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THE CAMBRO-ORDOVICIAN FORMATIONS AND FAUNAS OF SOUTH KOREA, PART VI, *PALAEONTOLOGY V.*

By

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THE CAMBRO-ORDOVICIAN FORMATIONS AND FAUNAS OF SOUTH KOREA, PART VI.

Palaeontology V.

By

Teiichi KOBAYASHI*

With Plates XII–XIV

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Introductory Notes

The geology of the Kangwŏn-do (Kogendo) Limestone Plateau which I lately described is the part 4 of this series of publications. However, more than twenty years elapsed since the third part of Palaeontology had been published. During this interval new localities were discovered in the Mun'gyŏng (Bunkei), Tan'gyang (Tanyo) and other areas by SHIRAKI, AMANO, YOSIMURA, IWAYA, HUKASAWA, AOTI and others including myself, and new materials were collected by them. Some of the fossils are however, poorly preserved, while some others are not yet precisely allocated in the stratigraphic sequence. This was one of the reasons that I postponed to monograph them, although many other works interrupted me in this study.

The last paper (1958) containing the description of 7 species of gastropods from Mun'gyŏng district is the part 5 of the Cambro-Ordovician Formations and Faunas of South Korea.

Among the papers which I have published after the third part of palaeontology the followings deal with the Cambro-Ordovician fossils of South Korea.

1. 1936. An Introduction to the Classification of the Primitive Cephalopoda, Pts. 1-5. *Chikyu, the Globe, Vol. 25.*
   Kotoceras, Kawasakiceras, Sigmorthoceras, Sigmocycloceras, Sactorthoceras and some other genera discussed.
2. 1936. Three contributions to the Cambro-Ordovician Faunas. *Japan. Jour. Geol. Geogr. Vol. 13.*
   Asaphopsis nakamurai, n. sp. and *Asaphopsis* cfr. *nakamurai.*
3. 1936. On the Stereoplasmoceratidae. *Ibid. Vol. 13.*
   Some changes made in generic references.
4. 1937. Contribution to the Study of the Apical End of the Ordovician Nautiloids. *Ibid. Vol. 14.*
   Detailed description of *Selkirkoceras yokusenense* and *S.* cfr. *yokusenense.*
5. 1939. On the Agnostida, Part I. *Jour. Fac, Sci. Imp. Univ. Tokyo, Sect. 2, Vol. 5, Pt. 5.*
   Agnostidian species revised.
6. 1939. Restudy on LORENZ's *Raphistoma bröggeri* from Shantung with a Note on *Pelagiella. Jub. Publ. Comm. Prof.* YABE's *60th Birthday. Vol. 1.*
   Proscaevogyra established for *Pelagiella* (?) *reversa;* remarks on *Pelagiella hana.*
7. 1941-42. Studies on Cambrian Trilobite Genera and Families, 1-4. *Japan. Jour. Geol. Geogr. Vol. 18.*
   Damesellidae species revised.
8. 1942. With Toshio KIMURA. A discovery of Lower Ordovician Graptolites in South Chosen with a Brief Note on the Ordovician Graptolite Zones in Eastern Asia. *Ibid. Vol. 18.*
   Describes *Dictyonema* cfr. *flabelliforme* and *Clonograptus* (?) sp.
9. 1942. An occurrence of Dolichometopids in South Chosen with a Summary Note on the Classification of the Dolichometopinae. *Jour. Geol. Soc. Japan. 49.*
   Amphoton derceto var. *spinula,* new var. and *Amphoton microlops,* new species.
10. 1943. Brief Notes on the Eodiscids. 1-2. *Proc. Imp. Acad. Vol. 19.*
    Metadiscus bunkeiensis KOBAYASHI, new species and *M. bunkeiensis* var. *sulcata* KOBAYASHI, new var.
11. 1944. On the Cambrian Sea-Connection between South Chosen and Eastern Tien-

shan. *Proc. Imp. Acad. Vol. 20.*
Discovery of *Hedinia regalis* in Bunkei district.

12. 1944. Discovery of *Olenus* in South Chosen. *Ibid. Vol. 20.*
Olenus asiaticus. n. and *Acrocephalina trisulcata,* n. described from near Neietsu.
13. 1949. The *Glytagnostus* Hemera, the oldest world Instant. *Japan. Jour. Geol. Geogr. Vol. 21.*
Describes *Glyptagnostus reticulatus* from north of Neietsu.
14. On *Birmanites,* a Lower Ordovician Genus of Trilobite. *Jour. Geol. Soc. Japan. Vol. 56.*
Ogyginus cordensis from Saishori referred to *Birmanites.*
15. 1953. On the Kainellidae. *Japan, Jour. Geol. Geogr., Vol. 23.*
Includes descriptions of *Kainella euryrachis,* n. sp., *Pseudokainella iwayai,* n. sp., *Pseudokainella* a. sp., *Pseudokainella* (?) b. sp., *Hukasawaia,* n. g. of *Richardsonella, Hukasawaia cylindrica,* n. sp. and *Apatokephalus hyotan,* n. sp.
16. 1954. On the Komaspidae. *Ibid. Vol. 24.*
Redescribes *Komaspis* (*Parairvingella*) *convexa.*
17. 1956. On the Kaolishaniinae. *Ibid. Vol. 27.*
Restoration of *Chosenia laticephala.*
18. 1958. Some Cambro-Ordovician Fossils from the Tan'gyang or Tanyo District, South Korea. *Trans. Proc. Pal. Soc. Japan. N. S. No. 30.*
Describes *Kingstonia parallela, Plethometopus longispinus, Iddingsia orientalis, Berkeia shantungensis, Hamashania* (?) sp.
19. 1958. On Some Cambrian Gastropods from Korea. *Japan. Jour. Geol. Geogr. Vol. 29.*
Hampilina goniospira described from Mun'gyŏng district.
20. 1958. Some Ordovician gastropods from the Mun'gyŏng or Bunkei District, South Korea. *Jour. Fac. Sci. Univ. Tokyo, Sect. 2, Vol. 11, Pt. 2.*
Describes *"Bellerophon" aotii,* n. sp., *Scalites irregulare,* n. sp., *Helicotoma amanoi,* n. sp. and some other species.

The Cambrian and Ordovician Faunas of South Korea described in the Parts 1-3 in 1934-35 were mostly procured from the strata on the southeastern side of the limestone plateau, in the sequence of which is now known by the name of the Tsuibon type. It is quite distinct from that of the axial part of the Yokusen folded mountains. The so-called *Olenoides* zone of Neietsu, however, has been the sole fossil bed in the Neietsu anticlinorium known before 1935.

Intensive investigations were repeated from 1938 to 1940 by I. YOSIMURA and T. HUKASAWA jointly with me. As a result copious faunas were found at many localities in various horizons and the Cambro-Ordovician sequence of the Neietsu type was classified as follows:

The Middle Ordovician Eiko formation.
The Lower Ordovician Bunkoku formation.
The Upper Cambrian Gakoku formation.
The Upper and Middle Cambrian Machari formation.
The Middle Cambrian Samposan formation.

The base of the Samposan is unexposed. A few graptolites discovered by HUKASAWA from the Bunkoku formation were described in 1942 by KIMURA and myself; a few trilobites from the Bunkoku and Machari formations also described by me on some occasions. It is aimed here to figure the whole picture of the Gakoku and Bunkoku faunas and, at the same time to supple-

ment some notes to the Ordovician fauna in the Tsuibon zone.

Anatifopsis is indeed a new find outside Europe. On this occasion the Trilobite classification is briefly reviewed and my view added. A precise stratigraphic description of the Bunkoku and Gakoku formations and a detailed discussion on their faunas are, however, deferred to a later occasion.

Here I wish to record my sincere thanks to Dr. G. A. COOPER of the U.S. National Museum, Wanshington, D.C. for sending me the plaster casts and photographs of the holotypes of *Dikellocephalus flabellifer* HALL and WHITFIELD and *D. multicinctus* HALL and WHITFIELD.

Formation and Localities

The Gakoku formation is chiefly composed of dolomitic limestone, but chert layers are intercalated in the lower part. Fossils are very rare in it. Brachiopods and trilobites which were obtained at the following four localities, all in Yŏngwŏl-gun, Kangwŏn-do, are poorly preserved. The *Apheoorthis* faunule is proposed for them because of the superiority in the number of specimens.

Loc. 253. Northwest of Nŭng-dong, Yŏngwŏl; Ryodo Decke.
寧越面陵洞北西
Loc. 262. Southwest of Nŏl-tari, Puk-myŏn; Machari Decke.
北面磨碓里南西，磨碓里共同墓地の山
Loc. 263. Southwest of Mach'a-ri, Puk-myŏn; Chikari Decke.
北面磨碓里南西
Loc. 275. Southwest of Kok-kol, Puk-myŏn; Machari Decke.
北面谷洞南西

Apheoorthis ranges in North America from Upper Cambrian to Basal Ordovician or Upper Ozarkian by ULRICH and occurs commonly in the Cordilleran province. Because the Gakoku formation lies between the Machari formation and Lower Ordovician Bunkoku formation and because the Machari yields *Olenus* in the upper part, the Gakoku must be medieval and late Upper Cambrian in age.

The Bunkoku formation consists of limestone, limestone-conglomerate, marl and shale in alternation. *Yosimuraspis* is ubiquitous in the dolomitic limestone in the basal part which contains *Asaphellus* in rare instances (ex. Loc. 289). Hence the name *Yosimuraspis* beds. *Yosimuraspis* is, however, absent in the beds which bear various other fossils. The fossil localities of the formation are as follows:

YOSIMURA collection. (Y: *Yosimuraspis* zone)
Loc. 206. 14 km. NNE of Chŭng-san, Puk-myŏn; Machari Decke.
北面甑山北北東
Loc. 221. East of Namae-ri, Puk-myŏn; Chikari Decke.
北面南崖里東方
Loc. 232. East of Mungong-ni, Puk-myŏn; Nangairi Decke.
北面文谷里東方
Loc. 233. West of Chŭng-san, Puk-myŏn; Chikari Decke.
北面甑山西方

Locs. 234–236. (Y), West of Chŭng-san, Puk-myŏn; Chikari Decke.
北面甑山西方
Locs. 238–240. West of Chŭng-san, Puk-myŏn; Chikari Decke.
同　上
Loc. 247. Munp'ori, Puk-myŏn, Yŏngwŏl-gun, Nangari Decke.
北面文浦里
Locs. 248–249. West of Chŭng-san, Puk-myŏn; Chikari Decke.
北面甑山西方
Locs. 250–252. Highway at Mohari, Puk-myŏn; Chikari Decke.
北面茅下里自動車路
Loc. 266. Noŭn-tong, Puk-myŏn; Chikari Decke.
北面老隱里
Loc. 272. (Y), 500m. West of Changsong-gok, Moha-ri, Puk-myŏn; Nangairi Decke.
北面茅下里獐成谷西方500米
Loc. 277. (Y), SW of Kok-kol, Puk-myŏn; Machari Decke.
北面谷洞南西
Loc. 282. Kok-kol, Puk-myŏn; Macahri Decke.
北面谷洞
Loc. 289. (Y), West of Karae-gol, Puk-myŏn; Nangairi Decke.
北面楸洞西方

HUKASAWA collection.

Yosimuraspis zone.

Loc. 01907. East of Umji, Chongbu-ri, P'yongch'ang-myŏn.
平昌面鐘阜里陰地東方
Loc. 91602. 500 m. saddle of Paeil-ch'i, Paeg'un-dong, Mungong-ni, Puk-myŏn.
寧越北面文谷里白雲洞拝日峙
Loc. 91603. 2 km. northwest of Loc. 91602.
Loc. 91602 の北西2粁
Loc. 91902. East of Tŏksang-ni, Puk-myŏn.
北面德上里東方
Loc. 91903. North of Tŏksang-ni, Puk-myŏn.
北面德上里北方
Loc. 91904. Saman, Toksang-ni, Puk-myŏn.
北面德上里沙湾
Loc. 91905. 300 m. west of the pass of Saman, north of Toksang-ni, Puk-myŏn.
北面德上里北方沙湾へ行く峠の西下300米
Loc. 92005. East of Sajong-ch'i, Ongjŏng-ni, Sŏ-myŏn.
西面舍亭里射亭山峙東方
Loc. 92007. P'ong-dong, Puk-myŏn.
北面坪洞
Loc. 92101. NNE of Puksang-ni, Sŏ-myŏn.
西面双里北北東
Loc. 100102. South of Wŏn-dong, southwest of San'yŏngwŏl, Puk-myŏn.
北面山靈月南西，院洞南方
Loc. 100906a. West of Myŏngna-gok, Sanae-ri, Sŏ-myŏn.
西面新川里鳴羅谷

Higher beds.

Loc. 91405. Paeg'un-dong, Puk-myŏn.
北面白雲洞
Loc. 92002. Boulder at Hwapyŏng at the foot of the pass to Puksang-ni, Ongjong-ni, Sŏ-myŏn.
西面愛亭里北双里へ行く峠の麓 花屏の転石
Locs. 92902–92903. 2 km. south of Kal-kol, Puk-myŏn.
北面蘆洞南方2粁

Loc. 92906. 1 km. east of Yongso-gol, southwest of Kal-kol, Puk-myŏn.
北面竜洞東方1料
Locs. 93002-93004. Mudong-gol, Yongong-ni, Puk-myŏn.
北面延徳里舞童谷
Loc. 100101. South of San'yŏng-wŏl, west of Yondong-ni, Puk-myŏn.
北面延徳里西方山霊月の南
Loc. 100903. West of Pae-Maul, Sŏ-myŏn.
西面舟村西方
Loc. 100906b. See 100906a.
Loc. 101110. North of Ap'asil, Mai-ri, P'yongch'ang-myŏn.
平昌面馬池里阿波実北方
Loc. 101909, SSE of Umji, Chongbu-ri, P'yongch'ang-myŏn.
平昌面鐘阜里陰地南南西

The main Bunkoku fauna which is contained in the formation above the *Yosimuraspis* zone is a copious one as shown in the table on page 225. In the Tsuibon type of sequence *Lingulella tomkolensis Micragnostus coreanicus* and *Asaphellus tomkolensis* occur in the lower or *Asaphellus* zone, *Shumardia pellizzarii, Protopliomerops punctatus, Metapilekia martellii* and *Plumulites primus* in the middle or *Protopliomerops* zone and *Pomatotrema shinsoensis, Koraipsis spinus* and *Hystricurus megalops* in the upper or *Clarkella* zone.

In the type section of the Bunkoku formation the fossil localities 238, 239, 240, 248, 249 and 233 are aligned from the lower to the upper horizon. *Apatokephalus hyotan, Asaphellus tomkolensis* and *Anatifopsis cocaban* are vertically long-ranged and *Asaphellus tomkolensis* is found together with *Shumardia pellizzarii* and *Hystricurus megalops* in the highest horizon in the section. At Loc. 252 *Micragnostus coreanicus* and *Asaphellus tomkolensis* are accompanied by *Protopliomerops punctatus* and *Pomatotrema* cfr. *shinsoensis*. Thus the vertical distribution of these species is somewhat different from that found in the Tsuibon sequence. Nevertheless, it is certain that the Bunkoku fauna can be correlated on the whole to those of the Tomkol and lower Makkol formations. The Lower Ordovician age of the Bunkoku fauna is further endorsed by the inclusion of *Apatokephalus, Dikelokephalina, Metapilekia, Hintzeia, Anatifopsis* and *Dictyonema* cfr. *flabelliforme*.

Beside these *Palaeacmaea* (?) sp., *Clarkella vulgaris* and *Ribeirella subcircularis* were procured by YOSIMURA from Loc. 193 which is presumably located in the *Clarkella* zone at a point about 1 km. to the east of Yemiri, Sangdong-myŏn, Yŏngwŏl-gun, Kangwŏn-do, 江原道寧越郡上東面礼美里東方 1 粁.

In addition, some fossils described here belong to SHIRAKI's collection from two localities in the Tomkol shale on the north and south wings of the Hakunsan syncline as follows:

Shi-2. NNE. of Chamiwŏn, Nam-myŏn, Chŏngsŏn-gun, Kangwŏn-do.
江原道旌善郡紫味院北北東
Sei-14. About 800 m. north from the branching point of roads between Sosa-gok and Ch'ojon-chon, Sangdong-myŏn, Yŏngwŏl-gun, Kangwŏn-do.
江原道寧越郡上東面沙谷・草田村間道路

Finally, some comments are given on a few fossils from the Tomkol shale at the following localities which are already described in Part 3.

Locality	Yosimura's Collection: Type Section															Hukasawa's Collection										
	238	239	240	248	249	233	206	221	232	247	250	251	252	265	266	91405	92002	92902	92903	92906	93002	93004	100101	100906	100903	101909	101110
1. *Lingulella tomkolensis*		(×)		×								×						×									
2. *Pomatotrema* (?) sp.										×			×														
3. *Hyolithes* (?) sp.					×																						
4. *Micragnostus coreanicus*				×									×		×										×		
5. *Shumardia pellizzarii*					×	×																					×
6. *Hystricurus megalops*			×			×												×	×	×						×	
7. *Hukasawaia cylindrica*					×																						
8. *Pseudokainella* a sp.								×																			
9. *Aotiaspis* sp. indt.								×																			
10. *Apatokephalus hyotan*	×	×		×	×	×					×		×	×													
11. *Dikelokephalina parva*				×	×																						
12. *Dikelokephalina conica*				×																							
13. *Asaphellus tomkolensis*		×		×	×	×	(×)	×					×														
14. *Metapilekia* sp. nov.									×																		
15. *Protopliomerops punctatus*											×		×														
16. *Koraipsis spinus*								×																×			
17. *Hintzeia glabella*																								×			
18. Pliomerid, thorax, gen. indt.																					×						
19. *Anatifopsis cocaban*		×	×	×		×																×					
20. *Anatifopsis truncatum*													×														
21. Cystoid, indt.													×														
22. *Plumulites* cfr. *primus*				×																							
23. *Plumulites* sp.							×	×			×																
24. *Dictyonema* cfr. *flabelliforme*																×										×	
25. *Clonograptus* (?) sp.																×										×	
26. Coprolites (?)																							×			×	

The Bunkoku Fauna (exclusive of the fossils from the *Yosimuraspis* zone)

Doten: Tongjom-ni, Sangjang-myŏn, Samch'ŏk-gun, Kangwŏn-do.
江原道三陟郡上東面銅店里
Makkol: Makkol, Sangdong-myŏn, Yŏngwŏl-gun, Kangwŏn-do.
江原道寧越郡上東面莫洞
Saishori: Sesong-ni, Sangdong-myŏn, Yŏngwŏl-gun, Kangwŏn-do.
江原道寧越郡上東面細松里
Tomkol: Tumu-kol, Sangdong-myŏn, Yŏngwŏl-gun, Kangwŏn-do.
江原道寧越郡上東面斗務洞

Description of Fossil

One new family, five new genera, twelve new species and one new subspecies instituted through this paper are as follows:

Birmanitidae
Aotiaspis
Dainellicauda
Girvanopyge
Hederacauda
Yosimuraspis
Anatifopsis cocaban
Anatifopsis truncatum
Apheoorthis orientalis
Aotiaspis oblonga
Aotiaspis ovalis
Dikelokephalina conica
Dikelokephalina parva
Hintzeia glabella
Hystricurus calvus
Micragnostus coreanicus
Ribeirella subcircularis
Yosimuraspis vulgaris
Yosimuraspis vulgaris longulum

Some remarks are given on the Dikelocephalidae, Geragnostidae, Monkaspidae, Ribeiridae, Richardsonellidae, Teihungshaniidae, a few subfamilies, several genera and Upper Cambrian asaphids.

Phylum Brachiopoda

Class Inarticulata

Order Atremata.

Family Obolidae KING

Genus *Lingulella* SALTER, 1866

Lingulella tomkolensis KOBAYASHI, 1934

Plate XIII, Figures 12-13.

PB2354-13-12
PB2355-13-13

XIII
XIII

1934. *Lingulella tomkolensis* KOBAYASHI, *Jour. Fac. Sci., Imp. Univ. Tokyo, Sect. 2, Vol. 3, Pt. 9*, p. 527, pl. 3, fig. 4.

Dorsal valve nearly parallel-sided; lateral margins slightly arcuate, abruptly bent toward anterior margin which is also nearly straight; posterior margin forms an obtuse angle; ventral valve much longer than the dorsal; umbonal area protruded, forming an acute angle at the beak.

Occurrence:—Bunkoku Formation at Loc. 258; *Asaphellus* zone at Tomkol and Dotenri.

Class Articulata

Order Protremata

Family Billingsellidae WALCOTT and SCHUCHERT, 1908

A small collection from the Gakoku formation contains at least three kinds of protremate brachiopods. Little, however, is known of either the cardinal area or musculature except for a dorsal valve of *Eoothis* (?) sp. indt. in which the deltidium is absent. Surface ornaments of *Apheoorthis orientalis* is typical of the genus.

Genus *Eoothis* WALCOTT, 1908

Eoorthis (?) sp. indt.

Plate XII, Figures 5-6.

PB2356-12-5
PB2357-12-6

Shell a little broader than long and gently convex. The dorsal valve in fig. 5 has a broad obtuse umbo where ornamentation is obscure. Near the margin, however, there are many radial ribs of similar strength which are separated from one another by narrow and deep furrows. Fine numerous concentric lines are impressed on the ribs.

Another dorsal valve in fig. 6 shows well developed interareas, large triangular delthyrium without a deltidium but a spondylium of moderate size is present; no distinct vascular trunks as in *Billingsella* seen on the valve.

Occurrence:—Gakoku formation at Locs. 253 and 276.

Genus *Apheoorthis* ULRICH and COOPER, 1936.

Apheoorthis orientalis KOBAYASHI, new species

Plate XII, Figure 2.

PB2358

Description:—Shell small, gently convex; ventral (?) valve two-thirds as long as wide, scarcely alate at hinge margin; mesial sinus narrow and very shallow; umbo a little projected above the margin; growth lines strongly impressed at regular intervals. In the median part are 4 ribs and 4 or more riblets in each interval, but the difference of prominence between the ribs and riblets is reduced laterally.

Comparison:—The fasciculate ornamentation is an important external dis-

tinction of *Apheoorthis* from *Eoorthis*, s. str. The plication is not so sharp in this species as in *Apheoorthis ocha* (WALCOTT) and *A. meeki* ULRICH and COOPER. *Eoothis shakuotunensis* SUN and *E. pagodiformis* KOBAYASHI have the same kind of ornamentation, but the fineness of the ornaments shows that these species are closer to *A. ornata* and *A. melia* than this species.

Occurrence:—Bunkoku formation at Loc. 253.

Apheoorthis (?) sp. indt.

PB2359-12-3
PB2360-12-4

Plate XII, Figures 3-4.

Shell almost twice broader than long, multicostellate, but not fasciculate at the preceding; hinge line a little shorter than the maximum breadth; radials increase their number by forking; concentric growth markings well impressed with short intervals. Ventral valve gently convex, somewhat flattened in medio-ventral part, but scarcely sulcate; dorsal valve strongly convex near umbo which is projected above hinge margin and somewhat incurved.

This resembles *Apheoorthis emmonsi* ULRICH and COOPER, but its outline is more transversal and the umbo of the dorsal valve larger and more prominent.

Occurrence:—Bunkoku formation at Locs. 253-262.

Family Deltatretidae SCHUCHERT and COOPER, 1931

Genus *Pomatotrema* ULRICH and COOPER, 1932

Pomatotrema (?) sp.

Two external moulds of dorsal valve, though poorly preserved, resemble *Pomatotrema shinsoensis*, but smaller and about 6 mm. wide.

Occurrence:—Bunkoku formation at Locs. 247 and 252.

Family Clarkellidae SCHUCHERT and COOPER, 1931

Genus *Clarkella* WALCOTT, 1908

Clarkella vulgaris KOBAYASHI

PB2361

Plate XIV, Figure 1.

1934. *Clarkella vulgaris* KOBAYASHI, *Jour. Fac. Sci., Imp. Univ. Tokyo, Sec., 2, Vol. 3, Pt. 9*, p. 530, pl. 2, figs. 11-18.

A ventral valve agrees with the valve in fig. 11, pl. II, 1934, in outline and the size of the median sinus, although the convexity of the valve appears a little stronger in the present valve than in that specimen.

Occurrence:—Loc. 193 with *Ribeirella subcircularis*.

Phylum Mollusca CUVIER

Class Gastropoda CUVIER

Family Tryblidiidae PILSBRY, 1899

Genus *Palaeacmaea* HALL and WHITFIELD, 1782

Palaeacmaea (?) sp. indt.

Plate XIV, Figure 4. PM2362

Shell very low patelliform; aperture broad, ovate in outline; apex small, at about one-fourth of shell length from the anterior. The aperture is about 3 mm. broad and 4 mm. long. Only the internal view is allowed to the observer. It is broad undulated and a few such undulations radiate from the apex to the broad posterior margin. Beside them, there are very fine radial and concentric striae.

Although the upper surface is invisible, the apex is presumed to be somewhat acuminate. The anterior slope may be more or less concave. The lateral and posterior slopes are flattish. However, a broad low internal elevation extending backward from the apex in the apertural view must be a large depression. There is no indication for rugose folds or terraces as seen in *Scenella*, *Palaeacmaea* or *Helcionella*. With such a specimen it is difficult to determine its taxonomic position.

Occurrence:—Loc. 193 with *Clarkella vulgaris*.

Mollusca (?) Incerta Sedis

Family Hyolithidae NICHOLSON

Genus *Hyolithes* EICHWALD, 1840

Hyolithes (?) sp. indt.

Plate XIII, Figures 22 a-b. PM2363

An internal mould of an operculum (?) consists of a subcircular main plate and subquadrate dorsal (?) projection. The plate is slightly longer than broad, and forms an obtuse angle at the median point of the dorsal margin. The mould rises up toward this point and two obtuse carinae extend ventrally from this point, dividing the subcircular plate into three areas of subequal size. The subquadrate part is represented by a deep depression which is somewhat expanded from the subcircular plate and truncated by the straight dorsal margin. It is bisected by a thick axial wall which extends from the dorsal margin. Because this specimen is an internal mould, it must have been a profound groove. Ignoring the subquadrate projection, this fossil reminds me of an operculum of hyolithid. I know no comparable fossil in which the two parts are combined. It appears to hold bilateral symmetry, but there is a small process at about the middle of the left dorsal margin of the main part, but not on the other side. No hyolithid shell is as yet found from the Bunkoku formation. Therefore it is probable to belong to an unknown animal quite unrelated to *Hyolithes*.

Occurrence:—Bunkoku formation of Loc. 249.

Phylum Arthropoda

Class Trilobita WALCH

In 1897 BEECHER has proposed Hypoparia, Opisthoparia and Proparia for his scheme of Trilobita Classification. It was certainly epoch-making, but its validity was soon questioned by POMPECKJ in the next year. On the basis of the ontogenetical study BEECHER laid special stress on the eyes and facial sutures in his classification, but the heterogenity of the Hypoparia was exemplified by REED (1898) in his paper on blind trilobites (1898). POULSEN's Intergricephalida (1927) in which most hypoparian families are combined with the Conocoryphidae are no less heterogeneous than the Hypoparia. SWINNERTON (1915) ignored the Hypoparia, but accepted the view that the Proparia are more advanced than the Opisthoparia. POULSEN (1923) found that *Peltura scaraboeoides* is proparian in the early meraspid stage. RICHTER (1932) considered that the Proparia are more primitive than the Opisthoparia. Thus BEECHER's classification was modified in fundamental lines. Nevertheless, the Opisthoparia or the other taxon was maintained by some authors as valid for about a half century, but completely neglected in the modern classifications by WHITEHOUSE (1936, 39), HENNINGSMOEN, HUPÉ, HARRINGTON et al. (1959) and some others.

It was in 1935 that I have concluded the polyphyletism of not only the Hypoparia but also the Proparia, in pointing out the fact that the Cambrian proparians have little relationship among themselves as well as to the later proparians. The invalidity of the Proparia was immediately vindicated by the discovery of proparian olenids in the Lower Ordovician of Argentina which are, however, by no means ancestral to other proparian trilobites. It was my conclusion in 1935 that, although the facial suture is one of important criteria, the natural classification must be founded on the combination of evolutional characters, and that not only morphological and ontogenetical evidences, but also the specio-temporal distribution should be brought into account for the evolution of trilobites.

The parallelism of the trilobite evolution among the Older Palaeozoic zoopalaeogeographic provinces was then exemplified. The Damesellidae (1941-42) and some other families which flourished in Asia or the Pacific province were later revised in detail. It was further pointed out in 1935 that at least four groups of trilobites have already existed in the early Cambrian period which indicate the palaeontological stocks. The pre-Cambrian divergence of these stocks is prepalaeontological, or something what cannot be documented with fossils. From this viewpoint the Agnostida, Mesonacida (or Redlichida), Corynexochida and Ptychoparida must be recongnized as four primary orders. The Dikelocephalida was added to them as a secondary order by the reason that its derivation either from the Corynexochida or Ptychoparida was indecisive at that time, although the latter alternative was subsequently found veritable (1936).

In 1936 STUBBLEFIELD concluded the polyphyletism of the Proparia, noting that proparian condition may be regarded as arrested development. WHITEHOUSE

(1936, 39) on the other hand distinguished seven discrete Lower Cambrian groups, namely the Mesonacida, Conocoryphida, Ptychoparida, Ellipsocephalida, Corynexochida, Agnostida and Eodiscida. He combined the last two into the Miomera and placed the remainder in the Polymera.

Prior to this GÜRICH (1907) combined the Agnostidae with the Microdiscidae (or Eodiscidae) in the Isopyga of the Oligomera, while JAEKEL (1909) divided trilo- bites into the Miomera and Polymera. The opinions of the two authors agreed in laying special weight on the number of thoracic segments, but they are opposed in that the former regarded the Isopyga to be primitive whereas the latter took the Miomera for the advanced group.

Intensive studies have been repeated on the miomeric trilobites in last century by various authors. While RESSER (1938) segregated the agnostids out of the Trilobita inclusive of eodiscids, I have emphasized in my monographs on the agnostids (1939) and the eodiscids (1944) that the Agnostida comprising eodiscids and agnostids constitute a solid and highly specialized group of the Trilobita.

As for the polymeric trilobites the taxonomy and phylogeny were especially confused for Cambrian genera and families. Therefore I have carried out a preliminary study on them. Although very tentative, I proposed my scheme of classification in 1935. Some of the new families were later investigated in greater details. Many new genera and families were erected by many authors with the materials from Siberia, Central Asia, North Africa, South America and other little known territories. Trilobite morphology and ontogeny were greatly improved in a quarter of this century by sectioning of rolled specimens or etching of silicified materials. RASETTI (1952) distinguished 7 types of ventral cephalic sutures among the early Cambrian trilobites to which two new types were added in the Upper Cambrian. The existing knowledge on the ventral morphology is, however, still limited to a small number of genera.

Taking the olenellid anaprotaspids for the incipient form, STØRMER (1948) tried to explain the evolution of the sutures by partial neoteny. He adapted Protoparia for the Olenellidae, instead of the Marellidae for which the term had originally been proposed by SWINNERTON (1915). The three other orders were BEECHER's. STØRMER was, however, not quite convinced himself of the validity of the Hypoparia. At the same time his Proparia comprising the Eodiscidae, Norwoodidae, Burlingidae and Phacopidae cannot be a natural group (KOBAYASHI and KATO, 1951). Recently WHITTINGTON (1957) noted that the smallest larva so far known of the olenellids is already in the meraspid stage.

Paying special attention to the glabellar outline and furrows HENNINGSMOEN (1951) discussed the relationship among the trilobite-families. Thus he recognized 12 superfamilies and concluded that most of the superfamilies are derivatives from the Conocoryphacea except for the Agnostacea, Redlichacea, Olenellacea and Zacanthoidacea which indicate isolate branches. HUPÉ (1925-55) revised the relationship more extensively and precisely and grouped trilobite families into 24 superfamilies most of which were referred to the Polymera except the Eodiscoidae and the Agnostoidae in the Miomera. His Polymera or

HENNINGSMOENS's Conocoryphacea group is a large waste basket which ought to be set to rights. Such an arrangement was undertaken by HARRINGTON et al. (1959) and the Trilobita are schematized into 7 orders in addition to several suborders. It is surprising for me to find in this classification that my prediction was not much deviated from it as below.

Treatise, 1959	KOBAYASHI, 1935
Agnostida KOBAYASHI	Agnostida
Redlichiida RICHTER	Mesonacida (Redlichida)
Corynexochida KOBAYASHI	Corynexochida
Ptychopariida SWINNERTON	Ptychoparida
Ptychopariina RICHTER	
Asaphina SALTER	Dikelocephalida (Ptychoparid branch, 1936)
Illaenina JAANUSSON	Proetacea (Ptychoparid branch, 1935)
Harpina WHITTINGTON	Harpedacea (ditto)
Trinucleina SWINNERTON	Trinuclacea (ditto)
Phacopida SALTER	
Phacopina STRUVE	Phacopacea (unknown derivation)
Cheirurina HARRINGTON and LEANZA	Cheiruridae (ditto) Encrinuridae (ditto)
Calymenina SWINNERTON	Calymenacea (Ptychoparid branch)
Lichida MOORE	Lichadacea (from Mesonacid, (?) Zacanthoidae)
Odontopleurida WHITTINGTON	Odontopleuridae (ditto)

The two classifications coincide with each other in the following fundamental lines:

1. The four primary orders which appeared in the early Cambrian.
2. The Dikelocephalida or Asaphina and all superfamilies which were considered Ptychopariid-branches are recognized as suborders of the Ptychopariida except the Calymenacea.
3. In addition to the Calymenacea, Post-Cambrian families and superfamilies of which origin was unknown or which were presumed derivatives from the Redlichiida throught the Zacanthoididae are accepted as secondary orders or suborders.

Incidentally, whether the Calymenacea are really more related to the Cheirurina than the Ptychopariida may be a matter of moot discussion. There are of course various differences between these classifications with regards to the families involved in these orders. It is my opinion that the major configuration of the cephalon or the whole shield may not be the less important than certain specified criteria of the glabella or cephalic sutures. It requires more and more studies to settle such details. For their solution, I think, much is expectable to the future studies on Pacific or Asiatic materials because many questions attached to the families which have flourished in the Asiatic or Pacific province.

In my opinion JAEKEL's bipartation must be accepted in a higher rank than the order, because except for a few probable exceptions, all trilobites have either

bi- or tri-segmented thoraces, or five or more segments in thorax, the fact showing the Pre-Cambrian divergence to be much greater between the Miomera and Polymera than among the polymeric orders.

Reconsidering with the new facts, the scheme of classification is here revised and, though still tentative, it is shown below.

Class Trilobita
- Subclass Miomera
  - Order Agnostida
    - Suborder Agnostina
    - Suborder Eodiscina
- Subclass Polymera
- —Primary orders and suborders—
  - Order Redlichiida
    - Suborder Olenellinae
    - Suborder Redlichiina
  - Order Corynexochida
  - Order Ptychopariida
    - Suborder Ptychopariina
- —Secondary orders and suborders—
    - Suborder Burlingina
    - Suborder Dikelocephalidina
    - Suborder Asaphina
    - Suborder Illaenina
    - Suborder Calymenina
    - Suborder Harpina
    - Suborder Trinucliina
  - Order Phacopida
    - Suborder Phacopina
    - Suborder Cheirurina
  - Order Lichida
    - Suborder Lichina
    - Suborder Odontopleurina

Subclass Miomera JAEKEL, 1909

Order Agnostida KOBAYASHI, 1935

Family Geragnostidae HOWELL, 1935

As noticed by HOWELL (1935), the morphic variation among geragnostids and micragnostids is gradual. Therefore it may be too far going to separate them in the family rank. However, they constitute the largest agnostidian group in the Upper Cambrian and Ordovician periods. Therefore it may appropriate to accept *Micragnostus*, *Anglagnostus*, *Corrugatagnostus*, *Geragnostella* and *Girvanagnostus* as five genera of the Geragnostidae, instead of subgenera of *Geragnostus* as done in my revision (1939).

It is certain that *Rudagnostus* LERMONTOVA and *Eurudagnostus* LERMONTOVA which were respectively founded on *Agnostus princeps* var. *rudis* SALTER and *Eurudagnostus grandis* LERMONTOVA belong to the same family, because the former species was once referred to *Micragnostus* and the latter is a micragnostid having subcircular shields, each having a pair of well developed posterior spines. It is, however, a question whether the family can safely hold *Homagnostoides* and *Hyperagnostus* whose axial lobe of the pygidium is extraordinally developed for the family.

PA2364-13-7
PA2365-13-8
PA2366-13-9
PA2367-13-10
PA2368-13-11

Genus *Micragnostus* HOWELL, 1935

Micragnostus coreanicus KOBAYASHI, new species

Plate XIII, Figures 7-11.

1934. Comp, *Agnostus*, a sp. KOBAYASHI, *Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 3, Pt. 9*, p. 537, pl. 3, figs. 2-3.

Description:—Cephalon subquadrate, as long as wide; anterior outline rounded; marginal rim and furrow narrow and running below the cheek rolls in the posterior of lateral sides; shield inside the furrow strongly convex; glabella prominent, subconical, but rounded in front, outlined by deep dorsal furrows, and bilobed by a strong transverse furrow; anterior lobe one-third as long as posterior one which carries a median tubercle; basal side-lobe very small and triangular; posterior rim outside this lobe pointed back.

Pygidium subquadrate, provided with a thick rim which is pointed at a pair of short posterior spines; marginal groove well developed; axial lobe large, strongly convex, elevated above pleural slope, surrounded by deep furrows and composed of two short anterior lobes and a long posterior one; the latter longer than the combined length of the two anteriors; a prominent median ridge lies on the anterior lobes.

Comparison:—This is diagnostic of the genus. *Agnostus chiushuensis* KOBAYASHI, 1931, is another typical *Micragnostus* common in the Chiushukou shale in South Manchuria. The axis, especially that of the pygidium, is larger in this than in that species.

Among the three Ordovician agnostids in South Korea the nearest is *Agnostus*, a sp. from the *Asaphellus* zone of Makkol, although the cephalon is longer, the marginal rim thicker and the basal side-lobe larger.

As TROEDSSON (1937, p. 31) states that "it will hardly be possible to distinguish our Central Asiatic form (i. e. *Geragnostus kobayashii* TROEDSSON) from KOBAYASHI's *Agnostus* a sp.," they look alike, but the glabella is evidently more slender in the Tienshan species. The axial lobe of the pygidium is pointed back in that species.

Occurrence:—Bunkoku formation at Locs. 248 and 252.

Subclass Polymera JAEKEL, 1909

Order Ptychopariida SWINNERTON, 1915

Suborder Ptychopariina SWINNERTON, 1915

Family Shumardiidae LAKE, 1907

Genus *Shumardia* BILLINGS, 1865

Shumardia pellizzarii KOBAYASHI, 1934

PA2369-13-23
PA2370-13-24
PA2371-13-25

Plate XIII, Figures 23-25.

1934. *Shumardia pellizzarii* KOBAYASHI, *Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 3, Pt. 9*, p. 538, pl. 7, fig. 11a.

Cephalon relatively long; glabella very broad; frontal lobe not much expanded laterally, truncated or even somewhat sinuated in front; posterior lobe parallel-sided; lateral furrows in two pairs, short or indiscernible; transverse furrows between these lobes discrepant on axis; dorsal furrows broad on lateral sides of posterior lobe; neck ring clearly defined by a furrow.

Thorax composed of 6 or 7 segments; axial rings broader than pleurae; fourth pleura prolonged backward into a long spine.

Pygidium short; axial lobe broad, strongly convex, composed of three rings and a terminal lobe; pleural lobe narrow and divided into 4 ribs; marginal rim narrow but distinct; posterior margin somewhat sinuated.

In the specimen in fig. 25 the seventh segment appears to belong more probably to the thorax than the pygidium.

This species is a member of the *pusilla* group. Its cephalon bears the specific characteristics. Rows of granules seen on the thorax and pygidium of *S. pusilla* are apparently absent.

Occurrence:— Bunkoku formation at Locs. 249 and 101110; *Protopliomerops* zone at Saishori.

Family Solenopleuridae ANGELIN

Genus *Hystricurus* RAYMOND, 1913

Hystricurus megalops KOBAYASHI, 1934

PA2372

Plate XIII, Figure 20.

1934. *Hystricurus megalops* KOBAYASHI, *Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 3, Pt. 9*, p. 540, pl. 6, figs. 8-9.

An imperfect crandium from Loc. 233 is diagnostic of this species in the pustulate test, ovate concave glabella, weak posterior furrows, deep dorsal furrows, relatively narrow fixed cheeks and large posterior eyes as judged from their broken parts. *H. eurycephalus* can be easily distinguished from this by the outline of the glabella and much finer granules of the test. Furthermore, the anterior facial sutures are not so widely divergent.

Occurrence:—Bunkoku formation at Locs. 233, 9202, 92903 and 92906.

Hystricurus cfr. *megalops* KOBAYASHI, 1934

PA2373

Plate XIII, Figure 21.

This is the first example of a hystricuroid pygidium found in Korea. Its outline is lenticular, attaining the maximum width at the mid-length where the width corresponds about twice the length. The rachis is as wide as a pleural lobe, conical, strongly convex, elevated above the latter and composed of four rings and a small terminal lobe; pleural lobe gently convex, divided into four ribs by furrows; marginal rim narrow, but more or less thickened toward the rear end.

There is no other genus but *Hystricurus* in the Bunkoku fauna which would have this pygidium. Unfortunately the test is weathered and the characteristic pustulation which warrants its identification with the preceding cannot be seen.

Occurrence:—Bunkoku formation at Loc. 240.

PA2374-14-5
PA2375-14-6

Hystricurus calvus KOBAYASHI, new species

Plate XIV, Figures 5-6.

A small hystricuroid cranidium having a long ovate, strongly convex, unfurrowed glabella, distinct occipital furrow, occipital ring carrying a median tubercle pointed behind, and a thick eye-band fairly large, located somewhat posteriorly and disconnected from the glabella by a narrow fixed cheek. No eye-ridge; dorsal furrow distinct and joins its fellow at the median point of the rounded glabellar front whence the axial furrow extends forward. The frontal limb is relatively large, gently convex, inclined distally and separated from a narrow, wire-like rim by a furrow.

An associated free cheek which may belong to this species has a strongly convex ocular platform which elevates toward the large eye and is separated from the marginal rim by a deep groove; genal spine short, extending back without forming an angle with the lateral border.

Facial suture anterior to eye runs obliquely from eye and diagonally crosses the border; that posterior to eye cutting articulating margin shortly inside the genal spine.

This may be an aberrant form of *Hystricurus*, s. l. Its specialities are the smooth test, relatively large eyes located posteriorly, preglabellar axial furrow and the glabella which is not so bulbous as usual in typical *Hystricurus*.

Occurrence:—Bunkoku formation at Shi 2.

Family Monkaspidae KOBAYASHI, 1935

(Maladidae HUPÉ, 1953)

The typical members of this family are characterized by the large or medium sized subquadrate glabella, two pairs of lateral furrows, clear-cut occiptal

ring without spine, medium sized eyes, distinct eye-ridge, thick convex marginal rim, diagonal anterior facial sutures, serrated margin of pygidium and smooth test or very fine granulation.

Monkaspis KOBAYASHI, 1934, (Text-fig. 1e-f) is represented by monotypic *Anomocare daulis* WALCOTT, 1905, which occurs in the late Middle Cambrian or Taitzuan-Kushanian passage in Shantung. Like some members of the Anomocaridae and Dikelocephalidae its cranidium has a semi-circular lobe on each side of the glabellar base. The eyes are, however, not so large as in the Anomocaridae and the brim is not so developed as in the Dikelocephalidae. Many small spines on each side of its pygidium are also quite distinctive from these families.

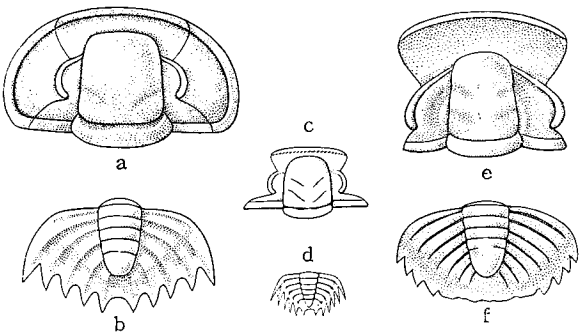

Figure 1.

a-b. *Maladia americana* WALCOTT
c-d. *Tostonia iole* (WALCOTT)
e-f. *Monkaspis daulis* (WALCOTT)

In *Maladia* WALCOTT, 1942, (Text-figs. 1a-b) and *Tostonia* WALCOTT, 1924, (Text-figs. 1c-d) from the Upper Cambrian of western North America the glaballa becomes larger and the fixed cheek and frontal limb narrower. The pygidial spines in 5 or 6 pairs are more prominent than those of *Monkaspis* or *Yosimuraspis*.

In Tremadocian *Yosimuraspis* the glabella is similar to that of *Monkaspis* in relative size, but the lateral furrows are completely effaced and the marginal border is thickened and produced into a long genal spine. The facial sutures are intramarginal on the frontal border.

It is quite probable that the Eurekiinae HUPÉ, 1935, which include *Eurekia* WALCOTT, 1924, *Bayfieldia* CLARK, 1924, *Corbinia* WALCOTT, 1924, and probably *Apatokephaloides* RAYMOND, 1914, are different from the typical monkaspids in the smaller eyes, narrower frontal limb and fixed cheeks, less divergent or subparallel anterior sutures, greater relief of the shield and granulose test. It is, however, probable that they represent an Upper Cambrian branch of the Monkaspidae in North America.

Genus *Yosimuraspis* KOBAYASHI, new genus

Type-species:—*Yosimuraspis vulgaris* KOBAYASHI, new species.

Diagnosis:—Cephalon with conical smooth glabella, large eyes detached from it in posterior and broad free cheek with a long genal spine; facial suture half marginal on frontal border; pygidium small, relatively broad and provided with a few marginal spines.

Remarks:—Further informations are found in the description of the type-species. The genus is denominated in honour of the late Itiro YOSIMURA who has made a valuable contribution to the geology of the Yŏngwŏl (Neietsu) district.

Distribution:—Lowest Ordovician of South Korea.

PA2376-12-9,10
PA2377-12-11
PA2378-12-12,15
PA2379-12-13,16
PA2380-12-14
PA2381-12-17
PA2382-12-18
PA2383-12-19
PA2384-12-20

Yosimuraspis vulgaris KOBAYASHI, new species

Plate XII, Figures 9–20, Text-figure 2.

Description:—Dorsal shield subelliptical and flattish; axial lobe narrower than pleural ones; test smooth.

Cephalon exclusive of stout spines large, semicircular and a little broader than twice its length; glabella truncate-conical, about two-thirds as long as cephalon, flat and unfurrowed; occipital ring somewhat broadened, short, though somewhat thickened mesially, and limited by a weak furrow in front; eyes large, half as long as glabella, starting from anterior of glabella, more or less protruded postero-laterally and terminates at a short distance from posterior of glabella; free cheek at eye nearly twice as broad as fixed cheek; preglabellar area bisected by a furrow into a nearly flat limb and moderately convex rim; genal spine protruded from marginal border as far as fifth or sixth thoracic segment. Anterior facial sutures diagonally divergent from eye-bands at a short distance from glabella, but abruptly bent inward on border and running along its margin for some distance, join with each other and sagittal on doublure; their posterior branches gently inclined, but more abruptly before cutting posterior margin. Hypostoma subovate, but provided with a pair of small anterior wings, surrounded by a narrow rim and groove; main body swelling up and separated from a posterior lunate ridge by a pair of depressions.

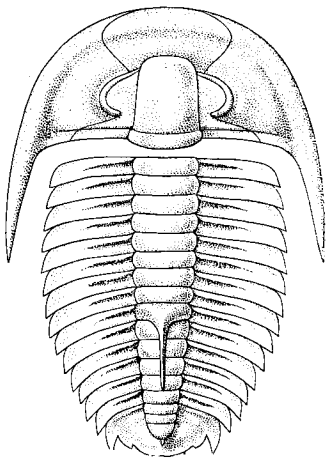

Figure 2.
Yosimuraspis vulgaris KOBAYASHI

Thorax composed of 14 or more segments, broadest on the 10th segment counted from posterior, where axial ring is slightly narrower than a fourth of thoracic breadth; 6th segment from posterior bears a sharply keeled, short axial spine; pleura truncated at lateral end and distinctly grooved in inner half where a pleural ridge is fairly prominent.

Pygidium small, relatively broad; axis short, conical, strongly convex and divided into two or three rings and a terminal lobe whence a tiny post-axial ridge issues; pleural lobe gently inclined and becomes subhorizontal near margin; first pleural furrow usually distinct, but others are not always discernible; first segment produced behind from border into a fairly long spine; second spine very short.

Test smooth.

Observation:—There are two hypostomata. One is broad and flat and the other long and inflated, but the difference depends probably on secondary deformation.

Occurrence:—Bunkoku formation at Locs. 234, 272, 277 and 289.

Yosimuraspis vulgaris subsp. *longulum* KOBAYASHI, new subsp. PA2385-12-7 PA2386-12-8

Plate XII, Figures 7-8.

This is distinguished from the typical form primarily by the greater length of the glabella in comparison with the preglabella area. In the typical form the former inclusive of the occipital ring corresponds to twice the latter whereas in this subspecies the former exclusive of the ring is equal to twice the latter. In this subspecies a pair of pits are occasionally seen just behind the lateral ends of the glabellar front. Another pair are found less commonly close to the posterior ends of the eyes. Posterior lateral furrows appear to extend from the vicinities of the latter pits toward the median point of the neck ring. When depressed, three pairs of lateral furrows emerge on the surface where the anterior and middle ones are short and not so oblique as the posterior ones.

Occurrence:—Bunkoku formation at Locs. 234 and 92702.

Family Richardsonellidae RAYMOND, 1924

(Kainellidae ULRICH and RESSER, 1930)

The Remopleurinae were generally considered to be closely related to the Paradoxidae. SWINNERTON (1915) derived the Remopleuridae from the Mesonacidae. WARBURG (1925) noted the close resemblance of the Remopleuridae with *Apatokephalus* which was in turn considered by POULSEN (1927) an undoubted member of the Dikelocephalidae. POULSEN suggested the evolution from the Mesonacidae to the Remopleuridae through the Zacanthoidae and Dikelocephalidae. RICHTER (1933) placed the Remopleuridae in the Zacanthoididea of the Redlichiina.

In agreement with them I recognized in 1935 the Remopleuridae as a family

of the Mesonacida i. e. Redlichiida, to which, however, *Apatokephalus* and *Macropyge* were referred. At the same time I recognized the Kainellidae to be another family of the same order which was derived from the Zacanthoidae. Further I noted its alliance to the Richardsonellidae. Subsequently, in 1937, I distinguished the (1) *Apatokephaloides-Corbinia* group, (2) Kainellidae, (3) Macropygidae and (4) Remopleuridae and pointed out that the fourth family was introduced from the second through *Apatokephalus*. Next year HARRINGTON (1938) accepted the Kainellidae in the Mesonacida when he added *Pseudokainella* to it. In 1953 I reclassified the Kainellidae into the Kainellinae, Richardsonellinae, Apatokephalinae and Macropyginae and pointed out that the Remopleuridae developed from the Apatokephalinae probably through the forms like *Apatokephalus* and *Robergia* (Text-fig. 3c). Incidentally, *Corbinia* and *Apatokephaloides* are here located in the Eurekiinae of the Monkaspidae.

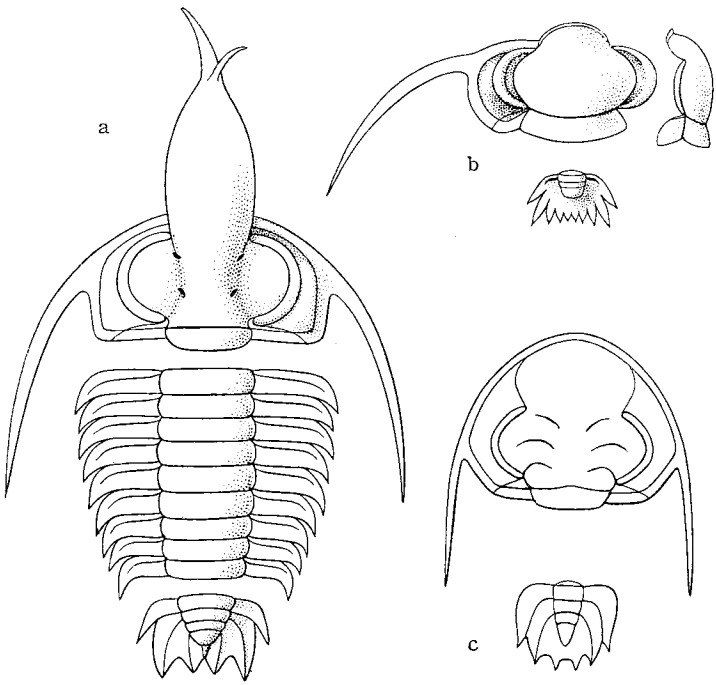

Figure 3.

a. *Teratorhynchus bicornis* (PORTLOCK)
b. *Remopleuridiella caudalimbata* ROSS
c. *Robergia microphthalmus* (LINNARSSON)

In 1951 HENNINGSMOEN removed the Richardsonellidae inclusive of the Kainel lidae and the Remopleuridae inclusive of the Macropygidae from the Zacan-

thoididea and placed in the Dikelocephalacea which in turn he thinks a derivative from the Conocoryphacea. HUPÉ (1953) on the other hand, located the Remopleuridae and Richardsonellidae in the Olenoidae. In Treatise (1959) the Dikelocephalacea, Olenacea and Remopleuracea are accepted as three independent superfamilies, but all in the Ptychopatiina, where the Zacanthoididae are considered a family of the Corynexochida, following RASETTI (1951).

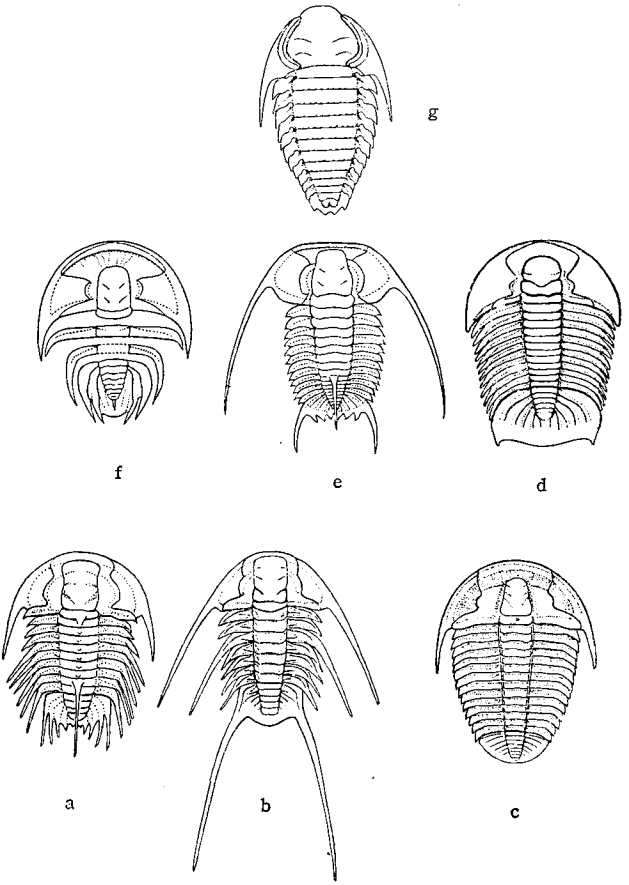

Figure 4.

a. *Zacanthoides spinosus* WALCOTT. (After RICHTER)
b. *Albertella helena* WALCOTT. (ditto.)
c. *Ptychoparia striata* (EMMERICH). (ditto.)
d. *Dikelocephalus oweni* ULRICH and RESSER. (ditto.)
e. *Pseudokainella keideli* HARRINGTON. (After HARRINGTON)
f. *Kainella billingsi* (WALCOTT). (After WALCOTT)
g. *Remopleurides colbi* PORTLOCK. (After WHITTINGTON)

The Richardsonellinae were originally proposed by RAYMOND as a subfamily of the Dikelocephalidae, when he instituted *Richardsonella*, 1924, on *Dikelocephalus megalops* BILLINGS. *Dikelocephalus oweni* BILLINGS was another species which RAYMOND assigned to this genus, but ULRICH (1930) erected *Levisella* out of it. In 1935 I tentatively added *Euloma* and *Loganellus* to the subfamily. Because these genera have the Ptychoparian nerve-like lines and wide subtriangular pygidia, I suggested the possibility of their derivation from the ptychoparian stock. Lately I combined *Euloma* with *Eulomella* in the Eulominae of the Ptychoparidae (1955). For the Longanellidae to which *Loganellus* and *Levisella* belong, RASETTI (1959) gave a statement, "Probably derived from Ptychopariids through *Wilbernia* or similar forms; also closely related to early Remopleuridae (*Richardsonella*)."

The ancestor is unknown of the Richardsonellidae (exclusive of Longanellids), but the family appears to be related to the Dikelocephalidae and Eurekiinae in many aspects. By this reason its derivation from the ptychoparian stock is probable and if so, the resemblance of *Kainella* or *Pseudokainella* respectively with *Zacanthoides* or *Albertella* becomes a remarkable example of homoeomorphy. (See Text-fig. 4).

The Richardsonellidae and Remopleuridae are different in the preglabellar area and anterior facial sutures. The thorax consists of 12 segments in *Apatokephalus* and *Pseudokainella*, but one segment is generally reduced in the Remopleuridae. *Remopleuridiella* (Text-fig. 3b) and *Teratorhynchus* (3a) are highly specialized in the development of the glabella, diminution of the preglabellar area and others.

Macropyge has only 9 segments in thorax and is aberrant in the prolongation of the spatulate pygidium. It differs from the Richardsonellidae and Remopleuridae further in the basal side-lobes on the glabella and the narrow preglabellar area. ROSS (1951) noted the asaphoid aspect of the cephalon. It is proper to accept a small but distinct branch which issued in the Lower Ordovician period from the stem of the Richardsonellidae.

More Upper Cambrian members of the Richardsonellidae are expectable among the Asiatic trilobites which are however, not well known. *Mansuyia maladiformis* KOBAYASHI (1935, Text-fig. 5e) has the cranidium with a quadrate glabella, two pairs of pits on it, large eyes attached to the glabella and a broad preglabellar area, all of which are suggestive of the Kainellinae alliance. *Pseudokainella* (?) sp. (Text-fig. 5d) from loc. 263 is similar to *Conokephalina* on one side and *Pseudokainella* on the other, but the eyes are detouched from the glabella.

The following three genera from the Upper Cambrian of the Salair mountains, Siberia, are attributed by the authors (1955) to the Remopleuridae, s. l.

1. *Apatokephalina bruta* SIVOV (Text-fig. 5c), monotypic of the genus, is said intermediate between *Richardsonella* and *Apatokephaloides*. In my opinion it constitutes a group probably of the Richardsonellidae with *Princetonella* LOCHMAN, 1953, which is totally different from the Komaspidae in the semicircular eyes attached to the glabella at the posterior extremities.

2. *Artokephalus* SIVOV and JEGOROVA which is founded on *A. minimus* SIVOV (Text-fig. 5b) is also considered an ally to *Apatokephaloides* and *Richardsonella*. These North American genera, however, can easily be distinguished from this as well as *Apatokephalina* by the greater preglabellar area which consists of a narrow rim and a limb of moderate size.
3. *Portentosus brevis* JEGOROVA (Text-fig. 5a) is represented by relatively flat cranidia having a conical glabella with three pairs of weak lateral furrows, large semicircular eye bands and a narrow frontal border separated from the glabella by a groove. Except the conical outline of the glabella it appears allied to *Hukasawaia*.

Here is described an Ordovician genus, *Aotiaspis*.

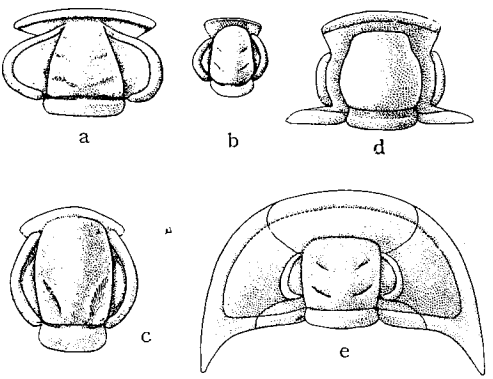

Figure 5.

a. *Portentosus brevis* JEGOROVA
b. *Artokephalus minimus* SIVOV
c. *Apatokephalina bruta* SIVOV
d. *Pseudokainella* (?) sp. indt.
e. "*Pseudokainella*" *maladiformis* (KOBAYASHI)

Subfamily Richardsonellinae RAYMOND, 1924

Genus *Richardsonella* RAYMOND, 1924

Richardsonella flabellifera (HALL and WHITFIELD), 1877

Text-figure 8e

1877. *Dikellocephalus flabellifer* HALL and WHITFIELD, *U. S. Geol. Expl. 40th Par., Vol. 4*, p. 227, pl. 2, figs. 29-30.
1914. *Apatokephalus flabellifer* WALCOTT, *Smiths. Misc. Coll. Vol. 57, No. 3*, p. 350.
1938. *Parabriscoia flabellifera* RESSER, *Smiths. Misc. Coll. Vol. 97, No. 10*, p. 38.
1953. *Parabriscoia* (?) *flabellifer* KOBAYASHI, *Japan. Jour. Geol. Geogr. Vol. 23*, p. 58.

As suggested by WALCOTT, certainly the pygidium resembles that of *Apatokephalus* in the outline and narrow axis. But in *flabellifer* each pleural rib terminates at a sinuation and an interpleural depression extends in form of a

short flat spine. Beside three pairs of such spines the authors illustrated a posterior obtuse spine on which the last pleural ribs are fused to form a post-axial ridge.

In the plaster casts and their photographs of the holo- and paratype, however, the margin appears to be somewhat sinuated, instead of projected and more or less elevated toward the post-axial ridge. The aspect suggests the fusion of the fourth pair of pleurae and of the pleural ribs which the latter is thought to become the post-axial ridge. Furthermore the first pleura is longer than its original illustration.

As I have cast a question already (1953), the pygidium is evidently distinct from *Parabriscoia* (or *Elkia*) to which Resser (1938) referred. In my opinion it agrees best with *Richardsonella* (or *Protapatokephalus*). The associated pygidia of *R. megalops* (BILLINGS), 1860, and *R. unisulcata* RASETTI, 1944, have the post-axial sinus and three spines on each side. In them, however, the axial lobe is relatively broad and consists of three rings and a terminal lobe, while the axial lobe of this species is more slender and composed of 5 rings and a terminal lobe. *Protapatokephalus arctostriatus* RAYMOND, 1937, and *P. spiculatus* RAYMOND, 1937, have more spines on their pygidia and 5 or 6 pairs are countable in the respective species. Therefore this species can readily be distinguished from these allied ones.

Distribution:—Dark crystalline limestone (Upper Cambrian Secret Canyon) of the Potsdam group on the west side of the Pogonip Mountains, White Pine district and in Eureka district, Nevada.

Genus *Hukasawaia* KOBAYASHI, 1953

Type-species:—*Hukasawaia cylindrica* KOBAYASHI, 1953.

Remarks:—In the long narrow glabella to which a large semicircular eye-band is attached on each side this genus resembles *Macroculites*, but in that genus the glabella tapers forward and the concave proglabellar brim is present, but absent in this genus.

Distribution:—Lower Ordovician; Korea.

Hukasawaia cylindrica KOBAYASHI, 1953

Text-figure 6g.

1953. *Hukasawaia cylindrica* KOBAYASHI, *Japan. Jour. Geol. Geogr. Vol. 23*, p. 50, pl. 3, fig. 15.

Occurrence:—Bunkoku formation; Loc. 252.

Subfamily Kainellinae ULRICH and RESSER, 1930

Genus *Kainella* WALCOTT, 1924

Since the find of this genus in the collection from Prerie Catamarca, Argentina (KOBAYASHI 1,935) its flourishment in the Andean geosyncline was thoroughly

manifested by HARRINGTON and LEANZA (1957). It is distributed further in South Korea, Hopei (?), Szachuan and Yunnan-Tonkin border (1953). According to SHENG (1956) *Kainella lohanpoensis* is accompanied in Szechuan by *Andesaspis sinensis* which belongs probably to *Parabolinopsis*.

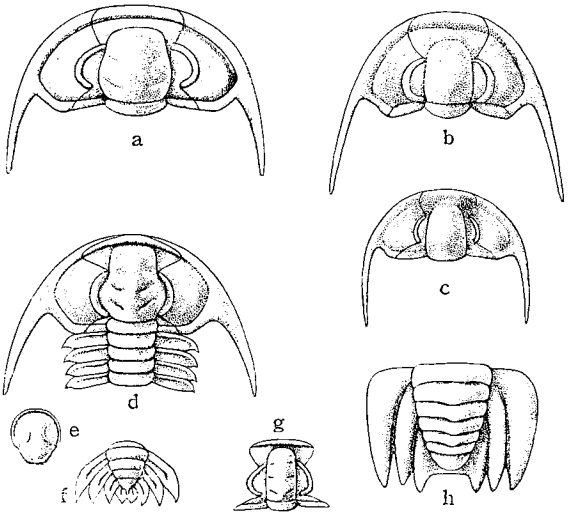

Figure 6.

a. *Pseudokainella iwayai* KOBAYASHI
b. *Aotiaspis oblonga* KOBAYASHI
c. *Aotiaspis lohanpoensis* (SHENG)
d—f. *Apatokephalus hyotan* KOBAYASHI
g. *Hukasawaia cylindrica* KOBAYASHI
h. *Kainella euryrachis* KOBAYASHI

Kainella euryrachis KOBAYASHI, 1953

Text-figure 6h.

1953. *Kainella euryrachis* KOBAYASHI, *Japan. Jour. Geol. Geogr. Vol. 23*, p. 45, pl. 3, fig. 9.

Occurrence:—Tomkolian argillaceous limestone at Sei 14.

Genus *Pseudokainella* HARRINGTON, 1938

Pseudokainella iwayai KOBAYASHI, 1953

Text-figure 6a.

1953. *Pseudokainella iwayai* KOBAYASHI, *Japan. Jour. Geol. Geogr. Vol. 23*, p. 46, pl. 3, figs. 2-14.

Occurrence:—Limestone lens in the Doten quartzite at Yon'pyongni near

Uiimgil, Sangdong-myŏn, Yŏngwŏl, Kangwŏn-do (江原道寧越郡義林吉達坪里), Iwaya Collection.

Pseudokainella a sp.

1953. *Pseudokainella* a sp. KOBAYASHI, *Japan. Jour. Geol. Geogr. Vol. 23*, p. 4, pl. 3, fig. 16.

Occurrence:—Bunkoku formation, Loc. 221.

Pseudokainella (?) sp. nov.

Plate XII, Figure 1, Text-figure 5d.

PA2389

An imperfect but interesting cranidium with a large glabella which is as long as wide, most expanded at the mid-length, narrower in anterior than in posterior, surrounded by deep furrows, distinctly elevated, but not strongly inflated; lateral furrows absent; occipital furrow deeper; occipital ring narrow and moderately arcuate; eye-bands two-thirds as long as glabella, attached to it at the anterior end, but detached from it by a narrow space at the posterior end; intra-ocular part of fixed cheek narrow and long; postocular limb apparently short and broad; preocular limb small and triangular; frontal limb absent; frontal border as thick as frontal groove and somewhat narrowing laterally.

This looks like *Pseudokainella* (?) *macarenae* HARRINGTON and KAY (1951), especially the one in fig. 21, in the outline of the glabella, but a well developed frontal limb is present in their form from East Columbia. In the presence of the intraocular cheek it is distinct from *Apatokephalus* and agrees with *Hukasawaia* and *Menoparia*. In the shape of the glabella it is more allied to *Menoparia* than *Hukasawaia*, but the glabeliar furrows are undeveloped in this as in *Hukasawaia*. The eye-band is not semi-circular as in most kainellids, but elongated as in *Tramoria*. Judging from the combination of these biocharacters this represents an undescribed genus, although the specimen before hand is too poorly preserved to propose a new name.

Occurrence:—Gakoku formation at Loc. 263.

Genus *Aotiaspis* KOBAYASHI, new genus

Type-species:—*Aotiaspis oblonga* KOBAYASHI, new species.

The generic name is dedicated to the late Kiyohiko AOTI who made a valuable contribution to the geology of the Mun'gyŏng District. It includes kainelloids having the cephalon more similar to *Kainella* than *Pseudokainella* in the presence of the frontal limb of moderate size, but it is not so laterally expanded as in *Kainella*, because the anterior sutures are diagonal, instead of transversal in *Kainella*. The glabella is evidently more rounded in this genus. The complete effacement of lateral furrows and the absence of pits on the frontal groove are two important distinctions from *Kainella*, *Pseudokainella* and other allied genera. In the broad outline and serrated margin the associated pygidium best agrees with that of *Apatokephalus*.

Beside the type species the genus is represented in Korea by *Aotiaspis ovalis*, nov. and *Pseudokainella* (?) b sp. (KOBAYASHI, 1953). *Kainella lohanpoensis* SHENG from Szechuan-Kweichow border may be an additional member of the genus.

Distribution:—Lower Ordovician; Eastern Asia.

PA2388-14-7
PA2389-14-8
PA2390-14-9
PA2391-14-10
PA2392-14-11
PA2393-14-12
PA2394-14-13

Aotiaspis oblonga KOBAYASHI, new species

Plate XIV, Figures 7-13, Text-figure 6b.

Description:—Cephalon not much inflated but glabella is fairly convex, rising above cheeks three-fourths as long as cephalon, subelliptical, parallel-sided in middle part where its breadth corresponds to a half of cephalic length, distinctly elevated above cheeks; no lateral furrows; occipital furrow deep; occipital ring short and narrows laterally; eye-band semicircular, as long as a half of cephalon exclusive of neck ring and directly attached with glabella; frontal limb and border nearly equal in length, the border being only a little convex and elevated above the limb; marginal groove shallow and lacks a row of pits; free cheek of moderate size; its postero-lateral margin straight, forming an obtuse intergenal angle with posterior margin of cranidium; ocular platform a little more inflated than lateral border; the two parts separated by marginal groove; facial suture diagonal anterior to eye and intramarginal for a short distance on frontal border; suture posterior to eye transversal and abruptly turning toward intergenal angle.

Pygidium twice broader than long, gently convex; axial lobe a little narrower than a third of pygidium, moderately convex, elevated above side-lobes and quinquipartate by four ring-farrows; pleural and interpleural furrows present; pleura produced into a short spine at the end.

Occurrence:—Tomkolian; Shi 2.

Aotiaspis ovalis KOBAYASHI, new species.

Plate XIV, Figure 14.

PA2395

This species differs primarily for the preceding in the outline of the glabella which tapers gradually forward. It is subtruncated in front in a cranidium, but more rounded in a large illustrated cranidium. In these cranidia the preglabellar area is remarkably bent down laterally. In the large one the marginal furrow is shallow and so obliterated that the frontal limb appears to merge into the frontal border. The difference of convexity between the two parts is also reduced.

Occurrence:—Same as the preceding.

Aotiaspis lohanpoensis (SHENG), 1958

Text-figure 6c.

1958. *Kainella lohanpoensis* SHENG, *Acta Pal. Sinica, Vol. 6, No. 2*, p. 187, pl. 1, figs. 2a-j.

This species fits in *Aotiaspis* nicely in the relatively large oblong glabella, obsolete lateral furrows, short preglabellar area and the small angle between the divergent anterior facial sutures. Compared to the Korean forms of the genus, the eyes are smaller and the frontal and occipital furrows more effaced in this species.

Occurrence:—Basal Ordovician. Lohanp'o formation at Omeishan, Szechuan; lower Tungtzu formation at Tungtzu, Kweichow, China.

Aotiaspis sp. indt.

1953. *Pseudokainella* (?) b sp. KOBAYASHI, *Japan. Jour. Geol. Geogr. Vol. 23*, p. 47, pl. 3, figs. 10–11.

This form agrees better with *Aotiaspis oblonga* than with any other kainelloid that I know, but evidently distinct from that species in the more quadrate outline and much stronger convexity of the glabella and rudimentary lateral furrows which are perceptible only under cross light and shorter genal spine on the associated free cheek.

Occurrence:—Bunkoku formation at Loc. 221; Tomkol shale at Sei 14.

Genus *Apatokephalus* BRÖGGER, 1897

Apatokephalus hyotan KOBAYASHI, 1953

Text-figures 6d–f.

1953. *Apatokephalus hyotan* KOBAYASHI, *Japan. Jour. Geol. Geogr. Vol. 23*, p. 52, pl. 3, figs. 17–23.

Occurrence:—Bunkoku formation; common at Loc. 238, but occurring also at Locs. 248 and 249.

Suborder Dikelocephalidina KOBAYASHI, 1936

Family Dikelocephalidae MILLER, 1889

While SWINNERTON placed the Dikelocephalidae and Asaphidae in his Ptychoparina, POULSEN and RICHTER agree in that the two families in addition to the Remopleuridae are derivatives from the Zacanthoididae. Because the ancester of the Dikelocephalidae was in question, I erected Dikelocephalida in 1935, as a separate order. In the next year, however, I pointed out that the Dikelocephalidae were evolved from *Alokistocare* through *Paracoosia*. Broadly speaking, it means that the family was derived from the Ptychoparid stock through the Anomocaridae. Lately HENNINGSMOEN accepted the Anomocaridae as a member of the Conocoryphacea, i. e. the ptychoparid group. HUPÉ on the other hand, made the Anomocarinae a subfamily of the Dikelocephalidae. In other words the two evolutional segments figured by the two authors are linked at the Anomocaridae in the evolutional line which I suggested in 1936.

Subfamily Dikelocephalinae MILLER, 1889

This subfamily is represented in Eastern Asia by *Briscoia*, *Dikelocephalites* and *Coreanocephalus*. The first of them is a cosmopolitan genus distributing from Britain to Persia through North America and Eastern Asia. *Saukia* (*Briscoia*?) *vagans* REED, 1934, from Kashmir is however, evidently not a *Briscoia*. Previously I have noted that *Coreanocephalus*, *Dikelocephalites* and *Parabriscoia* are endemic off-shoots from the main stem.

As noted by SUN (1935), the assceiated free cheek of *Dikelocephalites flabelliformis* (Text-fig. 7b) is broad and triangular in outline with an obtuse genal angle. The genal spine is present in *Coreanocephalus kogenense*. (Text-fig. 7a).

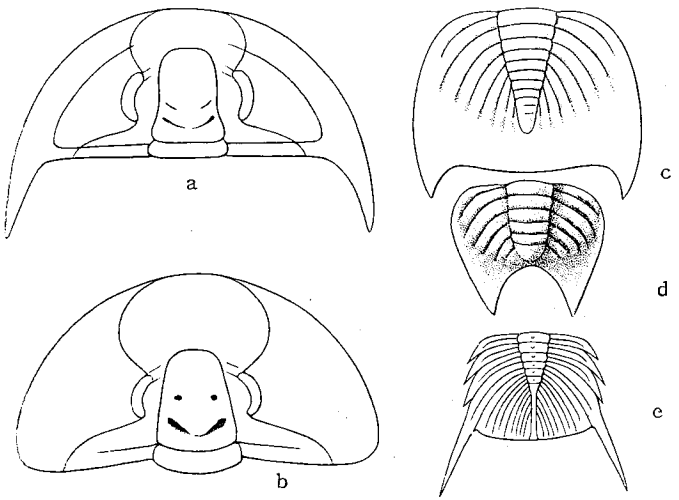

Figure 7.

a. *Coreanocephalus kogenense* KOBAYASHI
b. *Dikelocephalites flabelliformis* SUN
c. *Dainellicauda elegantulus* (GORTANI)
d. *Temnura granulosa* RESSER and ENDO
e. *Girvanopyge problematica* (REED)

The pygidia of *Parabriscoia dolichorachis* are said by LOCHMAN (1956) to occur in the lower Pogonip, in Nevada always in association with the cranidia of *Elkia nasuta*. By this reason *Parabriscoia* (Text-fig. 8f) founded on the pygidium is now combined with cephalon of *Elkia*. By some reason, however, MERTIE's collection from Alaska contained many pygidia of the genus, but no *Elkia* cephalon, although detached cephala as well as pygidia of *Briscoia* were as abundant as the pygidia of *Parabriscoia*.

Here a new genus, *Hederacauda*, is added to them.

Genus *Hederacauda* KOBAYASHI, new genus

Type-species:—*Dikellocephalus multicinctus* HALL and WHITFIELD, 1877

Diagnosis:—Dikelocephalid with unfurrowed conical glabella, rounded in front, medium sized eyes, oblique eye-ridges; fairly broad depressed brim, genal spine of moderate length and intramarginal anterior sutures; pygidium subtriangular, multisegmented, provided with slender long axis and depressed border having a few serrations.

Distribution:—Upper Cambrian; eastern North America.

Hederacauda multicincta (HALL and WHITFIELD), 1877

Text-figures 8c-d.

1877. *Dikellocephalus multicinctus* HALL and WHITFIELD, *U. S. Geol. Expl. 40th Par. Vol. 4*, p. 226, pl. 2, fig. 36.
1914. *Apatokephalus multicinctus* WALCOTT, *Smiths. Misc. Coll. Vol. 57, No. 3*, p. 352.
1938. *Pterocephalia multicincta* RESSER, *Smiths. Misc. Coll. Vol. 97, No. 10*, p. 39.
1953. *Pterocephalia* (?) *multicincta* KOBAYASHI, *Japan. Jour. Geol. Geogr. Vol. 23*, p. 58.

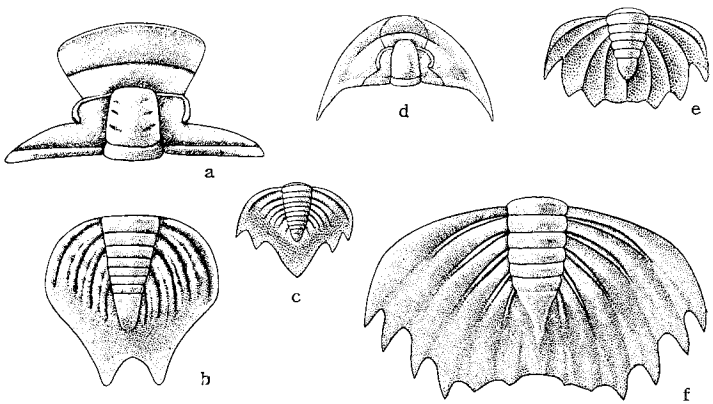

Figure 8.

a-b. *Dikelocephalopsis amsassensis* POLETAYEVA
c-d. *Hederacauda multicincta* (HALL and WHITFIELD)
e. *Richardsonella flabellifera* (HALL and WHITFIELD)
f. *Elkia elegans* (KOBAYASHI)

This was once referred to *Apatokephalus* by WALCOTT and to *Pterocephalia* by RESSER, but I questioned this reference. Its subtriangular and multisegmented pygidium with the slender axis and only 5 spines on the margin exclude it from either the above two genera or any other known genus. Judging from the postero-lateral margin, the restoration by the authors may be accepted for the large rear spine and the second lateral one, but the spines are strongly destroyed on the holotype.

The associated cranidium has a narrow glabella without lateral furrows, but with an axial carination and occipital furrow; eye-band of moderate size connected with glabella by distinct oblique eye-ridge; frontal brim twice longer than frontal limb, depressed and concave. Free cheek fairly broad; its depressed border protruded into a genal spine. Two branches of facial suture diagonally divergent from eye and intramarginal on frontal border.

The cephalon can easily be distinguished from that of *Pterocephalia* in the relatively long glabella, obsolete lateral furrows, much shorter brim and the course of the facial suture. The pygidium is of course different in outline. It is distinct from the pygidium of *Parabriscoia* or *Elkia* in the longer and more triangular outline and the mode of marginal serration.

Distribution:—Limestone (Upper Cambrian, Secret Caynon) of Potsdam group; Pogonip Mountain, White Pine district, Nevada.

Subfamily Dikelokephalininae Kobayashi, 1936

It looks to me improbable that the dikelokephalinids are phylogentically closer to the asaphids than the dikelocephalids as considered by Lochman (1959), because the first and third groups have many biocharacters common between them, while the second is distinct from these two groups. Because the first flourished in Upper Cambrian and the third in Lower Ordovician, the Dikelokephalininae were established with the thought that the subfamily was derived from the Dikelocephalinae. As discussed later, there is no Upper Cambrian asaphid which is so closely related to the Dikelokephalininae that it can be considered ancestral.

Like in the Dikelocephalinae, the glabella of the Dikelokephalininae is generally conical and rounded in front, but the posterior furrows are rare to be connected on the axis as in the former. Lateral furrows are somewhat pitted in the latter and entirely effaced in *Dikelokephalina ulrichi* Růžička, 1926. The basal side-lobes are often seen in the latter. Eyes are medium in size and connected with the glabella by oblique eye-ridges. Facial sutures are semicircular in front of the eyes and then run along the frontal margin; median suture crosses the doublure. The hypostoma of *D. ulrichi* is more rounded than those of *Dikelocephalus* and has a shallow posterior sinuation.

The thorax has 12 segments in *Asaphopsis welleri brevica* (Sheng), 1934 and 13 segments in *Hungioides graphicus* Richter, 1954. The pygidium is provided with a pair of spines in most genera and with two pairs of them in *Hungioides*. Interpleural furrows are generally absent, but present in *Dikelocephalopsis*.

Beside *Dikelokephalina* Brögger, 1896, this subfamily includes *Asaphopsis* Mansuy, 1920, *Hungioides* Kobayashi, 1936, *Dactylocephalus* Hsü, 1948, *Asaphopsoides* Hupé, 1955, and probably *Leimitzia* Sduzy, 1955, *Dikelocephalopsis* Poletayeva, 1955, and *Temnura* Resser and Endo, 1937.

Leimitzia was founded by the author on *Conocephalites bavaricus* Barrande as a subgenus of *Pterocephalina* in the Paracoosiinae. Its pygidium is sinuated at the hind, but bears no spine. The basal side-lobes are distinctly marked

on the cranidium. *Temnura* (Text-fig. 7d) is represented by the pygidium resembling *Uncaspis* on one side and *Dactylocephalus* on the other. Whether it is a member of this subfamily or whether it is a relic of the Crepicephalidae cannot be solved without its cephalon.

Dikelocephalopsis POLETAYEVA (Text-fig. 8a-b) was originally proposed as a genus of the Dikelocephalidae. It is referred to the Dikelokephalininae in Treatise (1959), noting its resemblance with *Leimitzia*. The pygidium of *Dikelocephalopsis* is certainly allied to those of *Dikelokephalina* and *Dactylocephalus*, but in the thick frontal border of the cranidium it agrees better with *Leimitzia* than these two allies. The relatively small eyes connected with the glabella by long eye ridges and the large laterally prolonged posterolateral limb of the fixed cheek are quite strange for the Dikelokephalininae. In the general outline of the cranidium it resembles *Wentsuia* and *Tingocephalus* for the last of which HUPÉ proposed Tingocephalinae. It is a question if these three genera constitute a separate group.

Here *Dainellicauda* is proposed for *Asaphus elegantulus* and *Girvanopyge* for *Lichapyge* (?) *problematicum*. It is beyond doubt that the last species represents a new genus, but its belonging to this family is not highly probable.

Distribution:—Lower and Middle (?) Ordovician; Eurasia and Tasmania.

PA2365-13-27
PA2396-13-28
PA2399-13-29
PA2398-13-30

Genus *Dikelokephalina* BRÖGGER, 1896

Dikelokephalina parva KOBAYASHI, new species

Plate XIII, Figures 27–30.

Description:—Glabella convex, remarkably elevated above cheeks, two-thirds as long as cranidium, gently tapering forward, and rounded in front, its breadth at the neck corresponding to a half length of cranidium; posterolateral and occipital furrows remarkably oblique, the latter narrow, deep and running across the glabella, while the former is discrepant on axis, broadened laterally and confluent with dorsal furrows; long lobe of glabella anterior to this furrow subcylindrical; posterior lobe very narrow, and interrupting the dorsal furrow, it extends into cheeks; occipital lobe narrow and bent backward; median tubercle indiscernible on the neck; eyes medium in size, located a little posterior to the middle of glabella and connected with glabella by a blunt oblique eye-ridge; frontal brim well developed; facial suture semicircular in front of eyes.

Observation:—The holotype measures 1.3 mm. in length (fig. 27). Another cranidium (fig. 28), also very small, is not well preserved. There are three pygidia, the largest of which is 7.5 mm. broad.

Comparison:—The large pygidium of *Dikelokephalina* from loc. 249 is a little longer, its axial lobe more cylindrical, and posterior spines are narrower and longer, if compared with the pygidium of *D. asiatica*. Its lateral margin appears more or less wavy. The above described cephalon is quite distinct from *D. asiatica*, *D. kanaegata* or any other species of *Dikelokephalina*.

Occurrence:—Bunkoku formation at Locs. 248 and 249.

Dikelokephalina conica KOBAYASHI, new species

PA2365-13-3/

Plate XIII, Figure 31.

Compared to the preceding, the glabella is more conical and more strongly convex and the palpebral lobe larger. The posterior furrows tend to be pronounced pits, while the dorsal furrow is weakened. This has a median tubercle on the V-shaped line drawn by the posterior furrows. The anterior margin of the glabella is nearly straight and the frontal brim concave whereas it is nearly flat in the preceding.

The holotype cranidium is 3 mm. long. An imperfect cheek fitting this cranidium is found on the same slab. It shows the wide doublure suggesting for the facial suture to be marginal and meeting its fellow in front of the cephalon to form a median suture on the doublure.

Occurrence:—Bunkoku formation at Loc. 248.

Genus *Asaphopsis* MANSUY, 1920

Asaphopsis nakamurai KOBAYASHI, 1936

1936. *Asaphopsis nakamurai* KOBAYASHI, *Japan. Jour. Geol. Geogr. Vol. 13*, p. 175, pl. 20, figs. 18–20, pl. 21, fig. 12.

Occurrence:—Tomkol shale at Doten. Coll. of Geol. Inst. Kyoto Univ.

Asaphopsis cfr. *nakamurai* KOBAYASHI, 1936

1936. *Asaphopsis* cfr. *nakamurai* KOBAYASHI, *Ibid. Vol. 13*, p. 176, pl. 21, fig. 14.

Occurrence:—Same at the preceding. Coll. of Geol. Inst. Kyoto Univ.

Genus *Dainellicauda* KOBAYASHI, new genus

Type-species:—*Asaphus elegantulus* GORTANI, 1934 (Text-fig. 7c)

Diagnosis:—Dikelocephalid-pygidium whose antero-lateral margin is regularly rounded; lateral border terminating behind at a short spine; axial lobe narrow, longiconic and multisegmented; interpleural furrows absent.

Remarks:—As noted already (1936), this agrees better with *Dikelocephalus* rather than *Asaphopsis* in outline, but evidently too long for *Dikelocephalus*. The spine issues from the anterior in this, instead of the middle segment in *Asaphopsis*. The type pygidium was collected by Prof. Giotto. DAINELLI at Chisil, Carakorum in association with other trilobites, cephalopods and so forth which as a whole indicate Llandeilian, or Llanvirnian for the age of the fauna. In other words, it is younger than *Dikelocephalus* or even *Asaphopsis*.

Distribution:—Middle Ordovician; Himalayan geosyncline.

Genus *Girvanopyge* KOBAYASHI, new genus

Type species:—*Lichapyge* (?) *problematica* REED, 1906, i. e. *Dionide* (?) sp. by NICHOLSON and ETHERIDGE, 1880. (Text-fig. 7e)

Similar to *Dainellicauda*, but the anterior margin is strongly arcuate, axial lobe short, conical and produced into a long slender post-axial ridge, pleural and interpleural furrows extending far toward the posterior margin, and a long spine issuing from the first pleural segment.

As pointed out elsewhere (1936), it is quite distinct from either *Dionide* or *Lichapyge* to which it has been compared. It may be more similar to *Dainellicauda* than those two genera, insofar as the pygidium is concerned. It is, however, distinct from the Dikelokephalininae in the long pleural and interpleural furrows and also the short axis with a long post-axial ridge. There is no question about its being a new genus, but its reference to this subfamily or family is very tentative.

Distribution:—This is the latest of the family, if it be really a dikelocephalid, because the type pygidium occurs in the Whitehouse group (Middle Bala) of Girvan, Scotland.

Genus *Hungioides* KOBAYASHI, 1936

This is different from all of the preceding genera in the possession of two pairs of spines on the pygidium. Beside *Dicellocephalina bohemica* PERNER in NOVAK and PERNER, 1918, which is the type-species the genus comprises the followings;

Hungioides novaki KOBAYASHI, 1936.

Hungioides graphicus RICHTERS, 1954.

Hungioides bohemicus arouquensis THADEU, 1955.

Now *Hungioides* is not restricted to the d$_{\gamma}$1 stage of Bohemia, but occurs in the Griffelschiefer of Thüringia and in the Llandeilian (?) slate in the south of Douro, Portugal.

Family Birmanitidae KOBAYASHI, new family

This family typified by *Birmanites* is different from the typical Dikelocephalidae primarily in the absence of spines on the pygidium. It looks like an asaphoid and the thorax is composed of 8 segments; the eyes are too large and such a large brim as seen in *Birmanites* is never found in the Asaphidae. The genus was proposed by SHENG (1934) with *Birmanites birmanicus* (REED) from the Tremadocian of Chekiang, Central China. Its cephalon is different from those of dikelocephalids in the urceolate glabella to which large semicircular eyes are attached.

As noted already (1950), *Ogyginus* aff. *cordensis* by KOBAYASHI (1934), from the Tomkolian of South Korea probably represents an undescribed species of *Birmanites*.

Caradocian *Birmanites hupeiensis* YI, 1957, (Text-fig. 9c) from the Yangtze gorge has a pair of prolonged triangular basal lobes on the glabella which would serve for distinction from *Birmanites* s. str. Because this morphic differencecorresponds to the time displacement from Lower Ordovician *Birmanites*,

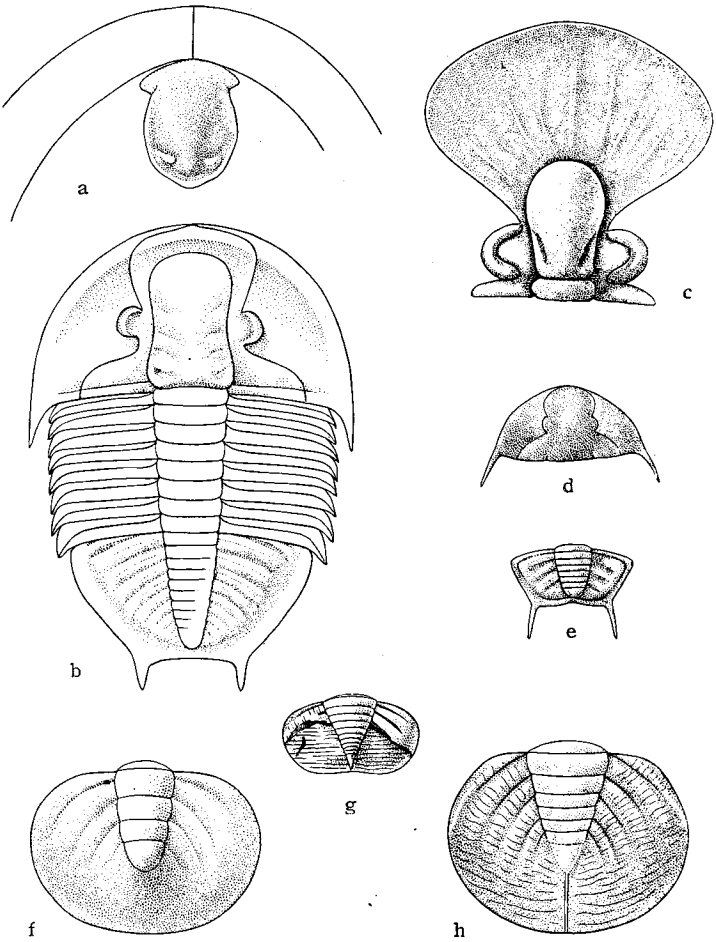

Figure 9.

a, b. *Asaphelina barroisi* MUNIER-CHALMAS et BERGERON
c. *Birmanites* (*Birmanitella*) *hupeiensis* YI
d, e. *Tungtzuella kweichowensis* SHENG
f. *Hagiorites omeishanensis* KOBAYASHI
g. *Hagiorites* (?) sp.
h. *Tropidopyge bröggeri* (MOBERG and SEGERBERG)

Birmanitella is proposed for this Caradocian species.

Birmanites, s. l. of the Birmanitidae may not be endemic to Eastern or Southeastern Asia, seeing that *Ogygites* cfr. *birmanicus* is reported to occur in the Middle Ordovician Ishimsk formation in the northeastern part of Kazakstan (BELIAEVSKY et. al. 1958).

Tripidopyge HARRINGTON and KAY, 1951 (Text-fig. 9h) and *Hagiorites* KOBAYASHI, 1951 (Text-fig. 9f) were both founded on aspinose pygidia of dikelocephaloid-aspect. The former was first proposed as a genus of the Dikelocephalidae, but later transfered by HARAINGTON and LEANZA (1957) into their Hypermecaspidae. The latter genus is different from the former in the subcylindrical axial lobe well round at the rear whence no post-axial ridge issues.

Hagiorites (?) sp. by KOBAYASHI, 1951, (Text-fig. 9g) having a broad elliptical pygidium, short conical axis and wide doublure belongs most probably to an unnamed genus, but little is known to settle its taxonomy.

Distribution:—Ordovician; Eastern and (?) Central Asia.

Suborder Asaphina SALTER, 1864

Family Taihungshaniidae SUN, 1931

Taihungshania, *Omeipsis*, *Asaphelina* and *Tungtzuella* are generally referred to this family. Putting aside *Omeipsis*, the remaining three genera agree with one another in the possession of one pair of spines on the pygidium, but they are quite different in many other aspects. *Asaphelina* (Text-fig. 9a–b) is more allied to the Niobinae or Ogygiocardinae than *Taihungshania*, while *Tungtzuella* (Text-fig. 9d–e) resembles certain genera of the Isotelinae, *Isoteloides* for example. I think it quite probable that these two genera are independent offshoots from different branches of the Asaphidae. The hypostoma associated with *Tungtzuella yunnanensis* is subtriangular, but well rounded in posterior and alate on the two sides of the anterior margin. It is quite different from the hypostomata of the Asaphidae and Taihungshaniidae. Therefore it is also probable for *Tungtzuella* to be derived from the Tsinanidae or some other Upper Cambrian branch.

The glabella is narrowing backward in *Taihungshania* and forward in *Omeipsis*. The pygidium of the former or latter genus has one or two pairs of spines respectively. The two genera, however, agree in the relatively long glabella and small eyes located anteriorly and close to the glabella. While *Taihungshania* is widely distributed from Arenigian to early Llandeilian, or possibly appears already in the late Tremadocian, *Omeipsis huangi* is monotypic of the genus and its occurrence is restricted to the top (lower Llandeilian) of the Tachengssu formation of Szechuan.

Genus *Taihungshania* SUN, 1931

Taihungshania was greatly amplified in China by SHENG (1958) and com-

prises 5 species and 3 varieties. It is interesting to see among them that there are two morphological series.

1. *Shui* series having semi-parabolic and multisegmented pygidia.
   Taihungshania miqueli (BERGERON) by SHENG.
   Taihungshania shui SUN.
   Taihungshania multisegmenta SHENG.
2. *Brevica* series having semi-circular and paucisegmented pygidia.
   Taihungshania brevica SHENG.
   T. brevica var. *tachengssuensis* SHENG.
   T. brevica var. *orientalis* SHENG.
   Taihungshania omeishanensis SHENG.
   T. omeishanensis var. *liui* SHENG.

T. brevica is long-ranged whereas *T. omeishanensis* is a short-ranged terminal species introduced by the hypertrophy of the axial lobe. Likewise, *T. multisegmenta* having more than 21 rings on the axis of the pygidium is the terminal species of the *shui* series in which the axial lobe is generally divided into 14 to 16 rings.

In looking through these Chinese forms it can hardly be overlooked that the genal angle issues from the lateral side and the intergenal angle is distinct in *Taihungshania* s. str. If special weight is laid on these characteristics, *Miquelina miqueli* (BERGERON) and its varieties must be segregated from *Taihungshania*, and *Miquelina* THORAL, 1935, revived for the Mediterranian forms. *Taihugshania hectori* (REED) from New Zealand (KOBAYASHI, 1940) is closer to *Miquelina* than *Taihungshania* s. str. in the lack of the intergenal angle, but evidently distinct from them in the development of the eyes at the relatively posterior position, although the specimens are so crudely deformed to restore the original form correctly.

Family Asaphidae BURMEISTER, 1843

There are five asaphoid genera in the Upper Cambrian. *Charchaqia* is one of them which is now known to have been widely distributed from East Tienshan to Australia through Kweichow, South China, in association with *Hedinaspis* or *Eugonocare*. The genus was founded by TROEDSSON on *Charchaqia norini* (Text-fig. 10h) and placed in the Ogyginae of the Asaphidae. It is however, quite distinct from other genera of the Asaphidae in the narrow unfurrowed cylindrical glabella, relatively broad fixed cheek, fairly anterior eyes and subparallel anterior sutures. Although a precise comparison is deferred to a later occasion, it is more closely related to an undescribed genus (*Iwayaspis*) from the Machari formation. It is intermediate between the Asaphidae and Ceratopygidae, principally different from the latter family in the absence of a pair of spines on the pygidium and from the former in the possession of nine segments in thorax.

Yüpingia niobiformis LU (Text-fig. 10b) is a contemporary with *Charchaqia* and early Upper Cambrian in age, because it is found in East Kweichow toge-

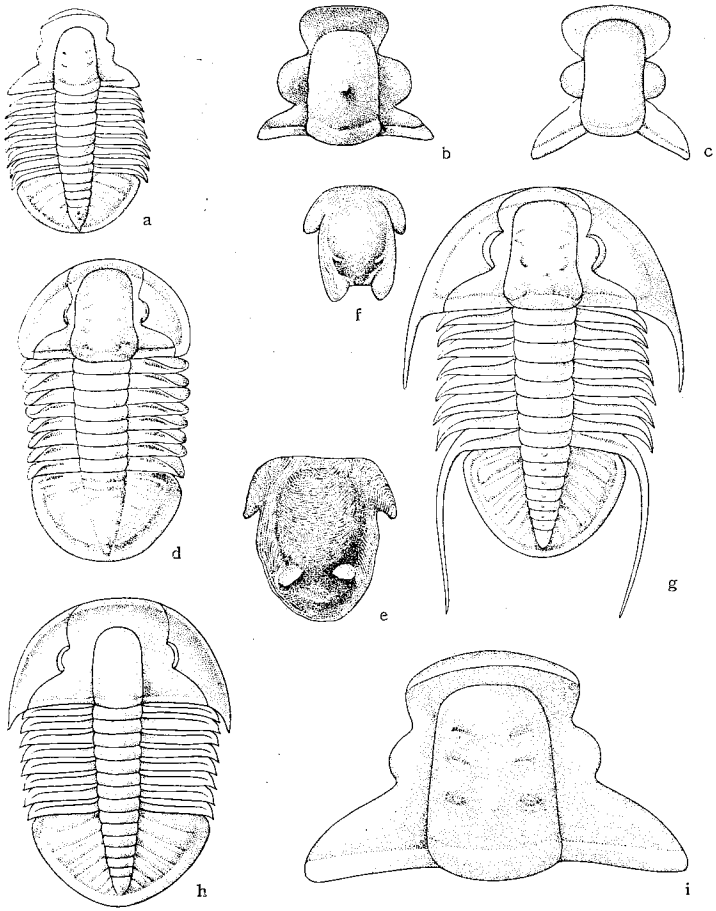

Figure 10.

a. *Eoasaphus superstes* (LINNARSSON)
b. *Yüpingia niobiformis* LU
c. *Metoptogyrus grangeri* RAYMOND
d, e. *Niobella aurora* WESTERGÅRD
f, g. *Promegalaspides kinnekullensis* WESTERGÅRD
h. *Charchaqia norini* TROEDSSON
i. *Norinia convexa* TROEDSSON

ther with *Eugonocare* and *Prochuangia*. It is recongnized by JAANUSSON as a member of his subfamily, Niobinae, but not the less allied to late Middle Cambrian *Haniwoides* on one side and to Lower Ordovician *Metoptogyrus* (Text-fig. 10c) on the other. In my opinion *Haniwoides* is the closest relative to it. Simply it differs from *Haniwoides* by the prominent median tubercle, rounded

anterior outline of the glabella and distinct occipital furrow. Lower Ordovician *Metoptogyrus* can be distinguished from *Yüpingia* by the relatively longer glabella contracted at the midlength, absence of the median tubercle and the more expanded preglabellar area. *Columbicephalus* is another Lower Ordovician ally which however, has the distinct isoteli-form suture.

In Sweden *Eoasaphus* occurs in the *Orusia lenticularis* zone. *Eoasaphus* (or *Anorina*) of which *Liostracus* (?) *superstes* LINNARSSON (Text-fig. 10a) is monotypic, has the cranidium and pygidium closely related to those of *Norinia convexa* (Text-fig. 10i) in the conical glabella and three pairs of short lateral furrows. Although the eyes are located more anteriorly and the postero-lateral limb of the fixed cheek is larger in the latter, I think that the two genera belong to the same lineage. According to TROEDSSON the hypostoma associated with *N. convexa* resembles that of *Symphysurus*. No hypostoma is known of *Eoasaphus*. JAANUSSON referred *Norinia* to the Niobinae.

Niobella (Text-figs. 10d, e) and *Promegalaspides* (Text-figs. 10f, g) occur in Sweden in the *Peltura* zone and possibly in the *Acerocare* zone. The latter for which JAANUSSON instituted the Promegalaspidinae has the cranidium resembling those of *Niobe* and *Niobella*, but the free cheek carries a genal spine and the pleura of the eighth thoracic segment is prolonged into a spine. The hypostoma is sinuated in posterior in *Promegalaspides*, but entire in *Niobella*. LOMOVITSKAJA (in KHALFIN, 1955) erected four new species of *Promegalaspides* for cranidia from the upper Tremadocian of Siberia. It is desirable to search a spiniferous thoracic segment to confirm their generic reference. At any arte it is interesting to see that one or two post-cephalic segments are spiniferous in this subfamily or the Ceratopygidae, although such a segment is in thorax in the former and in pygidium in the latter.

In short, *Niobella* and *Eoasaphus* belong to the Niobinae; *Promegalaspides* and *Charchaqia* are related to the Niobinae as well as the Ceratopygidae in one or the other character; *Yüpingia niobiformis* is, as suggested by its specific name, allied to the Niobinae, but at the same time to the the Anomocaridae. There is no Upper Cambrian asaphid or asaphoid very intimate to the Dikelokephalinae or Dikelocephalidae.

PA2399-14-15
PA2400-14-16
PA2401-14-17
PA2402-14-18
PA2403-14-19
PA2404-14-20
PA2405-14-21
PA2406-14-22
PA2407-14-23
PA2408-14-24

Subfamily Isotelinae ANGELIN, 1854

Genus *Asaphellus* CALLAWAY, 1877

Asaphellus tomkolensis KOBAYASHI, 1934

Plate XIV, Figures 15-24.

1934. *Asaphellus tomkolensis* KOBAYASHI, *Jour. Fac. Sci. Imp. Univ. Tokyo, Sec. 2, Vol. 3, Pt. 9*, p. 549, pl. 4, figs. 1-4, (?) 5-7.
1934. *Asaphelllus* aff. *gyracanthus* KOBAYASHI, *Ibid.* p. 551, pl. 4, figs. 8-11.
1934. *Asaphellus* (?) sp. KOBAYASHI, *Ibid.* p. 553, pl. 4, figs. 13-14.

Although no complete dorsal shield has as yet been discovered, the pygidia which occur in the Bunkoku formation are not truncated on the posterior side

and their outline is semi-circular, like those of *Asaphellus* aff. *gyracanthus* and *Asaphellus* (?) sp. Therefore it is probable that the trapezoidal pygidium previously referred to this species belongs to some other species. In a pygidium from loc. 248 (fig. 19) the marginal border is remarkably depressed. The border is not so angulated along the inner margin in another pygidium from loc. 249 (fig. 20). In an immature pygidium from loc. 252 (fig. 23) anterior two rings and pleural ribs are quite distinct. Seeing the variability, it is considered that the relatively long pygidium of *Asaphellus* (?) sp. may be involved in this species.

At loc. 239 a hypostoma (fig. 22) was found together with a pygidium of this kind (fig. 21) to which a posterior thoracic segment is attached. Its posterior outline is entire and somewhat produced at the middle point. The central body is embraced by a depressed lateral border on each side. The anterior aspect is, however, obscure in this specimen. Another hypostoma from loc. 206 (fig. 16) is nearly perfect, but the very posterior median projectile is unpreserved.

It is fortunate to find at Shi 2 (fig. 15) the same kind of hypostoma having a pair of maculae and a small projectile at the middle of the posterior border as seen in the hypostomata of *Asaphellus homfrayi* (LAKE, 1942) and *Asaphellus catamarcensis* (HARRINGTON and LEANZA, 1957). It is accompanied by the cranidium and other parts of *tomkolensis*. A further confirmation is the find of a hypostoma at Doten (fig. 24). Though it is imperfect, it agrees with the preceding in the observable characteristics. Therefore it is quite reasonable at present to assign the above hypostoma to this species.

Occurrence:—Tomkol shale at Dotenri, Shi 2, and other localities. Detached carapaces of this species were found in the Bunkoku formation at various localities, 206, 239, 248, 249, 252, 282, etc. In the *Yosimuraspis* zone, though rare, it is represented by the cranidium from loc. 282 which is quite typical of this species (fig. 17).

Order Phacopida SALTER, 1864

Family Pliomeridae RAYMOND, 1913

Subfamily Pilekiinae SDUZY, 1955

Genus *Metapilekia* HARRINGTON, 1938

Metapilekia martellii (KOBAYASHI), 1934

1934. *Metopolichas* (?) *martellii* KOBAYASHI, *Jour. Fac. Sci. Imp. Univ. Tokyo, Sec. 2, Vol. 3, Pt. 9*, p. 565, pl. 7, fig. 1.

Since I had described this pygidium, I was strucked to find its close resemblance with the pygidium of *Metapilekia bilirata* HARRINGTON, 1938. These two in addition to the pygidium provisionally assigned to *Dikelocephalus* (?) *corax* BILLINGS bear so many characters common among them that their congenity is forcefully suggested. Namely, they have subrectangular first pleural ribs by which their general outline looks subquadrate. The three pleural ribs

are all flat and prolonged back into spines. The axis is conical and composed of three rings and a terminal lobe.

M. martellii appears to have the fourth pleural rib, though it is simple and rudimentary. The pleural and interpleural furrows are developed in the three others. In *M. bilirata* the axial lobe is much broader and the lateral angle of the first pleural rib more rounded than in *martellii*.

Least possibility remains for *martellii* to belong to the Lichidae not only because of its morphology but also because no lichid has as yet been found in Korea.

Occurrence:—*Protopliomerops* zone of Sesong-ni (Saishori).

Metapilekia sp. nov.

Plate XIII, Figure 26.

PA2409

Though fragmentary, the close alliance of this pygidium to *Metapilekia martellii* is hardly deniable, because it has more than three flat pleural ribs each bearing a pleural furrow. The second rib is strongly suggestive of its rectangular bent at about the middle. It is however, specifically different from *martellii* because the pleural part is much broader in comparison to the axial part. If it is not a *Metapilekia*, it may belong to *Pilekia*.

Occurrence:—Bunkoku formation at loc. 232.

Genus *Protopliomerops* KOBAYASHI, 1934

Protopliomerops punctatus KOBAYASHI, 1934

PA2410-13-14
PA2411-13-15

Plate XIII, Figures 14-15.

1934. *Protopliomerops punctatus* KOBAYASHI, *Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 3, Pt. 9*, p. 572, pl. 7, figs. 4-5.

A small cranidium from loc. 252 has a subquadrate glabella, three pairs of profound lateral furrows, small eyes close-set to the first furrows and strongly punctate free cheeks. With this specimen one can get a better concept of the cranidium than the previous restoration. The glabella exclusive of the neck ring is nearly as long as broad and its anterior margin less arcuate than presumed on that occassion. The three lateral furrows are all straight, oblique, parallel to one another and extending more than one third the breadth of the glabella. Its test is smooth or very sparsely granulate.

Another specimen from loc. 250 which is ill-preserved, is similar in size to the type cranidium from Tongjomni (Dotenri). The cheeks of these specimens are similarly punctate, but the lateral and posterior borders smooth and marginal furrows fairly strong. In the two cranidia before hand the genal angle is 40 to 50 degrees. The genal spine of moderate length is projected in the same direction with the lateral border.

The glabella of this species is shorter than those of *P. seisonensis, P. granulatus* or *Koraipsis spinus*. In the texture of the glabella and cheeks and

in the size and position of the eyes this species fits better with *Koraipsis spinus* than these species of *Protopliomerops*.

Occurrence:—Bunkoku formation at Locs. 252 and 250; *Protopliomerops* zone of Dotenri.

Genus *Koraipsis* KOBAYASHI, 1934

1934. *Koraipsis* KOBAYASHI, *Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 3, Pt. 9*, p. 574.

Type-species:—*Koraipsis spinus* KOBAYASHI, 1934, monotypic.

Remarks:—This genus is known only of the cranidium which looks similar to *Protopliomerops*. The unique feature of this genus among cheirurids is the frontal spine issuing from the glabella which is so distinct that it leaves no difficulty of recongnizing its generic independence. As noted already, the agreement of the type-species with *Protopliomerops punctatus* in many aspects suggests that the latter may be the second species of the genus, if it bears such a spine.

Distribution:—Lower Ordovician; South Korea.

Koraipsis spinus KOBAYASHI, 1934

PA2412

Plate XIII, Figures 16a-b, Text-figure 11.

1934. *Koraipsis spinus* KOBAYASHI, *Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 3, Pt. 9*, p. 574, pl. 8, fig. 1.

The cranidium from loc. 221 consists of an internal and external mould. Compressed laterally, the glabella is elongated and subcarinated along the axis; lateral furrows are long and assume greater obliquity than they have originally been. The glabella is quadrate, but somewhat rounded in front. Eyes are close-set to the first lateral furrows which start from the antero-lateral angles of the glabella. Its frontal lobe whence the stout spine issues is relatively small. Fixed cheeks are strongly punctate, but not the marginal borders. Some minute tubercles are found scattered on the glabella.

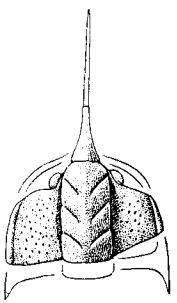

Figure 11. *Koraipsis spinus* KOBAYASHI

Occurrence:—Bunkoku formation at Loc. 221; *Clarkella* zone of Sesong-ni (Saishori).

Genus *Hintzeia* HARRINGTON, 1957

Hintzeia glabella KOBAYASHI, new species

PA2413

Plate XIII, Figure 32.

Description:—Glabella outlined by profound dorsal furrows, subquadrate, almost as long as broad, moderately tapering forward and subrounded in front,

more or less flattish on top and provided with three pairs of lateral furrows which are parallel to one another and equally strong; anterior furrow starting a little inside of antero-lateral angle; posterior furrow abruptly bent back near axis and meets with broadly arcuate occipital furrow; neck ring thickened mesially, but its posterior margin is straight; fixed cheek probably narrower than glabella, gently convex, nearly as high as glabella; eyes opposed at middle glabellar furrows and connected with antero-lateral angle of glabella by strong eye-ridge; frontal border flat, slant forward, delimited inside by a deep furrow on which the frontal lobe of glabella is somewhat protruded; test smooth.

Comparison:—The cheek is so imperfectly preserved that no statement can be given of the facial suture. Nevertheless, this species is diagnostic of *Hintzeia*. *Protopliomerops aumula* HINTZE which is the type-species differs from this in the more arcuate and convex frontal border, smaller frontal lobe and weaker anterior furrow of the glabella, more anterior position of the eye and granulate test.

Occurrence:—Bunkoku formation at Loc. 100906.

Pliomerid, gen. et sp. indt.

PA2414-13-33
PA2415-13-34

Plate XIII, Figures 33-34. ✓

Small pliomerid thorax composed of 11 or 12 segments; pleurae a little broader than axial rings, bent back in distal half or a third; anterior pleural rib strong; pleural furrow weak.

It is smaller than the thorax which was referred to *Protopliomerops seisonensis*. It may belong to *Hintzeia glabella*, as it is the only small pliomerid.

Occurrence:—Bunkoku formation at Locs. 93002 and 93006.

Hypostoma, fam. gen. et sp. indt.

Plate XIV, Figure 3. V

PA2416

An external mould of a hypostoma is mainly occupied by a large ovate fairly convex central body in the posterior part of which a pair of narrow and shallow lunate grooves are opposed with the convexity on the anterior and inner side. The body is surrounded by a narrow rim, but on its antero-lateral side there is a triangular wing. The anterior margin of the hypostoma which is separated from the central body by a groove, is erect and arcuate and forms the anterior margin of the wing on the lateral side.

The hypostoma resembles that of *Apatokephalus hyotan*, although they are somewhat different in outline.

Occurrence:—Associated with some plates of *Plumulites* cfr. *primus*, but no trilobite on the same slab. However, *Apatokephalus hyotan*, *Dikelocephalus parva*, *D. conica* and *Asaphellus tomkolensis* are polymeric trilobites collected from Loc. 248 where the slab was procured.

Class Crustacea (?)

Subclass Branchiopoda (?)

Order Ribeirida KOBAYASHI, 1954

Family Ribeiridae KOBAYASHI, 1933

I have once considered that the Ribeiridae and Eopteridae are synonymous, because *Eopteria* which is the type-genus of the latter was included in the former. Now I think, however, the Ribeiridae must stand for the group of *Ribeiria* having the smooth carapace, entire in outline. Most others of the order have radial sculptures on the test or one or two wings are often protruded along the dorsal margin. *Ribeiria* and *Ribeirella* have two clavicles, instead of one, but the posterior one is generally a thickening along the postero-dorsal margin which is not always distinct nor protruded ventrally.

Incidentally, *Aluta paiensis* ENDO and its variety, *tenuis* ENDO (1937) from the late Upper Camprian at Paichiashan, Chinchiachengtzu, Liaoning, (China) is extraordinarily large for *Aluta* and do not show any characteristic of the genus. On the other hand their size, outline and other aspects suggest their being *Wanwanias* closest to *W. cambrica* which was also procured from the same formation at Paichaishan hill (KOBAYASHI, 1933).

Genus *Ribeirella* SCHUBERT and WAAGEN, 1903

Ribeirella subcircularis KOBAYASHI, new species

PA2417 (PL.14, Fig.2)

Carapace almost circular, as long as high and gently convex. Internally, anterior clavicle of moderate size, triangular and pointed toward the center of the valve; the other clavicle which is a thickening of the rounded postero-dorsal margin, is protruded a bit ventrally at the extremity.

The test is unpreserved. The specimen, however, suggests that a shallow sinuation may exist in front of the umbo. It is certain that the other margins are well rounded. In the subcircular outline this species closely resembles *Ribeirella crassa* THORAL from the lower Arenig of South France and *Ribeirella* sp. (1936) or Bivalve indt by ETHERIDGE from the Table Cape conglomerate in Tasmania. In the French form the carapace is more convex and the anterior clavicle narrower. In the Tasmanian form the posterior clavicle is as prominent as the anterior one.

Occurrence:—Loc. 193 with *Clarkella vulgaris*.

Subclass Cirripedia (?)

Genus *Anatifopsis* BARRANDE, 1872

This is a peculiar fossil of unkown taxonomic position. Because of its resemblance with terga of *Lepas*, BARRANDE referred it to the Cirripedia. This opinion was later upheld by CHAUVAL. BROILI (1924) placed it provisio-

nally in the Lepidocoleidae of the Cirripedia. WITHERS (1926), however, proposed Machaeridia to include this family as well as the Turrilepadidae and emphasized its alliance to the Echinodermata. THORAL (1935) on the other hand brought *Anatifopsis* to the Phyllopoda.

BARRANDE described four species of *Anatifopsis* as follows:

1. *A. prima* BARRANDE from d1
2. *A. acuta* BARRANDE from d2
3. *A. bohemica* BARRANDE from d3-4
4. *A. longa* BARRANDE form d4

The genus is best represented by *A. prima* which is not essentially different from the Korean forms in the presence of two internal clavicles divergent ventrally from the anterior end of the dorsal margin. The outline of *prima* is somewhat quadrate, or better to say, triangular, elongated laterlly and far more elongated than that of the Korean forms and even pointed behind. An additional distinction lies in the subdorsal narrow and very long depressed area and much greater convexity of the shell.

The triangular outline is more typically represented by *A. acuta*. *A. longa* looks quadrate, but protruded postero-ventrally. In outline *A. bohemica* is the nearest to the Korean forms, but still the valve is divided into a subdorsal, median and anterior area by obtuse angulations.

THORAL described the following two species from the Montagne Noire, South France.

5. *A. trapeziformis* THORAL common at the top of *Asaphelina barroisi* zone and rare at the base of *Taihungshania* (i. e. *Miquelina*) *miqueli* zone. Similar to *A. bohemica*, but more trapezoidal, having parallel dorsal and ventral margins.
6. *A. escandei* THORAL, common in *miqueli* zone, more qudarate and cylindrical than *A. trapeziformis*.

Compared to these European species, the Korean forms have the outlines evidently higher, shorter and more quadrate. There is no submarginal groove or carina internal or external. The convexity of the shell is moderate and never so strengthened as that of *A. prima* and some other species.

PA 2418-13-2
PA 2419-13-3
PA 2420-13-4
PA 2[illegible]365-13-5
PA 2421-13-6

Anatifopsis cocaban KOBAYASHI, new species

Plate XIII, Figures 2-6.

Shell bivalved, subquadrate; anterior margin semi-circular. Internally, two clavicles extending ventrally from the anterior end of the dorsal margin.

On a specimen (Fig. 6) from loc. 248 there are two valves smooth externally, but fine growth lines are closely impressed on the internal surface. These lines run parallel to the ventral and posterior margins. The right valve on the left side of the observor shows a weak sinuation along the posterior margin. Supposing it to be an arthropod, its abdomen is inferred to have been protruded therefrom backward. The anterior margin of the

13-5 ⇒ 13-8 Aguiostus,
13-29 = 13-8
13-31 = 13-8

other valve is somewhat recurved, taking the aspect of a narrow rim.

As seen in the internal moulds from locs. 233 and 249, there are two strong grooves which are impressions of internal clavicles. The section in front of the anterior clavicle is narrow and lunate. In a specimen in fig. 4, it is crossed by a weak ridge or groove. The next section is long, triangular and broader than the preceding. The posterior clavicle is as a rule stronger than the anterior one.

In an internal mould (fig. 3) the second or posterior clavicle is represented by a deep groove and provided behind it with a narrow groove, i. e. a ridge on the mould.

Occurrence:—Widely distributed in the Bunkoku formation and collected at Locs. 248, 233, 93004 and 100101.

Anatifopsis truncatum KOBAYASHI, new species

Plate XIII, Figure 1.

PA2422

This is distinguished from the preceding species by the carapace-outline which is diagonally truncated on the postero-ventral side and distinctly sinuated to the ventral side near the point where the posterior clavicle terminates. Growth lines are clearly impressed on the other side.

Occurrence:—Bunkoku formation at Loc. 252.

Phylum Echinodermata

Class Cystoidea VON BUCH

Cystoid, gen. et sp. indt.

Plate XIV, Figure 27.

PE2423

Small rhombic plate on which deep relatively broad grooves radiate toward the angles from the fairly large central depression.

Occurrence:—Bunkoku formation at Loc. 252.

Class Machaeridia WITHERS

Family Turrilepadidae CLARKE

Genus *Plumulites* BARRANDE, 1872

Plumulites cfr. *primus* KOBAYASHI, 1934

Plate XIII, Figure 17.

PE2415

1934. Cfr. *Plumulites primus* KOBAYASHI, *Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. 2, Vol. 3, Pt. 9*, p. 526, pl. 2, figs. 1-3.

The triangular outline of this keeled plate is fairly similar to that in fig. 2, pl. 2, 1934, but more asymmetrical and twisted. The inner margin is remarkably concave. The basal margin is distinctly sinuated in the median part, but neither the longitudinal fold nor growth lines are well impressed.

Hence its identification cannot be definite.

Occurrence:—Bunkoku formation at Loc. 248.

Plumulites sp. nov.

PE2399-13-18
PE2424-13-19

Plate XIII, Figures 18-19.

Two kite-shaped plates, poorly preserved, but quite distinctive from the known plates of *Plumulites* from Korea in its slender outline. In the better one in fig. 18, the length corresponds to almost two and a half of the breadth. It is gently curved and grooved mesially, but nearer to the convex than the other side. The two sides of the groove are marked by fine striae which form an angle of about 100 degrees. The other plate is also long, slightly curved, mesially grooved and striated on its two sides.

Occurrence:—Bunkoku formation at Locs. 206 and 233.

Phylum Prochordata

Class Graptolithina Bronn, 1846

Shiraki was the first to discover graptolites in Korea. In 1922 he found them at Hwangii-ri, Sangjang-myŏn, Samchŏk-gun, Kwanwŏn-do. (江原道三陟郡上長面黃池里). In 1934 I made a study on the graptolites from the Chikunsan shale at Hwangii-ri and Makkol, Sangdong-myŏn, Yŏngwŏl-gun, Kwangwŏn-do, (江原道寧越郡上東面莫洞) which were collected by Shiraki and myself respectively. There were *Diplograptus* (*Amplexograptus*) *preexcavatus* Lapworth and *Dicellograptus* or *Dicranograptus* sp. indt. Shimizu and Obata (1935) reported the occurrence of *Climacograptus* cfr. *bicornis* (Hall), ? *Diplograptus* (*Glyptograptus*) *teretiusculus* var. *siccatus* Elles and Wood and ? *Diplograptus* (*Glpytograptus*) *teretiusculus* var *kansuensis* Grabau from the same shale at Chiktong-ni and Tumu-kol (稷洞里, 斗務洞) both in Sandong-myŏn, but none of them was described or illustrated.

The graptolite which Hukasawa discovered in the Bunkoku formation at Paeg'un-do (Hakununudo) and Chongbou-ri (Shokyuri) were *Dictyonema* cfr. *flabelliforme* and *Clonograptus* (?) sp.

The graptolite shale must be Tremadocian and approxiamate in age to the *Dictyonema flabelliforme* zone of the Yehli-limestone in Hopei, North China and the *Dictyonema* shale near Ichang, Hupeh, Central China.

Order Dendroidea Nicholson, 1872

Family Dendrograptidae Roemer in Frech, 1897

Genus *Dictyonema* Hall, 1850

Dictyonema cfr. *flabelliforme* Eichwald, 1840

1942. *Dictyonema* cfr. *flabelliforme* Kobayashi and Kimura, *Japan. Jour. Geol. Geogr. Vol. 18*, p. 308, pl. 29, figs. 1-3.

Occurrence:—Bunkoku formation at Locs. 91405 and 101909.

Family Dichograptidae LAPWORTH, 1873

Genus *Clonograptus* HALL and NICHOLSON, 1873

Clonograptus (?) sp.

1942. *Clonograptus* (?) sp. KOBAYASHI and KIMURA, *Japan. Jour. Geol. Geogr. Vol. 18*, p. 309, pl. 29, figs. 4-5.

Occurrence:—Bunkoku formation at the preceding localities.

Problematicum

PP2425-14-25
PP2426-14-26

Coprolites (?)

Plate XIV, Figures 25-26.

A narrow strip in fig. 25 is constricted at short intervals nearly equal to the breadth of the strip. It is, however, thickened at an end where are crowded small segments which are narrower, but relatively long.

Another strip in fig. 26 is thicker than twice the preceding, but the constriction is obscure and irregular.

These strips take irregular courses not in an horizontal place. It is certain that they are neither remains of organisms by themselves, nor cralwing impressions. They are probably excrements left behind when animals crawled.

Occurrence:—Bunkoku Formation at Locs. 100101 and 101909.

Postscript

Liaoningaspis taitzehoensis CHU, 1959, is so astonishingly similar to *Monkaspis daulis* that they are considered probably congeneric with each other. The former is the type-species of *Liaoningaspis* CHU, 1959, which was collected from the *Blackwelderia paronai* zone of the Yentai and Penhsi coal-fields, Liaoning. It is specifically distinct from the latter which is the type-species of *Monkaspis*, in the weakness of the lateral furrows on the glabella and the eye-ridges which start a little behind the anterior margin of the glabella in *taitzehoensis*, while they begin at the lateral ends of the margin in *daulis*. The pygidium is broader, the pleural lobes are less segmented and the lateral margin has only two anterior serrations in *taitzehoeneis*, but more than three serrations are present in *daulis*.

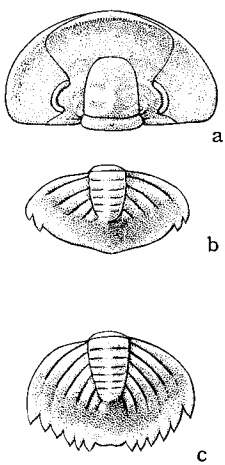

Figure 12.
a-b. *Liaoningaspis taitzehoensis* CHU
c. *Kushanopyge serrata* CHU

In the mode of serration *M. daulis* agrees better with *Kushanopyge serrata* CHU, 1959, also from these coal-fields. The species was founded on the pygidium and made the type-species of *Kuhsanopyge*. Compared with *daulis*, the anterior margin is more arcuate, and the concave marginal brim more developed in *serrata*. Therefore it is evident that they are two distinct species, but it is a question that they represent separate genera. If *Kushanopyge* is not a synonym with *Monkaspis*, *Monkaspis* is the most intimate genus to *Kushanopyge*.

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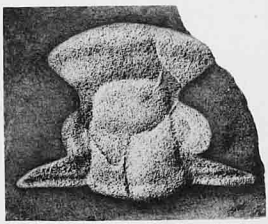

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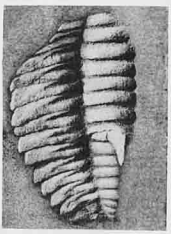

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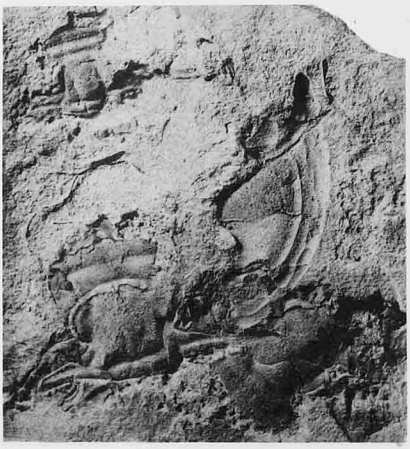

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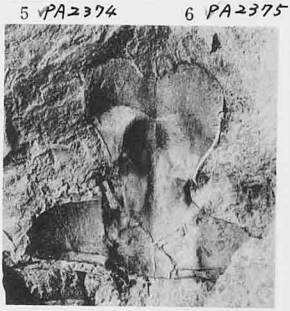
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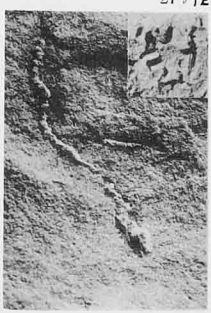
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