom. 182.*

——— and ORGANOVA, N.M. (1959): The first discovery of remains of a Devonian fauna in Western Primoria. *Doklady*, *Vol. 128*, *No. 3.*

MAITRE, D. le et PILLET, J. (1964): Première découverte de Trilobite: *Scabriscutellum* sp. dans le calcaire de Chalonnes (Bassin d'Ancenis). *Ann. de la Soc. géol. di Nord*, *Pt. 84.*

MANSUY, H. (1908): Contribution à la carte géologique de l'Indochine. Paléontologie.

——— (1916a): Faunes paléozöiques du Tonkin septentrional. *Mém. Serv. géol. de l'Indochine*, *Vol. 5*, *fascl 4.*

——— (1916b): Etude complémentaire des faunes paléozoiques et triasisques dans l'est du Tonkin (Feuilles de Thât-khé, Pho-binh-gia, Lang-son). *Ibid.*, *Vol. 5*, *fasc. 4.*

——— (1918): Description de quelques fossiles paléozoïques de la région de Pho-binh-gia et de Thai-nyuyen, Tonkin. *Ibid.*, *Vol. 5*, *fasc. 11.*

——— (1920): Nouvelle Contribution à l'étude des faunes paléozoïques et mésozoïques de l'Annam septentrional, région de Thanh-hoa. *Ibid.*, *Vol. 7*, *fasc. 1.*

——— (1921): Description de fossiles des Terraines paléozoiques et mésozoiques du Tonkin septentrional (feuilles de Cao-bang, de Ha-Lang, de Thât-khe et de Lang-Song. *Ibid.*, *Vol. 8*, *fasc. 1.*

MARKOV, F.G., CHERKESOVA, S.V. and GRAMBERG, I.S. (1967): Devonian of the Soviet Arctic. *Proc. Intern. Symp. Dev. System*, *Calgary. 1967*, *Vol. 1.*

McKALLER, R.C. (1969): Brachiopods and trilobites from Silurian-Devonian strata in the Rockhaupton district, Queensland. *Queensland Geol. Surv.·Publ.*, *No. 337.* (*Pal. Pap.*, *No. 11*).

McLAREN, D.J. (1961): The role of fossils in defining rock units with examples from the Devonian of Western and Arctic Canada. *Am. Jonr. Sci.*, *257*, *10*, *1959.*

McLEARN, F.H. (1924): Palaeontology of the Silurian rocks of Arisaig, Nova Scotia. *Canada Geol. Surv.*, *Mem. 137.*

MERRIAM, C.W. (1940): Devonian stratigraphy and paleontology of the Robert Mountains region, Nevada. *Geol. Soc. Am.*, *Spec. Pap. 25.*

MINATO, M. (1956): Palaeogeography of the Japanese Islands and their adjacent lands in the Upper Paleozoic Era. *Earth Sci.*, *Vol. 28.*

——— (1959): Ueber das Devon des fernen Ostens. *2 Arbeitstagung über die Silur/Devon Grenze u. die Statigraphite des Unteren u. Mittel Devon.* Bonn.

MITCHELL, J. (1887): On some new trilobites from Bowning, N.S.W. *Proc. Linn. Soc. NSW.*, *Vol. 2*, *Pt. 3.*

——— (1919a): Some additional trilobites from New South Wales. *Ibid.*, *Vol. 44.*

——— (1919b): On two new trilobites from Bowning. *Ibid.*, *Vol. 44*, *Pt. 2.*

——— (1924): New trilobites from Bowning with notes on *Encrinurus* and *Cordania gardneri.* *Ibid.*, *Vol. 49.*

MODZALEVSKAYA, E.A. (1965): Mongolo-Ochotsk geosynclinal belt. In O.I. NIKIFOROVA and A.M. OBUT's *Silurian System.*

——— (1967): Biostratigraphical subdivision of the Devonian in the Far East and Transbaikal region, U.S.S.R. *Proc. Intern. Symp. Dev. System*, *Calgary*, *1967*, *Vol. 2.*

——— (1969): Field atlas of the Silurian, Devonian and Lower Carboniferous faunas of the Far East.

MONKE, H. (1903): Beiträge zur Geologie von Schantung, 1. Obercambrische Trilobiten von Yen-tsy-yai. *Jahrb. königl. preuss. geol. Landsanst. für 1902.*, *Bd. 23*, *Hft. 1.*

MOORE, R.C. (ed. 1956): Coelenterata. *Treatise on Invertebrate Paleontology*, *Part F.*

——— (ed. 1965): Brachiopoda. *Ibid.*, *Part H.* 2 vols.

MORZADEC, P. (1967): Le Dévonien de la Rive Nord de la Riviere du Fou Faou (Finistère). *Thèse*, *Fac. des Sci. Univ. de Rennes.*

——— (1969a): Révision de *Phacops* (*Phacops*) *portieri* BAYLE 1878 (Trilobites). *Bull. Soc. géol. de France*, *7e sér.*, *Pt. 11.*

——— (1969b): *Ceratarges faouensis* nov. sp. nouveau-Trilobite mésodévonien du Finistère. *C.R. Soc. géol. France*, *fasc. 7.*

——— (1971): Quelques Asterophyginae (Trilobites, Phacopacea) des Schistes et calcaires à

Athyris undata (Dévonien inférieur) du Massif armorican. *Palaeontogr., Abt. A, Vol. 138, No. 5-6.*

Mu, A.T. (1955): A Devonian blastoid from Kirin. *Acta Pal. Sinica, Vol. 3, No. 2.*

——— (1964): The Silurian System of China. *Sci. Rep. Stratigr. Conf. China.*

Mu, An-tze et al. (1973): Stratigraphy of the Mount Jolmo Lungma Region in Southern Tibet, China. *Scientia Sinica, Vol. 16, No. 1.*

Müller, K.J. (1968): Malaya and Burma. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1.*

Murata, M. and Mori, K. (1973): Discovery of *Schedohalysites* from the Ōno formation. *Jour. Geol. Soc. Japan, Vol. 79.*

———, Kanisawa, S., Ueda, Y. and Takeda, N. (1974): Base of the Silurian System and the pre-Silurian granites in the Kitakami massif, Northeast Japan. *Ibid., Vol. 80, No. 10.*

———, ——— and Okami, K. (1975): Stratigraphical evidences for the Pre-Silurian age of the granites in the Kitakami massif, Northeast Japan. *Proc. Japan. Acad., Vol. 51, No. 7.*

Nalivikin, D.V. (1973): The Devonian System, 2 vols. *Stratigraphy of U.S.S.R.*

Nanking Institute of Geology and Palaeontology, Academia Sinica (1974): Hand-book of stratigraphy and palaeontology of Southwest China.

Nikiforova, O.I. (Ed.) (1955): Field atlas of the Ordovician and Silurian faunas of the Siberian platform.

———, Predtechensky, N.N. and Abushik, A.F. (1967): The importance of the Silurian section of Podolia for defining the Siluro-Devonian boundary in Europe. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 2.*

Nikolaev, A.A. and Rzhonsnitskaya, M.A. (1967): Devonian of Northeastern U.S.S.R. *Ibid., Vol. 1.*

Noda, M. (1934): Geology of the environs of Nagasaka, Kitakami mountainland. *Jour. Geol. Soc. Tokyo, Vol. 41, No. 490.*

Nomura, M. (1964): Miscellaneous notes on new localities of minerals and fossils in the southern part of Gifu Prefecture and Aichi Prefecture. *Chigaku-kenkyu, Vol. 15, No. 19.*

Nonaka, J. (1944): A preliminary report on the Devonian brachiopods from North Manchuria. *Japan. Jour. Geol. Geogr., Vol. 18.*

——— (1946): Devonian formation near the Kinsui Station, Northern Manchuria. *Ibid., Vol. 52.*

Norris, A.W. (1964): Brachiopods and other fossils of the Devonian Horn Plateau formation. *Bull. Geol. Surv. Canada, 114.*

Novák, O. (1883): Zur Kenntnis der böhmischen Trilobiten. *Beitr. Palaeont. Geol. Oest.-Ung., Bd. 3.*

——— (1890): Vergleichende Studien einigen Trilobiten aus dem Hercyn von Bicken, Wildungen, Greifenstein und Böhmen. *Paläont., N.F. 1(5), Hft. 3.*

Oehlert, M.D. (1886): Étude sur quelques trilobites du groupe de Proetidae. *Bull. Soc. d'Etudes Sci. d'Angers (annèe 1885).*

Okazaki, Y. (1974): Devonian trilobites from the Fukuji formation in the Hida massif, Central Japan. *Mem. Fac. Sci. Kyoto Univ., Ser. Geol. & Min., Vol. 11, No. 2.*

———, Tanaka, K. and Tanaka, Y. (1974): A discovery of the Devonian trilobites from Fukui Prefecture. *Jour. Geol. Soc. Japan., Vol. 80, No. 11.*

Okubo, M. (1950): On the Gotlandian and Devonian deposits of Hikoroichi, Kesen-District, Iwate Prefecture. *Jour. Geol. Soc. Japan, Vol. 56, No. 657.*

——— (1951a): Zur Hikoroichi-Serie und der bedeutenden Diskordanz von der Hikoroichi-Epoche. *Ibid., Vol. 57.*

——— (1951b): Trilobites from Japan. *Chikyu-Kagaku, No. 4.*

——— (1956): Some Devonian brachiopods and trilobites of the Southern Kitakami mountainland. *Japan. Jour. Geol. Geogr., Vol. 27.*

Onuki, Y. (1937): Discovery of a Gotlandian formation and Palaeozoic stratigraphy of Kesen district, Iwate Prefecture, Kitakami mountains. *Jour. Geol. Soc. Japan, Vol. 45, No. 525.*

——— (1969) : Geology of the Kitakami massif, Northeast Japan. *Tohoku Univ. Inst Geol. Pal., Contr. No. 69.*

ORMISTON, A.R. (1967) : Lower and Middle Devonian trilobites of the Canadian Arctic Islands. *Geol. Surv. Canada, Bull. 153.*

——— (1968) : Lower Devonian trilobites of Hercynian type from the Turkey Creek Inlier, Marshall County, South-Central Oklahama. *Jour. Pal., Vol. 42, No. 5.*

——— (1969) : The trilobite *Koneprusia* in the Lower Devonian of Alaska. *Ibid., Vol. 43, No. 5.*

——— (1972) : Lower and Middle Devonian trilobite zoogeography in northern North America, *24th Int. Geol. Congr. Montreal, Sec. 7.*

——— (1975) : *Humeia*, new Middle Devonian trilobite from Western Canada. *Jour. Pal., Vol. 49, No. 3.*

OSMOLSKA, H. (1957) : Trilobites from the Couvinian of Wydryszów (Holy Cross Mts., Poland). *Acta Pal. Polonica, Vol. 2, No. 1.*

——— (1958) : Famennian Phacopidae from the Holy Cross Mountains (Poland). *Ibid., Vol. 3, No. 2.*

——— (1962) : Famennian and Lower Carboniferous Cyrtosymbolinae (Trilobita) from the Holy Cross mountains, Poland. *Ibid., Vol. 7, Nos. 1-2.*

——— (1963) : On some Famennian Phacopinae (Trilobita) from the Holy Cross mountains (Poland). *Ibid., Vol. 8, No. 4.*

——— (1967) : Some Otarionidae (Trilobita) from the Lower Carboniferous of Europe. *Ibid., Vol. 12, No. 2.*

——— (1970) : Revision of non-cyrtosymbolinid trilobites from the Tournaisian-Namurian of Eurasia. *Pal. Polonica, No. 23.*

——— (1973) : Tournaisian trilobites from Dalnia in the Holy Cross mts. *Acta Geol. Polonica, Vol. 23, No. 1.*

OSWALD, D.H. (ed. 1967) : Proceedings of the International Symposium on the Devonian System, Calgary, 1967, *Vols. 1-2.*

OWENS, R.M. (1970) : The Middle Ordovician of the Oslo region, Norway, 23. The trilobite family Proetidae. *Norsk Geol. Tidss., Vol. 50, No. 4.*

——— (1973a) : Ordovician Proetidae (Trilobita) from Scandinavia. *Ibid., Vol. 53, No. 2.*

——— (1973b) : British Ordovician and Silurian Proetidae (Trilobita). Palaeotogr. Soc.

——— (1974) : The affinities of the trilobite genus *Scharyia* with a description of two new species. *Palaeont., Vol. 17, Pt. 2.*

OZAKI, K. (1957) : A Study on *Oborophyllum oborensis* OZAKI from Obora-dani. *Jour. Sci. Earthsci. & Amateurs, Japan, Vol. 9, No. 3.*

PACKHAM, G.H. (ed. 1969) : The Geology of New South Wales. *Jour. Geol. Soc. Austr., Vol. 16.*

PADULA, E.L., ROLLERI, E.O., MINGRAMM, A.R.G., ROQUE, P.C., FLORES, M.A. and BALDIS, B.A. (1969) : Devonian of Argentina. *Proc. Intern. Symp. Dev. System. Calgary, 1967, Vol. 2.*

PAECKELMANN, W. (1925) : Beiträge zum Kenntnis des Devons aus Bosporus, insbesondere in Bithynien. *Abh. Preuss. Geol. L.-A., N.F. 98.*

PASCOE, E.H. (1959) : A manual of the geology of India and Burma, *Vol. 2.* Govt. of India Publ.

PATRULIUS, D., JORDAN, M. and MIRAUTA, E. (1967) : Devonian of Romania. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1.*

PATTE, E. (1926) : Etudes paléontologiques relative à la géologie de l'est du Tonkin. *Bull. Serv. géol. de l'Indochsne, Vol. 15, fasc. 1.*

——— (1929) : Description de fossiles paléozoïques et mésozoïques recuillis par MM. DUSSAULT et FROMAGET en Extrême-Orient. *Ibid., Vol. 18, fasc. 1.*

PEDDER, A.E.H. (1967) : Devonian rocks of the Murrumbridges river area, New South Wales, Australia. *Proc. Intern. Symp. Dev. System, Calgary, 1976, Vol. 2.*

PHILIP, G.M. (1962a) : The palaeontology and stratigraphy of the Silurian-Devonian sediments of the Tyers area, Gippsland, Victoria. *Proc. Roy. Soc. Vict., Vol. 75.*

——— (1962b) : The problems of Siluro-Devonian correlations in South-Eastern Australia. *2 Intern. Arbeitstagung über Silur/Devon-Grenze und die Stratigraphie von Silur und Devon. Bonn-Bruxelles, 1960, Symposiums-Band.*

——— (1967) : Late Silurian-early Devonian relationships in the central Victorian and western Tasmanian clastic sequences, Australia. *Proc. Intern. Symp. Dev. System. Calgary, 1967, Vol. 2.*

——— (1971) : The Silurian-Devonian boundary in Australia. *Proc. Intern. Union Geŏl. Sci. Geol. Newslett., Vol. 1971, No. 1.*

PHLEGER, F. (1936) : Lichadian trilobites. *Jour. Pal., Vol. 10.*

——— (1937a) : Further notes on the Lichadacea. *Ibid., Vol. 11.*

——— (1937b) : New Lichadacea in the collections of the Museum of Practical Zoology. *Bull. Mus. Comp. Zool., Vol. 80.*

——— (1937c) : Species and geographic distribution of the Lichadacea. *Am. Mid. Nat., Vol. 18.*

PILLET, J. (1962) : Contribution à l'étude des Homalonotidae (Trilobites) des Grès à *Dalmanella mounieri* (Siegénien inférieur) du massif armoricain. *Bull. Soc. géol. France, Sér. 7, Vol. 3, No. 5,* (1961).

——— (1964) : *Astycoryphe* R. et E. RICHTER, 1919 et *Ungloproetus* ERBEN, 1951 (Proetidae, Trilobites) dans l'Eodévonien supérieur du Massif Armoricain. *Ibid., Vol. 6.*

——— (1965) : Le genre *Crotalocepoalus* dans le massif Armoricain. *Bull. de la Soc. géol. et Minerl. de Bretagne, 1962-63, Nouv. Sér.*

——— (1968) : Les *Calymene* dévoniens d'Europe et d'Afrique du Nord. *Ann. de Pal., t. 54, fasc. 1.*

——— (1969a) : La Classification des Proetidae (Trilobites). *Bull. Soc. d'études scient. de l'Anjou, t. 7.*

——— (1969b) : Révision de *Proetus* (*Proetus*) *oehlerti* BAYLE, 1878 (Proetidae, Trilobita). *Bull. Soc. géol. France, 7e Sér, Pt. 11.*

——— (1969c) : Un nouveau genre de Trilobite dévonien en Afghanistan (*Neocalmonia* nov. gen., Calmoniinae, Trilobite). *C. R. Soc. géol. France, fasc 5.*

——— (1972) : Les Trilobites du Dévonien inférieur et du Dévonien moyen du Sud-Est du Massif armoricain. *Soc. d'études Scient. de l'Anjou, Mém. No. 1.*

——— et LAPPARENT, A. F. de (1969) : Description de Trilobites ordoviciens, siluriens et dévoniens d'Afghanistan. *Ann. Soc. géol. du Nord, Pt. 89.*

POLETAYEVA, O. K., TCHERNYSHEVA, N. E. et al. (1956) : Trilobita. In new families and genera of Invertebrata. *Materials of Palaeontology, All Soviet Union Sci. Res. Geol. Inst. (Moscow), N. S., tom. 12.*

POMPECKJ, J. F. (1890) : Die Trilobiten-Fauna der Ost- und Westpreussiachen Diluvialgeschiebe. *Beitr. zur Naturkunde Preussens, 7.*

——— (1898) : Ueber *Calymene* BRONGNIART. *N. Jb., für Mim. usw. Jhrg. 1898, Bd. 1.*

PRANTL, F. (1946) : Some Abnormalities in *Crotalocephalus* SALTER (Trilobitae). *Bull. Intern. Acad. techo. Sci. Boheme, XLVIII An. No. 1.*

——— and PŘIBYL, A. (1948) : Classification of some Bohemian Cheiruridae (Trilobitae). *Acta Mus. Nat. Prague, Vol. 3, B, No. 1.*

——— and ——— (1949) : A study of the superfamily Odontopleuracea nov. superfam. (Trilobites). *Rozpravy Stràt. Geol. ùst. CSV., Sv. 12.*

PŘIBYL, A. (1946) : Notes on the recognition of the Bohemian Proetidae (Trilobitae). *Bull. Intern. l'Akad. tehéque des Sci. 1945, 46, Ann. No. 10.*

——— (1946) : Two new Otarionidae from the Devonian of Bohemia. *Vest. Kràlov. české spol. nauk-Třida matem. přorod-Roč. 1946.*

——— (1964) : O několika nových trilobitivých rodech z českéjo siluru a devonu *Přiroda, Vol. 38, Nos. 5-6.*

——— (1964) : Neue Trilobiten (Proetidae) aus dem böhmischen Devon. *Rev. Bulg. geol. Soc., 25-1, 1964.* (not seen).

——— (1969) : Revision on the Devonian representatives of species of *C.* (*Cornuproetus*) *complanatus* (BARR.) and *C.* (*C,*) *buchi* (H. & C), Trilobita. *Nàr. Muz. (Prague), Cas*

Oddil Prirodoved, Vol. 137.

——— (1971) : Proetid trilobites from the new collection in the Silurian and Devonian of Bohemia. Part 3. *Ibid., Vol. 140, No. 1-2.*

——— und ERBEN, H.K. (1952) : Ueber einige neue oder wenig bekannte Acanthopyginae (Tril.) des böhmischen und des deutschen Devons. *Palaeontol. Zeitschr., Bd. 26.*

——— and VANĚK, J. (1962) : Die Trilobiten Fauna aus dem böhmischen Obersilur (Budnanium und Lochkovium) und ihre Biostratigraphische Bedeutung. *Acta Mus. Nat. Prague, Vol. 18, B, No. 2.*

——— and ——— (1964) : Einige Bemerkungen zur Klassification der Gattung *Cheirurus* BEYRICH, 1845 (Trilobita). *Časopis Nàrodního Muzea-Oddíl Přirodovědný, Ročník 83, Cerven, 1964, Číslo 2.*

——— and ——— (1966) : Zur Kenntnis der Odontopleuridae-Trilobiten aus dem böhmischen Altpalpäozoikum. *Acta Univ. Carolinae, Geol., No. 4.*

——— and ——— (1970) : Phacopina STRUVE, 1959 (Trilobita) im böhmischen Silur und Devon. *Ibid., Geol. No. 1.*

——— and ——— (1971) : Studien über die Familie Scutelluidae RICHTER et RICHTER (Trilobita) und ihre phylogenetische Entwicklung. *Ibid., Geol. No. 4.*

——— and ——— (1973) : Ueber Hypostome von Odontopleuriden (Trilobita) und ihre Systematik. *Casopis pro min. a geol. roč. 18, č 3.*

RASETTI, F. (1944) : Upper Cambrian trilobites from Lévis conglomerate. *Jour. Pal., Vol. 18, No. 3.*

——— (1952) : Revision of the North American trilobites of the Family Eodiscidae. *Jour. Pal., Vol. 26, No. 3.*

———(1966a) : Revision of the North American species of the Cambrian trilobite genus *Pagetia. Ibid., Vol. 40, No. 3.*

——— (1966b) : New Lower Cambrian trilobite faunule from the Taconic sequence of New York. *Smithsonian Misc. Coll., Vol. 148, No. 9.*

——— (1967) : Lower and Middle Cambrian trilobite faunas from the Taconic sequence of New York. *Ibid., Vol. 152, No. 4.*

——— and THEOKRITOFF, G. (1967) : Lower Cambrian agnostid trilobites of North America. *Jour. Pal., Vol. 41, No. 1.*

RAYMOND, P.E. (1916a) : The genera of the Odontopleuridae. *Ottawa Natur., Vol. 29.*

——— (1916b) : New and old Silurian trilobites from Southeastern Wisconsin, with notes on the genera of the Illaenidae. *Bull. Mus. Comp. Zool. (Harvard), Vol. 60.*

Research Group for the Palaeozoic of Fukuji (1973) : On the occurrence of *Rhizophyllum* (Rugosa) from the Devonian Fukuji formation, Central Japan. *Jour. Geol. Soc. Japan, Vol. 79, No. 6.*

REED, F.R.C. (1902) : Notes on the genus *Lichas. Q.J.G.S. London, Vol. 58.*

——— (1905) : Sedgwick Museum Notes. New fossils from the Haverfodwest district. No. 3. *Geol. Mag., Dec. 5, Vol. 2.*

——— (1906) : The Lower Palaeozoic fossils of the Northern Shan States, *Pal. Ind., N.S., Vol. 2, Mem. No. 3.*

——— (1908) : The Devonian faunas of the Northern Shan States. *Ibid., No. 5.*

——— (1911) : Devonian fossils from Chitral, Persia, Afghanistan and the Himalayas. *Rec. Geol. Surv. India, Vol. 41.*

——— (1912) : Ordovician and Silurian Fossils from the Central Himalayas. *Pal. Indica, Ser. 15, Vol. 7, Mem. No. 2.*

——— (1915) : Supplementary memoire on new Ordovician and Silurian fossils from the Northern Shan States. *Ibid., N.S., Vol. 6, Mem. No. 1.*

——— (1922) : Devonian fossils from Chitral and the Pamirs. *Ibid., Vol. 6, No. 2.*

——— (1923) : The subgenera of *Lichas. Geol. Mag., 60.*

——— (1925) : The classification of the Acidaspidae. *Ibid., Vol. 62, (no. 735).*

——— (1926) : Revision of the fauna of the Bokkeveld beds. *Ann. S. African Mus., Vol. 22, 1925.*

——— (1927) : Palaeozoic and Mesozoic fossils from Yunnan. *Mem. Geol. Surv. India,* *Palaeontol. Indica, N.S., Vol. 10, Mem. No. 1.*

——— (1928): Notes on the Bronteidae (i.e. Goldiidae). *Ann. Mag. Nat. Hist. Ser., 10, Vol. 1.*

——— (1929): Note on a specimen of *Homalonotus (Burmeisteria) herscheli* (MURCHISON). *Ann. Natal Mus., Vol. 6, Pt. 2.*

——— (1930): New Devonian fossils from Burma. *Rec. Geol. Surv. India, Vol. 62, Pt. 2.*

——— (1931): Notes on a specimen of *Homalonotus (Digonus) noticus* CLARKE var. *africana* REED. *Ann. Natal Mus., Vol. 6, Pt. 3.*

——— (1936): The Lower Palaeozoic Faunas of the Southern Shan States. *Palaeont. Ind., N.S., Vol. 21, Mem. No. 2.*

RICHTER, R. (1913): Beiträge zur Kenntnis devonischer Trilobiten, I. Die Gattung *Dechenella* und einige verwandete Formen. *Abhandl. Senckenberg. Naturforsch. Gesell., 31.*

RICHTER, R. und E. (1917a): Die Lichadiden des Eifer Devons. *N. Jb. für Min. usw., Jahrg. 1917.*

——— und ——— (1917b): Ueber die Einteilung der Familie Acidaspidae und über einige ihre devonischen Vertreter. *Cbl. Miner., 1917.*

——— und ——— (1919): Proetiden aus neueren Aufsammulungen im vogtländischen und sudetischen Oberdevon. *Senckenberg., Bd. 21, Nr. 1/2.*

——— und ——— (1923): Der Genotyp von *Proetus* STEIN., 1831. *Ibid., Bd. 25.*

——— und ——— (1926): Die Trilobiten der Oberdevons. Beiträge zur Kenntnis devonischer Trilobiten, IV. *Abh. Preuss. Geol. Landesanst., N.F. 99.*

——— und ——— (1930): Neue Horner Trilobiten in unserer Schausammulung. *Natur u. Mus., Bd. 60, Hft. 1.*

——— und ——— (1933): Die Letzten Phacopidae. *Bull. Mus. Royal d'Hist. Nat. de Belgique, T. 9, No. 24.*

——— und ——— (1939): Neue Beiträge zur Kenntniss der Geologie, Palaeontologie und Petrographoe der Umgegend von Konstantinopel. 4. Trilobiten aus dem Bosporus Gebiet. *Abh. Presuss. Geol. Landesanst., N.F., H. 190.*

——— und ——— (1950): Arten der Dechenllinae (Tril.) *Senckenberg., Bd. 31, Nr. 3/4.*

——— und ——— (1951): Der Beginn des Karbons im Wechsel der Trilobiten. *Ibid., Bd. 32, Nr. 1/4.*

——— und ——— (1952): Phacopacea von der Grenze Emsium/Eifelium (Tril.) *Ibid., Bd. 33, Nr. 1/3.*

——— und ——— (1954): Die Trilobiten des Ebbe-Sattels und zu vergleichende Arten (Ordovizium, Gotlandium/Devon). *Abh. Senckenberg. Naturf. Gesell., 488.*

——— und ——— (1956): Grundlagen für die Beurteilung und Einteilung der Familie Scutelluidae (Tril.). *Senckenberg. Leth., Bd. 37, Nr. 1/2.*

——— und STRUVE, W. (1959): Family Proetidae SALTER. MOORE (ed.) *Treatise on Invertebrate Paleontology, Part 0, Arthropoda 1.*

ROSOVA, A.V. (1960): On some new trilobites from the Upper Cambrian System of Salair. *Acad. Sci. U.S.S.R., Siberian Branch, Trudi Inst. Geol. Geophys., Fasc. 1.*

——— (1963): Biostratigraphic scheme of the Upper and Upper-Middle Cambrian and new Upper Cambrian trilobites. *Acad. Sci. U.S.S.R., Siberian Branch, Geol. Geophys.*

——— (1968): Biostratigraphy and trilobites of Upper Cambrian and Lower Ordovician of Northwest Siberian platform. *Acad. Sci. U.S.S.R., Siberian Branch Trud. Inst. Geol. Geophys. Fasc. II. 36.*

ROSS, R.J. (1967a): Some Middle Ordovician brachiopods and trilobites from the Basin Ranges, Western United States. *U.S. Geol. Surv., Prof. Pap. 523D.*

——— (1967b): Calymenid and other Ordovician trilobites from Kentucky and Ohio. *Ibid., 583B.*

RUTTNER, A., NABAVI, M.H. and HAJIAN, J. (1968): Geology of the Shirgesht area (Tabas area, East Iran). *Iran Geol. Surv., Rept. No. 4.*

RZHONSNITSKAYA, M.A. (1967): Devonian of the U.S.S.R. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1.*

——— and HARIN, G.S. (1967): Devonian of the Kuznetsk basin. *Ibid., Vol. 2.*

Salfeld, H. (1911): Versteinerungen aus dem Devon von Bolivien, dem Jura und der Kreide von Peru. In R. Hauthal: Reisen in Bolivien und Peru, 1. Anhang: Palaeontologie. *Wiss. Veröff. Ges. Erdkde.* 44, Leipzig. (not seen).

Saltar, J.W. (1861): On the fossils from the High Andes, collected by David Forbes. *Quart. Jour. Geol. Soc. London, Vol. 17.*

Saul, J.M. (1967): *Burmeisteria* (*Digonus*) *accaensis*, a new homalonotid trilobite from the Devonian of Ghana. *Jour. Pal., Vol. 41, No. 5.*

———, Boucot, A.J. and Finks, R.M. (1963): Fauna of the Accraian Series (Devonian of Ghana including a revision of a gastropod *Plectonotus*. *Jour. Pal., Vol. 37, No. 5.*

Saurin, E. (1956): Indochine. *Lexique Stratigr. Intern., Vol. 3, Asie, Fasc. 6a.*

Scherwin, L. (1968): *Denckmannites* (Trilobita) from the Silurian of New South Wales. *Palaeont., Vol. 11.*

——— (1971): Trilobites of the subfamily Phacopinae from New South Wales. *Rec. Geol. Surv. N.S.W., Vol. 13.*

Schrank, E. (1969): Odontopleuriden (Trilobita) aus silurischen Geschieben. *Ber. Deutsch. Ges. Geol. Wiss. A, Geol. Palaont., 14, 6.*

——— (1970): Calymeniden (Trilobita) aus silurischen Geschieben. *Ibid., 15, 1.*

——— (1970): Die Trilobiten des Silurs der Bohrung Leba 1. (Ostseeküste der VR Polen). *Ibid., 15, 4.*

——— (1972): Proetacea, Encrinuridae und Phacopina (Trilobita) aus silurischen Geschieben. *Geolog. Jahrb. 31, Beiheft 76.*

Sdzuy, K. (1955): Die Fauna der Leimitz-Schiefer (Tremadoc). *Abh. Senckenb. Naturforsch. Gess., 492.*

——— (1957): Bemerkung zur Familie Homalonotidae. *Senckenb. Leth., Bd. 38, Nr. 5/6.*

Selwood, E.B. (1965): Dechenellid trilobites from the British Middle Devonian. *Bull. Brit. Mus.* (*Nat. Hist.*), *Geol., Vol. 10, No. 9.*

——— (1966): Thysanopeltidae (Trilobita) from the British Devonian. *Ibid., Vol. 13, No. 3.*

Sheng, S.F. (1973): Outline of the division and correlation of the Ordovician System in China. *Acta Geol. Sinica, 1973, Pt. 2.*

Shergold, J.H. (1968): On the occurrence of the trilobite genera *Acaste* aus *Acastella* in Victoria. *Proc. Roy. Soc. Vict., Vol. 81.*

Shirley, J. (1931): A redescription of the known British Ordovician species of *Calymene* (s.l.). *Mem. Proc. Manchester Libr. and Phil. Soc., Vol. 75.*

——— (1933): A redescription of the known British Silurian species of *Calymene* (s.l.). *Ibid., Vol. 77.*

——— (1936): Some British trilobites of the Family Calymenidae. *Quart. Jour. Geol. Soc. London, Vol. 92.*

——— (1938): The fauna of the Barton River beds (Devonian), New Zealand. *Ibid., Vol. 92.*

Šnajdr, M. (1960): Studie o čeledi Scutelluidae (Trilobitae). *Razoravy Ústr. Ústavu Geol., Svazek 26.*

Soruco, Suarez (1971): *Tarijactonoidas jarcasensis*, n. gen. u. sp. del Devonico Inferior de Tarija. *Ramiro Geobol.* (*Bolivia Serv. Geol.*), *Bol., No. 15.*

Stauffer, K.W. (1967): Devonian of India and Pakistan. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1.*

Steinmann, G. (1929): Geologie von Peru. Heidelberg.

Stibane, F.R. (1967): Devonian of the Cordillera of Columbia. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 2.*

Stφrmer, L. (1940): Early descriptions of Norwegian trilobites: The type specimens of C. Boeck, M. Sars and M. Esmark. *Norsk Geol. Tidssk., 20.*

Strusz, D.L. (1964): Devonian trilobites from the Wellington-Molong district of New South Wales. *Proc. Roy. Soc. N.S.W., Vol. 97.*

Struve, W. (1959): *Volkops volkopi* n. g., n. sp., ein Phacopinae aus dem deutschen Ordovizium. *Senckenberg. Leth., Bd. 40, Nr. 1/2.*

——— (1970): *Phacops* Arten aus dem Rheinischen Devon. 1. *Ibid., Bd. 51, Nr. 2/3.*

——— (1972): *Phocops*-Arten aus Rheinischen Devon. 2. Untergattungs-Zuweisung. *Ibid.,* *Bd. 53, Nr. 5.*

STUBBLEFIELD, C.J. (1948): Carboniferous trilobites from Malaya. H.M. MUIR-WOOD'S *Malayan Lower Carboniferous Fossils.*

STUMM, E.C. (1953a): Trilobites of the Devonian Traverse Group of Michigan. *Contr. Mus. of Paleont. Univ. of Michigan, Vol. 10, No. 6.*

——— (1953b): Lower Middle Devonian proetid trilobites from Michigan, Southwestern Ontario, and Northern Ohio. *Ibid., Vol. 11, No. 2.*

——— (1954): Lower Middle Devonian phacopid trilobites from Michigan, Southwestern Ontario and the Ohio valley. *Ibid., Vol. 11, No. 11.*

——— (1964): Silicified trilobites from the Devonian Jeffersonville Limestone at the Falls of the Ohio. *Ibid., Vol. 19, No. 1.*

——— (1965): Two new species of trilobites from the Middle Devonian Silica Shale of Northwestern Ohio. *Itid., Vol. 19, No. 13.*

——— (1967): Devonian trilobites from Northwestern Ohio, Northern Michigan and Western New York. *Ibid., Vol. 21, No. 6.*

——— (1968): Two unusually well-preserved trilobites from the Middle Devonian of Michigan and Ohio. *Ibid., Vol. 22, No. 2.*

——— and KAUFMANN, E.G. (1958): Calymenid trilobites from the Ordovician rocks of Michigan. *Jour. Pal., Vol. 32, No. 5.*

SUGIYAMA, T. (1940): Stratigraphical and palaeontological studies of the Gotlandian deposits of the Kitakami mountainland. *Sci. Rep. Tohoku Univ. 2nd ser. (Geol.), Vol. 21, No. 2.*

——— (1941): A tentative correlation of the Gotlandian formations in Japan and Central China. *Jour. Geol. Soc. Japan, Vol. 48.*

——— (1944): On Japanese trilobites. *Studies from Geol. Min. Inst. Tokyo Bunrika Daigaku, No. 1.*

——— and OKANO, H. (1941): On the discovery of *Phacops* (s.s.) from the Nakazato Series (Middle Devonian) of the Kitakami mountainland, Japan. *Jour. Geol. Soc. Japan, Vol. 48.*

SUN, Y.C. (1931): Ordovician trilobites of Central and Southern China. *Palaeont. Sinica, Ser. B, Vol. 1, fasc. 1.*

——— (1937): Two new species of Devonian trilobites from Hunan. *Bull. Geol. Soc. China, Vol. 17.*

——— and SZETU, S.S. (1947): Preliminary notes on the stratigraphy and structure of the Paoshan region, W. Yunnan. *Contr. Geol. Iost. Univ. Peking, No. 32.*

SWARTZ, M. (1925): The Devonian fauna of Bolivia. *The John Hopkins Univ. in Geol., 6.* (not seen).

TACHIBANA, K. (1949): On the Tobigamori flora. *Jour. Geol. Soc. Japan, Vol. 55, Nos. 648-649.*

——— (1950): Devonian plants first discovered in Japan. *Proc. Japan Acad., Vol. 26, No. 9.*

——— (1952): On the Tobigamori group of the Nagasaka district, Kitakami mountainland. *Jour. Geol. Soc. Japan, Vol. 58.*

——— (1953): On the occurrence of *Products nummularis* (WINCHELL) from the late Upper Devonian of Japan. *Sci. Rep. Tokyo Bunrika Daigaku, Ser. C, Vol. 2, No. 14.*

——— (1963): Upper Devonian and Lowest Carboniferous formations in the vicinity of Minamiiwairi, Higashiyamamachi, Iwate Prefecture, Pt. 1. *Bull. Fac. Lib. Arts, Nagasaki Univ., Nat. Sci., Vol. 4.*

TALENT, J.A. (1963): The Devonian of the Mitchell and Wentworth Rivers. *Geol. Surv. Vict., Mem., Vol. 24.*

——— (1965): The Silurian and early Devonian faunas of the Heathcote district, Victoria. *Ibid., Vol. 26.*

——— (1972): Provincialism and Australian early Devonian faunas. *Jour. Geol. Soc. Austral., Vol. 19, Pt. 1.*

——— and BANKS, M.R. (1967): Devonian of Victoria and Tasmania. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 2.*

TANG, K.D. and SU, Y.Z. (1966): New data about the Palaeozoic formation and their significance in the Northwestern Minor Khingan. *Acta Geol. Sinica, Vol. 46, No. 1.*

TEICHERT, C. (1947) : Stratigraphy of Western Australia. *Jour. Proc. Roy. Soc. N. S. W., Vol. 60.*

TEMPLE, J.T. (1956) : Notes on the Cheiruracea and Phacopacea. *Geol. Mag., Vol. 93, No. 5.*

——— (1969) : Lower Llandovery (Silurian) trilobites from Keisley, Westmorland. *Bull. Brit. Mus. (Nat. Hist.), Geol., Vol. 18. No. 6.*

——— (1970) : The Lower Llandovery brachiopods and trilobites from Ffridd Mathrafal, near Meifod, Montogomeryshire. Palaeontogr. Soc.

TERMIER, G. et H. (1950) : Annélides, Arthropodes, Echinodermes, Conularides et Graptolithes. *Paléont. Marocaine, Tom. 2, fasc. 4.*

THADEU, D.D. (1949) : Calimenideos Portugueses. *Bol. Soc. Geol. Portugal, 8.*

THOMAS, I. (1905) : Neue Beiträge zur Kenntnis der devonischen Fauna Argentiniens. *Zeitschr. deutsch. geol. Gesell., Bd. 57.*

TICKY, N.Y. (1967) : The Devonian history of the U.S.S.R. *Proc. Intern. Symp. Dev. System. Calgary, 1967, Vol. 1.*

TILLMAN, C.G. (1960) : *Spatacalymene*, an unusual new Silurian trilobite genus. *Jour. Pal., Vol. 34, No. 5.*

TINT, U Thaw and WAI, U Hla (1970) : The Lower Devonian trilobite fauna from the East Medaw area, Maymyo district. *Union Jour. of Sci. & Technology, Vol. 3. No. 2.*

TOMCZYKOWA, E. (1970) : Silurian *Spatacalymene* TILLMAN, 1960 (Trilobita) of Poland. *Acta Pal. Polonica, Vol. 15, No. 1.*

——— (1975) : The trilobite subfamily Homalonotinae from the Upper Silurian and Lower Devonian of Poland. *Ibid., Vol. 20, No. 1.*

TRIPP, R.P. (1957) : The classification and evolution of the Superfamily Lichacea (Trilobita). *Geol. Mag., Vol. 94, No. 2.*

——— (1958) : Stratigraphical and geographical distribution of the named species of the trilobite superfamily Lichacea. *Jour. Pal., Vol. 32, No. 3.*

——— (1962) : Trilobites from the Confinis Flags (Ordovician) of the Girvan district, Ayrshire. *Trans. Roy. Soc. Edinb., Vol. 65, No. 1.*

TSCHERNYSHEVA, N.E. (1937) : Silurian and Devonian trilobites of Mongolia and Tuva. *Trud. Mongol. Kom. No. 28.*

——— (1951) : Upper Silurian and Devonian trilobites from the Kuznetsk basin.

——— (ed.) (1960) : Trilobitomorpha and Crustacea. ORLOV's *Osnovy Paleontologii, Vol. 8.*

——— (1961) : Outline of Middle and Upper Cambrian trilobites of Siberia. *El Sistema Cambrico, su Paleogeografia el Problema de su Base. Symposium, Part 3, Problem General, Europe occidental, Africa, URSS, Asia and America.* Moscow.

———, POLETAYEVA, P.E. REPINA, L.N., OGIENKO, L.V. and JEGOROVA, O.K. (1956) : Trilobita in Material of Palaeontology. *VSEGEI, N.S., Fasc. 12, Paleontology.*

TSCHERNYSCHEW, Th. (1885) : Die Fauna des Unteren Devon am Westabhange des Urals. *Mém. du Comité Géol., Vol. 3, No. 1.*

——— (1887) : Die Fauna des Mitteleren und Oberen Devon am Westabhange des Urals. *Ibid., Vol. 3, No. 3.*

——— (1893) : Die Fauna des Unteren Devon am Ostabhange des Urals. *Ibid., Vol. 4, No. 3.*

ULRICH, A. (1893) : Palaeozoische Versteineinerungen aus Bolivien. In G. STEINMANN: Beiträge zur Geologie und Palaeontologie von Südamerka 1. *N. Jb. Miner. etc., Beil.,-Bd. 8.*

VAN INGEN, G. (1901) : The Silurian fauna near Batesville, Arkansas. Pt. 2, Palaeontology: Trilobita. *School of Mines, Quart. Columbia Univ., Vol. 23.*

VANĚK, J. (1959) : Celeď Lichaidae HAWLE & CORDA, 1847, zu stredočeského staršího paleozoika (Trilobitae). *Boh. centr. A., Vol. 1 (3).*

——— (1963) : New genera of the family Harpidae HAWLE et CORDA, 1847. Trilobitae from the Barrandian Area (Bohemia). *Casopis Narodniho Muzea-Oddil Prirodivendny. Roc. 82, Cis. 4.*

——— (1965) : New species of the suborder Calymenina SWINNERTON, 1915 (Trilobita) from the Barrandian area. *Sb. Geol. Včd. Paleont. řada P., SV. 6.*

——— (1968) : *Weberopeltis matutina* n. sp. (Trilobita) from the Devonian of the Barrandian.

Věstn, Ústred Ústav Geol., Vol. 43, No. 3.

WALCOTT, C.D. (1913): Cambrian faunas of China. *Research in China, Vol. 3.*

WARBURG, E. (1925): The trilobites of the *Leptaena* Limestone in Dalarne with a discussion of the zoological position and the classification of the Trilobita. *Bull. Geol. Inst. Univ. Upsala, Bd. 27.*

——— (1939): The Swedish Ordovician and Lower Silurian Lichidae. *Kungl. Svenska Vetens.-akad. Handl. 3 ser., Bd. 17, nio 4.*

WARDER, J.A. (1838): New trilobites. *Amer. Jour. Sci., Vol. 34.*

WANG, Y. and YÜ Chang-ming (1964): The Devonian System of China. *Sci. Rep. Stratigr. Conf. China.*

———, YÜ Chang-ming and WU Qi (1974): Advance in the Devonian biostratigraphy in South China. *Mem. Nanking Inst. Geol. Palaeont., No. 6.*

WEBBY, B.D. (1974): Upper Ordovician trilobites from Central New South Wales. *Palaeont., Vol. 17, Pt. 2.*

WEBER, V.N. (1932): Trilobites of the Turkestan. *Mem. Comm. Geol., N.S. 178.*

——— (1948): Trilobites of the Silurian rocks, No. 1. Lower Silurian trilobites. *Monogr. Palaeontol. U.S.S.R., VSEGEI, Vol. 69.*

——— (1951): Upper Silurian trilobites, U.S.S.R. *Trud. VSEGEI, Ministry of Education.*

WEISBORD, N.E. (1967): The Devonian System in Western Venezuela. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 2.*

WELLER, S. (1907): The paleontology of the Niagaran limestone in the Chicago area. *Chicago Acad. Sci., Bull., Vol. 4, (2).*

WHIDBORNE, G.F. (1889): A monograph of the Devonian fauna of the south of England. I. The fauna of the limestones of Lummaton, Wolborough, Chircombe Bridge and Chudleigh. Palaeontogr. Soc.

WHITTARD, W.F. (1938): The Upper Valentian trilobite fauna of Shropshire. *Ann. Mag. Nat. Hist., Ser. 11, Vol. 1.*

——— (1960, 61): The Ordovician trilobites of the Shelve Inlier, West Shropshire. Pts. 4 & 6. Palaeontogr. Soc. London.

WHITTINGTON, H.B. (1954): Status of invertebrate paleontology. Part IV. Arthropoda: Trilobita. *Mus. Comp. Zool., Bull., Vol. 112, No. 3.*

——— (1956a): BEECHER's lichid protaspis and *Acanthopyge consanguinea* (Trilobita). *Jour. Pal., Vol. 30, No. 5.*

——— (1956b): Silificied Middle Ordovician trilobites: the Odontopleuridae. *Bull. Mus. Comp. Zool., Harvard Coll., Vol. 114, No. 5.*

——— (1956c): Type and other species of Odontopleuridae (Trilobita). *Jour. Pal., Vol. 30.*

——— (1958): New Lower Ordovician Odontopleuridae (Trilobita) from Oeland. *Bull. Geol. Inst. Univ. Uppsala, Vol. 38.*

——— (1960): *Cordania* and other trilobites from the Lower and Middle Devonian. *Jour. Pal., Vol. 34, No. 3.*

——— (1961): Silurian *Hemiarges* (Trilobita) from Cornwalls Island and New York State. *Ibid., Vol. 35, No. 3.*

——— (1963): Middle Ordovician trilobites from Lower Head, Western Newfoundland. *Bull. Mus. Comp. Zool. Harvard Univ., Vol. 129, No. 1.*

——— (1966): Phylogeny and distribution of Ordovician trilobites. *Jour. Pal., Vol. 40, No. 3.*

——— (1971a): Silurian calymenid trilobites from the United States, Norway and Sweden. *Palaeont., Vol. 14, Part 3.*

——— (1971b): A new calymenid trilobite from the Maquoketa Shale, Iowa: A paleontological tribute to G. Arthur COOPER. *Smithsonian Contrib. Paleobiol., Vol. 3.*

——— and BOHLIN, B. (1958): New Lower Ordovician Odontopleuridae (Trilobita) from Oeland. *Bull. Geol. Inst. Univ. Uppsala, Vol. 38.*

——— and CAMPBELL, K.S.W. (1967): Silicified Silurian trilobites from Maine. *Bull. Mus. Comp. Zool., Harvard Univ., Vol. 135, No. 9.*

——— and EVITT, II. (1954): Silicified Middle Ordovician trilobites. *Geol. Soc. Am., Mem.*

59.

——— and HUGHES, C. P. (1973) : Ordovician trilobite distribution and geography. *Organisms and Continents through Time. Sp. Pap. in Palaeont. 12. Systematic Ass., Publ. 9.*

——— and WILLIAMS, A. (1955) : The fauna of the Derfel limestone of the Arenig district, North Wales. *Phil. Trans. Royal Soc. London, Ser. B, No. 658, Vol. 238.*

WOLFART, R. (1961) : Stratigraphie und Fauna des älteren Paläozoikums (Silur, Devon) in Paraguay. *Geol. Jahrb., Bd. 78.*

——— (1967) : Die Trilobiten aus dem Devon Bolivien und ihre Bedeutung für Stratigraphie und Tiergeographie. *Beih. Geol. Jahrb., 74.* Hannover.

——— (1970) : Fauna, stratigraphie und Palaeontologie des Afghanistan. *Ibid., Hft. 89.*

——— und VOGDES, A. (1968) : Beiträge zur Kenntnis des Devons von Bolivien. *Ibid., Hft. 74.* Hannover.

WRIGHT, A. J. (1967) : Devonian of New Zealand. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1.*

YABE, H. (1940) : An occurrence of Devonian fossils in Manchoukuo. *Proc. Imp. Acad. Tokyo, Vol. 16.*

——— and NODA, M. (1933) : Discovery of *Spirifer verneuili* MURCHISON in Japan. *Ibid. Vol. 9, No. 9.*

——— and SUGIYAMA, T. (1937) : Preliminary report on the fossiliferous Gotlandian and Devonian deposits newly discovered in the Kitakami mountainland. *Ibid., Vol. 13, No. 10.*

——— and ——— (1939) : Discovery of corals of Devonian type from Tyosen (Korea). *Ibid., Vol. 15, No. 9.*

——— and ——— (1942a) : A Lower Devonian faunule from North Manchuria. *Ibid., Vol. 18, No. 8.*

——— and ——— (1942b) : Devonian fossils from Heitai, Mishanhsien, Manchoukuo, Second note. *Ibid., Vol. 18.*

——— and ——— (1943) : On the fossil from Nichiuho, Nenchiang-hsien, Peian Prov. *Bull. Centr. Nat. Mus. Manchoukuo, No. 5.*

——— and SUZUKI, A. (1955) : Second occurrence of colonial corals of Devonian type in Tyosen (Korea). *Proc. Imp. Acad. (Tokyo), Vol. 31, No. 6.*

YANG, King-chih (1956) : The Middle Devonian Bryozoa from the Heitai formation of Mishan county, Kirin. *Acta Pal. Sinica, Vol. 4, No. 3.*

YIN, T. H. (1938) : Devonian fauna of the Pochia shale of Eastern Yunnan. *Bull. Geol. Soc. China, Vol. 18, No. 1.*

YOLKIN, E. A. (1967) : Trilobites and the Lower-Middle Devonian boundary in southern West Siberia. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 2.*

——— (1968) : Trilobites and stratigraphy of the Lower and Middle Devonian of Southwest Siberia. *Acad. Nauk U.S.S.R., Siberian branch, Inst. Geol. & Geophys.*

ZITTEL, K. v. und BROILI, F. (1924) : Grundzüge der Palaeontologie (Palaozoologie), 1 Abteil.

Place Names

Amicheou	阿迷州
Cheongseong-ni	天聖里
Chichibu	秩父
Chinchangkai	金沙江
Chinshuei (=Kinsui)	金水
Choanji	長安寺
Chungchao	中朝
Chungch'eong-bukto	忠清北道
Fukuji	福地
Heilungchiang	黒竜江
Heitai	黒台
Henghsien	横県
Hida	飛騨
Higuchizawa	樋口沢
Hikoroichi	日頃市
Hitoégané	一重ヶ根
Hongjeom (Koten)	紅店
Houlungmen	霍龍門
Hsikuangshan	錫礦山
Hunan	湖南
Hwanghae-do	黄海道
Hwangho	黄河
Ichinotani	一の谷
Imoktong	梨木洞
Jenhochiao	仁和橋
Kaiyüan	開遠
Kamitakara-mura (village)	上宝村
Kanajiro-zako	金白迫
Karaumédaté	唐梅舘
Kawauchi	川内
Kentuyho	根図河
Kesen-gun (county)	気仙郡
Khingan-range	興安岺
Kilien-shan	祈連山
Kinma-michi	木馬道
Kinsui	金水
Kiyomi-mura (village)	清見村
Kosu-ri	古籔里
Kuantung, Kwangtung	広東
Kuenlun	崑崙
Kuhua	古化
Kumko-myeon	金崗面
Kuzuryu-gawa (river)	九頭竜川
Kwangsi	広西
Kyeomip'o	兼二浦
Liaotung	遼東
Lienhua-shan	蓮花山
Lingchuan	霊川
Liouching	六景
Lukou	鹿溝
Lunghua-shan	龍華山
Luofu	羅冨
Manmo	満蒙
Maotzuling	帽子岺
Nagasaka	長坂
Nakakura	中倉
Nakazato	中里
Nakaoling	那高岺
Nantan	南丹
Napiao	納標
Naradani	楢谷
Nichiuho	泥鰍河
Nünkian (Nengkiang)-hsien	嫩江県
Ōhira	大平
Ōfunato	大船渡
Okch'eon	沃川
Oisé	オ伊勢
Ōmori	大森
Ōno	大野
Peiliu	北流
Pochiao	坡脚
P'yeongan-namdo	平安南道
P'yeongnam	平南
Sakari	盛
Sinchang-myeon	新倉面
Sorayama	空山
Suhuho	蘇呼河
Suncheon-kun	順川郡
Szupai	四排
Takahara-gawa (river)	高原川
Takainari-yama (Mt.)	高稲荷山
Tali	大理
Tanghsiang	塘郷
Tangting	塘丁
Tangyang-kun	丹陽郡
Tiaomachien	跳馬澗
Tienshan	天山
Tobigamori	鳶ヶ森
Tsaidam	柴達木
Tungkangling	東崗岺
Yokokura-yama (Mt.)	横倉山
Yoshiki-gun (county)	吉城郡
Yüchiang	郁江
Yunnan	雲南
Yütienchiao	余田橋

Postscript

1) Yi and Hsiang (1975) described the following six species of trilobites in four genera from the Napiao formation which lies on the Luofu formation in the Nantan area, Kwangsi. Their age is considered by them to be Eifelian.

Phacops guangxiensis Chang (MS)
Phacops transversalis Yi et Hsiang (sp. nov.)
Plagiolaria nandanensis Chang (MS)
Ductina vietnamica Maximova
Cyphaspides orientalis Yi et Hsiang (sp. nov.)
Cyphaspides paradoxus Yi et Hsiang (sp. nov.)

Yi Yung-en and Hsiang Lee-wen (1975), Middle Devonian trilobites of Nantan, Kwangsi. *Collection of Articles on Strata and Fossils, No. 1.*

2) According to Ormiston (1975) the Siegenian sea on the northwestern side of Greenland-North America was more similar to the Gedinnian than the Emsian-Eifelian one in extension. The Gedinnian trilobite fauna of Arctic North America is intimately related to those of the Old World in the inclusion of *Prodrevermannia*, *Denemarkia*, *Ceratarges*, *Coniproetus*, *Eremoproetus*, *Maurotarion* and *Otarionella* and particularly in two occurrences of *Crotalocephalus* (i. e., *Crotalocephalina*) in Alaska.

Ormiston, A. R. (1975), Siegenian trilobite zoogeography in Arctic North America. Evolution and morphology of the Trilobita, Trilobitoidea and Merostomata. *Fossils and Strata, No. 4.*

3) The Florentine quartzite of the Eldon Group in Tasmania is said to be Devonian in age (Spry and Banks, 1862).

Talent, J. A., Berry, W. B. N., Boucot, A. J., Packham, G. H., and Bischoff, G. C. O. (1970), Correlation of the Silurian rocks of Australia, New Zealand and New Guinea. *Geol. Soc. Am. Sp. Pap. 150*, p. 57.

4) Landrum and Sherwin (1976) described *Warburgella* (*Anambon*) *jelli*, subgen. et sp. nov., a close ally of *Warburgella rugulosa*, from the Derriwong beds of New South Wales. It is accompanied by *Encrinurus* sp. and *Molongia elegans capricorniae* and considered to be of late Silurian or early Devonian age.

Landrum, R. S. and Sherwin, L. (1967), *Warburgella* from Central New South Wales. *Records Geol. Surv. N. S. W, Vol. 17, Pt. 2.*

5) The specio-temporal development of phacopids in the Middle Palaeozoic Era was summarized by Chlupáč (1975). The provincialism was insignificant in the Silurian, but become conspicuous in the Devonian Period. Phacopids were profused in the Bohemian magnifacies, but depauparated in the Rhenish magnifacies.

In the early Devonian epoch *Phacops* (*Paciphacops*) was distributed widely from the Appalachians to Kazakhstan on one side and to South America on the other and the trans-Pacific distribution of this subgenus was maintained into the middle Devonian epoch. In the post-Zlichovian times, however, *Phacops* (*Chotecops*) was common in the Europe-North Africa- Asia Minor and phacopids with reduced eyes (*Eocryphos*, *Plagiolaria*, etc.) and blind ones (*Ductina*) often occur in the Tethyan zone. *Phacops*

(*Phacops*) distributed extensively in the three northern continents, but no phacopid is known from the Arctic region of Canada.

In the late Devonian Epoch oldep phacopid genera, like some other trilobite families, declined, but phacopids with reduced eyes flourished, especially in the Famennian age, until all phacopids died out together with clymenids at the end of the Devonian period.

CHULPÁČ, I. (1975), The distribution of phacopid trilobites in space and time. *Fossils and Strata, No. 4.*

6) Recently odontopleurids were greatly amplified in the Chinese fauna as follows:

Dicranurus oviformis LU and CHANG, 1964. Middle Ordovician (Shihtzupu formation), Kweichou.

Ningnanaspis ningnanensis SHENG, 1974, Middle Ordovician, Szechuan

Diacanthaspis laokuangshanensis LU and CHANG, 1974. Upper Ordovician (Wufengian top), Szechuan.

Diacanthaspis cf. *decacantha* (Angelin), by SHENG, 1974, Upper Ordovician (Upper Pupiao), West Yunnan.

Leonaspis sinensis CHANG, 1974. Basal Silurian (Kuanyinchiao *Dalmanitina* beds), Kweichou.

Leonaspis pusillus CHANG, 1974. Basal part of Lower Silurian, Kweichou.

Gaotania ovata CHANG, 1974. Late Lower and Middle Silurian, Kweichou.

Gaotania pulchella CHANG, 1974. Late Lower and Middle Silurian, Kweichou

LU, Yen-ho and CHANG, W.T. (1974), Ordovician trilobites; CHANG, W.T. (1974), Silurian trilobites. Nanking Institute of Geology and Palaeontology, Academia Sinica: *Handbook of Strata and Fossils from Southwest China.*

SHENG, S.F. (1974), Division and correlation of the Ordovician System in China.

7) JAANUSSON, (1975), established *Gyrometopus* gen. nov. with *Nileus*? *lineatus* ANGELIN, 1854 and placed the Gyrometopinae nov in the Diaphanometopidae. The type-species was described in detail and the comparison of the new genus made with pilekiids and other trilobites, saying that "If the ancestors of Phacopina resemble *Gyrometopus* and this genus is related to *Diaphanometopus*, then the ancesters of Phacopina may ultimately be traced back to pilekiid-like forms."

JAANUSSON, V. (1975), Evolutionary process leading to the trilobite suborder Phacopina. *Fossils and Strata, No. 4.*

If so, it is probable that the suborder Phacopina was branched off from the Cheirurina from the common Corynexochidian stock at the Pilekiinae.

8) *Phacops* (*Omegops*) founded by STRUVE, 1976, on *Calymene accipitrina* PHILLIPS, 1841 is the latest phacopid subgenus widely distributed in the Upper Devonian VI (Strunian) of Asia, Europe and North Africa.

STRUVE, W. (1975), *Phacops* (*Omegops*) n. sg. (Trilobita; Ober-Devon). *Senckenbergiana, Bd. 56, Hft. 6.*

9) FORTEY and OWENS (1975) proposed a new order, Proetida to include the Aulacopleuridae, Bathyuridae, Brachymetopidae, Celmidae, Dimeropygidae, Glaphuridae Otarionidae and Proetidae and concluded their probable derivation from various species of the Hystricurinae probably during the Tremadocian age.

FORTEY, R.A. and OWENS, R.M. (1975), Proetida-a new order of trilobites. *Fossils and Strata*, *No. 4*.

It is highly probable that some proetoid groups were derived from the Ptychoparian stock through hystricuroids during the Tremadocian age. The domain of the Proetida is, however, a question in view of the diverse opinions on cetain families as shown in the table below and FORTEY and OWENS' discussions on genera of problematical affinities and problematical proetids.

Proetida FORTEY et OWEN, 1975	HUPÉ 1953, 1955	MOORE's Treatise, O-1, 1959	ORLOV's Osnovy, 1960
Aulacopleuridae	Solenopleuroidae	Proetacea	Solenopleuroidea
Bathyuridae	Solenopleuroidae	Bathyuracea	Solenopleuroidea
Brachymetopidae	Proetoidae	Proetacea	Proetoidea
Celmidae	*	Proetacea	Cheiruroidea
Dimeropygidae	Solenopleuroidae	Proetacea	Solenopleuroidea
Glaphuridae	Telephoidae	Komaspidacea	Solenopleuroidea
Otarionidae	Splenopleuroidae	Proetacea	Solenopleuroidea
Proetidae	Proetidae	Proetacea	Proetoidea

* Family Celmidae JAANUSSON, 1956 was founded on *Celmus* ANGELIN, 1854, of which no mention was given in HUPÉ's *Classification des Trilobites*, 1953, '55.

10) CHANG (1974) added the following two new species of a new genus to the Otarionidae from China.

Songkania CHANG, 1974. Lower Silurian, Hupeh and Kweichou.

Songkania hanjiadianensis CHANG, 1974, (tyep-species of *Songkania*). Lower Silurian, Kweichou and Hupeh.

Songkania pijiazhaiensis CHANG, 1974. Lower Silurian (middle and upper parts), Kweichou.

CHANG, W.T. (1974), Silurian trilobites. Nanking Institute of Geology and Paleontology, Academia Sinica: *Handbook of Strata and Fossils*.

(Nov. 1976)

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Brackets bounding a page number indicate a provisional identification with cf., aff. or the like.

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Plate 1

Explanation of Plate 1

Hidascutellum multispiniferum KOBAYASHI and HAMADA, gen. et sp. nov. ....p. 76

Fig. 1. The smallest cranikium showing the frontal sinuation of the glabella. Loc. Oise, Fukui Prefecture; TANAKA coll. (YT-13), PAt 7381, ×5.6.

Fig. 2. The next smallest cranidium showing the frontal sinuation and shallowly incised glabellar furrows. Loc. *ditto*; TANAKA coll. (YT-14), PAt 7382, ×5.4.

Fig. 3. A part of a small cranidium showing a frontal sinuation and median tubercle on the glabella. a: internal mould, b: external replica. Loc. *ditto*; TANAKA coll. (YT-15), PAt 7383, ×3.8.

Fig. 4. An incomplete cranidium showing the frontal expansion of the glabella and a boss like median tubercle on the neck ring. Loc. *ditto*; TANAKA coll. (YT-12), PAt 7384, ×3.7.

Fig. 5. The holotype specimen showing general features of the cranidium. a, c: rubber replica. Loc. bed 10 at Kanajiro-zako, Fukuji, Gifu Prefecture; ONO coll. (730 5280). 5b is the same specimens as OKAZAKI's *Scutellum* sp. (1974, pl. 9, fig. 15), Kyoto Univ., no. 16, ×2.5.

Fig. 6. The largest cranidium from the same locality as above. KOIZUMI coll., PAt 7385, ×2.0.

Fig. 7. An incomplete but well preserved cranidium showing the glabellar features and the characteristic eye mound. Loc. Oisé; TANAKA coll. (YT-11), PAt 7386, ×4.0.

Fig. 8. An incomplete hypostoma showing general outline and the maculae. Loc. *ditto*; TANAKA coll. (YT-54), PAt 7387, ×4.5.

Fig. 9. A small hypostoma probably of this species. Loc. *ditto*; TANAKA coll. (YT-31), PAt 7388, ×7.0.

Figs. 10, 11. Rubber impressions of two free cheeks from Oisé. TANAKA coll. (YT-22, 21). PAt 7389, 7390, ×4.3, ×3.8.

Fig. 12. A large free cheek collected at Kanajiro-zako. KOIZUMI coll., PAt 7391, ×2.0.

Figs. 13, 14. Two incomplete free cheeks showing surface ornamentations and a part of a right eye. Loc. Oisé; TANAKA coll. (YT-19, 20), PAt 7392, 7393, ×3.1.


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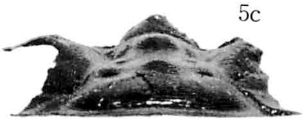
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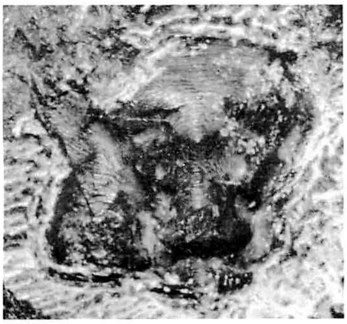
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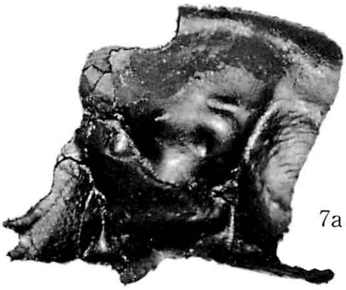
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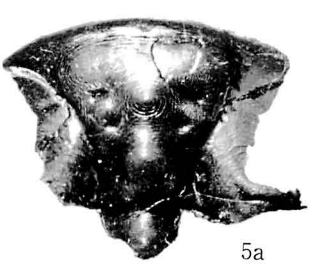
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Plate 2

Explanation of Plate 2

Scutellum densigranulatum Kobayashi and Hamada, sp. nov. ....p. 79

Fig. 1. Rubber impression of the holotype pygidium showing granulation and narrow interpleural furrows. Note the undivided median rib at the posterior end. Loc. bed 11? at Sorayama, Fukuji, Gifu Prefecture; Yamakoshi coll. (Okazaki, 1974, pl. 9, fig. 16), Kyoto Univ., no. 17, ×1.5.

Figs. 2, 3. Two fragmentary specimens of this new species showing rough granulation. Loc. Kanajiro-zako, Fukuji; Koizumi coll., PAt 7394, 7395, ×1.25, ×1.5.

Scutellum (?) sp. indet. ....p. 80

Fig. 4. An incomplete pygidium collected from the Devonian? formation at Hitoégané, Gifu Prefecture. Yasue coll., Yokohama National University, ×2.2, ×1.0.

Hidascutellum multispiniferum Kobayashi and Hamada, sp. nov. ....p. 76

Figs. 5, 6. Two incomplete small pygidia from Kanajiro-zako; Koizumi coll., PAt 7396, 7397, × , ×5.0.

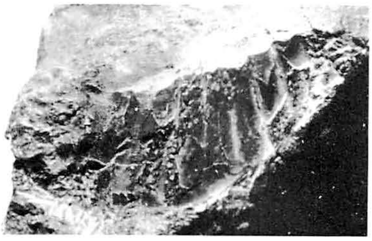
Fig. 7. Another small pygidium showing a little truncated antero-lateral margin. Loc. Oisé, Fukui Prefecture; Tanaka coll. (YT-23), PAt 7398, ×5.2.

Figs. 8, 9. Two incomplete pygidia showing sharply tuberculate axial lobe. Loc. *ditto*; Tanaka coll. (YT-54, 52), PAt 7399, 7400, ×2.0.

Figs. 10, 13-15. Four large pygidia showing general features of the species. Loc. *ditto*; Tanaka coll. (YT-53, 16, 18, 17), PAt 7401, ×1.1, PAt 7402, 7403, 7404, ×1.5.

Fig. 11. A small pygidium collected from Kinma-michi (?), Fukuji; Yamakoshi coll., 7405, ×2.2.

Fig. 12. An enlarged figure of the axial part of the pygidium showing a weakly tuberculate ring and a posteriorly prominent median tubercle. Note a pair of narrow and short transversal depression at the frontal margin of the axial lobe. Loc. Oise; Tanaka coll. (YT-24), PAt 7406, ×4.7.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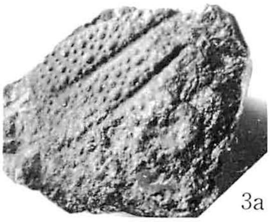
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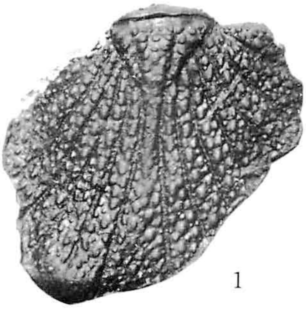
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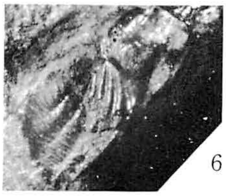
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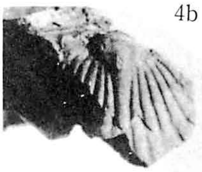
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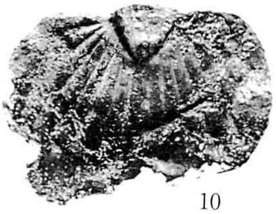
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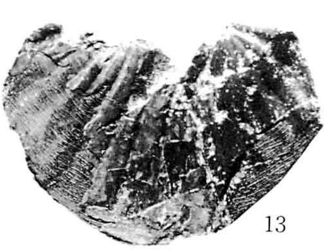
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Plate 3

Explanation of Plate 3

Primaspis (?) *tanakai* KOBAYASHI and HAMADA, sp. nov. ....p. 85

Fig. 1. Top (a), posterior (b), anterior (c), right lateral (d) and left lateral views (e) of the holotype small cephalon showing a pair of curved, long and postero-ventrally projected genal spines and spinose anterior margin of both sides. Loc. Kanajiro-zako, Fukuji, Gifu Prefecture; TANAKA coll., PAt 7407, ×6.0.

Otarion megalops KOBAYASHI and HAMADA, sp. nov. ....p. 150

Fig. 2. Rubber impression (a) and an internal mould of the type specimen showing densely and evenly granulate glabellar surface, highly prominent eyes, and long, curved genal spines. Loc. bed 1 (*Otarion* bed) beneath the *Gravicalymene* bed at Sorayama, Fukuji; KITAGAWA coll. (OKAZAKI, 1974, pl. 9, fig. 10) Kyoto Univ., no. 12, ×6.1.

Fig. 3. An internal mould of another cranidium showing the frontal area of the glabella. Loc. *ditto* (on the same slab as the preceding specimen), ×8.3.

Fig. 4. Thorax and attached pygidium showing the general outline of the segments. Note the weakly serrate pleural margin. Loc. *ditto* (on the same slab). This specimen was illustrated by OKAZAKI (1974, pl. 9, fig. 11), ×6.5.

Ceratocephala nipponica KOBAYASHI and HAMADA, sp. nov................................p. 86

Fig. 5. An internal mould and an external rubber replica of the holotype specimen showing broken but distinct spines projecting backward of the cephalon. Loc. *Gravicalymene* bed (bed 1) at Sorayama; YAMAKOSHI coll., PAt 7408, a ×2.0, b ×1.7.

Fig. 6. Mould and cast (b) of a small hypostoma showing the outline and maculae. Note the finely denticulate posterior margin. Loc. Sorayama; ONO coll., PAt 7409, ×6.5.

Proetoid free cheek ....p.

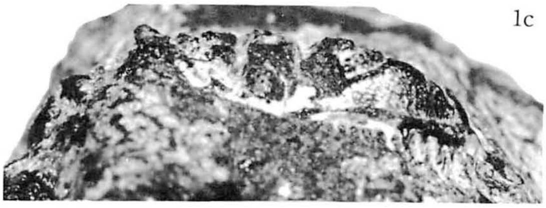
Fig. 7. A small left free cheek with an eye collected from loc. RK21, 12 km west of Sri Sawat, Changwat Kanchanaburi, Thailand. It was found in asfociation with *Pseudotrinodus* constrictus; HASHIMOTO, SATO and KOMALARJUN coll., ×9.0.

Pseudotrinodus constrictus KOBAYASHI and HAMADA, sp. nov. ....p. 74

Fig. 8. An internal mould of the holotype cephalon showing the weak constriction at the posterior half of the glabella and the peripheral flattening of the anterior border. Loc. *ditto*, × 9.0.


1d


1e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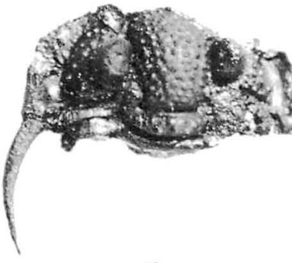
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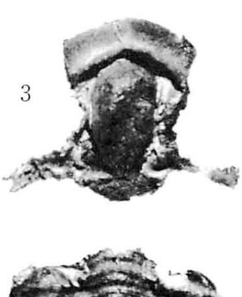
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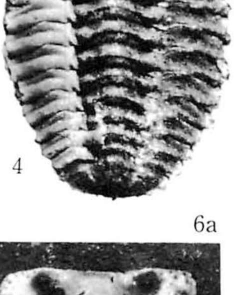
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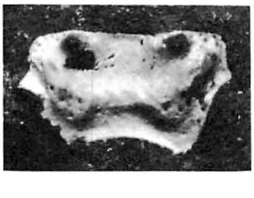
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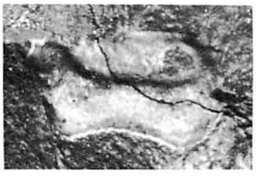
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Plate 4

Explanation of Plate 4

Ceratocephala nipponica KOBAYASHI and HAMADA, sp. nov. ....p. 86

Fig. 1. An incomplete hypostoma showing surface ornamentation. Loc. bed 1 (shale and limestone alternation) at Sorayama, Fukuji, Gifu Prefecture; OKAZAKI coll. (699 011), Kyoto Univ., no. 11-2, ×5.7.

Acanthopyge (*Lobopyge*?), sp. indet. ....p. 94

Fig. 2. A small and incomplete cranidium showing narrow frontal margin of the glabella. Loc. Sorayama; KOIZUMI coll. (71. 8. 5), PAt 7410, ×5.7.

Craspedarges superbus Kobayashi and Hamada, sp. nov. ....p. 92

Figs. 3-5. Three incomplete cranidia showing the general features of lobation and ornamentation. Loc. tuffaceous sandstone bed of bed 2 at Sorayama; KOIZUMI coll. PAt 7411, ×2.1; ONO coll., PAt 7412, ×2.2; and YAMAKOSHI coll., PAt 7413, ×1.6, respectively.

Fig. 6. The holotype rubber replica showing the external surface of the cranidium. Loc. *ditto*; ONO coll. (O-4), PAt 7414, ×3.9.

Figs. 7-9. Three mature cranidia from the same locality. KITO coll. (OKAZAKI, 1974, pl. 9, fig. 12), Kyoto Univ., no. 13, ×2.9; KITO coll., Kyoto Univ., no. 22, ×3.6; and an internal mould coll. by ONO (O-3), PAt 7415, ×3.7.

Fig. 10. Rubber replica of a left free cheek. ONO coll. (O-2), PAt 7416, ×3.6.

Figs. 11-14. Four pygidia occurred at the same locality. TANAKA coll., PAt 7417, ×3.4; KITO coll., Kyoto Univ., no. 15 (OKAZAKI, 1974, pl. 9, fig. 14), ×3.5; ONO coll. (O-5), PAt 7418, ×2.4; YAMAKOSHI coll., Shizen-kan, a ×1.8, b ×2.1, respectively.

Fig. 15. The largest pygidium collected from the *Gravicalymene* bed (bed 1) at Sorayama showing details of spination and granulation. OHNO coll., PAt 7419, ×1.5.

Fig. 16. An incomplete hypostoma found in the same slab with the cranidium illustrated by OKAZAKI (1974, pl. 9, fig. 13), Kyoto Univ., no. 14, ×4.6.


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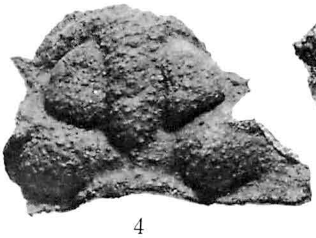
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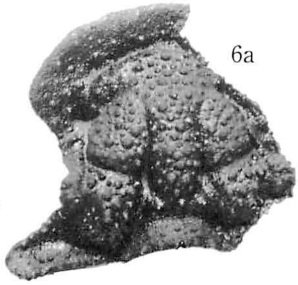
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6b


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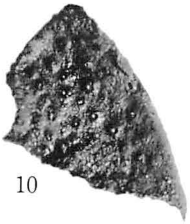
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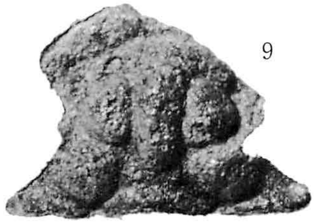
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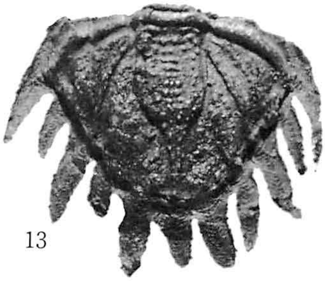
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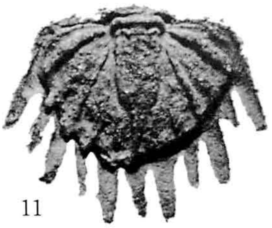
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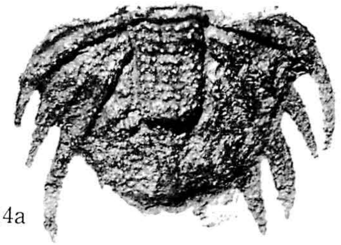
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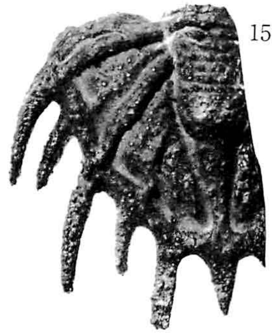
15a


15b


14b

Plate 5

Explanation of Plate 5

Crotalocephalina (*Pilletopeltis*) *japonica* (KOBAYASHI and IGO, 1956) ....p. 104

Fig. 1. Internal mould of a weakly deformed cephalon with thoracic segments. Loc. Kinma-michi (?), Fukuji, Gifu Prefecture; YAMAKOSHI coll., Shizen-kan, no. 125, ×1.5.

Figs. 2, 3. Two large cranidia of the species found at Oisé, Fukui Prefecture. TANAKA coll. (YT-45, 1), PAt 7420, 7421, ×1.5, ×1.2. Both specimens were illustrated by OKAZAKI et al. (1974, pl. 1, figs. 2 and 1 respectively).

Fig. 4. Rubber replica of a pygidium from the bed 11 at Kinma-michi. OKAZAKI coll. Kyoto Univ. (OKAZAKI, 1974, pl. 8, fig. 9), ×1.7.

Figs. 5, 6. Two incomplete pygidia from Oise. TANAKA coll. PAt 7422, ×1.7 and PAt 7423, ×1.9. The former pygidium was found on the same slab as the cranidium in Fig. 2 of this plate.

Fig. 7. Another pygidium found on a float probably derived from the bed 10 at Ichinotani, Fukuji. a: rubber replica. KITO coll. (1970. 8. 18), Kyoto Univ., ×1.5, ×1.7.

Fig. 8. Detached two thoracic segments from Oise. TANAKA coll. (YT-3), PAt 7424, ×1.7.

Crotalocephalina (*Pilletopeltis*) *japonica granulata* KOBAYASHI and HAMADA, subsp. nov. . .p. 105

Fig. 9. A complete cranidium collected from bed 7 (?) at Ichinotani. OKAZAKI coll., Kyoto Univ., no. 1 (OKAZAKI, 1974, pl. 8, fig. 4a), ×2.0.

Crotalocephalina (*Pilletopeltis*) *kameii* KOBAYASHI and HAMADA, sp. nov. ....p. 106

Fig. 10. Almost complete holotype cranidium showing somewhat sparse granulation and short genal spines. Loc. bed 10 at Ichinotani; TATEMATSU coll. (721103), Kyoto Univ., no. 2, ×2.3.

Fig. 11. Another small cranidia from Kanajiro-zako. TANAKA coll. (YT-0), PAt 7425, ×3.5.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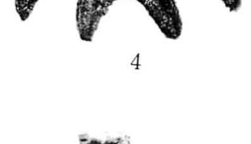
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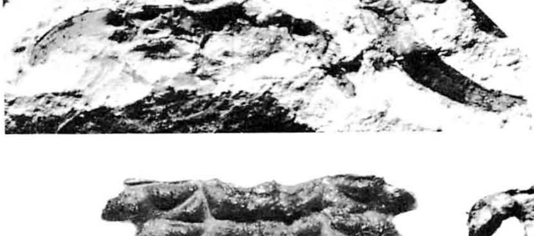
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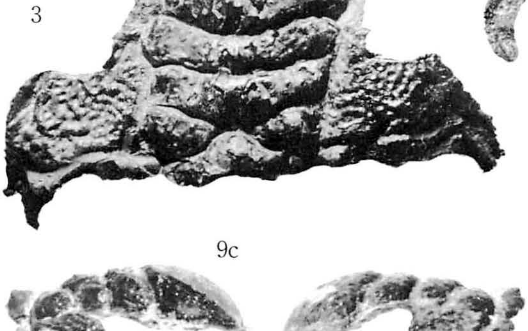
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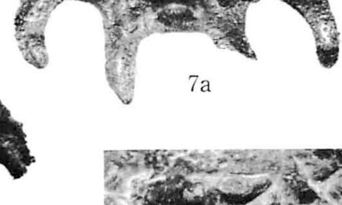
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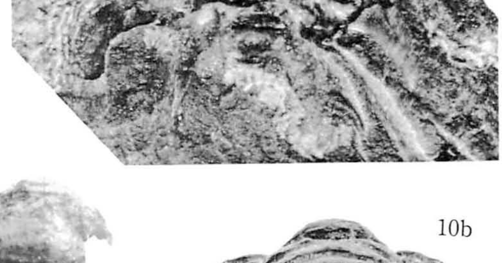

7b


9c


9d


9b


11


10b


9a


10c


10d


10a

Plate 6

Explanation of Plate 6

Crotalocephalina (*Geracephalina*) *secta* KOBAYASHI and HAMADA, subgen. et sp. nov. ....p. 108

Fig. 1. The holotype cranidium (rubber replica) showing wide fixed cheek, granulation and segmentation. Note the shallowly but distinctly bisected anterior glabellar ring. Loc. *Gravicalymeme* bed (bed 1) at Sorayama, Fukuji, Gifu Prefecture; YAMAKOSHI coll., Shizenkan, no. 075, ×1.3.

Crotalocephalina (*Geracephalina*) *secta projecta* KOBAYASHI and HAMADA, subsp. nov. ....p. 109

Fig. 2. A large but compressed and fragmentary cranidium showing internal (b) and external (a) features of a glabella and an attached hypostoma (c: internal). Loc. bed 10, Ichinotani, Fukuji; OKAZAKI coll., Kyoto Univ., ×1.3.

Fig. 3. The holotype specimen showing surface texture and the facial suture line. Loc. blackshale of bed 8 at Ichinotani; OHNO coll., Kyoto Univ., no. 17′, ×1.1.

Fig. 4. Rubber replica of a part of cranidial exterior. Loc. Kanajiro-zako, Fukuji; KOIZUMI coll., PAt 7426, ×1.5.

Crotalocephalina (*Geracephalina*) *convexa* KOBAYASHI and HAMADA, sp. nov. ....p. 109

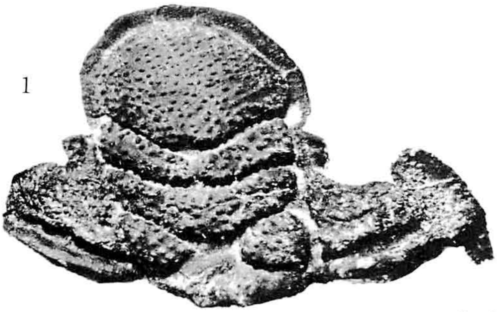
Fig. 5. An incomplete cranidium showing a little wide glabellar furrows and broadly bisected glabellar ring. Loc. Kanajiro-zako; KOIZUMI coll., PAt 7427, ×1.5.

Figs. 6, 7. Two detached free cheeks showing roughly pitted ornamentation. Loc. *ditto*; KOIZUMI coll., PAt 7428, 7429, ×2.0.

Fig. 8. Internal mould (a, c) and external replica (b) of an incomplete pygidium showing two rows of sharply pointed tubercles on the axial segments. Loc. *ditto*; KOIZUMI coll., PAt 7430, ×1.5.

Fig. 9. The holotype specimen showing a well convex carapace of the cranidium. Loc. ditto; Ono coll., PAt 7431, ×1.1.

Fig. 10. Internal mould (a) and external replica of a part of thoracic segments. Loc. *ditto*; KOIZUMI coll., PAt 7432, ×2.0.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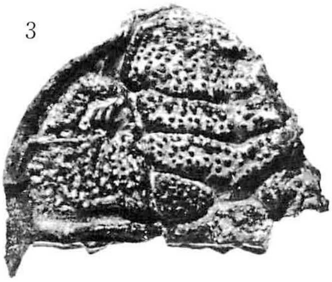
2a


2b


3


2c


5a

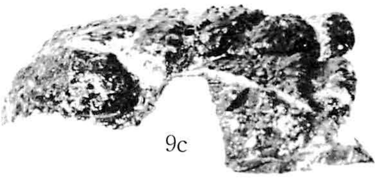

4


5b


5c


6


7


9c


9b


8a


9a


8c


10a


8b


10b

Plate 7

Explanation of Plate 7

Crotalocephalina (*Geracephalina*) *euryrachis* KOBAYASHI and HAMADA, sp. nov. ....p. 110

Figs. 1, 2. Internal moulds of two cranidia showing general features of the cephalic segmentation and ornamentation. Loc. *Gravicalymene* bed (bed 1) at Sorayama, Fukuji, Gifu Prefecture; YAMAKOSHI coll., Shizenkan, ×1.1; OKAZAKI coll., Kyoto Univ., no. 19, ×1.5.

Fig. 3. Another internal mould of a cephalon showing facial suture line and an eye. Loc. *ditto*; YAMAKOSHI coll., PAt 7433, ×1.7.

Figs. 4, 5. Two depressed cranidia, from the same locality, YAMAKOSHI coll., PAt 7434, ×1.5: and from Kinma-michi, Fukuji; OKAZAKI coll., Kyoto Univ., no. 4 (OKAZAKI, 1974, pl. 8, fig. 8), ×1.5.

Fig. 6. The holotype specimen collected from bed 8 (black shale) at Ichinotani showing surface ornamentation and a short genal spine. TATEMATSU coll., Kyoto Univ., no. 3 (OKAZAKI, 1974, pl. 8, fig. 7), ×1.6.

Crotalocephalina (*Crotalocephalides?*) sp. indet. ....p. 107

Fig. 7. A large cranidium showing a long genal spine and a rudimentary pregenal spine with granulate surface of the text. Loc. bed 1 at Sorayama; YAMAKOSHI coll., Shizenkan, no. 3 (OKAZAKI, 1974, pl. 7, fig. 7), ×1.5.

Crotalocephalina (*Crotalocephalides*) sp. indet. ....p. 107

Fig. 8. External rubber replica of a right half side of a cephalon showing a prominent pregenal angulation where the facial suture line starts. Loc. Ichinotani; KOIZUMI coll., PAt 7435, ×1.5.

Crotalocephalinid hypostomata

Fig. 9. Frontal portion of an indeterminable large hypostoma showing rather minute granulation and gentle curvature of the test. Loc. Oisé, Fukui Prefecture; ONO coll., PAt 7436, ×1.3.

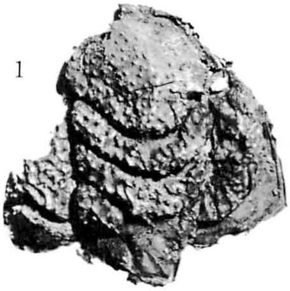
Figs. 10-12. Three hypostomata probably belong to *Crotalocephalina* (*Geracephalina*) *convexa* showing the the general features. Loc. *Proetus* bed at Sorayama; TATEMATSU coll., Kyoto Univ., ×1.7; Ichinotani, ONO coll., PAt 7437, ×1.3; Kanajiro-zako, KOIZUMI coll., PAt 7438, ×2.0, respectively.

Fig. 13. Another hypostoma, probably of *Crotalecephalina* (*Geracephalina*) *secta projecta*, collected from bed 10 at Ichinotani; TATEMATSU coll., Kyoto Univ., ×1.5.

Crotalocephalinid pygidia

Fig. 14. A ventral view of an indeterminable pygidium having stout and blunt caudal spines and a pointed caudal extremity. Loc. bed 8 (black shale) at Ichinotani; MIZUNO coll., Kyoto Univ. (OKAZAKI, 1974, pl. 8, fig. 10), ×1.8.

Fig. 15. Another small indeterminable pygidium procured from Oisé, Fukui Prefecture. TANAKA coll. (YT-56), PAt 7439, ×6.9.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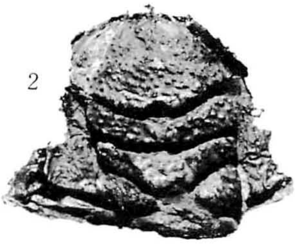

2

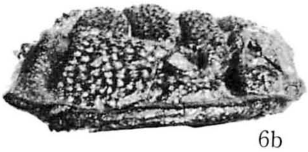

3


4


5a


5b


6a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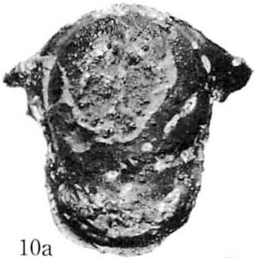
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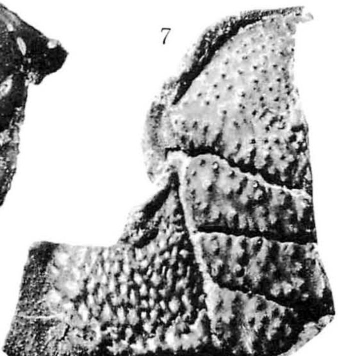
7


8


9


10a


11a


12


11b


14


15


11c


13

Plate 8

Explanation of Plate 8

Phacops (subgen. nov. ?) *manchuricus* KOBAYASHI and HAMADA, sp. nov. .... p. 117
Fig. 1. The holotype cephalon showing the internal features. Loc. Kinsui, Northeast China; NONAKA coll., PAt 7740, ×1.5.

Crotalocephalina (*Crotalocephalina*) sp. indet. .... p. 103
Fig. 2. Two different views of a specimen. The facial suture line and an eye are well represented. Note the frontal projection of the glabella. Loc. Takaharagawa formation at Kinma-michi, Fukuji, Gifu Prefecture; IGO coll., Geol. Min. Inst., Tokyo Univ. Educ., T.U.E., ×2.5.

Crotalocephalina (*Pilletopeltis*) *japonica* (KOBAYASHI and IGO, 1956) .... p. 104
Fig. 3. The holotype carapace showing a part of cephalon and thoracic segments. Loc. *ditto*; IGO coll., Geol. Min. Inst. Tokyo Univ. Educ., T.U.E., ×2.5.
Figs. 4, 5. Two fragmentary glabellae from the same locality. ×2.5.
Fig. 6. A part of a pygidium showing the tuberculation on the axis. Loc. and repository; *ditto*, ×2.5.

Flexicalymenid, gen. et sp. indet .... p. 131
Fig. 7. An incomplete pygidium collected from the same locality as above, ×2.5.

Dechenella (*Dechenella*) *minima* OKUBO, 1951 .... p. 143
Fig. 8. Dorsal and left lateral views of the holotype cranidium. Loc. Nakazato Series at Higuchi-zawa, Sakari district, Iwaté Presecture; OKUBO coll., PAt 7441, ×5.

Thysanopeltella (*Septimopeltis*) *paucispinosa* (OKUBO, 1951) .... p. 80
Fig. 9. Cast and mould of the holotype specimen. Loc. Nakazato Series, Omori-zawa, Sakari district; OKUBO coll., PAt 7442, ×2.0.

The figures from 2 through 7 are reproduced from plate 10 by KOBAYASHI and IGO (1956), and figures 8 and 9 are from plate 1 by KOBAYASHI (1957), respectively.


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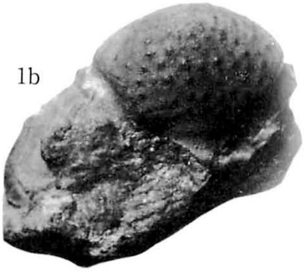
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1c


1d


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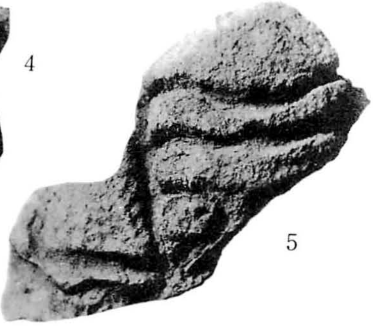
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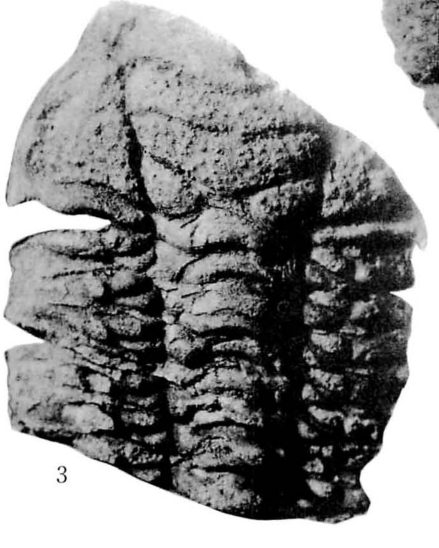
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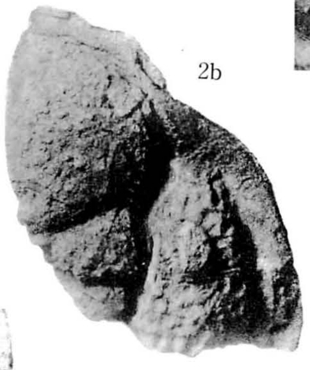
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8b


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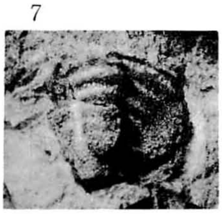
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6

Plate 9

Explanation of Plate 9

Reedops nonakai (OKUBO, 1956) .... p. 121

Fig. 1. The holotype specimen showing the general outline and a vincular furrow. Loc. Nakazato Series at Higuchizawa, Sakari district, Iwate Prefecture; OKUBO coll., PAt 7443, ×1.6.

Phacops (new subgenus?) *manchuricus* KOBAYASHI and HAMADA, sp. nov. .... p. 117

Fig. 2. An internal mould of a pygidium. Loc. Kinsui, Northeast China; NONANA coll., PAt 7444, ×2.8.

Fig. 3. Frontal portion of a glabella showing surface granulation. Loc. *ditto*; NONAKA coll., PAt 7445, ×1.5.

Fig. 4. A fragmentary thoracic segment. Loc. and coll., *ditto*; PAt 7446, ×1.7.

Odontochile sp. indet. .... p. 122

Fig. 5. A part of a large pygidium showing pleural segmentation and narrow marginal border. Loc. and coll., *ditto*, PAt 8908, ×1.1.

Fig. 6. Upper (a) and lower (b) surface of a genal spine. Loc. and coll. *ditto*, PAt 8909, ×1.1.

Phacops cf. *okanoi* SUGIYAMA, 1944 .... p. 120

Fig. 7. Different views of two cephala closely set on a slab showing very large compound eyes and the broad, longitudinally elongate glabellar portion. Loc. Nakazato Series at Higuchi-zawa, Sakari district; OKANO coll., PAt. 8910, ×2.1.

Phacops okanoi SUGIYAMA, 1944 .... p. 120

Fig. 8. Obliquely frontal view of a clay model of the holotype cranidium showing granulation and a large compound eye. Loc. *ditto*; SUGIYAMA coll., IGPS 64549, ×1.3.


1b

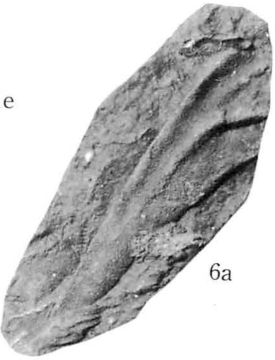

1a


5


1c


1d


1e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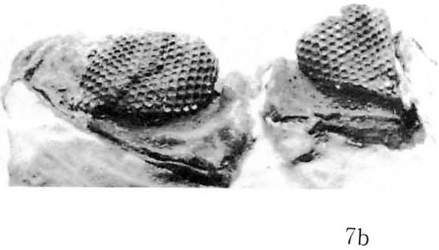
3


2


6b


4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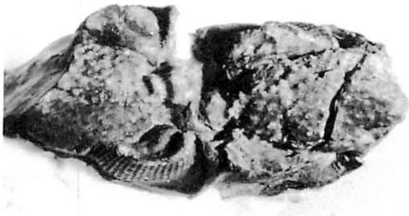
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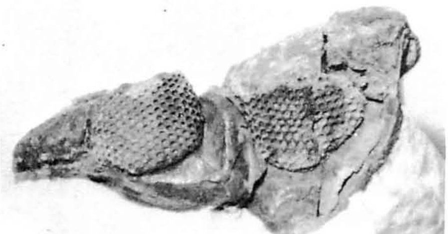
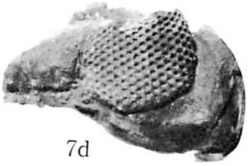



7d

8

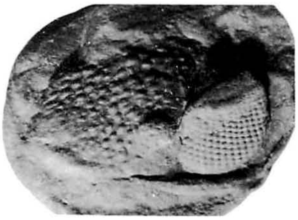


Plate 10

Explanation of Plate 10

Gravicalymene yamakoshii KOBAYASHI and HAMADA, sp. nov. ....p. 127

Fig. 1. The largest cranidium. Loc. *Gravicalymene* bed (bed 1) at Sorayama, Fukuji, Gifu Prefecture; YAMAKOSHI coll., PAt 8911, ×1.5.

Fig. 2. The holotype syecimen. Loc. *ditto*; YAMAKOSHI coll., Shizenkan, no. 121, ×2.2.

Fig. 3. Another large cranidium. Loc. *ditto*; WAKATA coll. (W-1), ×2.2.

Fig. 4. Internal and external features of a paratype-1 cranidium from the same locality. KOIZUMI coll., PAt 8912, ×3.2.

Fig. 5. Another cranidium that possesses a part of the shelly material of the test showing fine granulation. Loc. *ditto*; YAMAKOSHI coll., PAt 8913, ×1.7.

Fig. 6. Slightly compressed cranidium. Loc. *ditto*; OKAZAKI coll., Kyoto Univ., (OKAZAKI, 1974, pl. 9, fig. 1), ×1.7.

Fig. 7. An incomplete cranidium obtained from a limestone float at Ichinotani, Fukuji; KOIZUMI coll., PAt 8914, ×2.0.

Figs. 8, 10, 13. Three cranidia collected from Oise, Fukui Prefecture. TANAKA coll. (YT-26), PAt 8915, ×4.5; (YT-6), PAt 8916, ×4.6 and (YT-25), PAt 8917, ×1.5, respectively.

Figs. 9, 11, 12. Three cranidia from Sorayama (bed 1). OKAZAKI coll., Kyoto Univ., no. (on the same slab as the specimen in Fig. 6 of this plate), ×1.7; YAMAKOSHI coll., PAt 8918, ×1.6; OKAZAKI coll., Kyoto Univ., no. 8 (OKAZAKI, 1974, pl. 9, fig. 2), ×1.7.

Fig. 14. An internal mould of a cranidium collected from bed 1 at Sorayama. WAKATA coll. (W-2), ×1.8.

Flexicalymenid, gen. et sp. indet. ....p. 131

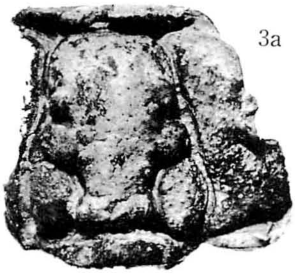
Fig. 15. An internal mould of an incomplete cranidium collected from Kinma-michi. HAMADA coll., PAt 8919, ×1.3.

1

2a

2b

3a



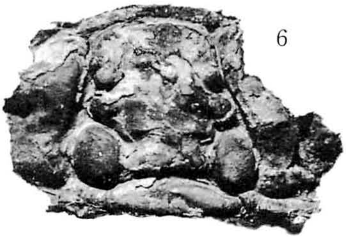
4a

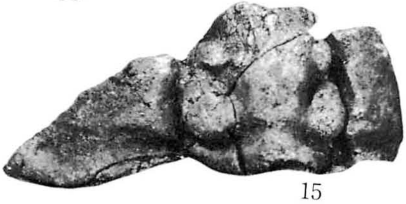
5

3b

4b

6





15

7

8

14b

10

11

14c

9

14a

13

12

Plate 11

Explanation of Plate 11

Gravicalymene yamakoshii KOBAYASHI and HAMADA, sp. nov. ....p. 127

Figs. 1, 2. Two left free cheeks showing the exterior. Loc. Oisé, Fukui, Prefecture; TANAKA coll. (YT-9), PAt 8920, ×6.4 and paratype-2 (YT-10), PAt 8921, ×5.0, respectively.

Figs. 3, 4. Two left free cheeks showing the internal surface. Loc. *Gravicalymene* bed (bed 1) at Sorayama, Fukuji, Gifu Prefecture; WAKATA coll. (W-5), ×2.6 and paratype 3 (W-4), PAt 8922, ×2.1.

Fig. 5. Another free cheek found in a limestone float from Ichinotani, Fukuji. KOIZUMI coll., PAt 8923, ×2.0.

Fig. 6. A small hypostoma from Oisé. TANAKA coll. (YT-43), PAt 8924, ×6.6.

Fig. 7. An incomplete hypostoma in a limestone float at Ichinotani; KOIZUMI coll., PAt 8925, ×3.0.

Fig. 8. A small pygidium showing its high convexity. Loc. Kanajiro-zako, Fukuji (in association with *Primaspis* (?) *tanakai*); TANAKA coll., PAt 8926, ×7.4.

Fig. 9. A thoracic segment embedded in a mother rock. Loc. *Gravicalymene* bed (bed 1) at Sorayama, Fukuji; WAKATA coll. (W-2′), ×1.8.

Fig. 10. Almost complete pygidium of moderate size. Loc. *ditto*; OKAZAKI coll., Kyoto Univ., no. 9 (OKAZAKI, 1974, pl. 9, fig. 5), ×1.7.

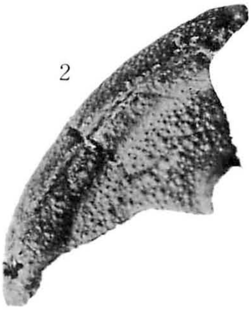
Fig. 11. Another pygidium from the same locality. WAKATA coll. paratype-5 (W-3), PAt 8927, ×1.7.

Figs. 12, 13. Two small pygidia from Oisé. TANAKA coll. (YT-7, 8), PAt 8928, 8929, ×4.5.

Fig. 14. A large pygidium from bed 1 at Sorayama. YAMAKOSHI coll., Shizen-kan, no. 121-a (OKAZAKI, 1974, pl. 9, figs. 3 and 4), ×2.2.

Fig. 15. Rubber replica of an incomplete pygidium showing large, smooth terminal piece of the axial segment. Loc. In a limestone float at Ichinotani; KOIZUMI coll., PAt 8930, ×2.0.

2



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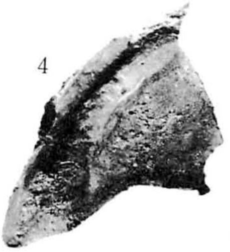
6

7

5

1

4

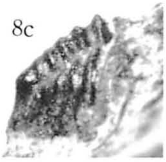


8a

10b

10c

8c



8b

9

10a

11c

10d

12

11b

11d

11a

13

14

11e

15

Plate 12

Explanation of Plate 12

Unguliproetus oisensis KOBAYASHI and HAMADA, sp. nov. . . . . p. 134

Figs. 1-8. Eight cranidia showing variation in size and features. Loc. Oisé, Fukui Prefecture; TANAKA coll. YT-29), PAt 8931, ×6.3, (YT-62), PAt 8932, ×6.5, holotype specimen (YT-30), PAt 8933, ×6.2, (YT-61), PAt 8934, ×6.6, (YT-28), PAt 8935, ×3.5, (YT-65), PAt 8936, ×6.2, (YT-44), PAt 8937, ×6.9 and (YT-60), PAt 8938, ×6.2, respectively.

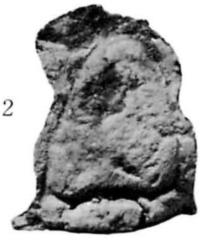
Figs. 9-11. Three incomplete hypostomata from the same locality. TANAKA coll. (YT-42), PAt 8939, ×6.4, (YT-67-68), PAt 8940, ×9.0 and (YT-51), PAt 8941, ×6.6.

Fig. 12. An incomplete cephalon (rubber replica) showing genal spine, facial suture line and the left eye. Loc. *ditto*; IMAI coll., PAt 8942, ×2.6.

Figs. 13-16. Four free cheeks from Oisé. TANAKA coll. (YT-5), PAt 8943, ×4.8, (YT-33), PAt 8944, ×4.6, (YT-4), PAt 8945, ×6.4 and (YT-41), PAt 8946, ×6.5, respectively.

Figs. 17-25. Series of pygidia showing the general features and variation in size and form. Note rather transversely elongate form in the smaller specimens. Loc. Oisé; TANAKA coll. (F010103), PAt 8947, ×6.7, (YT-39), PAt 8948, ×6.7, (YT-38), PAt 8949, ×6.7, (YT-36), PAt 8950, ×6.2, (YT-37), PAt 8951, ×6.7, (YT-34), PAt 8952, ×5.0, (YT-48), PAt 8953, ×4.1, (YT-35), PAt 8954, ×6.3, (YT-55), PAt 8955, ×4.9, respectively.


1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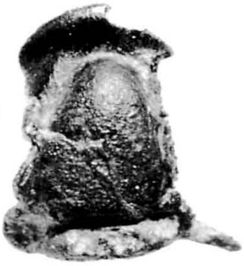
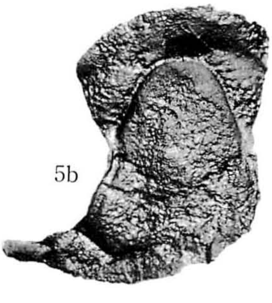

3


4


5a


5b


6


7


8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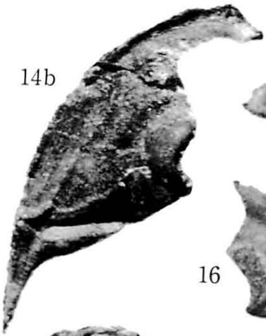
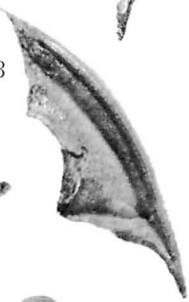

14b


14a


13


11


16


15


17a


17b

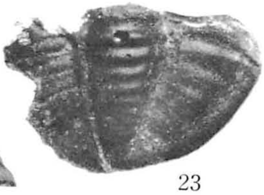

19a


19b


18b


20a


20b


23


18a


18c


21b


20c


24b


21a


22


24a


25

Plate 13

Explanation of Plate 13

Unguliproetus oisensis KOBAYASHI and HAMADA, sp. nov. ....p. 134

Fig. 1. The largest pygidium (paratype specimen) in the collection. Loc. Oisé, Fukui Prefecture; TANAKA coll. (YT-32), PAt 8956, ×4.5.

Proetus (*Coniproetus*) *fukujiensis* KOBAYASHI and HAMADA, sp. nov. ....p. 133

Figs. 2-6. Series of pygidia showing variation in size and form. Loc. bed 1 (shale and limestone alternation) at Sorayama, Fukuji, Gifu Prefecture; OKAZAKI coll., Kyoto Univ., no. 11-1 (OKAZAKI, 1974, pl. 9, fig. 8), ×6.1; *ibid.*, no. 10-2 (*loc. cit.*, pl. 9, fig. 9), ×5.4; Kinma-michi?, Fukuji; YAMAKOSHI coll., PAt 8957, ×4.9; platy limestone below *Gravicalymene* bed (bed 1); WAKATA coll. (W-6), paratype specimen, PAt 8958, ×6.0; *ibid.*, (W-7), ×6.0, respectively.

Figs. 7, 8, 14. Three free cheeks from Sorayama. Loc. *Gravicalymene* bed (bed 1); YAMAKOSHI coll., PAt 8959, ×2.7; alternation of bed 1; OKAZAKI coll., Kyoto Univ., no. 10 (OKAZAKI, 1974, pl. 9, fig. 7), ×3.8; *Gravicalymene* bed; YAMAKOSHI coll., PAt 8960, ×2.5.

Fig. 9. The holotype cranidium showing general features and surface ornamentation. Loc. *Gravicalymene* bed; YAMAKOSHI coll., PAt 8961, ×3.4.

Figs. 10-12. Three other cranidia from the same bed as the holotype specimen. YAMAKOSHI coll., PAt 8962, ×3.5, PAt 8963, ×3.3 and PAt 8964, ×2.6.

Fig. 13. An incomplete cranidium showing surface ornamentation. Loc. bed 1 (alternation); OKAZAKI coll., Kyoto Univ., no. 10-1 (OKAZAKI, 1974, pl. 9, fig. 6), ×4.7.

Proetid, gen. et sp. indet. (a) ....p. 136

Figs. 15, 16. Two incomplete pygidia from different localities, both of which showing the stenorhachis nature. Loc. Oisé; TANAKA coll. (YT-49), PAt 8965, ×4.2 and *Gravicalymene* bed (bed 1) at Sorayama; YAMAKOSHI coll., PAt 8966, ×3.2.

Proetid, gen et sp. indet. (b)..p. 136

Fig. 17. A deltoid pygidium from *Gravicalymene* bed at Sorayama; YAMAKOSHI coll., PAt 8967, ×3.3.

Proetoid, gen. et sp. indet...p. 136

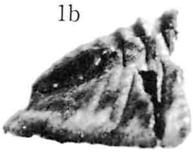
Fig. 18. Internal mould of a fragmentary pygidium. Loc. Kinma-michi, Fukuji; YASUÉ coll. (61071707d), Yokohama Notional Univ., ×3.0.


2


3


5a

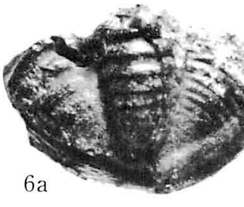

4


1b


5c


5b


1a


6a


6b


15

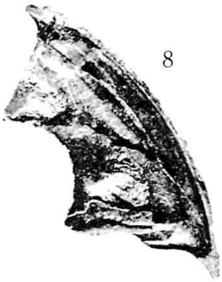

9a


9b


7


16


10b


8


11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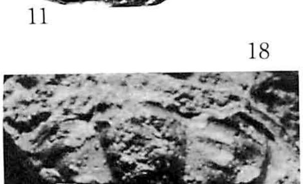
14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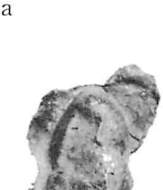
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13


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