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nications relating to this JOURNAL should be addressed to the HE FACULTY OF SCIENCE, IMPERIAL UNIVERSITY OF TOKYO.

The Cambro-Ordovician Formations and Faunas of South Chosen.

Palaeontology.

Part III. Cambrian Faunas of South Chosen with A Special Study on the Cambrian Trilobite Genera and Families.

By

Teiichi KOBAYASHI.

With Plates I-XXIV.

CONTENTS.

Introduction.

The Cambrian faunas of South Chosen here described attain 131 species which are distributed as follows :—

Cystoidea.	1 species.
Brachiopoda.	19 species.
Gastropoda.	2 species.
Conularida.	3 species.
Cephalopoda.	1 species.
Trilobita.	104 species.
Incerta Sedis.	1 species.

On the basis of stratigraphical successions and the faunal characters, fossil zones are distinguished in the Cambrian strata of the region as below :—

Kasetsu group.	*Eoorthis* zone.
	Dictya zone.
	Kaolishania zone.
	Chuangia zone.
	Prochuangia zone.
Seison slate.	*Drepanura* zone.
	Stephanocare zone.
Taiki group.	*Olenoides* zone.
	Solenoparia zone.
	Megagraulos zone.
Beiho slate.	*Elrathia* zone.
	Mapania zone.
	Salterella zone.
Sohsan quartzite.	(No fossil zone.)

The Kasetsu group is the Chaumitian or Upper Cambrian; the Seison slate the top of the Middle Cambrian; the *Salterella* zone may possibly be the late Lower Cambrian.[1]

1) Since this manuscript has been completed, *Redlichia* is discovered in Bunkei area, Chusei-hoku-do, South Chosen.

Near Neietsu is found an interesting *Olenoides* zone which contains a large fauna corresponding to the Stephen fauna of western North America. As the fossil zone occurs isolated from other sections, the stratigraphical position cannot actually be determined, but judging from the lithological succession and faunal aspects, the zone quite clearly belongs to a certain horizon in the Taiki group, and is probably higher than the *Megagraulos* zone, but the decision as to the relative position referred to *Solenoparia* zone will be left for future research.

In this study particular attention is paid to the family relationships of the trilobite genera.

DESCRIPTION OF FOSSILS

PE902-2-17
PE903-2-18
PE904-3-24

Phylum ECHINODERMATA.

Class CYSTOIDEA Leopold von Buch.

Cystoid, gen. et sp. undt.

Plate II, figures 17-18 ; Plate III, figure 24.

Some columnar joints and numerous detached plates of Cystoid are found in the *Eoorthis* zone.

The plates hexagonal; radial ribs connected from center to the median points of the edges; five to six V-shaped ridges arranged in each division between these radial ribs. The columnar joints are small, flat, and circular rings.

This is the common type of Cystoid plates occurring in the Upper Cambrian and Lower Ordovician. Though the fragmentariness of the material makes it hard to tell the generic position, at any rate this probably represents a certain primitive genus of Rhombifera.

Reed's *Echinoencrinus*[1] sp. from Pupiao, Yunnan, and Mansuy's *Heliocrinus* (?) sp.[2] from the *Asaphopsis* beds of Annam are the similar forms of this order known from the Orient.

A quite similar kind of Rhombifera is known from the Lower Cambrian of England ;[3] another allied form found in the Cass Fjord formation of Greenland[4] is however, distinguished from this Korean one by low rows of tubercles.

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1) F.R. Cowper Reed (1917), Ordovician and Silurian Fossils from Yunnan, (Pal. Indica, New Ser. 6, No. 3.)

2) H. Mansuy (1920), Nouvelle Contribution a l' Étude des Faunes paléozoiques et mésozoiques de l'Annam septentrionale, Région de Thanh-Hao, (Mém. Serv. Géol. de l' Indochine, Vol. II, Fasc. 1.)

3) E.S. Cobbold (1931), Additional Fossils from the Cambrian Rocks of Comley, Shropshire, (Q. J. G. S. London, Vol. LXXXVII,) p. 499, Pl. XL, figs. 11a-b.

4) C. Poulsen (1927), Cambrian, Ozarkian and Canadian Faunas of Northwest Greenland, (Jubilaemsekspeditionen nord om Grønland, No. 2,) p. 283, text-fig. 3, Pl. XVII, figs. 37-39.

In the hexagonal plate only this Korean form is not unlike *Macrocystella mariae* Callaway[1] from the Shineton shales: Cystidae *bavarica* Barrande[2] known from the Lower Ordovician of Hof is also very similar to it.

Eocystites sp. is known to occur in the Cambrian of Spiti,[3] but *Eocystites* as well as *Protocystites*[4] usually has the pentagonal, instead of hexagonal, arrangement.

Formation and locality :—Common in the *Eoorthis* zone of Tomkoi where this form is found in association with *Eoorthis shakuotunensis* and *Pseudagnostus cyclopygeformis* ; several plates found in the same zone at Doten where it is accompanied by *Eoorthis shakuotunensis* and *Tellerina* (?) *obsoleta*.

Phylum MOLLUSCOIDEA.
Class BRACHIOPODA Duméril.
Order Atremata Beecher
Family Obolidae King.
Genus OBOLUS Eichwald, 1929.

PB905

Obolus taianensis Sun.

Plate XIV, figure 22.

1905. *Obolus matinalis* (?) Walcott, Proc. U. S. Nat. Mus. Vol. XXVIII, p. 325.

1912. *Obolus matinalis* (?) Walcott, Cambrian Brachiopoda, p. 402, Pl. VIII, figs. 3,3a.

1913. *Obolus matinalis* Walcott, Cambrian Faunas of China, p. 65, Pl. 2, fig. 2, 2a.

1924. *Obolus taianensis* Sun, Cambrian Faunas of North China, p. 19, Pl. 1, figs. 6a-b.

1931. *Obolus taianensis* Kobayashi, Japan. Jour. Geol. & Geogr., Vol. VIII, p. 152, Pl. XXI, fig. 10.

1933. *Obolus taianensis* Kobayashi, Upper Cambr. of the Wuhutsui basin etc. p. 90.

Dorsal valve illustrated is small, 5.2 mm. in length and breadth, roundly triangular ; shell thick ; radial lines observed where the surface is exfoliated. Extending from umbo to the middle of the valve is found a longitudinal area, but the muscular scar is not clear ; vascular sinus diverges from umbo on both sides of the area.

Upon studying Walcott's type specimen of *Obolus matinalis* from

1) C. Callaway (1877), On a new Area of Upper Cambrian Rocks in South Shropshire, (Q. J. G. S. London, Vol. XXXIII,) p. 670, pl. XXIV, fig. 13.

2) J. Barrande (1868), Faune Silurienne des Environs de Hof, en Bavière, p. 106, figs. 60-61.

3) Cowper Reed (1910), Cambrian Fossils of Spiti, (Pal. Indica, New Ser. 15, 7, No. 1,) p. 57, Pl. VI, figs. 31-32.

4) H. Hicks (1872), Q. J. G. S. London, Vol. XXVIII, p. 180, Pl. V, fig. 19

Shantung I have come to agree with Sun in identifying Walcott's specimen to this Asiatic species *O. taianensis*, because the type bears no contradiction in the outline, size, shell thickness and occurrence. On the same block as the specimen are found *Asioptychaspis ceto* and *Tsinania canens*, and therefore there is no doubt that Walcott's species belongs to the *Tsinania* zone.

Obolus matinalis Hall is more inequivalved than *Obolus taianensis*, that is to say, in *O. matinalis* the umbonal margin of the ventral valve is more acuminated and the same margin of the dorsal valve is more rounded than those of *O. taianensis*; and *O. matinalis* attains a much greater size than does *O. taianensis*; a large specimen of the former species is more than three times longer and broader than that of the latter.

Formation and locality:—*Dictya* zone of Kasetsu-ji. This species occurs widely in the middle and upper portions of the Upper Cambrian formation in North Chosen, South Manchuria, and North China.

Obolus subcircus, new species.

PB906-1-2
PB907-1-3

Plate I, figures 2-3.

1924. *Obolus mollisonensis* (?) Sun, Cambrian Faunas of North China, p. 17, Pl. 1, figs. 4a-b.

Description:—Shell moderately convex, nearly as long as wide; dorsal valve subcircular; ventral valve subangulated at the umbo at 110 degrees; shell thick and the surface entirely smooth.

The ventral valve (pl. I, fig. 3,) measures 9.5 mm. in length, 11 mm. in breadth and 3 mm. in thickness; dorsal valve 13 mm. in length and breadth and 2 mm. in thickness.

Comparisons:—The subcircular outline and comparatively large size of the shell are the distinguishing characters of the species.

Sun's *Obolus mollisonensis* (?) from the Changshan formation in Chihli is so similar to this form that it very likely represents a young stage of the species. Walcott's *Obolus mollisonensis*[1] from the Goodsir formation in British Columbia is more triangularly ovate and has distinct concentric lines.

Formation and locality:—*Chuangia* zone of Saisho-ri, South Chosen; Changshan formation (early Upper Cambrian) of Chao-kou-chuang, Luan-hsien, Chihli.

1) Walcott (1912), Cambrian Geology & Paleontology, II, No. 7, p. 231, Pl. 35, figs. 10-12

PB908

Obolus damesi (Walcott).

Plate XIV, figure 2.

1905. *Obolus* (*Lingulella*) *damesi* Walcott, Proc. U. S. Nat. Mus. Vol. XXVIII, p. 329.

1912. *Lingulella damesi* Walcott, Monogr. U. S. Geol. Surv. Vol. LI, p. 489, Pl XXXIX, figs. 8, 8a-c.

1913. *Obolus damesi* Walcott, Cambrian Faunas of China, p. 65, Pl. 2, figs. 1, 1a-e.

Obolus damesi, *O. chinensis* and *O. shansiensis* are very close to one another. When further extensive collections are made, they will be very probably proved to be members of a continuos morphological series, but here in accordance with Walcott's idea they are recognized as distinct species on the basis of outline, surface texture, and other characters.

Formation and locality:—*Olenoides* zone of Neietsu. It occurs also in the Middle Cambrian strata of Shantung and Liaotung.

Obolus cf. *shansiensis* Walcott.

PB909

Plate XVIII, figure 1.

1905. cf. *Obolus shansiensis* Walcott, Proc. U. S. Nat. Mus. Vol. XXVIII, p. 327.

1912. cf. *Obolus shansiensis* Walcott, Monogr. U. S. Geol. Surv. Vol. LI, p. 415, Pl. XI, figs. 7, 7a-c.

1913. cf. *Obolus shansiensis* Walcott, Cambrian Faunas of China, p. 67, Pl. 2, figs. 4, 4a-g.

1916. cf. *Obolus shansiensis* Mansuy, Faunes Cambriennes de l' Extrême-Orient Méridional, p. 9, Pl. I, figs. 1a-b.

1916. *Obolus* cf. *shansiensis* Mansuy, Op. cit. p. 9, Pl. I, fig. 2.

Formation and locality:—A horizon in the Taiki group of Taiki. This species is widely distributed in Shensi, Shansi, Liaotung, and Tonkin.

Subgenus WESTONIA Walcott, 1901.

PB910-2-1
PB911-2-2
PB912-2-3

Obolus (*Westonia*) cf. *blackwelderi* Walcott.

Plate II, figures 1-3.

1905. cf. *Obolus* (*Westonia*) *blackwelderi* Walcott, Cambrian Brachiopods with descriptions of new genera and species, p. 335.

1912. cf. *Obolus* (*Westonia*) *blackwelderi* Walcott, Cambrian Brachiopoda, p. 443, Pl. XXXIX, figs. 10, 10a-c.

1913. cf. *Obolus* (*Westonia*) *blackwelderi* Walcott, Cambrian Faunas of China, p. 68, Pl. II, figs. 5, 5a-c.

1916. cf. *Obolus* (*Westonia*) *blackwelderi* Mansuy, Faunes Cambriennes de l' Extrême-Orient Méridional, p. 10, Pl. I, figs. 4a-c, 5a-b.

Because South Korean specimens are mostly deformed and their tests altered, exact identification of form is rarely possible. The typical reticulation marking the surface is, however, observable in some specimens. Therefore it is probable that they belong to the subgenus *Westonia*. Hitherto *Obolus* (*Westonia*) *blackwelderi* has been the only species of *Westonia* known in the Kushan faunas and this present form is quite similar to it in the elongately ovate outline and relatively strong concentric lines.

Formation and locality:—*Drepanura* zone of Saisho-ri. This is a wide spread species in the Middle Cambrian of Shantung and Pen-kai.

PB913 =(PA1038, PA1039)

Obolus (*Westonia*) a sp.

Plate I, figure 1.

A specimen whose anterior and posterior margins are partly broken, measures 6 mm. long and 6.5 mm. broad. The shell is roundly triangular, and moderately convex. Surface is marked by fine reticulation. Nothing is known of the interior.

Hitherto three species of *Westonia* were known from Eastern Asia, *Obolus* (*Westonia*) *blackwelderi* Walcott, *Obolus* (*Westonia*) *leei* Sun and *Obolus* (*Westonia*) *houtiensis* Kobayashi, but the convex form and roundly trigonal outline of this new species serves to distinguish it from them.

Formation and locality:—*Kaolishania* zone; Doten.

Obolus (*Westonia*) b sp.

PB914

Plate I, figure 24.

An imperfect specimen of *Westonia* would be about 4.5 mm. long and 4 mm, broad, if it were complete.

The shell is thick, triangularly ovate and rather strongly convex. The surface is marked by irregular fine lines crossing the concentric lines of growth.

The irregular undulating markings of this species recalls to me *Acritis* and *Westonia*, but the markings of *Acritis* is usually arranged concentrically. Judging from the surface marking this is closer to *Westonia*. This species is distinguished from the preceding by the surface ornamentation.

Formation and locality:—Kasetsu-ji, probably from the *Dictya* zone.

Genus LINGULELLA Salter, 1866.

Lingulella kayseri Grabau.

1923. *Lingulella kayseri* Grabau, in Sun, Bull. Geol. Soc. China. Vol. II, p. 89, (listed).
1924. *Lingulella kayseri* Sun, Cambr. Faunas of N. China, p. 22.
1931. *Lingulella kayseri* Kobayashi, Japan. Jour. Geol. & Geogr. Vol. VIII, p. 155, Pl. XXI, figs. 5a–b.
1933. *Lingulella kayseri* Kobayashi, Upper Cambrian of the Wuhutsui Basin, etc. p. 93.

Formation and locality:—*Dictya* zone of Doten. This species has a wide distribution in North Chosen, South Manchuria and North China from the *Kaolishania* zone to the latest Upper Cambrian.

Lingulella marcia Walcott.

Plate XIV, figure 1.

1911. *Lingulella marcia* Walcott, Smithsonian Misc. Coll. Vol. 57, No. 4, pp. 74–75, Pl. 14, figs. 3, 3a.
1913. *Lingulella marcia* Walcott, Cambrian Faunas of China, p. 69, Pl. 2, figs. 6, 6a–f.
1916. *Lingulella* cf. *marcia* Mansuy, Faunes Cambriennes de l'Extrême Orient Méridional, p. 11, Pl. I, figs. 8a–b.

Lingulella marcia and *Lingulella manchuriensis* are very close in their outline, convexity, and size. It is doubtful that the mere difference in the outline to such a small degree is valid for the specific distinction. But until further revision is undertaken, both species will be tentatively kept separate.

Formation and locality:—*Olenoides* zone of Neietsu. It occurs in the Fuchou series of Liaotung; species from Tien-fong is conferred by Mansuy to this.

Lingulella manchuriensis Walcott.

Plate XIV, figure 3.

1911. *Lingulella manchuriensis* Walcott, Smiths. Misc. Coll. 57, No. 4, p. 74, Pl. 14, figs. 2, 2a.
1913. *Lingulella manchuriensis* Walcott, Cambrian Faunas of China, p. 69, Pl. 3, figs. 1, 1a–e.
1916. *Lingulella* cf. *manchuriensis* Mansuy, Faunes Cambriennes de l' Extrême Orient Méridional, p. 11, Pl. I, figs. 7a–b.

Formation and locality:—*Solenoparia* zone of Doten; Fuchou series of Liaotung; and a form from *Anomocare subquadratum* horizon of Tien-fong may also be included in this species.

Genus DICELLOMUS Hall, 1873.

Dicellomus parvus Walcott.

Plate II, figure 6.

1905. *Dicellomus parvus* Walcott, Proc. U. S. Nat. Mus. Vol. 28, pp. 315–316.
1912. *Dicellomus parvus* Walcott, Monogr. U. S. Geol. Surv. Vol. LI, pp. 574–575, Pl. LXXXIX, figs. 11, 11a–d.
1913. *Dicellomus parvus* Walcott, Cambrian Faunas of China, p. 71, Pl. 3, figs. 3, 3a–d.

Formation and locality:—*Drepanura* zone of Saisho-ri; the same zone at Shantung and a boulder from an uncertain horizon in the Kisinling limestone of Shensi.

Order NEOTREMATA Beecher.
Family Obolellidae Walcott and Schuchert.
Genus OBOLELLA Billings, 1861.

Obolella sp. aff. *Obolella asiatica* Walcott.

Plate XIV, figure 14; Plate XX, figure 11.

1905. aff. *Obolella asiatica* Walcott, Proc. U. S. Nat. Mus. Vol. XXVIII, p. 297.
1912. aff. *Obolella asiatica* Walcott, Cambrian Brachiopoda, pp. 588–589, Pl. LV, figs. 6, 6a.
1913. aff. *Obolella asiatica* Walcott, Cambrian Faunas of China, p. 72, Pl. 3, figs. 4, 4a.

In the broad subovate outline and gentle convexity of the shell and fine concentric lines of growth on the surface the Korean form is in good accordance with *Obolella asiatica*.

The internal mould of the ventral valve shows a short cylindrical tube at the middle of cardinal area and a pair of vascular sinus diverges from this tube with a small angle between. The internal mould of the dorsal valve has a strong median septum which crosses to the midpoint from the posterior end; two pairs of muscular scars situated on both sides of the septem and close to the posterior margin.

The dorsal valve measures 2.7 mm. in length and breadth.

Formation and locality:—The *Salterella* zone of the Doten section. This species is associated with fragmentary cheeks of trilobites.

Family Acrotretidae Schuchert.
Genus ACROTHELE Linnarsson, 1876.

Acrothele elliptica, new species.

Plate I, figures 9–10.

Description:—A small elliptical ventral valve 2 mm. long and 2.3 mm. broad; a long median septum runs across three-fourths the length of the valve; a pair of vascular sinus diverges on both sides of the septum from the posterior end and runs close to the posterior margin; two paris of large muscular scars found between the space of the septum and sinus; surface with concentric lines.

The transverse outline, the course of the vascular sinus and median septa, large muscular scars and concentric surface ornaments are the distinguishing specific characters.

Formation and locality:—Green shale of Doten, probably belongs to the *Dictya* zone. *Acrothele* is common in the Middle Cambrian of Eastern Asia, but this is the first instance of its being found in the Upper Cambrian of this region.

Genus ACROTRETA Kutorga, 1848.

Acrotreta semiconica, new species.

PB922 - 3-25-27

Plate III, figures 25-27.

Description:—Dorsal valve high, semiconical, slightly convex on the antero-lateral slope; apex marginal, bent slightly backward, with a small opening; cardinal area broad, a little less than the breadth of the valve, flat but near the apex slightly concave; median depression distinct; surface smooth except for faint concentric markings.

The figured specimen measures 2.2 mm. in length, 2.8 mm. in breadth, and 1.4 mm. in height; the cardinal area is about 2 mm. broad.

Comparisons:—The semi-circular basal outline and broad cardinal area are very distinct characters by which this species may be easily distinguished from other *Acrotreta* from the Middle Cambrian of the Orient.

Formation and locality:—*Chuangia* zone of Saisho-ri.

Acrotreta venia Walcott.

PB923-2-4~5

Plate II, figures 4-5.

1911. *Acrotreta venia* Walcott, Smiths. Misc. Coll. Vol. 57, No. 4, p. 75, Pl. 14, figs. 4, 4a.

1913. *Acrotreta venia* Walcott, Cambrian Faunas of China, p. 77, Pl. 3, figs. 10, 10 a-b.

The ventral valve at hand is conical with a triangular, flat false area; the apical callosity not strong; straight vascular sinus seen divergent on both sides of the callosity.

Formation and locality:—*Solenoparia* zone of Doten.

Order Protremata Beecher.

Family Nisusiidae Schuchert and Cooper.

Genus NISUSIA Walcott, 1905.

Nisusia cooperi, new species.

Plate II, figures 15–16.

Description:—Shell biconvex, subquadrate, with beaks elevated above the hinge margin. Dorsal valve more strongly convex than the ventral, which in turn has a shallow median sinus. The surface marked by numerous ribs increasing in number through insertion.

The cardial area cannot be very well examined in any specimen in hand, but so far as it observable, the structure appears to be very simple without any trace of teeth. Delthylium is covered by a convex deltidium, at least in part.

Comparisons:—A solitary species of this genus hitherto known from Eastern Asia is *Nisusia hayasakai* Sun[1] from the Changhia limestone of Chihli. Sun's species is obviously distinct from this by its coarser ribs.

Formation and locality:—*Elrathia* zone of Taiki.

Family Billingsellidae Schuchert.

Genus BILLINGSELLA Hall and Clarke, 1892.

Billingsella goettschei Kobayashi.

1933. *Billingsella goettschei* Kobayashi, Upper Cambrian of the Wuhutsui Basin, etc. (Japan. Jour. Geol. Geogr. Vol. XI,) p. 93, Pl. IX, figs. 15–16.

Several specimens of ventral and dorsal valves are found in the *Kaolishania* and *Dictya* zones. In the subquadrate outline, a distinct mesial fold or sinus on the ventral or dorsal valve respectively and the mode of ribs, these specimens are quite similar to *Billingsella goettschei* from North Chosen, but the specific reference is merely based on the external appearance. A dorsal valve from the *Eoorthis* zone has four or five lines in each interval between the radial ribs.

Formation and locality:—*Kaolishania* zone of Saisho-ri; *Dictya* zone of Doten.

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1) Sun (1924), Paleont Sinica, B, I, 4, p. 3, Pl. I, fig. 12.

Billingsella pumpellyi Walcott.

Plate I, figures 11–13 ; Plate II, figures 10–14.

1905. *Billingsella pumpellyi* Walcott, Proc. U. S. Nat. Mus. Vol. XXVIII, p. 242.
1912. *Billingsella pumpellyi* Walcott, Monogr. U. S. Geol. Surv. LI, pp. 760–761, pl. XCVII, figs. 8, 8a–c.
1913. *Billingsella pumpellyi* Walcott, Cambrian Faunas of China, pp. 79–80, Pl. 4, figs. 4, 4a–c.

Description:—Ventral valve subovate, dorsal somewhat subquadrate in outline; shells unequally biconvex in the lateral profile; the maximum breadth of the shell located in most cases a little below the hinge margin.

Ventral valve strongly convex near the umbo; umbonal angle about 150 degrees; internal wall of the umbonal cavity thickened and from it a pair of pallial sinus diverge to the antero-lateral angles of the shell; cardinal area wide; delthyrium entirely open. Dorsal valve much less convex than the ventral; median sinus about one-third the breadth of the anterior margin; median septum and muscular scars very strong.

Surface marked by many radial ribs of moderate strength.

This form is very variable in outline. For example a dorsal valve (pl. II, fig. 13) has a transverse outline with a long hinge-margin, while another dorsal valve (pl. I, fig. 13) is somewhat subcircular. The strength of the radial ribs also varies in the various stages of growth. Most of the large specimens have very strong ribs.

Comparisons:—In the outline, convexity and internal characters this form is safely identified as *B. pumpellyi*. *Billingsella tonkiniana* Mansuy is[1] also very much allied to this species.

In comparing with the genotype *O. pepina* Hall, this species differs in the strong convexity and the open delthyrium in which respects it reminds me of *Otusia*,[2] but it lacks the wing, such as seen in *Otusia sandbergi* Winchell.

It is allied to even some Middle Cambrian genera as *Oligomys* and *Bohemiella*.[3]

Formation and locality:—Very common in the *Chuangia* zone of

1) Mansuy (1915), Faunes Cambriennes du Haut-Tonkin, p. 7, Pl. I, figs. 2a–q.
2) Walcott (1912), Monogr. U. S. Geol. Surv. Vol. LI, p. 769.
3) Schuchert and Cooper (1932), Brachiopod Genera of the Suborder Orthoidea and Pentameroidea, (Mem. Peabody Mus. Nat. Hist. Yale Univ. Vol. IV, Pt. I,) pp. 52–54

Kasetsu-ji and Saisho-ri; Walcott's figured specimen came from the early Upper Cambrian of Shantung.

Family Eoorthidae Schuchert and Cooper.

Genus EOORTHIS Walcott, 1908.

Eoorthis shakuotunensis Sun.

PB933-1-4,5
PB934-1-5,6.
PB935-1-7,8.
PB936-1-22,23

Plate I, figures 4–8, 22–23.

1924. *Eoorthis shakuotunensis* Sun, Cambrian Faunas of North China, p. 24, Pl. I, figs. 13a–b.

1930. *Eoorthis* sp. Kobayashi, Cambrian and Ordovician Faunas of S. Korea, etc., (Proc. Imp. Acad., VI, No. 10,) p. 423, (listed).

Shell medium sized, biconvex, subquadrate, rounded at the postero-lateral angle; umbo more or less acuminated; hinge margin produced into small wings at both extremities; surface ornamented by radial ribs and riblets.

About twenty ribs are counted and three or four riblets are interposed in the interval between the ribs. Some specimens, however, show no such a regularity in the arrangement of the radial ribs and riblets. A short and narrow longitudinal ridge is sometimes found on the ventral valve; the corresponding depression is also observed occasionally on the dorsal valve, but these foldings are not very distinct and, when present, they mostly disappear near the mid-point from beak to anterior.

Interiors may be satisfactorily studied in the specimens from Tomkol. The ventral valve (pl. I, figs. 7-8) 10 mm. long and 13 mm. broad; umbo acuminated, forming an open delthyrium, wider than long, 3.5 mm. broad on the base; dental plates small, supported by two parallel plates; the wall of the umbonal cavity thickened. The dorsal valve (pl. I, figs. 5-6) is slightly deformed, 9 mm. long and 11 mm. broad; notothyrium open, with a tiny cardinal process; median septum short.

This species was established with the ventral valves from the Shakuotun limestone of Manchuria as the basis. The size, outline, surface markings and other aspects of the ventral valve indicate the specific identity, although the delthyrium of the Manchurian form is a little larger than that of the Korean one.

Formation and locality:—Common in the *Eoorthis* zone of Tomkol and Doten.

Genus SHIRAGIA, new genus.

Generic diagnosis:—Shell plano-convex dorso-ventrally, transversely semi-elliptical; hinge line straight, narrower than the breadth of the shell. Ventral valve strongly convex, acuminated at the umbo and sharply incurved at the beak; cardinal area large with a triangular open delthyrium; the basal wall of the umbonal cavity thickened; median septum long and strong; pallial trunks distinct, divergent on both sides of the septum; strong ridges develop at a short distance inside of the lateral and anterior margins, and become confluent with the median septum. Dorsal valve flat, with a shallow and wide mesial sinus; cardinal area large, inclined outwardly; notothyrium open; cardinal process, crural plates and median septum very strong; the septum continues to the marginal thickening. Surface marked by radial ribs which fade out toward the margin.

Genotype:—*Shiragia biloba*, new species.

Remarks:—The strongly curved beak of the ventral valve, inclined area of the dorsal valve with a strong cardinal process and crural plates, the strong median ridge, and marginal thickening of both valves are the distinguishing characters of this genus. This has a strong pallial trunk as *Billingsella* and its allied genera, but *Billingsella* is biconvex in the lateral profile and has a convex deltidium and chilidium. In the nature of the notothyrium and in the strong median septum in the dorsal valve this genus approches *Otusia*, but again is quite distinct from it in the outline of the shell, characters of the ventral valves, etc. From *Bohemiella* this is to be distinguished primarily on the presence of strong median septa on both valves.

So far as I have been able to make out, *Eoorthis kayseri* Walcott from the *Tsinania* zone of China is very close to, if it is not actually a representative of, this genus.

Geological and geographical distribution:—Early Upper Cambrian of Eastern Asia.

PB937-1-14,15.
PB938-1-16,17.
PB939-1-18
PB940-1-19,21
PB941-1-20

Shiragia biloba, new species.

Plate I, figures 14–21

Description:—Shell medium sized, plano-convex dorso-ventrally, subelliptical, one and half times as wide as long; hinge line straight, shorter than the breadth of the shell.

Ventral valve strongly convex, thickest at the middle; umbo acuminate, forming an obtuse angle of about 150 degrees; beak sharply incurved; cardinal area wide and somewhat concave; delthyrium perforate, triangular, twice as broad as long; wall of umbonal cavity slightly thickened; median septum very strong, especially in its anterior portion; pallial trunks diverging with an angle of 40 degrees between; a strong ridge and groove running inside and along the lateral and anterior margins.

Dorsal valve nearly flat with a broad and shallow sinus in the middle, slightly convex along the margin; cardinal area large, inclined antero-outwardly; notothyrium open, more than twice as wide as long; cardinal process distinct; crural plates prominent; median ridge strong, bifurcated at the middle and continuous to the marginal ridges, describing ovate and depressed areas on both sides of the median ridge.

Surface mostly smooth except for the fine radial ribs and furrows which are rather prominent near the umbo of the dorsal valve.

Observations:—In the ventral valve the inner wall of the umbonal cavity is thickened forming a pseudospondylium; a subovate area found outside of each pallial trunk is frequently striated and is to be considered as an ovarian impression; the margin outside of the marginal ridge finely striated on well preserved specimens.

In the dorsal valve muscular scars and pallial sinus are observed on both sides of the median septum, but are rather faint.

The specimens figured give the following dimensions:—

	Ventral valve Pl. I, figs. 16-17.	Ventral valve Pl. I, fig. 18.	Dorsal valve Pl. I, figs. 14-15.	Dorsal valve Pl. I, fig. 21.
Length	9 mm.	ca. 11 mm.	8.5 mm.	9 mm.
Breadth	13 mm.	14 mm.	10 mm.	10.5 mm.
Thickness	3.2 mm.		1.3 mm.	

Comparisons:—*Eoorthis kayseri* Walcott[1] is the only species close to this, so far as the dorsal valve is concerned, but the ventral valve associated with the dorsal of *E. kayseri* has a distinct median ridge and its umbo is not so convex and acuminate as that of this species.

Formation and locality:—*Chuangia* zone; Kasetsu-ji.

1) Walcott (1913), Cambrian Faunas of China, p. 82, Pl. 4, figs. 8, 8a-b.

Phylum MOLLUSCA.
Class GASTROPODA.
Order ASPIDOBRANCHIATA Schweigger.
Family Euomphalidae de Koninck.
Genus PELAGIELLA Matthew, 1895.

Pelagiella hana, new species.

Plate III, figures 15–18.

Description:—Shell rather large for this genus; spire consisting of about two to three volutions, coiling in one plane and enlarging very rapidly; volutions very much compressed laterally, their outer margin angulate; apertural margins convex outwards and meeting each other to form a V on the dorsal side; the aperture enlarging slightly in trumpet-shape. Surface smooth except for lines of growth.

The holotype measures 5.5 mm. across and 3 mm. and 5 mm. along the short and long diameters of the aperture respectively. A larger specimen (pl. I, figs. 17–18) is 9 mm. across.

Comparisons:—This species is much allied to *Pelagiella pagoda* (Walcott) and *Pelagiella hinomotoensis* Kobayashi[1] in its large size and mode of coiling, but differs in the lateral compression. In cross section of the last whorl *P. hinomotoensis* is lenticular and *P. pagoda* rather rhomboidal, while this species is somewhat like an elongate triangle.

Formation and locality:—*Chuangia* zone; Kasetsu-ji.

Pelagiella (?) *reversa*, new species.

Plate XI, figures 4–6.

Description:—Shell discoidal, almost perfectly flat on the upper side; spire coiling sinistrally, consisting of four volutions which are contiguous and enlarge rather gradually; body-whorl a little narrower than half the breadth of the shell, depressed, elliptical in cross section; lower side more convex than the upper; peripheral margin not sharply angulated as it is in *Pelagiella hana*; umbilical margin abruptly curved; umbilicus deep and as wide as one-fourth the width of the shell; apertural margin convex outward and V-shaped on the periphery of the whorl; surface smooth.

The specimen figured is 18 mm. wide; its body-whorl 8.2 mm. wide and 4 mm. high.

1) T. Kobayashi (1933), Japan. Jour. Geol. Geogr. Vol. XI, p. 96, pl. IX, figs. 17–18.

Comparisons:—The most significant feature of this species is the sinistral coiling of the spire, because *Pelagiella,* so far as I am aware, coils as a rule dextrally.

In this respect it agrees with a discoidal form of *Scaevogyra,* such as *S. ulrichi* Kobayashi.[1)] The generic reference of this, therefore, is a subject to doubt to a certain extent.

Formation and locality:—*Drepanura* zone of Kasetsu-ji.

Class CONULARIDA Miller and Gurley.

Family Hyolithida Nicholson.

Genus HYOLITHES Eichwald, 1840.

Hyolithes subcarinatus, new species.

Plate III, figures 19–22.

PM945-3-19, 20.
PM946-3-21.
PM947-3-22

Description:—Long subtriangular pyramid; dorsal side slightly convex and subangulated along the median line, its apical angle amounting to about 20 degrees; apertural margin round; ventral side angulated into a roof-shape and subcarinated along the median line, the lateral angle measures about 125 degrees in the transverse section; surface marked by transverse lines which run along the dorsal side with a broad convexity toward the aperture. Operculum semi-conical with a narrow ventral wing on each side of the apex; surface ornamented by concentric lines which cross the wings obliquely.

The relatively rapid tapering of the shell, distinct carination on the ventral side and the transverse striation are the distinguishing characters of this species.

Formation and Locality:—*Chuangia* zone; Saisho-ri. This is the first occurrence of *Hyolithes* in the Upper Cambrian of Eastern Asia, although this group is very common in the Middle and Lower Cambrian.

Hyolithes a sp. undt.

Plate II, figures 8–9.

PM948-2-8
PM949-2-9.

Operculum nearly semiconical, its apex abruptly curved and directed toward the ventral side; ventral wing clearly defined by a groove; surface ornamented by a number of distinct concentric lines and grooves.

Comparisons:—This operculum is quite similar to that of *Hyolithes*

1) Kobayashi (1933), Faunal study of the Wanwanian (Basal Ordovician) Series, etc. (Jour. Fac. Sci. Imp. Univ. Tokyo, Sect. II, Vol. III, Pt. 7,) p. 265, Pl. V, figs. 5 & 7.

subcarinatus, new species, and *Hyolithes* sp. undt. from Shantung described by Walcott (1913, pl. 5, fig. 20). The triangular opening which fits with the lingual extension of the shell, is very wide in the Korean form and through this feature this species is distinguished from Walcott's form. From *Hyolithes subcarinatus* this is easily separated by its distinct and strong surface markings.

Formation and locality:—Two opercula found in the *Solenoparia* zone of Doten.

PM950

Hyolithes b sp. undt.

Plate II, figure 7.

A very flat operculum of a fan-shape; lateral sides concave and make an acute angle of about 80 degrees at the apex; extending beyond each side there is found a narrow wing marked by a deep groove; surface of the test has a few faint radial and concentric grooves separated by wide intervals.

This form is entirely different from the opercula hitherto known from the Orient by its depressed form and surface ornamentation.

Formation and locality:—*Solenoparia* zone of Doten.

Class CEPHALOPODA.

Subclass TETRABRANCHIATA Owen.

Order NAUTILOIDEA Zittel.

Family Salterellidae Walcott, 1886.

In 1933 Poulsen established a family name Salterellidae for this genus, but this had already been done by Walcott, in 1886. Therefore the author of the family is understood here to be Walcott. [Walcott (1886), Second Contribution of the studies on the Cambrian Faunas of North America, p. 131.] It should, however, be remembered that there is a difference of the opinion between the two authors, that is, Walcott put the Salterellidae in the Pteropoda, while Poulsen assigned it to the Cephalopoda.

Genus SALTERELLA Billings, 1865.

PM951

Salterella (?) *orientalis*, new species.

Plate XX, figure 12.

The specimen figured is a slender cone 5.5 mm. long and 1.4 mm. broad, circular in cross section. The cone seems to contract near the apertural end, but it is not yet certain, if this is an original feature or not. Septal sutures are transverse and crowded. Nothing is known about the interior.

This is a solitary specimen of this species found in the lowest fossil horizon of the Doten section and associated with *Obolella* aff. *asiatica* Walcott and a fragmentary thick brim of free cheek of a trilobite which is ornamented by irregular lines subparallel to the margin. The feature of this cheek is not unlike that found in fragments of *Redlichia* and there is need for no hesitancy in understanding it as a part of *Redlichia*, though unfortunately the specimen is too poor to be identified exactly.

The genus *Salterella*[1] was known first in the Atlantic Lower Cambrian, but later Foord[2] and Tate[3] described *Salterella hardmani* and *Salterella planoconvexa* from the Lower Cambrian of Australia respectively, and recently Poulsen[4] brought to light *Salterella expansa* and also *S. rugosa* from the Lower Cambrian of Greenland.

It is noted here that *Salterella hardemani* Etheridge and *Salterella planoconvexa* Tate have septate structures, but there is no definite information as to whether or not each septum is penetrated by a central tube, or siphuncle and therefore they are not as yet completely proved to be *Salterella*. If *S. hardemani* is, however, a true *Salterella*, as suggested by Etheridge, it most nearly resembles *Salterella pulchella* Billings, because its septum is "acutely conical." Judging from the description and illustrations, *S. planoconvexa* seems to me to be a *Hyolithes* rather than a *Salterella*.

Salterella sp.[5] is also recorded from a limestone lens intercalated in a purple shale and lying a little below a greenish limestone with *Dorypyge richthofeni* and other trilobites in the Cambrian section along the Hun-kiang, a tributary of the Oryokko River on the Manchurian side. But as the specimen has been neither described nor illustrated, we cannot be sure if it is really a *Salterella* or not, and the fact that the horizon from where it came is the Middle, instead of Lower, Cambrian casts further doubts.

As I hope to present further discussion on *Salterella* in another

1) Billings (1865), Pal. Fossils I, (Geol. Surv. Canada,) p. 17.

2) Etheridge (1890), Notes on the Palaeontology of Western Australia, (Geol. Mag. Dec. 3, 7,) p. 98, Pl. 4, fig. 1.

3) Tate (1892), Trans. Royal Soc. South Australia, 15, p. 186, Pl. 2, fig. 3.

4) Poulsen (1927), Cambrian, Ozarkian and Canadian Faunas of Northwest Greenland, p. 251, Pl. XIV, figs. 10–12; (1932) Lower Cambrian Faunas of East Greenland, (Med. om Grønland Bd. 87, Nr. 6,) p. 32, pl. 7, figs. 11–15, Pl. 8, figs. 1–2; text-fig. 5–6.

5) Yabe and Hayasaka (1920), Palaeontology of Southern China, p. 18.

paper of mine in some future, here it is noted simply that the genus in the Lower Cambrian period enjoyed a world wide distribution.

Formation and locality:—*Salterella* zone of Doten.

Phylum ARTHROPODA.

Class CRUSTACEA.

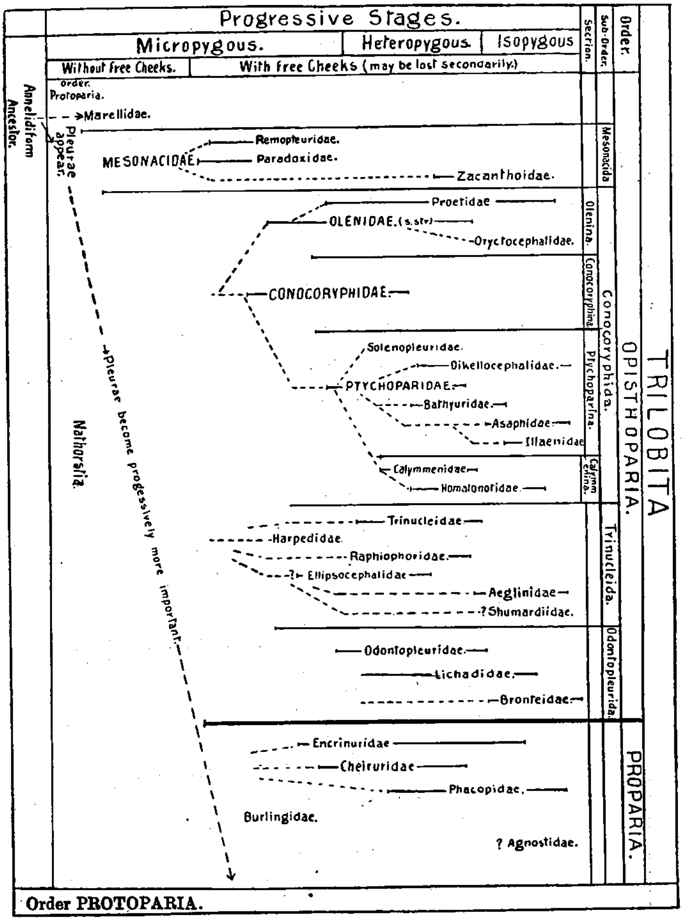
Subclass TRILOBITA Walch.

Since Beecher established his tripartite divisions for the trilobites, various students have made many important discoveries in the course

Text-figure 1, Tripartite Division of the Trilobite Families.

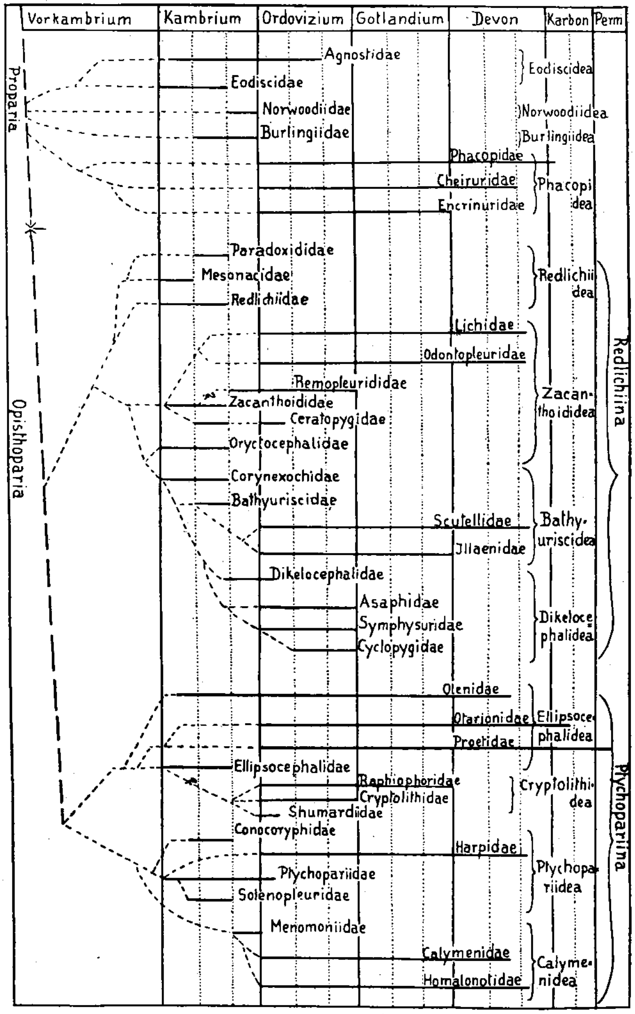
Beecher (1897).	Raymond (1913).	
	Hypoparia	
1. Agnostidae Dalman.	1. Agnostidae M'Coy······	Condylopyginae Raymond. Arthrorachinae Raymond. Agnostinae Jaekel. Phalacrominae Corda.
	2. Eodiscidae Raymond.	
	3. Shumardiidae Lake.	
2. Harpedidae Barrande.	4. Harpedidae Corda.	
3. Trinucleidae Barrande.	5. Trinucleidae Emmrich (Cryptolithidae Angelin.)	
	6. Raphiophoridae Angelin.	
	Opisthoparia	
4. Conocoryphidae Angelin.	1. Conocoryphidae Angelin.	
	2. Mesonacidae Walcott (Olenellidae Moberg.)	
	3. Paradoxidae Emmrich.	
5. Olenidae Salter.	4. Olenidae Burmeister.	
	5. Solenopleuridae Angelin.	
	6. Oryctocephalidae Beecher.	
	7. Ceratopygidae Raymond.	
	8. Ellipsocephalidae Matthew.	
	9. Remopleuridae Corda.	
	10. Bathyuridae Walcott.	
6. Asaphidae Emmrich.	11. Asaphidae Burmeister.	Ogygiocarinae Raymond. Asaphinae Raymond.
	12. Illaenidae Corda.	
	13. Dikelocephalidae Miller	
7. Proetidae Barrande.	15. Proetidae Corda.	
8. Bronteidae Barrande.	14. Goldiidae Raymond.	
	16. Aeglinidae Pictet.	
9. Lichadidae Barrande.	17. Lichadidae Corda.	
10. Acidaspidae Barrande.	18. Odontopleuridae Burmeister.	
	Proparia	
11. Encrinuridae Linnarsson.	1. Encrinuridae Angelin.	
12. Calymenidae Brongniart	2. Calymenidae Milne-Edwards.	
13. Cheiruridae Salter.	3. Cheiruridae Salter······	Cheirurinae Raymond. Pliomerinae Raymond. Deiphoninae Raymond.
14. Phacopidae Saltar.	4. Phacopidae Corda······	Dalmanitinae Reed. Phacopinae Reed. Pterygometopinae Reed.

of about forty years which have made it clear that his classification ought be modified in certain fundamental respects. (See Text-figure 1.) The most radical change above all, concerns his first order, Hypoparia,



Text-figure 2.

Swinnerton's Table showing the main lines of modification which occur among Trilobites and the probable general relation of Trilobite families to one another. [From Swinnerton (1915), Suggestions for a Revised Classification of Trilobites, (Geol. Mag. Dec VI, Vol. II,) p. 542.]



Text-figure 3

Rud. Richter's Table showing the family relationships of Trilobites. [From Handwörterbuch d. Naturwissenschaften, 2te Auflage, S 855.]

which he considered to be the most primitive group. The blindness characterising the order is now believed to represent a degenerative character. In light of this view the members of Hypoparia have been reassigned into Opisthoparia and Proparia. (See Text-figure 2.)

Subsequently the question arose, whether or not Proparia was more primitive than Opisthoparia. (See Text-figure 3.) The discovery of many Proparian trilobites in the Cambrian on one hand and the results of the ontogenetical studies of the trilobites on the other called for a critical review. Thus the geological evidences, as will be discussed in detail in a later chapter, necessitated a new explanation and pointed towards the heterogeneity of the Proparian trilobites.

After all, it becomes quite dubious that the facial suture is a criterion of prime importance for the natural classification. At least it can be said that several exceptional cases are amenable to Beecher's theory. A firmer basis will be found in the combination of the evolutional characters, although one of these characters might be, generally speaking, more important than the others. For a certain group of trilobites a character may advance very slowly or rapidly in reference to the progress of the others, a situation which soon leads a theory based on a single feature into difficulties. In dealing with many series of trilobites it is quite obvious that a character very important for one group is of little consequence in another. The specialization was very probably never directed toward just one side, but in diverse directions and sometimes even toward opposite ends. One classical example of the latter is found between the Trinucleidae and Aeglinidae (or Cyclopygidae). The former lost its eyes through a burrowing habit while the latter developed tremendous eyes by an adaptation to pelagic life.

There is probably no all-encompassing rule which would explain the evolution of all of the trilobites. Thus every item of evidence, morphological, ontogenetical, and geological, must be taken into account.

Among other things I wish to emphasize here that the factors of geographical and geological distribution might be more important than has hitherto been believed. Through my study upon Oriental materials I have found instances of many families whose evolutional histories were most satisfactorily explained by a parallelism between the progress of the Pacific and Atlantic lives in the Cambrian period. The idea shows good agreement with the facts of Cambrian paleogeography and migrations of the fauna and hence it might be quite valid for the interpretation of trilobite evolution, probably down to the family rank of modern authors.

In the Lower Cambrian there is known the existence of more than ten families such as, Agnostidae, Eodiscidae, Pagetidae, Mesonacidae, Redlichidae, Corynexochidae, Oryctocephalidae, Ellipsocephalidae, Ptychoparidae, Crepicephalidae, Conocoryphidae and Solenopleuridae.

They are all Opisthoparians except the Agnostidae and Pagetidae which, however, are to be considered as side branches from the main trilobite development. Though it is possible to trace the later variations of these Lower Cambrian stocks, so far no means to arrive at the original divergence of these stocks, which occurred probably in the so-called Lipalian period[1] have fallen into our hands. All explanations as to this are based upon indirect or negative evidences.

The ontogenetical study is a method of attack which, however, is unsatisfactory by the reasons that the protaspis reveals both the original character and adaptative modifications in the protaspis stage, the latter of which should be discounted from the phylogenetical considerations.

The main task which I shall try to carry out in this paper is not a solution of such a fundamental question but an elucidation of some of the details, mainly those of the family relationships, which is probably the only thing we can carry through with some certainty in the present chaotic state of trilobite phylogeny and which is probably the first thing to be done, so far as the Asiatic trilobites are concerned, because so many genera have been established in Asia without any reference to their family relationship as will be seen in the succeeding chapter.

This work has already been initiated in my previous paper, "Upper Cambrian of the Wuhutsui Basin, Liaotung, with Special Reference to the Limit and Subdivision of the Chaumitian, or Upper Cambrian, of Easten Asia." The present work represents its continuation and extension to the Middle and Lower Cambrian genera of the Pacific province. At the same time I have here brought the Atlantic assemblages of the genera and families into comparison with the Pacific ones.

As a result of this study the following scheme of classification, which is still tentative, is employed in this paper :—

1 Ch. D. Walcott (1915), Cambrian and its Problems, in "Problems of American Geology", p. 167

Suborder AGNOSTIDA Kobayashi.

(Superfamily EODISCIDEA Richter.)

1. Agnostidae Dalman. .... { Condylopyginae Raymond. / Arthrorhachinae Raymond. / Agnostinae Jaekel. / Phalacrominae Corda. }
2. Pagetidae Kobayashi.
3. Eodiscidae Raymond.

Suborder MESONACIDA Swinnerton, (REDLICHIDA Richter.)

4. Mesonacidae Walcott.
5. Redlichidae Poulsen.
6. Zacanthoidae Swinnerton, (Zacanthoididae Richter.)
7. Kainellidae Ulrich and Resser.
8. Paradoxidae Emmrich. ...... { Paradoxinae Kobayashi. / Centropleurinae Angelin. }
9. Remopleuridae Corda.
10. Ceratopygidae Raymond.
11. Olenopsidae Kobayashi.
12. Lancastridae Kobayashi.
13. Burlingidae Walcott.

Suborder CORYNEXOCHIDA Kobayashi.

14. Corynexochidae Angelin....... { Corynexochinae Raymond. / Dolichometopinae Walcott. }
15. Komaspidae Kobayashi.
16. Oryctocephalidae Raymond... { Oryctocephalinae Beecher. / Dorypyginae Kobayashi. }
17. Pagodidae Kobayashi.
18. Damesellidae Kobayashi...... { Damesellinae Kobayashi. / Dorypygellinae Kobayashi. / Kaolishaninae Kobayashi. }
19. Lloydidae Kobayashi.
20. Leiostegidae Bradley. .... { Eochuanginae Kobayashi. / Leiosteginae Kobayashi. / Illaenurinae Raymond. }

Suborder PTYCHOPARIDA Richter.

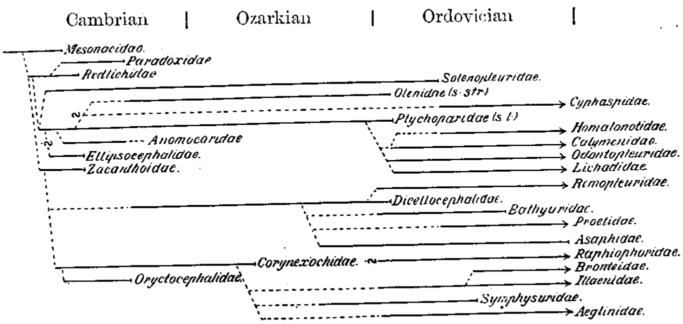
21. Ellipsocephalidae Matthew.
    - Ellipsocephalinae Kobayashi.
    - Agraulinae Raymond.
    - Kingstoninae Kobayashi.
22. Olenidae Burmeister.
    - Oleninae Kobayashi.
    - Leptoplastinae Angelin.
    - Triarthrinae Ulrich.
23. Shumardidae Lake.
24. Conocoryphidae Angelin.
25. Ptychoparidae Matthew.
    - Ptychoparinae Matthew.
    - Pterocephalinae Kobayashi.
    - Liostracinae Angelin.
    - Anomocarinae Poulsen.
    - Yokuseninae Kobayashi.
    - Elvininae Kobayashi.
26. Emmrichellidae Kobayashi.
    - Bowmaninae Kobayashi.
    - Utianae Kobayashi.
    - Emmrichellinae Kobayashi.
    - Changshaninae Kobayashi.
27. Solenopleuridae Angelin.
    - Solenopleurinae Kobayashi.
    - Dokimocephalinae Kobayashi.
28. Crepicephalidae Kobayashi.
29. Marujumidae Kobayashi.
30. Asaphiscidae Raymond.
    - Asaphiscinae Kobayashi.
    - Monkaspinae Kobayashi.
31. Tsinanidae Kobayashi.
32. Menomonidae Walcott.
33. Norwoodidae Walcott.

Suborder DIKELOCEPHALIDA Kobayashi.

34. Dikelocephalidae Raymond.
    - Dikelocephalinae Beecher.
    - Osceolinae Ulrich and Resser.
    - Saukinae Ulrich and Resser.
    - Ptychaspinae Raymond.
    - Hungaiinae Raymond.
    - Richardsonellinae Raymond.

The Agnostida, Mesonacida, Corynexochida and Ptychoparida lines had already branched off the original stock early at the beginning of the Cambrian. The Olenopsidae and Lancastridae suggest something between the Mesonacida and Ptychoparida and between Mesonacida and Corynexochida respectively; the Agnostida might be more related to Ptychoparida than the other two. But nothing is decisive as to the initial branching of the main stocks.

The important steps in the trilobite evolution came at the ends of the Lower, Middle, and Upper Cambrian. Above all the disappearance of the Mesonacidae by the end of the Lower Cambrian and the abrupt appearance of the Dikelocephalidae at the beginning of the Upper Cambrian are significant. As the coming of the Dikelocephalida was so sudden as not to leave any connecting link as an evolutional document, it gives a chance for suppositions on the part of the trilobite students whether the Dikelocephalida was brought forth from the Ptychoparida stock or from the Corynexochida one. Swinnerton considered that the Bathyuridae, Asaphidae and Illaenidae branched from the Ptychoparidae on one hand and the Dikelocephalidae from



Text-figure 4.

Diagram showing the family-relationship among the Suturicephalia. [From Poulsen (1927), Jubiliaemuseksped itionen nord om Grønland 1920–23, Nr. 3, p. 329.]

the same stock on the other. Poulsen and Richter on the contrary took these branches, Dikelocephalidae, Asaphidae, etc. on one side and the Scutellidae and Illaenidae on the other as relatives of the Corynexochida. (See Text-figs. 3 & 4.)

With the beginning of the Ordovician several new lines of trilobite evolution were initiated, such as those of the Lichacea, Proetacea, Calymenacea, Telephidae, several blind trilobite families and three Proparian families. It is presumed that the Calymenacea which includes the Calymenidae and Homalonotidae was derived from the Ptychoparida stock and the Trinucleacea including the Raphiophoridae, Trinucleidae, Dionideidae, Endymioniidae and the Harpidacea including the Harpedidae, Entomaspidae and Ityophoridae also came from the same main stock, but the former superfamily might have been closer to the Ellipsocephalidae whereas the latter one approached the Ptychoparidae. The Proetidae also came from the Ptychoparida stock probably from the neighbourhood of the Ellipsocephalidae. The Telephidae sprang forth from the Corynexochida, probably from the neighbourhood of the Komaspidae. The Lichidae and Odontopleuridae are on the other hand considered to be introduced from the Mesonacidae, probably from nearby the Zacanthoidae. Very little is known of the Cambrian ancestors of the Proparian families, Phacopidae, Cheiruridae and Encrinuridae.

If we consider these evolutional lines, and also the decadence of the Cambrian trilobite families, the transitional time between Cambrian and Ordovician becomes in fact the most significant one in the evolution of these ancient animal.

Notes on the Cambrian Trilobite Genera based upon the Asiatic Species.

Since Dames first threw light upon the Cambrian trilobites of Eastern Asia, the number of new genera instituted by himself, Bergeron, Redlich, Cossmann, Monke, Lorenz, Walcott, Mansuy, Sun and myself has attained a total of thirty-nine and it will increase by thirty-six more when those which are going to be established by myself through this paper and by Resser and Endo through their recent joint study now in print are counted. Such a tremendous number of genera, seventy-five in all naturally requires a thorough revision.

The family relationship among them is the most important point notwithstanding that so little about it has been discussed by previous authors. Zittel-Broili's Grundzüge der Palaeontologie is so far the only work which offers a scheme of trilobite classification in which the Asiatic Cambrian trilobites are arranged according to families as follows :—

1) Family Mesonacidae Walcott.
   Dorypyge Dames, *Damesella* Walcott, *Redlichia* Cossmann, *Tsinania* Walcott.
2) Family Olenidae Burmeister.
   Teinistion Monke, *Blackwelderia* Walcott, *Lisania* Walcott, *Palaeolenus* Mansuy, *Inouyia* Walcott, *Shantungia* Walcott, *Drepanura* Bergeron, *Stephanocare* Monke.
3) Family Dikelocephalidae Miller.
   ? *Pagodia* Walcott, *Lisania* Walcott, *Chuangia* Walcott, *Levisia* Walcott, *Anomocarella* Walcott.

During the prosecution of this research I had opportunities to study various collections of Cambro-Ordovician fossils from Argentina, Alaska, Mackenzie and Yukon districts of Canada, the Himalayas and Siberia, the reports on which will appear in separate papers, and also during my travel abroad I examined in museums and institutes numerous collections from various regions of the world, paying special attention to the Pacific, Asiatic or Arctic materials.

In looking over these collections, I was strongly impressed by an idea of parallelism of development among faunas of the paleogeographic provinces. Precisely speaking, the Pacific and Atlantic provinces are fundamental divisions which cannot be overlooked in the study of Cambrian trilobite evolution and probably the Arctic region was more related to the latter in the Lower Cambrian but to the former in the Middle and Upper Cambrian. Some evidences definitely reveal that the Pacific and Atlantic faunas once in a while commingled perhaps through the Techys or Himalayan trough on one hand, and through eastern part of North America on the other. The discussion as to the palaeogeographic provinces and the migrations of fauna will be undertaken in great detail in the stratigraphical part of this monograph. Here I shall confine myself to the implication in regard to palaeontology.

The first question which rises is how many cosmopolitan genera there are. In the pioneer days of research many Atlantic genera, *Liostracus*, *Agraulos* and so on, were introduced into the Pacific province, but whenever the material was more closely reexamined, it was, we might almost say, a custom to find out that the Pacific forms were distinct generically from the Atlantic ones.

The Middle Cambrian transgression was the most extensive one in the Cambrian period, and it naturally afforded conditions for a worldwide dissemination of the trilobite genera. *Conocoryphe* is one of the typical Atlantic genus which occurs also in the Pacific province. I believe that it reached western Pacific through the Himalayan trough, but never passed beyond into the eastern Pacific or Arctic region. *Dorypyge* is another one found in both Europe and Eastern Asia which might have pursued the same route of dispersion.

Not only the genera, but also many Cambrian families are confined to one or the other of these provinces. It is a well known fact that the Mesonacidae is distributed in Europe, North America and Arctic region, but never occurs in Asia and Australia; the Paradoxidae in the Middle

Cambrian and the Olenidae (s. str.) in the Upper Cambrian are significant families confined to the Atlantic province. In contrast to these there are many strictly Pacific families such as the Redlichidae, Zacanthoidae, and so forth.

As a matter of fact, the Cambrian strata in the Atlantic province have already been tolerably well explored, while relatively little has yet been done upon the extensive areas of the Pacific rocks and hence a great number of new trilobites are expected to be unearthed from the latter. The number of the trilobite families and genera will very likely be increased to more than twice that already established from the Atlantic province.

Not only is the distinguishing of new phylogenetical branches, but also the creating of subordinate groups differentiated by means of such prefixes as sub- and super-, to represent branchings of the genealogical tree in detail is required. These are really natural results of the new knowledge. It is for example obvious in reading the text-books that Zittle in 1881 had fifteen families for all of the trilobites, whereas there were sixteen families in Zittel-Broili in 1924. The same is true for the American School in which Beecher in 1897 had fourteen families, while Beecher-Raymond in 1913 attained twenty-eight families.

It is also a modern tendency to define the generic domain smaller than it fomerly was. Barrande's *Conocephalites* was applied in the sense to include *Ptychoparia*, *Conocoryphe* and *Ctenocephalus*. Today, we have more than fourteen genera from *Ptychoparia*, s. l. and more than six valid genera out of *Conocoryphe*, s. 1.; and really two families, Ptychoparidae and Conocoryphidae, are now accepted as valid by most trilobite-students.

Dikelocephalus is here taken as an example from the Pacific province which was in the old times applied almost in the same sense as the term Dikelocephalidae of today. As a result of repeated revisions by Brögger, Walcott, Raymond, Ulrich, Resser and myself, the family comprises nowadays about twenty-five genera in six subfamilies.

Thus the numbers of genera and families are increasing year after year, and at the same time relatively few genera are losing their standing on account of synonymy. Such is, however, the only way we can avoid putting every thing in the waste-basket until it cannot hold them all.

It is obvious that the group terms,—genus, family and others, all depend mainly upon the magnitude of the morphological difference and have to be used so that they may most clearly indicate the phylogenetical relationship. Thus the magnitude of family or genus cannot be too small or too big in itself. It will be worth while to establish a genus and family even for one species, if it is distinct enough.

From these viewpoints cited above, I have made great changes in the family-references of Asiatic genera of Cambrian trilobites arranging them in the scheme presented at the end of the preceding chapter as follows :—

Genus.	Genotype.	Family Reference.
Dorypyge Dames, 1883.	*Dorypyge richthofeni* Dames.	Oryctocephalidae.
Drepanura Bergeron, 1889.	*Drepanura premesnili* Bergeron.	Damesellidae.
Hoeferia Redlich, 1901.	*Hoeferia noetlingi* Redlich.	(Synonium of *Redlichia*.)
Redlichia Cossmann, 1902.	*Hoeferia noetlingi* Redlich.	Redlichidae.
Liostracina Monke, 1903.	*Liostracina krausei* Monke.	Emmrichellidae.
Teinistion Monke, 1903.	*Teinistion lansei* Monke.	Emmrichellidae.
Stephanocare Monke, 1903.	*Stephanocare richthofeni* Monke.	Oryctocephalidae.
Dorypygella Walcott, 1905.	*Dorypygella typicalis* Walcott.	Damesellidae.
Damesella Walcott, 1905.	*Cheirurus paroni* Airaghi.	Damesellidae.
Shantungia Walcott, 1905.	*Shantungia spinifera* Walcott.	Emmrichellidae.
Pagodia Walcott, 1905.	*Pagodia lotos* Walcott.	Pagodidae.
Anomocarella Walcott, 1905.	*Anomocarella chinensis* Walcott.	Asaphiscidae.
Blackwelderia Walcott, 1906.	*Calymene* (?) *sinensis* Bergeron.	Damesellidae.
Amphoton Lorenz, 1906.	*Dolichometopus deois* Walcott.	Corynexochidae.
Lioparia Lorenz, 1906.	*Anomocare latelimbatum* Dames.	Ptychoparidae.
Megalophthalmus Lorenz, 1906.	*Liostracus megalurus* Dames.	Asaphiscidae.
Schantungia Lorenz, 1906.	*Schantungia buchruckeri* Lorenz.	(Synonium of *Chuangia*.)
Emmrichella Walcott, 1911.	*Ptychoparia theano* Walcott.	Emmrichellidae.
Lisania Walcott, 1911.	*Anomocarella* (?) *bura* Walcott.	Asaphiscidae.
Chuangia Walcott, 1911.	*Ptychoparia* (?) *batia* Walcott.	Leiostegidae.
Levisia Walcott, 1911.	*Agraulos agenor* Walcott.	Solenopleuridae.
Inouyia Walcott, 1911.	*Agraulos* (?) *capax* Walcott.	Emmrichellidae.
Palaeolenus Mansuy, 1912.	*Palaeolenus douvillei* Mansuy.	Ellipsocephalidae.
Tsinania Walcott, 1914.	*Illaenurus canens* Walcott.	Tsinanidae.

Annamitia Mansuy, 1916.	*Ptychoparia* (*Annamitia*) *spinifera* Mansuy	Redlichidae.
Tonkinella Mansuy, 1916.	*Tonkinella flabelliformis* Mansuy.	Oryctocephalidae.
Changshania Sun, 1923.	*Changshania conica* Sun.	Emmrichellidae.
Mansuyia Sun, 1924.	*Ceratopyge orientalis* Grabau.	Asaphiscidae.
Kaolishania Sun, 1924.	*Kaolishania pustulosa* Sun.	Damesellidae.
Changia Sun, 1924.	*Changia chinensis* Sun.	Dikelocephalidae.
Quadraticephalus Sun, 1924.	*Quadraticephalus walcotti* Sun.	Dikelocephalidae.
Anderssonia Sun, 1924.	*Ptychaspis* (*Anderssonia*) *fengtiensis* Sun.	Dikelocephalidae.
Taianocephalus Sun, 1924.	*Taianocephalus grabaui* Sun.	Damesellidae.
Wongia Sun, 1924.	*Wongia triangulata* Sun.	Ellipsocephalidae.
Koldinioidia Kobayashi, 1931.	*Koldinioidia typicalis* Kobayashi.	Shumardidae.
Asioptychaspis Kobayashi, 1933.	*Ptychaspis ceto* Walcott.	Dikelocephalidae.
Dictya Kobayashi, 1933.	*Illaenurus dictya* Walcott.	Tsinanidae.
Dictyella Kobayashi, 1933.	*Dictyella wuhuensis* Kobayashi.	Tsinanidae.
Wuhuia Kobayashi, 1933.	*Solenopleura belus* Walcott.	Ptychoparidae.
Maladioides Kobayashi, 1933.	*Maladioides asiaticus* Kobayashi.	Ptychoparidae.
Haniwa Kobayashi, 1933.	*Haniwa sosanensis* Kobayashi.	Ptychoparidae.
Redlichaspis Kobayashi, 1935	*Redlichia* (?) *finalis* Walcott.	Redlichidae.
Komaspis Kobayashi, 1935.	*Komaspis typa* Kobayashi.	Komaspidae.
Cheiruroides Kobayashi, 1935.	*Atops orientalis* Resser and Endo.	Pagodidae (?)
Mimana Kobayashi, 1935.	*Mimana eurycephala* Kobayashi.	Damesellidae.
Eochuangia Kobayashi, 1935.	*Eochuangia hana* Kobayashi.	Leiostegidae.
Prochuangia Kobayashi, 1935	*Prochuangia mansuyi* Kobayashi.	Leiostegidae.
Chuangiella Kobayashi, 1935.	*Chuangiella elongata* Kobayashi.	Leiostegidae.
Kingaspis Kobayashi, 1935.	*Anomocare campelli* King.	Ellipsocephalidae
Haniwoides Kobayashi, 1935.	*Haniwoides longus* Kobayashi.	Ptychoparidae.
Yokusenia Kobayashi, 1935.	*Yokusenia vulgaris* Kobayashi.	Ptychoparidae.

Kokuria Kobayashi, 1935.	*Kokuria typa* Kobayashi.	Ptychoparidae.
Menocephalites Kobayashi, 1935.	*Menocephalus acanthus* Walcott.	Solenopleuridae.
Solenoparia Kobayashi, 1935.	*Ptychoparia (Liostracus) toxus* Walcott.	Solenopleuridae.
Lorenzella Kobayashi, 1935.	*Agraulos abaris* Walcott.	Ellipsocephalidae.
Metagraulos Kobayashi, 1935.	*Agraulos nitida* Walcott.	Ellipsocephalidae.
Megagraulos Kobayashi, 1935.	*Megagraulos coreanicus* Kobayashi.	Ellipsocephalidae.
Tollaspis Kobayashi, 1935.	*Anomocare pawlowskii* Schmidt.	Solenopleuridae
Kogenium, Kobayashi, 1935.	*Kogenium rotundus* Kobayashi.	Ceratopygidae.
Mesocrepicephalus Kobayashi, 1935.	*Crepicephalus damia* Walcott.	Crepicephalidae.
Coreanocephalus Kobayashi, 1935.	*Coreanocephalus kogenensis* Kobayashi.	Dikelocephalidae.
Shirakiella Kobayashi, 1935.	*Shirakiella elongata* Kobayashi.	Dikelocephalidae.
Aojia Resser and Endo.	*Aojia spinosa* Resser and Endo.	(Pl. XXIV, figs. 3–4.)
Crepicephalina Resser and Endo.	*Crepicephalus convexus* Walcott.	
Eilura Resser and Endo.	*Eilura typa* Resser and Endo.	(Pl. XXIV, fig. 13.)
Eymekops Resser and Endo.	*Anomocare hermias* Walcott.	
Fuchouia Resser and Endo.	*Bathyuriscus manchuriensis* Walcott.	
Hsiaiella Resser and Endo. 1)	*Hsiaiella striata* Resser and Endo.	(Pl. XXIV, fig. 12.)
Inouyella Resser and Endo.	*Inouyella peiensis* Resser and Endo.	(Pl. XXIV, fig. 1.)
Koptura Resser and Endo.	*Anomocare lisani* Walcott.	
Liaotungia Resser and Endo.	*Liaotungia puteata* Resser and Endo.	(Pl. XXIV, fig. 15.)
Manchuriella Resser and Endo. 2)	*Manchuriella typa* Resser and Endo.	

Some notes on Resser and Endo's new genera have been presented by Endo in his paper "Cambrian" in the Iwanami Series (in Japanese). I shall translate them below:—

1) *Hsiaiella*. *Hsiaiella striata* Resser and Endo is the typical species of *Hsiaiella*, new genus and found from the Hsiai (i. e. Kushan) formation. The significant characters are the relatively long palpebral lobe, beautiful course of the marginal rim, round genal angle without spine in the cephalon and the relatively broad axis, and very broad marginal border in the pygidium, (p. 74, without illustration.)

2) *Manchuriella*. Some of *Anomocare* and *Anomocarella* from the Asiatic Cambrian

	Mapania Resser and Endo.[1]	*Mapania striata* Resser and Endo.	
PA4174-24-5 PA4175-24-6	*Peishania* Resser and Endo.	*Peishania convexa* Resser and Endo.	(Pl. XXIV, figs. 5–6.)
PA4176-24-16	*Proasaphiscus* Resser and Endo.[2]	*Proasaphiscus yabei* Resser and Endo.	(Pl. XXIV, fig. 16.)
PA4177-24-9 PA4178-24-10 PA4179-24-11	*Psilaspis* Resser and Endo.	*Psilaspis manchuriensis* Resser and Endo.	(Pl. XXIV, figs. 9–11.)
	Kolpura Resser and Endo.	*Pterocephalus* (?) *lichas* Walcott.	
PA4180-24-2 (R)	*Taitzuia* Resser and Endo.	*Taitzuia insueta* Resser and Endo.	(Pl. XXIV, fig. 2.)
PA4181-24-14	*Temnura* Resser and Endo.	*Temnura granosa* Resser and Endo.	(Pl. XXIV, fig. 14.)
PA4182-24-7 PA4183-24-8 (R)	*Yabeia* Resser and Endo.[3]	*Yabeia lavigata* Resser and Endo.	(Pl. XXIV, figs. 7–8.)

In the research of the Asiatic trilobites one difficulty frequently met with is the fragmentary state of preservation. As to *Redlichia*, *Palacolenus*, *Annamitia*, *Tonkinella*, *Damesella* and *Proasaphiscus* their complete or nearly complete carapaces have been found but most of the others are known only from detached parts. Hence they stand only as reasonable combinations. It is not very difficult to unite a free cheek

described by Walcott and others are referred to this genus. The genotype of *Anomocare* is *Anomocare laeve* Angelin from Scandinavia which is entirely different from the Asiatic *Anomocare* through its narrow rim, very broad limb, wide fixed cheeks and well developed eyes. Hence the authors gave a name *Manchuriella* for this large group of trilobites very widely distributed in the Middle Cambrian of Orient, which have frontal limbs and rims of equal breadth, glabella with absent lateral furrows, insignificant eyes, and relatively wide and well defined borders on the pygidia. (pp. 75–76.) Genotype is not selected; *Manchuriella normalis* Resser and Endo, *M. tenuicaudata* Resser and Endo, *M. tenellusa* Resser and Endo, *M. transversa* Resser and Endo, *M. pertenuis* Resser and Endo, and *M. transversa* Resser and Endo are illustrated on Plate 20, without any description.

1) *Yabeia.* A new genus found from the Taitzu beds, *Yabeia*, is named in the honour of Prof. H. Yabe of the Tohoku Imperial University. This genus is characterized by the elongately ovate glabella without frontal furrows, poorly defined frontal rim and small eyes in the cephalon and the broad axis and marginal spines in the pygidium.

The genotype is *Yabeia laevigata*, new species, (illustrated on figure 36, without description of the species.)

2) *Proasaphiscus.* In the cephalon and thorax this genus is similar to *Asaphiscus*, but differs from that in the pygidium which is considerably small in reference to the size of the whole carapace and whose articulating segment is not so significant as that of *Asaphiscus*, but only faintly observed. It is denominated as *Proasaphiscus*, since it might be an ancestral form of *Asaphiscus*. The genotype is *Proasaphiscus yabei* of which complete carapace are well known to occur abundantly from various localities in Manchuria. (The genotype is illustrated in figures 17–21 on plate XXI without specific description.)

3) *Mapania.* (*Mapania striata* Resser and Endo is illustrated in figure 37.)

with a cranidium along the facial suture, but to tie together a detached hypostoma, thoracic segment, and pygidium with a cephalon gives opportunity for a play of imagination. It is practically impossible to derive the number of thoracic segments and relative size of the cephalon, thorax, and pygidium before hand. Therefore to escape from confusions I have paid little attention to the detached thorax and hypostoma in this study, although these are invaluable, when their true associations are ascertained.

The combination of these detached parts, however, has some logical bases, paleontological and stratigraphical. Some clues are found in the surface texture of the carapace, similar aspects between the cephalon and pygidium, especially applicable in cases where enrolling or some similar adaptation is present and the relative breadth of the axis to the carapace, if the axis is extraordinarily narrow or broad. In many cases the combination is suggested more strongly from a wide general knowledge of the trilobites through which a fragmentary form is compared to well known trilobites supposed to be closely related to it.

Another clue lies in the coexistence of the detached parts in one place. It is sometimes seen in examining the accumulations of carapaces in coastal deposits, that the cephala and pygidia have become sorted by their different resistance toward wave-action or some other reason. Therefore we have also to watch the mode of occurrence. If the same kind of combination is found frequently at several localities, it is tolerably safe and if these fossiliferous localities yield only a few species, the combination of the detached parts is still more reliable.

None of these clues are decisive, but they represent the best available and enable us to utilise a large group of otherwise indifferent materials. Among the six Asiatic genera three were originally established on complete trilobites, but *Redlichia, Damesella,* and *Tonkinella* were at first known only from fragments. Later the combinations of the authors, Redlich, Walcott, and Mansuy respectively, were verified by Mansuy's, Airaghi's and my materials. It is rather astonishing to see that these eminent authorities have so far turned out a performance of 100 percent in this respect. Though more complete individuals of various genera known only by fragments now may be unearthed through intensive fossil hunting, so far as the eastern Asiatic materials are concerned, the horizons yielding complete trilobites and also some protaspis appear to be confined to some shales and marls such as Manto shale, Huolienchai shale and Kushan shale. Few complete trilobites have ever been found elsewhere, and little is to be expected from the Upper Cambrian strata notwithstanding the fact that they are so very productive of various interesting parts.

Finally, it might not be superfluous to suggest here that the next steps which need to be taken in the Cambrian trilobite research of the Orient are: 1) checking the combinations set up by various authors by unearthing complete specimens, noting the frequent occurrence of the same combination at various localities, or by other ways; 2) paying especial attention to the hypostoma which will be a good touch stone for the proposed classification, and 3) the pursuing of ontogenetical study of which little has yet been done, but good results are in the offing in the case of such fine materials as those from the Huolienchai shale and some other horizons.

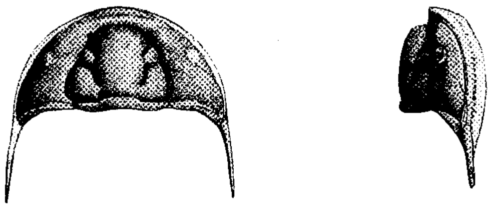
Notes on Proparia.

At the time Beecher established his classification, the Proparian families were known only from the Ordovician and later periods with no exception. Subsequent advancements in the Cambrian trilobite research have added several Proparian families in the preceding time. In 1908, Walcott[1] established a Proparian family, Burlingidae, for his *Burlingia* from the Stephen formation and included Moberg's *Schmalenseeia* from the *Agnostus pisiformis* zone of Sweden. *Duslia insignis* Jahn from $D-d_2$ of Ostrý and Drabov is much allied to *Schmalenseeia*[2]; *Triopus draboviensis* Barrande[3] from $D-d_2$ also more or less suggestive of the Burlingidae. Later Walcott set up two more families in 1914,[4] the Norwoodidae containing *Norwoodia* and the Menomonidae containing *Menomonia, Millardia* and *Dresbachia,* all confined to the early Upper Cambrian of North America. Then, in 1916[5] he described *Pagetia* from the Middle Cambrian of western North America, a few forms now known to occur also in England[6], Australia[7] and others. In 1924, T. H. Clark[8] established the Raymondidae for *Raymondia,* and Sun[9] erected *Wongia* and *Taianocephalus* (?) without any information about the family relationships.

1) Walcott (1908), Smiths. Misc. Coll. Vol. 53, pp. 14–18.
2) After Dr. J. Koliha's information.
3) Barrande (1872), System, Suppliment.
4) Walcott (1914), Smiths. Misc. Coll. Vol. 64, No. 3.
5) Walcott (1916), Smiths. Misc. Coll. Vol. 64, No. 5.
6) Cobbold (1931), Quart. Jour. Geol. Soc. London, Vol. XXXVII, p. 462.
7) David (1932), Explanately Notes to accompany a New Geol. Map of the Commonwealth of Australia.
8) Clark (1924), Bull. Am. Pal., Vol. 10, No. 41, p. 35.
9) Sun (1924), Paleont. Sinica, B, I, 4, pp. 83, 84.

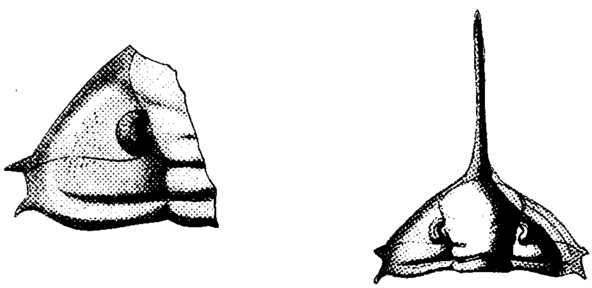
Beecher[1], however, originally defined the Proparian and Opisthoparian facial sutures with reference to the genal spine, namely, to the effect that the suture cuts the lateral margin of the cephalon anterior to the spine. Thus in the case of such forms as *Menomonia, Millardia, Dresbachia,* and *Taianocephalus,* it is difficult to decide whether they belong to the Proparia or Opisthoparia.

In fact, nothing definite can be said until a form possessing a



Text-figure 5.

Pharostoma pulchra (Barrande). [From Barrande (1852), Systême Silurien du Centre de la Bohême, Vol. I, Pl. 19, figs. 4–5.]



Text-figure 6.

Proboloides pessulus Clarke, the genotype of *Proboloides.* [From Clarke (1913), Fosseis Devonianos do Parana, (Monogr. Serv. Geol. e Min. do Brazil, Vol. I, Pl. 7, figs. 13–17.]

genal spine is discovered. The Calymenidae, for example, has lain on dubious ground because of the absence of the general spine in most genera, a few forms, such as *Pharostoma pulchra* (Barrande) (text-figure 5) and *Proboloides pessulus* Clark (text-figure 6) being exceptions. The

1) Beecher (1898), Am. Jour. Sci. Vol. 3, p. 198.

former species is intermediate between the Proparian and Opisthoparian suture, while the latter possesses one which cuts the lateral margin between the genal and intergenal spines. The Menomonidae is grouped in the Conocoryphidae in Zittel-Broili's Grundzüge[1], whereas it is considered to be an ancestor of the Calymenidae and Homalonotidae by Rud. Richter.[2] Even *Raymondia*, as pointed out by Walcott,[3] is very close to his *Desmetia* except on the point of the facial suture and *Wongia*, as mentioned later, is a member of the Ellipsocephalidae except also for that point. By the same reason it is doubtful, if *Cheiruroides* from the late Lower Cambrian of Eastern Asia and *Pseudolisania* (Pl. XXII, fig. 4,) from the Upper Cambrian of Tennessee, here established, are Proparian genera or not. (See pages 162, 163.)

In regard to the facial suture *Cedaria*[4] from the Upper Cambrian of the Appalachians and Wisconsin is intermediate between the Proparian and Opisthoparian types, in such a respect that its sutures cut the lateral margin in front of the genal spine on the dorsal side, but the spine is actually attached to the free cheek. In the general aspect the genus is, however, not far from the *Ptychoparia-Asaphiscus* line.

There are also several late Middle Cambrian trilobite[5] genera which reveal the Proparian tendency. For example, *Olenoides, Stephanocare* and *Damesella* show the posterior branches of the facial suture cutting lateral margins in front of the lateral angle, but behind the genal spines.

In looking over these Proparian or Proparia-like forms it can hardly be overlooked that the number of genera increases from the Lower to Upper Cambrian and these various later forms are quite different from one another, and show greater relationship to the Opisthoparian genera or families. Among them the real Proparian genera are relatively few, namely *Pagetia, Burlingia, Schmalenseeia* and *Norwoodia*. The first genus is accepted by most authors as being related to *Eodiscus* which is common in the Lower Cambrian, and hence it is more reasonable to explain that *Pagetia* was derived from *Eodiscus*, instead of vice versa. In the general aspects, especially in the thorax and pygidium, *Burlingia* and *Schmalenseeia* reveal good agreement with the older families such as the Mesonacidae and Olenopsidae. Even the

1) Zittel-Broili (1924), Grundzüge d. Palaeont, Abt. I, p. 647.
2) Rud. Richter (1933), Crustacea, in Handwörterbuch der Naturwissenschaften.
3) Walcott (1925), Smiths. Misc. Coll. Vol. 75, No. 3, p. 83.
4) Walcott (1925), Op. cit. p. 79.
5) Walcott (1913), Cambrian Faunas of China, p. 124.

Norwoodidae is very close to the Ptychoparidae.[1] The geological case of the Cambrian Proparian genera appears to be favourable toward the conclusion that the Proparian stage is the later development.

It is very interesting that little connection is to be found between the Cambrian Proparians and the Ordovician and later ones, although the latter are mostly traceable down to the early Ordovician. *Dalmanitina* and *Pterygometopus* are considered to be the oldest genera of the Phacopidae, and the subfamilies Dalmenitinae and Pterygometopinae had branched already in the Ordovician time.[2] According to Raw,[3] the Phacopidae manifests some similarity to the Paradoxidae through its ontogenetic career and in his opinion *Pterygometopus henteri* would be the most primitive phacopid. If this is right, the Phacopidae was derived from Opisthoparian stock.

Cowper Reed[4] once pointed out *Anacheirurus* of the Upper Tremadoc as an ancestor of the *Cheirurus* branch. Barton[5] selected *Eccoptochile* together with *Anacheirurus* as the ancestral forms and inclined to believe that the former had more primitive characters than did the latter.

Cheiruroides might have been the ancestral group of the Cheiruridae, but since there is a tremendous gap involving the whole Middle and Upper Cambrian, this is uncertain.

Thus we see that the Cambrian Proparians reveal little relationship among themselves as well as to the later Proparians. Each Proparian genus of a certain age suggests relationship with some Opisthoparian genus or family, older than itself. Therefore it might be deduced that the Proparians might be the terminals of evolutional lines, an idea which naturally leads to the polyphyletic origin of the Proparian trilobites and which shakes the foundation on which Proparia stands as a valid order.

Family Agnostidae M'Coy.

Historical Review:—This family has been considerably reviewed in

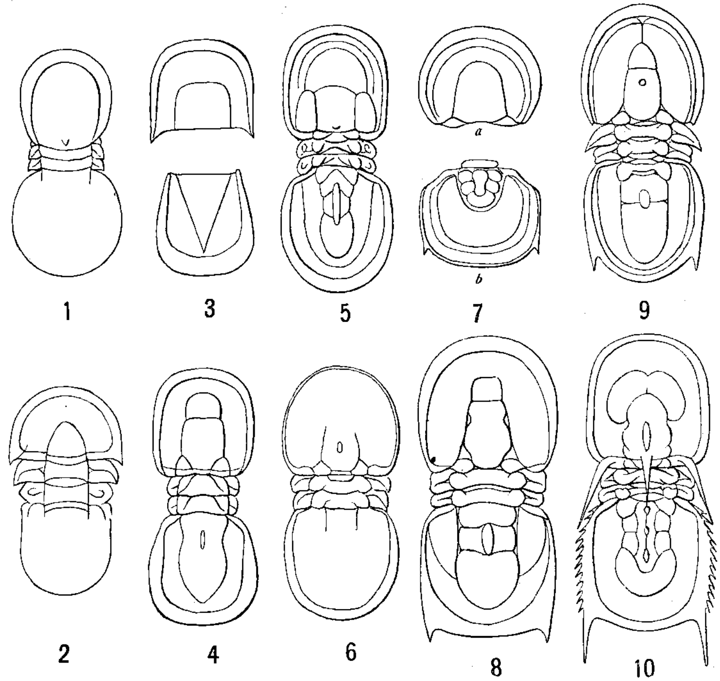
1) Walcott (1914), Op. cit. p. 168.

2) Reed (1905), Classification of the Phacopidae, (Geol. Mag. Dec. V); (1927), Recent work on the Phacopidae, (Geol. Mag. Dec. 4, Vol. 3.)

3) Raw (1925), Q. J. G. S. London, Vol. LXXVI.

4) Reed (1896), Evolution of *Cheirurus*, (Geol. Mag. Dec. 4, Vol. 3.)

5) Barton (1915), A Revision of the Cheirurinae with Notes on their Evolution, (Wash. Univ. Studies, Vol. III, Pt. I, No. 1.)



Text-figure 7.

Hawle and Corda's Phalocromides and Buttoides.

1. *Phalacromides scutiforme* Hawle and Corda.
2. *Selenoptychus rotundatus* Hawle and Corda.
3. *Mesospheniscus cuneifera* Hawle and Corda.
4. *Diplorrhina sirius* Hawle and Corda
5. *Condylopyge rex* Hawle and Corda.
6. *Lejopyge laevigati* Dalman.
7. *Arthrorhachis tarda* Hawle and Corda.
8. *Peronopsis integra* Hawle and Corda.
9. *Battus pisiformis* Dalman.
10. *Pleuroctenium granulatum* Hawle and Corda

[Reproductions of Hawle and Corda's original figures 20–25 on plate III and figures 60–63 on plate VI, (1847).]

the works of Hawle and Corda,[1] Tullberg,[2] Jaekel,[3] and others and it has become to be understood now in a more restricted sense than formerly. Through his study of agnostids, mostly from Andrarum, Tullberg established the four divisions, namely *Longifrontes, Laevigati, Limbati,* and *Parvifrontes,* and *Limbati* was again subdivided into *Regii* and *Fallaces.*

In modifying this division, Jaekel gave a scheme as follows :—

I. Family Paragnostidae Jaekel.[4]

Paragnostus Jaekel, (genotype : *A. rex* Barrande.)
Dichagnostus Jaekel, (genotype : *A. granulatus* Barrande.)
Diploagnostus Jaekel, (genotype : *A. planicauda* Angelin.)
Mesagnostus Jaekel, (genotype : *A. integer* Barrande.)

II. Family Metagnostidae Jaekel.[5]

Metagnostus Jaekel, (genotype : *Metagnostus erraticus* Jaekel.)
Hypagnostus Jaekel, (genotype : *A. parvifrons* Linnarsson.)

III. Family Agnostidae sensu stricto.[6]

Agnostus L. sensu stricto, (genotype : *A. pisiformis* L.)
Ptychagnostus Jaekel, (genotype : *A. punctuosus* Angelin.)
Pseudagnostus Jaekel, (genotype : *A. cyclopyge* Tullberg.)

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1) Ignaz Hawle and A. J. Corda (1847), Prodrom einer Monographie der Böhmischen Trilobiten.
Hawle and Corda's Phalacromides was divided into the following six genera. (See Text-figure 7.)

1. *Phalacroma* Hawle and Corda, (genotype *P. suctiforme* Hawle and Corda, fig. 1.)
2. *Selenoptychus* Hawle and Corda, (genotype *S. rotundatus* Hawle and Corda, fig. 2.)
3. *Mesospheniscus* Hawle and Corda, (genotype *M. cuneifera* Hawle and Corda, fig. 3.)
4. *Diplorrhina* Hawle and Corda, (genotype *D. sirius* Hawle and Corda, fig. 4.)
5. *Condylopyge* Hawle and Corda, (genotype *C. rex* Hawle and Corda, fig. 5.)
6. *Lejopyge* Hawl and Corda, (genotype *L. laevigata* Dalman, fig. 6.)

and their Battoides into four genera as follows :—

7. *Arthrorhachis* Hawle and Corda, (genotype *A. tarda* Hawle and Corda, fig. 7.)
8. *Peronopsis* Hawle and Corda, (genotype *P. integra* Hawle and Corda, fig. 8.)
9. *Battus* Dalman, (genotype *B. pisiformis* Dalman, fig. 9.)
10. *Pleuroctenium* Hawle and Corda, (genotype *P. granulatum* Hawle and Corda, fig. 10.)

Battus Dalman, 1827, is a synonym of Brongniart's *Agnostus* 1822, the genotype of both being *Entomolitus paradoxus pisiformis* Linnaeus, 1757.

2) Tullberg (1880), Om *Agnostus*-Arterna i de Cambriska Aflagringarne vid Andrarum, (Serv. Geol. Undersökning, ser. C, Nr. 42.)

3) Jaekel (1909), Über die Agnostiden, (Zeitsch. d. deutsch. Geol. Gesell. Bd. 61, Jahrg. Hft. 3 and 4.)

4) This contains Tullberg's *Limbati* and *Fallaces.*

5) Tullberg's *Parvifrontes* is contained here.

6) This corresponds to *Longifrontes.*

IV. Family Leiagnostidae Jaekel.[1]

Miagnostus Jaekel, (genotype: *A. laevigatus* Ang.)

Leiagnostus Jaekel, (genotype: *Leiagnostus erraticus* Jaekel.)

Later Raymond[2] noticed that Jaekel's several genera of 1909, however, are synonymous with Corda's genera proposed in 1847, because Jaekel's genotypes are duplicates of Corda's. On account of this duplication and some other reasons the following genera of the former author lose their standings:—

Condylopyge Corda, (genotype: *A. rex,*) i. e. *Paragnostus*

Pleuroctenium Corda, (genotype: *A. granulatus,*) i. e. *Dichagnostus.*

Peronopsis Corda, (genotype: *A. integer* Beyrich,) i. e. *Mesagnostus.*

Lejopyge Corda, (genotype: *A. laevigatus* Dalman,) i. e. *Miagnostus.*

Phalacroma Corda, (genotype: *A. bilullatus* Barrande,) i. e. *Leiagnostus,* (genotype: *L. erraticus.*)

Arthrorhachis Corda, (genotype: *Agnostus tardus* Barrande,) i. e. *Metagnostus,* (genotype: *M. erraticus.*)

Finally, Raymond mentions that "unfortunately, *Paragnostus, Metagnostus* and *Leiagnostus* are the genera which Jaekel considered typical of three of his new families, and their rejection faces the rejection of the family names derived from them. Corda's family name *Phalacromidae* would apply to the *laevigati,* and, using the same types as Jaekel, the *Paragnostidae* would become the *Condylopygidae,* and the *Metagnostidae* would be transformed into the *Arthrorhachidae.*" Later on Raymond[3] himself inclined, however, to recognize these divisions of agnostids in the subfamily, instead of family, rank.

Clark[4] added in 1923 a new genus *Plethagnostus* for *Plethagnostus gyps* Clark which he considered the ancestor of *Pseudagnostus.*

Remarks:—The *Agnostus* group is well defined by its possession of a typical cephalon and pygidium with two free segments between, and further by its lack of eyes and of the facial suture on the dorsal shield. On its general aspects it is placed next to the Eodiscidae by most authors.

Jaekel[5] pointed out the similarity of the cephalic construction

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1) Tullberg's *Laevigati.*

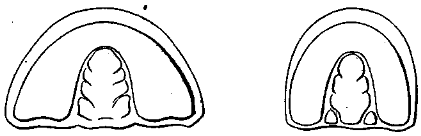
2) Raymond (1913), Some changes in the Names of Genera of Trilobites, (Ottawa Naturalist, Vol. XXVI.)

3) Raymond (1924), New Upper Cambrian and Lower Ordovician Trilobites from Vermont, (Proc. Boston Soc. Nat. Hist. Vol, 37, No 4.)

4) T. H. Clark (1923), A Group of New Species of *Agnostus* from Levis. Quebec, (Canadian Field Naturalist, Vol. XXXVII,) p. 122.

5) O. Jaekel (1909), Über die Agnostiden, (Zeitsch. deutsch. Geol. Gesell. Bd. 61, Jahrg. Hft. 3-4.)

between *Conocoryphe* and *Mesagnostus*. (Text-fig. 8); Walcott[1] compared *Agnostus* and *Litsoracina* in their cylindrical glabella, longitudinal furrows across the preglabellar field and side lobes on both sides of the glabella. Another case of similarity between the head and tail is seen in *Mollisonia*, as noticed by Walcott.[2]



Text-figure 8.
From Jackel's Über die Agnostiden [Zeitsch. deutsch. Geol. Gesell. Bd. 61, Jahrg. (1909,) p. 389.]

One feature which finds no counterpart in any of the other trilobites is seen in the median tubercles on the pygidium and cephalon. That of the pygidium is quite unlike the median node of an axial ring, and that of the cephalon, the median eye of *Symphysurus* and the like. So far as I am aware, nothing is definitely known about the origin and function of these tubercles.

In connection with the facial suture and eyes I here wish to direct the attention to *Dipharus* Clark[3] whose general construction is quite suggestive of the cephalon of the Agnostidae except for the Opisthoparian suture and the prominent eyes. It might be said that the relation of *Dipharus* to the Agnostidae is something like that of *Pagetia* to the Eodiscidae.

Remarks on the Oriental agnostids:—The precise revision of the agnostids has hitherto been mostly limited to the European and American materials, the latter of which has been studied by G. F. Matthew[4] and others, but as yet the Asiatic ones are almost entirely untouched. In the Orient hitherto no species of agnostid had been described from the Lower Cambrian, but many species were recorded from the Middle Cambrian to Lower Ordovician of south-eastern Asia. The expanse of time now known to be involved allowed a long evolutional series to reach full expression. The number of species described so far, attains fourteen as follows:—

Agnostus chinensis Dames, 1883.
Agnostus douvilléi Bergeron, 1889.

1) Walcott (1913), Cambrian Faunas of China, p. 144.

2) Walcott (1912), Smiths. Misc. Coll. Vol. 57, No. 6, p. 196.

3) T. H. Clark (1923), New Fossils from the Vicinity of Boston, (Proc. Boston. Soc. Nat. Hist. Vol. 36, No. 8,) pp. 478–479.

4) G. F. Matthew (1896), Faunas of the *Paradoxides* Beds in eastern North America, (Trans. New York Acad. Sci. Vol. XV.)

Agnostus pii Airaghi, 1902.
Agnostus koerferi Monke, 1903.
Agnostus kushanensis Walcott, 1905.
Agnostus fallax Linnarsson, var. *laiwuensis* Lorenz, 1906.
Agnostus parvifrons Linnarsson, var. *latelimbatus* Lorenz, 1906.
Agnostus spitiensis Reed, 1910.
Agnostus hoi Sun, 1924.
Agnostus cyclopygeformis Sun, 1924.
Agnostus chiushuensis Kobayashi, 1931.
Agnostus hoiformis Kobayashi, 1933.
Pseudagnostus orientalis Kobayashi, 1933.
Agnostus radiatus Kobayashi, 1934.

To these are added new species, *Agnostus coreanicus, Agnostus rakuroensis, Agnostus* (*Lejopyge* ?) *obsoletus, Pseudagnostus primus* and *Agnostus* (*Ptychagnostus* ?) *orientalis* from South Chosen, Additional two species *Agnostus czekanowskii* Schmidt, 1886 and *Agnostus schmidti* Toll, 1899 were described from Siberia. According to the revision by Walcott and others, *A. koerferi* is a synonym of *A. douvilléi.*

In looking over these species from the Orient, the most noticeable feature is that all of them fall into the Agnostidae s. str. and there is no representative of other families, except *Agnostus czekanowskii* and *A. parvifrons latelimbatus,* (see Lorenz, pl. V, fig. 10,) which in turn have possibility of being members of Phalacromidae or Arthrorhachidae respectively. *A. fallax,* according to Jaekel, is to be placed in his Paragnostidae, i. e. Raymond's Condylopygidae, but so far as *A. fallax laiwuensis* Lorenz is concerned, this variety is very close to *Agnostus chinensis.* The general situation naturally makes it easy to trace the various relationship among the genera and species of Agnostidae, s. str.

The results of my study will be described in detail in the succeeding pages, but one thing may be noticed here is that *Pseudagnostus* most probably represents a branch from *Agnostus* s. str. while *Ptychagnastus* seems to be polyphyletic. *Ptychagnostus orientalis* is found in the Middle Cambrian and *Agnostus* (*Ptychagnostus* ?) *radiatus* in the Lower Ordovician. The latter, however, is not a descendant of the former, but each of them seems to have been derived separately from the main line of *Agnostus.*

Genus AGNOSTUS Brongniart, 1822.

Genotype:—*Agnostus pisiformis* L.

Remarks:—Among the Asiatic agnostids the following species belong to this genus or come at least into its neighbourhood:—

Agnostus chinensis Dames.[1]
Agnostus czekanowskii Schmidt.
Agnostus kushanensis Walcott.
Agnostus fallax Linnarsson, var. *laiwuensis* Lorenz.
Agnostus spitiensis Reed.
Agnostus hoi Sun.
Agnostus chiushuensis Kobayashi.
Agnostus hoiformis Kobayashi.
Agnostus coreanicus, new species.
Agnostus (*Lejopyge* ?) *obsoletus*, new species.
Agnostus (*Ptychagnostus* ?) *orientalis*, new species.
Agnostus rakuroensis, new species.

These twelve species mostly agree with *Agnostus pisiformis* in the following respects:—

1) The carapace is surrounded by a marginal brim.
2) The glabella of moderate length, consists of a small anterior and long posterior lobes in addition to a pair of basal triangular lobes.
3) The axial lobe on the pygidium is divided into anterior and posterior lobes; the latter varies in shape and size, while the former is usually subquadrate and divided again into two portions of which the posterior one carries a tubercle on it.

These Asiatic forms together with European and American agnostids, are variant from one another in the outline and convexity of the carapace, strength of the median preglabellar furrow, position of a median tubercle on the glabella, shape and extension of the posterior axial lobe on the pygidim, presence or absence of posterior spines and other specific characters.

A fairly important point of difference lies in the feature of

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1) During my visit to Berlin I had an opportunity to study the Dames' types and found that *Agnostus chinensis* Dames is a compound species from the Upper Cambrian, instead of the Middle Cambrian as used to be considered by most Cambrian students, and nothing to do with Walcott's *Agnostus chinensis* commonly distributed in the early Middle Cambrian. The Dames', Monke's, and Lorenz's types will be discussed thoroughly in another paper now in preparation.

posterior lobe on the pygidium. It is subtriangular, semi-circular, or semi-ovately expanded and varies in its length; sometimes it extends back and completely divides the side lobes, but it is more commonly short and leaves at the hind a space where the side lobes are actually united. Another remarkable character is the convexity. In *Agnostus hoi* and *Agnostus hoiformis* the pygidia swell up usually. The smoothing of the surface relief is also very interesting, because *Agnostus obsoletus* is surely derived from *A. rakuroensis* through smoothing.

The radial marking on the side lobe was once considered to be a generic character, and out of it the name "*Ptychagnostus*" was established; but according to Westergård[1] *Agnostus pisiformis* covers the entirely smooth form (Taf. I, fig. 1,) as well as the clearly furrowed one (Taf. I, fig. 3). The same is true for *Agnostus coreanicus*, as noted in its description, a gradation from smooth to furrowed form being demonstrable.

Among the cited Asiatic species *Agnostus chinensis* requires a revision, because Walcott grouped two distinct forms into this species. Dames' *A. chinensis* is well characterized by the median longitudinal furrow, absent axial tubercle on the glabella and large expanded posterior lobe on the pygidium through which the forms from the Fuchou series of Liaotung and the Kiulung group of Shantung are easily distinguished.

Based upon the Korean specimens *Agnostus rakuroensis* is here established of which the main specific distinction from *A. chinensis* Dames is the triangular shape of the posterior lobe on the pygidium which separates the lateral lobes on its both sides in a clear cut fashion. Walcott's *A. chinensis* from Fuchou series is more allied to *A. rakuroensis* than to *A. chinensis* s. str. Reed's *A. spitiensis*, Walcott's *A. chinensis* from the Kiulung group, and Matthew's *A. montis*[2] from the Stephen formation are allied to one another. The distinguishing character of the first species is "a minute median tubercle on the frontal lobe and larger elongated one near base of main lobe" on the cephalon.[3] In the pygidium by itself the first and third species approach each other, but the second species has a long axial lobe which is actually in contact

1) Westergård (1922), Sveriges Olenidskiffer, (Sveriges Geologiska Undersökning, Ser. Ca, No. 18.)

2) Matthew (1899), Studies on the Cambrian Faunas, No. 3, Upper Cambrian Faunas of Mt. Stephen, British Columbia, (Trans. Roy. Soc. Canada, Ser. 2, Vol. V, Sect. IV,) p. 43, Pl. I, fig. 6

3) Reed (1910), Cambrian Fossils of Spiti, (Pal. Indica, new ser. 2,) p. 4.

with the posterior brim. The cephalon of the second and third forms are again much alike.

Incidentally Chapman[1] identified *Agnostus chinensis* from Queensland which looks to me to be closer to *Agnostus rakuroensis* than to Dames' *A. chinensis* s. str.

Agnostus czekanawskii Schmidt from Siberia is quite distinct from the others by its very tiny basal lobe on the cephalon, semi-ovate outline of the pygidium, and especially by the feature of the axial lobe on the pygidium.

The obscure anterior lobe of the glabella, and the short and pointed axial lobe and very broad border of the pygidium separate *A. kushanensis*; the former feature is similar to that of *Agnostus barrandei* Salter[2] and *A. lens* Grönwall.[3]

It is noticed that *A. chiushuensis* resembles *Agnostus insuetus* Raymond,[4] although the latter has an axial furrow on the pygidium.

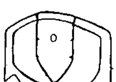
PA952'-14-18
PA952-14-17
PA953-21-1
PA954-21-2

Agnostus rakuroensis, new species.

Plate XIV, figures 17–18; Plate XXI, figures 1–2; Text-figure 9.

1913. *Agnostus chinensis* Walcott, Cambrian Faunas of China, pp. 99, Pl. 7, figs. 4, 4a–b, (not figs. 5, 5a–c.)

Description:—Cephalon subquadrate, surrounded by a distinct brim and groove of uniform breadth; axial lobe as wide as one-third, and as long as about two-thirds the breadth of the cephalon; the lobe subdivided into triangular anterior and cylindrical posterior lobes, the former division being about half as long as the latter which in turn bears a median tubercle; the side lobes on both sides of the axial lobe relatively small; longitudinal groove in the preglabellar field dies out in a short distance from the anterior axial lobe.



Text-figure 9. Pygidium of *Agnostus rakuroensis*, new species.

Thorax composed of subequal segments; axial segments relatively wide and bear three large tubercles.

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1) Fredrik Chapman (1929), On some Trilobites and Brachiopods from the Mount Isa District, N. W. Queensland, (Proc. Roy. Soc. Victoria, Vol. XLI, Pt. II, New Series,) p. 208, Pl. XXI, fig. 6, Pl. XXII, fig. 20.

2) Lake(1906), A. Monograph of the British Cambrian Trilobites, (Palaeontogr. Soc.) Part. I, p. 13, Pl. II, fig. 2.

3) Grönwall(1902), Bornholms *Paradoxides* lag og deres Fauna, (Danmarks geol Unders. II, Raekke, Nr 13,) Pl. I, fig. 8–9.

4) Raymond(1924), New Upper Cambrian and Lower Ordovician Trilobites from Vermont, (Proc. Boston Soc. Nat. Hist. vol. 37, No. 4,) p. 393, Pl. I, figs. 2, 6.

Pygidium subquadrate; marginal brim and groove distinct, parallel on the lateral sides, pointed at the posterior ends into a pair of tiny spines; posterior margin between the spines broadly rounded; articulating segment distinct, straight, and transverse on the axis, but a little oblique backwards in front of the side lobes; axis cylindrical, parallel sided, or even expanded backward, and then triangularly convergent, and very much elevated above the side lobes; a transverse furrow divides the axial lobe into a subquadrate anterior lobe and a triangular posterior one, on the former of which is located a strong longitudinal tubercle; axial furrow deep, pointed back, and actually in contact with the posterior furrows.

Surface smooth.

The complete carapace illustrated in figure 2, Plate XXI, is 3.9 mm. in length in which the cephalon and pygidium are both 1.5 mm. in length.

Comparisons:—The distinguishing characters are the subquadrate pygidium, and the outline of the axial lobe which extends to the brim and divides the side lobes. This species includes most of Walcott's *Agnostus chinensis*. His specimens of the species illustrated in figs. 5a-c, have a more rounded cephalon and pygidium on the latter of which is located a more round posterior axial lobe. Dames' *Agnostus chinensis* has a long trapezoidal cephalon with a strong longitudinal groove across the preglabellar field and an unusually swollen posterior axial lobe on the pygidium.

Formation and locality:—In association with *Ptychoparia* (?) *coreanica*, the holotype collected from a black shale of the early Middle Cambrian at Ritsu-ri, Daido-gun, Heian-nando, North Chosen. (平安南道大同郡栗里隱松泉洞)

Many detached cephala and pygidia are found in the *Olenoides* zone of Neietsu in South Chosen; and Walcott's specimens were procured from a shale in the Fuchou series of Tchang-hsing-tou Island, Liaotung, Manchuria.

PA955-14-4

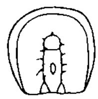
PA956-14-5

Agnostus coreanicus, new species.

Plate XIV, figures 4-5; Text-figure 10.

Description:—Cephalon much longer than wide, elongately subquadrate, rounded in front; frontal and lateral margins surrounded by a thick convex brim and concave groove, both of which narrow back along the lateral margin; axial lobe slightly narrower than the side lobe, long, convex, and elevated above the gently convex side lobes;

axial groove distinct; anterior lobe semi-ovate, one-fourth the glabellar furrow and clearly separated from the posterior lobe by a transverse furrow; another faint transverse furrow crosses the glabella at a point one-third the length on the posterior lobe; a longitudinal tubercle located on the middle of the posterior lobe; triangular lobes found on both sides of the glabella; preglabellar axial groove dies out in a short distance from the glabella; several short radial furrows sometimes occur near the axial furrow; articulating segment fairly distinct behind the side lobe.



Text-figure 10 *Agnostus coreanicus*, new species.

Surface smooth.

Comparisons:—The main specific characters are the very long cephalon, two short anterior and middle axial lobes, and a median tubercle behind them. In some cephala radial furrows begin to appear and tend to approach the ptychagnostid type.

Formation and localitg:—*Olenoides* zone of Neietsu.

Agnostus (*Ptychagnostus* ?) *orientalis*, new species.

Plate XIV, figures 11–12.

In the second part of this monograph I described *Agnostus* (*Ptychagnostus* ?) *radiatus* Kobayashi from the Lower Ordovician of South Chosen, so this is the second instance of this type of *Agnostus* being found.

Description:—Specimen represented by an incomplete mould of the cranidium, semicircular to semi-ovate in outline, and regularly convex except for the narrow and flat marginal brim; axial lobe very narrow, slender, spindle-shaped and undivided; it may be associated with a pair of triangular lobes on both sides of the base, but they cannot be clearly made out; several strong minute pits located upon the distinct axial furrow; on the wide and gently inclined side lobes there are found a number of radial grooves, which branch and unite, making a kind of net-work near the margin.

Comparisons:—The surface ornamentation and unfurrowed glabella are remarkable features with this Oriental agnostid. Jaekel established *Ptychagnostus* for the forms ornamented by radial furrows, but it is doubtful that such a surface modification actually deserves the generic value.

Among his ptychagnostids, *P. trisectus* (Salter) for example is quite different from the genotype *P. punctuosus* (Angelin) especially in its pygidium. If more attention is paid to the fundamental configurations, the ptychagnostid group has a possibility of being segregated into several groups of different evolutional lines. The form here described is unfortunately represented only by the cephalon and the characters of the pygidium which are especially important for the agnostid classification cannot be figured out; therefore it is uncertain, if this form falls into the same phylogenetical group as *Ptychagnostus punctuosus.* The gradation in the degree of radial marking and polyphyletic aspect in the fundamental configuration of the carapace form sufficient reasons to demand some emendation of the generic diagnosis of *Ptychagnostus.*

Formation and locality:—*Olenoides* zone of Neietsu.

Agnostus (*Lejopyge* ?) *obsoletus*, new species.

PA958-14-19

Plate XIV, figure 19 (19)

This form is in general features certainly related to *Agnostus rakuroensis*, but more rounded in outline, strongly convex and the axis and side lobe almost undefined. In the pygidium a longitudinal tubercle on the anterior axial lobe is the only significant feature recongnizable. Through the obsoletion and increasing convexity this form approaches *Lejopyge* and *Phalacroma,* but it still has a distinct marginal brim and groove and, when the faint trace of the axial outline is retained, it reveals the true *Agnostus* character. In such a range of variation it is certainly in the domain of *Agnostus.*

Agnostus schmidti Toll,[1] which was compared to *Agnostus nudus* and varieties of *Agnostus laevigati* by the author is the only representative of the Phalacromidae in Asia. In smoothing it has proceeded one step more than *A. obsoletus.* It has no trace of an axial segment nor of an axial tubercle on the cephalon and pygidium.

Formation and locality:—*Olenoides* zone of Neietsu.

Agnostus hoiformis Kobayashi.

PA959-3-1,2.
PA960-3-3,4.
PA961-3-5,6.

Plate III, figures 1-6.

1933. *Agnostus hoiformis* Kobayashi, Upper Cambrian of Wuhutsui Basin, etc. p. 97, pl. X, figs. 1-3.

Description:—Cephalon moderately convex, with a narrow convex

1) E. v. Toll (1899), Beiträge zur Kenntniss der Sibrischen Cambrium I, (Mém. d l' Akad. Imp. des Sci. St. Pétersbourg, VII, Ser. Vol. VIII, No. 10,) p. 25, Taf. I, fig. 5, 12, 13, 21, 22, 23.

brim and concave groove along the lateral and frontal margins; glabella strongly convex, elevated, narrower than one-third the width of the cephalon, divided into two lobes by a transverse furrow; the anterior lobe roundly triangular, occupying about one-third the length of the glabella; the posterior lobe accompanied by a lateral triangular lobe on each side of its base and contracted at a short distance from the anterior lobe by short depressions along the sides; a median tubercle small, located at the middle point between these depressions; glabellar furrows strong, somewhat angulated at the front of the glabella; a faint median longitudinal groove found on the preglabellar field.

Pygidium subquadrate, remarkably convex, surrounded by a narrow brim and groove; the marginal brims subparallel on the lateral sides and pointed into a tiny spine at the posterior end; the brim between the spines broadly rounded; axis occupies half the breadth of the tail, defined by subparallel axial furrows which are contracted in the middle; the posterior margin round at a short distance from the marginal groove; axis divided into subequal lobes by a transverse furrow and the anterior division is divided again by another transverse furrow; a median tubercle, prominent, elongated, and located on the first and second axial lobes. Surface smooth.

In my previous paper I wrote that *A. hoiformis* has no median longitudinal groove in front of the glabella. An examination of a large number of new specimens has shown me that occasional weak traces of the grooves are to be found.

Comparisons:—The most closely allied species is *Agnostus hoi*[1], but *A. hoiformis* is distinguished from it by the position of the median tubercle on the cephalon which is located on the posterior, instead of anterior, lobe of the glabella in *A. hoiformis* and also by the outline of the rachis on the pygidium which is shorter and more expanded laterally in the posterior portion in it than in *A. hoi*.

For the general specific distinction from the other Oriental agnostids, see also the generic remarks upon *Agnostus*. (On page 101.)

Formation and locality:—*Chuangia* beds of Kasetsu-ji and Saisho-ri.

Genus PSEUDAGNOSTUS Jaekel, 1909.

Remarks:—In his "Ueber die Agnostiden" Jaekel[2] gave the following information about this genus:—

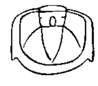
1) Sun (1924), Cambrian Faunas of North China, (Pal. Sinica, B, I, 4,) p. 28, Pl. II, fig. 2.

2) O. Jaekel (1909), Zeitsch. deutsch. Geol. Gesell. Bd. 61, S. 400.

"Kopfschild wie bei *Agnostus*, aber Schwanzschild mit kurzer breiter Rhachis, die in einen breiten, ovalen, das ganz Schwanzschild bis zum Limbus einnehmenden Endlobus endigt."

Genotype:—*Agnostus cyclopyge* Tullberg.

For convenience in connection with formal descriptions a trem, "*diagonal accessory furrow*," is proposed to signify the diagonal furrow usually starting from the posterolateral angle of the anterior axial lobe and running postero-laterally across the posterior portion of the pleural slope. This furrow is in my belief a later development. The evidence for that is furnished by some forms of the genus, such as *Pseudagnostus cyclopygeformis* in which the posterior lobe of the axis is marked by a set of pits which were due to muscular attachments, and hence the axial lobe should be traced into the posterior lobe along the pits and the accessary furrows should be interpreted as having arisen from some other adaptation. (Text-fig. 11.)



Text-figure 11. Diagrammatic drawing of *Pseudagnostus* pygidium showing the diagonal accessary furrow.

It is interesting to note that two species of *Pseudagnostus*, corresponding to *Pseudagnostus cyclopyge* (Tullberg) of Europe and *Pseudagnostus josepha* (Hall) of America, occur commonly in the Upper Cambrian of Eastern Asia; the one is *Pseudagnostus orientalis* Kobayashi in the early Upper Cambrian, and the other *Pseudagnostus cyclopygeformis* (Sun) in the late Upper Cambrian.

So far as I am aware, the described species of *Pseudagnostus* have been hitherto limited to the Upper Cambrian, but the discovery of *Pseudagnostus primus* extends the lower limit into the Middle Cambrian.

PA962-14-6
PA963-14-7
PA964-14-8
PA965-14-9
PA966-14-10

Pseudagnostus primus, new species.

Plate XIV, figures 6–10.

Description:—Cephalon and pygidium large, long and semiovate. Cephalon convex, surrounded by a narrow and flat brim; glabella as long as two-thirds the length of the cephalon and faintly divided into three lobes; the third lobe occupies half the length of the glabella and associated with a pair of triangular lobes on both sides of the base; the first and second equally short; a longitudinal tubercle lies across at the middle of the second glabellar furrow; an axial furrow across the frontal limb.

Pygidium bordered by a brim and groove; the anterior lobe of the axis quadrate, as wide as half the pygidium and divided into two by a transverse furrow; a longitudinal tubercle lies across the median point of the second transverse furrow which defines the posterior margin of the anterior lobe; diagonal accessary furrows starting at the postero-lateral angles of the anterior lobe and directed toward the posterior ends of the lateral margins; no posterior spine on the marginal border.

Surface smooth.

The cephalon as well as pygidium attains 5.5 mm. in length and width.

Comparisons:—This species bears the typical features of *Pseudagnostus.* Its large size, long ovate outline, obsolete posterior axial lobe and absence of the posterior spine on the pygidium are the distinguishing characters.

Formation and locality:—*Olenoides* zone of Neietsu.

Pseudagnostus douvilléi (Bergeron).

Plate XIII, figures 1 and 9.

1899. *Agnostus douvilléi* Bergeron, Étude de quelques Trilobites de Chine, p. 503, Pl. XIII, fig. 3.

1903. *Agnostus koerferi* Monke, Oberkambrische Trilobiten von Yen-tsy-yai, p. 111, Pl. III, figs. 1–9.

1913. *Agnostus douvilléi* Walcott, Cambrian Faunas of China, p. 100, Pl. VII, figs. 3, 3a–b; Pl. XI, figs. 6–7.

1916. *Agnostus* cf. *douvilléi* Mansuy, Faunes Cambriennes de l' Extrême-Orient méridional, p. 18, Pl. I, figs. 26a–b, 27.

This species was fully described and illustrated by Monke, but he separated it from Bergeron's *Agnostus douvilléi* and gave a new name *Agnostus koerferi.* The careful stratigraphical study by Blackwelder has proved that the limestone of Yen-tsy-yai in which *A. koerferi* was found and which Monke considered to be of the Upper Cambrian age, lies below the Chaumitian limestone of the Upper Cambrian age, and from the paleontological side Walcott assumed both species as being synonymous.

Bergeron brought his *Agnostus douvilléi* into Tullberg's *Regii* subgroup of *Limbati* group, while Monke noted that *A. koerferi* resembles Tullberg's *Fallaces* subgroup of *Limbati* group as well as *Laevigati* group in the cephalon, while in the pygidium it is quite different from both of them, but closely allied to *Agnostus cyclopyge* Tullberg, *A. neon* Hall and Whitfield, and *A. communis* Hall and Whitfield.

This species is rather variable in form, but well defined by its strong convexity, especially in its pygidium, strong and broad mariginal border and other features. The glabella tends to be divided into three lobes, but the second glabellar furrow is simply represented by a pair of short pits. The median tubercle is usually very faint, but in the well preserved specimens a small tubercle is fairly well marked and located at the median point between these pits. In the pygidium the anterior lobe is very wide and subquadrate, well marked by furrows and divided into two by a faint transverse furrow. A longitudinal tubercle is situated at the middle of the second lobe. A pair of furrows diverge from the postero-lateral angles of the anterior lobe. The spine at the posterior end of the lateral margin is small, and sometimes cannot be observed. When the specimens are preserved in shale, as is the case of those from the *Stephanocare* zone of Chosen, the outline and convexity are frequently deformed and the furrows on the carapace are more obsolete.

To me this species seems to be certainly distinct from Tullberg's[1] *Fallaces* group, (or Corda's[2] *Condylopyge* and Jaekel's[3] *Paragnostus*) as well as his *Laevigati* group, (or Corda's *Lejopyge* and Jaekel's *Miagnostus*), but it is possibly a representative of Jaekel's *Pseudagnostus*, judging from the general configuration.

Formation and locality:—Common in the *Drepanura* zone and less common in the *Stephanocare* zone of South Chosen. It is widely spread in the Kushan beds of Manchuria and China.
Mansuy referred an agnostid from the *Ptychoparia* (*Annamia*) *spinifera* zone of Penkai to this species.

PA969-3-7
PA970-3-8
PA971-3-9
PA972-3-10
PA973-3-11
PA974-3-23

Pseudagnostus orientalis Kobayashi.

Plate III, figures 7–11, 23.

1933. *Pseudagnostus orientalis* Kobayashi, Upper Cambrian of the Wuhutsui Basin, etc. p. 98, Pl. IX, figs. 20–22.

Together with *Agnostus hoiformis* this is an important indicator of the early Upper Cambrian in the Orient. As only the pygidium was

1) S. A. Tullberg (1880), Om *Agnostus*-arterna i de kambriska aflagringarne vid Andradum, (Sveriges Geologiska Undersökning Afhandlingar och Uppsatser, Ser. C, No. 42.)

2) Corda (1847), Prodrom einer Monographie der böhmischen Trilobiten.
Raymond (1913), Some Changes in the Names of Genera of Trilobites, (Ottawa Naturalist, Vol. XXVI.)

3) Jaekel (1909), Ueber von Agnostiden.

described in the cited paper, I shall here add the observations upon the cephalic shield.

Description:—Cephalon convex, roundly subquadrate, surrounded by a strong marginal brim and a narrow groove; glabella medium sized, conical, divided by transverse furrows into three unequal lobes, the third one long; the second is narrow and has a median longitudinal tubercle on it; a small triangular body located on each side of the base of the third lobe; cheek gently inclined toward the marginal border; a longitudinal median groove crosses the glabellar field; surface smooth.

Comparisons:—In the general feature of the cephalon this species is not different from *Pseudagnostus cyclopygeformis* Sun, but the cephalic outline is subquadrate in this species whereas it is more rounded in *P. cyclopygeformis*. More important difference is observed upon comparing their pygidia.

In *P. orientalis* the first and second lobs of the rachis conform a transversely subquadrate outline, and there is a median longitudinal tubercle on the second lobe. The margin of the pygidium is more or less quadrangular with a tiny spine at each postero-lateral corner, while in the *P. cyclopygeformis* the outline of the pygidium is more rounded and that of the first and second axial lobes is subpentagonal.

Formation and locality:—*Chuangia* zone of Kasetsu-ji and Saisho-ri, South Chosen; the same zone of the Wuhutsui basin, Liaotung.

(R) PA975-3-12 PA976-3-13 PA977-3-14.

Pseudagnostus cyclopygeformis (Sun).

Plate III, figures 12-14.

1924. *Agnostus cyclopygeformis* Sun, Cambrian Faunas of North China, p. 26, Pl. II, figs. 1a–h.

1933. *Pseudagnostus cyclopygeformis* Kobayashi, Upper Cambrian of the Wuhutsui Basin, etc. p. 97, Pl. 18, figs. 19, 23–24, Pl. 8, fig. 7.

The South Korean form is more smooth than those I have ever seen before, but the general configuration is identical. The pygidium collected at Tomkol (pl. I, fig. 12,) clearly shows the elliptical and divergent furrows behind the anterior pentagonal lobe. The elliptical furrow, however, does not extend to the posterior border as shown in Sun's illustrations, but is subangulated and terminates at a short distance within the border.

Formation and locality:—This species is widely distributed in the *Tsinania* and *Kaolishania* zones of North Chosen, South Manchuria and

North China. In South Chosen it is found also in the *Eoorthis* zone of Doten and Tomkol.

Family Pagetidae, new family.

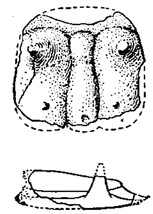
This has the combined characters of the Agnostidae and Eodiscidae. The thoracic segments number two and the axial lobe of pygidium is annulated in *Pagetia*. Most singnificant feature in *Pagetia* and *Dipharus* is the presence of the facial suture and eyes on the dorsal side, through which this is quite distinct from both of these allied families.

The new family includes the following two genera :—

Pagetia Walcott, 1916.(Genotype : *Pagetia bootas* Walcott.)

Dipharus Clark, 1923. (Genotype : *Dipharus insperatus* Clark.) (Text-fig. 12.)

The former has a wide distribution, being known in Australia, North America and Europe ; the latter is represented only by the genotype procured from the Lower Cambrian of Boston basin.



Text-figure 12. *Dipharus insperatus* Clark, Dorsal and lateral views of the type. X 20. [From Clark (1923), Proc. Boston Soc. Nat. Hist. Vol. 36, No. 8, p. 478.]

Family Eodiscidae Lake.

Blind trilobites similar to the Agnostidae, but having three thoracic segments and an annulated pygidium. This family includes the following genera.

Eodiscus Matthew, 1896.(Genotype : *Eodiscus schucherti* Matthew.)

Goniodiscus Raymond, 1913.(Genotype : *Microdiscus lobatus* Hall.)

Weymouthia Raymond, 1913.(Genotype : *Agnostus ? nobilis* Ford.)

Delgadodiscus, new genus. (Genotype : *Microdiscus caudatus* Delgado.)

That *Goniodiscus* Raymond is a synonium of *Eodiscus* Raymond is substantiated by Cobbold[1] and the opinion supported by Saito.[2] The latter added two species of *Eodiscus*, *fusifrons* and *spiniger*, from the Middle Cambrian of North Chosen.

All common in Europe and North America in the Lower and

1) E. S. Cobbold (1931), Additional Fossils from the Cambrian Rocks of Comley, Shropshire, (Q. J, G..S. London, Vol. 87.)

2) K. Saito (1934), Older Cambrian Trilobites and Conchostraca from Northwestern Korea, (Japan. Jour. Geol. Geogr. Vol. XI.)

Middle Cambrian. A few species of *Eodiscus* are known from the Middle Cambrian of India and Eastern Asia.

Genus DELGADODISCUS, new genus.

Eodiscidae with eyes.

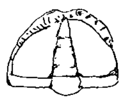
Microdiscus wenceslassi Delgado[1] has a caudal spine but no eyes, while *M. souzai* has eyes but no spine. This genus appears to link to *Eodiscus* or *Weymouthia* through such species.

Genus EODISCUS Matthew, 1896.

Eodiscus (?) sp.

Plate XIII, figure 8; Text-figure 13.

A minute cephalon about 1.5 mm. in length and breadth, semicircular, the margin entirely surrounded by a narrow border; glabella long, conical, regularly tapering forward, extended to the inner margin of the border and divided into several rings, but the divisions are not clear enough to be counted exactly; occipital ring, subtriangular, pointed back; dorsal furrow strong; lateral lobes moderately convex and smooth; the marginal border marked by fine lines across it.



Text-figure 13. *Eodiscus*(?) sp. Drawing of the same specimen illustrated in figure 8 on plate XIII.

Comparisons:—This is distinct from *Microdiscus griesbachi* Reed,[2] *Microdiscus haimantensis* Reed[3] and *Microdiscus orientalis* Walcott[4] by its narrow marginal border, furrowed long glabella and other characters.

Microdiscus lenaicus Toll and *M. kochii* Toll[5] have been described from Siberia; the second species is represented by the pygidium only; and the cephalon of the first species has a more smooth and shorter glabella and very narrow brim.

Here it is also noted that the names of Toll's, Reed's, and Walcott's species ought to be changed to *Eodiscus*, because, as pointed out by Raymond,[6] the genus *Microdiscus* was founded by Emmons on a young

1) J. F. H. Delgado (1904), Faune Cambrienne du Haut-Alemteja, (Protugal), (Comm. Comm. Serv. Geol. Protugal, Tom. V.)

2) Reed (1910), Cambrian Fossils of Spiti, p. 6, Pl. I, figs. 4–11.

3) Reed (1910), Op. cit. p. 7, Pl. I, figs. 12–13.

4) Walcott (1913), Cambrian Faunas of China, p. 102, Pl. 7, fig. 10.

5) E. v. Toll (1899), Beiträge zur Kenntniss des Siberischen Cambrium, pp. 23–24.

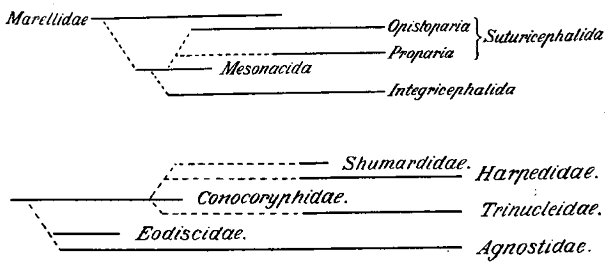
6) P. E. Raymond (1913), On the Genera of the Eodiscidae, (Ottawa Naturalist, Vol. XXVII,) p. 101.

specimen of *Cryptolithus* (*Trinucleus*), and thus Matthew's *Eodiscus* is the correct designation.

Formation and locality:—*Stephanocare* zone of Kasestu-ji.

Notes on Blind Trilobite Families, Beecher's Hypoparia, and Poulsen's Integricephalida.

In modifying Beecher's Hypoparia, Poulsen grouped the Conocoryphidae, Eodiscidae, Agnostidae, Trinucleidae, Harpedidae and Shumardidae (with some doubt for the last family) in his Intergricephalida and the rest of the trlobites in his Suturicephalida which corresponds to the sum of Beecher's Opisthoparia and Proparia minus the Conocoryphidae and Mesonacidae. His idea of the phylogenetical relation among the Integricephalida may be schematized as Text-figure 14.



Text-figure 14.

Diagrams showing the relationship between the Suturicephalida and Intergricephalida and of the various members of the Intergricephalida to one another. [From Poulsen (1927), Jubilaemusekspeditionen nord om Grønland 1920–23, Nr. 3, pp. 315 & 318.]

According to his classification the Pagetidae should be widely separated from the Eodiscidae; the Ityophoridae from the Harpedidae; *Orometopus* from the rest of the Trinucleidae; and *Leiocoryphe* from the Ellipsocephalidae, but there are some respects to support the close relationship between each of these pairs. It would be hard to explain away all of their similarities by calling upon homeorphism.

Many authors on the other hand now believe that blindness at least in some trilobites was of secondary and later origin and signifies a particular adaptation.

The Raphiophoridae, Trinucleidae (or Cryptolithidae,) Dionideidae, Shumardidae and Endymioniidae with some question as to the last two are allied to one another and they seem to be closely grouped off-shoots from one stock. Warburg noticed that the Harpedidae could hardly be placed in the same line with the Trinucleidae and Raphiophoridae; and Richter set the former between the Conocoryphidae and Ptychoparidae and the latter in a branch of the Ellipsocephalidae stock. I wonder if we can explain away the resemblances between the Harpedidae and Ityophoridae only by the adaptation of the mode of life. The families and genera of the blind or Hypoparian trilobites are tentatively bound with others here in such a taxonomic array as this (* not all blind):—

Superfamily Eodisciacea, new superfamily, (or **Eodiscidea** Richter.)

Family Agnostidae Dalman. (See page 95.)

Family Pagetidae*, new family. (See page 112.)

Family Eodiscidae Raymond. (See page 112.)

Superfamily Trinucleacea, new superfamily,(or Cryptolithidea Richter.)

Family Raphiophoridae Angelin.[1]

1. *Raphiophorus* Angelin, 1854. (Genotype: *Raphiophorus setirostris* Angelin.)
2. *Ampyx* Dalman, 1827. (Genotype: *Ampyx nasutus* Dalman.)
3. *Lonchodomas* Angelin, 1854. (Genotpye: *Ampyx rostratus* Sars.)

Family Trinucleidae* Emmrich.[2]

1. *Orometopus* Brögger, 1896.[3] (Genotype: *Holometopus ? elatifrons* Angelin.)

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1) Raymond suggests that free cheeks in the Raphiophoridae are not seen, but evidently very narrow, if present at all on the dorsal surface. P. E. Raymond (1925), Some Trilobites of the Lower Middle-Ordovician of Eastern North America, (Bull. Mus. Comp. Zool. Harvard Coll. Vol. LXVII, No. 1.)

2) Beside *Reedolithus* Bancroft proposed *Marrolithus*, *Salterolithus*, and *Reuscholithus*. Störmer questions the generic value of *Salterolithus* and considers *Botrioides* Stetson as a synonym of *Trinucleus*. B. B. Bancroft (1929), Some new species of *Cryptolithus* (s. l.) from the Upper Ordovician, (Mem. Proc. Manchester Lit. Phil. Soc. 1928–29): L. Störmer (1930), Scandinavian Trinucleidae with Special References to Norwegian Species and Variety, (Det Norske Videnskaps-Akademi i Oslo, II, Mat.-Naturv. LI, No. 4.)

3) Against Lake's opinion Stetson believes that *Eodiscus* provides the ancestral characters of the Trinucleidae and *Orometopus* has none. (H. C. Stetson (1927), The Distribution and Relationship of the Trinucleidae, (Bull. Mus. Comp. Zool. Vol. LXVIII, No. 2,) p. 94.

2. *Trinucloides* Raymond, 1925. (Genotype: *Trinucleus reussi* Barrande.)
3. *Tretaspis* M'Coy, 1849. (Genotype: *Asaphus seticornis* Hisinger.)
4. *Trinucleus* Murchison, 1839. (Genotype: *Trinucleus fimbriatus* Murchison.)
5. *Cryptolithus* Green, 1832. (Genotype: *Cryptolithus tessellatus* Green.)
6. *Reedolithus* Bancroft, 1929. (Genotype: *Trinucleus subradiatus* Reed.)

Family Dionideidae Raymond,[1] 1920.

(Dionideae Gürich, 1907, nom. nudum.)

Dionide Barrande, 1847. (Genotype: *Dionide formosa* Barrande.)

Family Endymioniidae Raymond.[2]

1. *Endymionia* Billings, 1865. (Genotype: *Endymionia meeki* Billings.)
2. *Anisonotus* Raymond, 1920. (Genotype: *Shumardia glacilis* Billings.)
3. *Ampyxina* Ulrich, 1922. (Genotype: *Endymionia bellatus* Savage.)
4. *Pseudosalteria* Raymond, 1924. (Genotype: *Pseudosalteria laevis* Raymond.)

Superfamily Ellipsocephalacea Kobayashi, (**Ellipsocephalidea** Richter.)

Family Shumarididae Lake. (See page 211.)

Superfamily Harpedacea, new superfamily.

Family Harpedidae Corda*.

1. *Harpes* Goldfuss, 1839. (Genotype: *Trilobites ungula* Sternberg.)
2. *Harpides* Beyrich, 1846. (Genotype: *Harpides hospes* Beyrich.)
3. *Eoharpes* Raymond, 1905. (Genotype: *Harpes primus* Barrande.)

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1) Raymond mentions that "the facial suture is marginal except at the genal angles, where it cuts off the spine." (Raymond (1925), Op. cit. p. 27.)

2) "This family was erected for trilobites which resemble the Raphiophoridae in the possession of narrow free cheek without eyes, and a short *Ampyx*-like pygidium, but which lack a glabellar spine. (Raymond (1925), Op. cit. p. 41.)

4. ? *Crossoura* Moberg & Segerberg,[1] 1906. (Genotype: *Crossoura parvula* Moberg & Segerberg.)

Family Entomaspidae Ulrich[2]

Entomaspis Ulrich, 1930. (Genotpye: *Entomaspis radiatus* Ulrich.)

Family Ityophoridae Warburg.[3]

*Ityophorus** Warburg, 1924. (Genotype: *Ityophorus undulatus* Warburg.)

In addition to these all of the Conocoryphidae, *Leiocoryphe* in the Kingstoninae in the Ellipsocephalidae and *Carmon mutilus* in the Proetidae are also blind trilobites.

Family Mesonacidae Walcott.

Historical Review:—Walcott[4] in his elaborate study grouped the following ten genera in this family:—

Elliptocephala Emmons, 1844. (Genotype: *Elliptocephala asaphoides* Emmons.)

Olenellus Hall, 1862. (Genotype: *Olenus thompsoni* Hall.)

Mesonacis Walcott, 1885. (Genotype: *Olenus vermontana* Hall.)

Holmia Matthew, 1890. (Genotype: *Paradoxides kjerulfi* Linnarsson.)

Olenelloides Peach, 1894. (Genotype: *Olenellus* (*Olenelloides*) *armatus* Peach.)

Callavia Matthew, 1897. (Genotype: *Olenellus bröggeri* Walcott.)

Nevadia Walcott, 1910. (Genotype: *Nevadia weeksi* Walcott.)

Wanneria Walcott, 1910. (Genotype: *Olenellus* (*Holmia*) *walcottanus* Wanner.)

Paedeumias Walcott, 1910. (Genotype: *Paedeumias transitans* Walcott.)

Paechella Walcott, 1910. (Genotype: *Olenellus iddingsi* Walcott.)

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1) The genotype species is represented by two minute pygidia different from each other, is probably an immature form of *Eoharpes*. (Raymond pointed out that the name of *Harpina* Barrande is preoccupied.)
J. C. Moberg. & C. O Segerberg (1906), Bidrag till kännedomen om Ceratopygeregionen, (Lunds Universitets Åsskrift, N. F. Afdeln 2, Nio 7.)

2) Ulrich's Entomaspidae resembles the Harpedidae in most characters but in which the genal spine is borne entirely upon the epistomal plate as in the Trinucleidae. E. O. Ulrich (1930), in Bridge's Geology of the Eminence and Cardareva Quadrangles, (Missouri Bureau of Geol. & Mines, Vol. XXIV, Sec. Ser.)

3) This family has clear cut eyes and facial sutures. [E. Warburg (1924), Trilobites of the *Leptaena* Limestone in Dalarne, (Bull. Geol. Inst. Upsala, Vol. XVII.]

4) Walcott (1910), *Olenellus* and other Genera of the Mesonacidae, (Smiths. Misc. Coll. Vol. 53, No. 6.)

The generic distinctions among them are mainly based upon the presence or absence of an enlarged third thoracic segment and of a large axial spine on the fifteenth thoracic segment and upon the features behind the fifteenth thoracic segment; also the outline of the glabella, course of the glabellar furrows and other characters are taken into consideration.

Based upon *Kjerulfia lata* Kiaer, another genus *Kjerulfia* was added to this family at the hand of Kiaer.[1]

Remarks:—It is remarkable that no representative of this family is found in Southern and Eastern Asia, and Australia whereas the family is widely distributed in North America, Europe and Arctic region.

Walcott claimed that "the family Mesonacidae is distinguished from the *Paradoxides* mainly by the presence in the latter of free cheeks separable on the line of the facial sutures from the cranidium." This also holds for the Redlichidae and Zacanthoidae. As already noticed by Walcott and others, these three families are on the other hand closely related to the Mesonacidae, probably being the descendants of the latter. Each one of the these three families retains some characteristics of the Mesonacidae which cannot be found in the other and has lost other features which are still retained by its relatives. In addition to this, each family has its own sphere of distribution, namely the Atlantic province for the Paradoxidae, eastern Pacific for the Zacanthoidae and western Pacific for the Redlichidae.

These points indicate that it would be better to recognize these three as distinct families probably divergent from the Mesonacidae stock rather than to make combinations among them.

Family Redlichidae Poulsen.

Genus REDLICHIA Cossmann, 1902.

1901. *Hoeferia* Redlich, (not Bittner, 1895), Mem. Geol. Surv. India, new ser. 1, p. 2.
1902. *Redlichia* Cossmann, Revue critique Paleontologie, 6th Ann., p. 52.
1905. *Redlichia* Walcott, Proc. U. S. Nat. Mus., 29, p. 24.
1912. *Redlichia* Mansuy, Mém. du Serv. Géol. de l'Indo-Chine, 1, p. 23.
1913. *Redlichia* Walcott, Research in China, 3, Carnegie Inst., 54, p. 103.
1919. *Redlichia* Etheridge, Trans. Proc. Royal Soc. South Australia, 43, p. 386.
1924. *Redlichia* Zittel-Broili, Grundzüge der Paläontologie, I, p. 645.

Genotype:—*Hoeferia noetlingi* Redlich.

1) J. Kiaer (1916), Lower Cambrian *Hormia* Fauna at Tomten in Norway, (Videnskaps Skrift, I, Mat.-Naturv. Kl. No. 10,) p. 71.

Remarks:—The generic name *Hoeferia* was changed to *Redlichia* by Cossmann simply for the reason that the former name was preoccupied.

Redlich compared his *Hoeferia*, (i. e. *Redlichia* Cossmann) to *Protolenus*, *Paradoxides*, and *Metadoxides*. Its close resemblance to *Zacanthoides* was first pointed out by Walcott. Later in 1910 he[1] mentions that the immediate descendants of the family (Mesonacidae) were probably *Paradoxides* about the Atlantic Basin, and *Redlichia* in Eastern Asia, Northern India and Australia.

Redlichia retains many characters common with the Mesonacidae. For example, the outline of the glabella with three transverse glabellar furrows is the typical feature of *Nevadia*. Well preserved specimens of *Redlichia* reveal a similar texture on the surface of the cephalon. The spine is produced from a certain point anterior to the genal angle, as frequently seen in *Wanneria* and *Olenellus*. In *Mesonacis*, *Paedeumias* and *Olenellus* a large axial spine is found on the fifteenth thoracic segment whereas in *Redlichia* it is usually observed on the eleventh, and in addition to it sometimes another spine is found on the fourth or fifth. (Pl. XXI, fig. 4.)

The number of thoracic segments posterior to the eleventh segment varies among the species. Mansuy's *Redlichia chinensis* from Keoukiaitse in Yunnan (Mansuy (1912), Pl. II, fig. 1 j,) for which Resser and Endo gave a new name, *Redlichia yunnanensis* (MS) has only four segments. Therefore Mansuy have described "les segments sont au number quinze" (p. 25). Resser and Endo's *Redlichia murakamii* from Sanshihlipu has also four (pl. XXI, fig. 9), but *Redlichia longispina* here described has six (Pl. XXI, fig. 5). In a specimen of *Redlichia* from Masan-ri, North Chosen (Pl. XXI, fig. 8) no more than two segments are to be counted with certainty.

The different position of the large spine between the Redlichidae and Mesonacidae might be explained by the reduction in the number of thoracic segments anterior to the segment with the large spine in *Redlichia*. Incidentally the presence or absence of the spine on the fourth or fifth thoracic segment might be a sexual dimorphism, the case of *Redlichia manchuriensis* Resser. and Endo (MS) which is a very common species in the *Redlichia* shale of Sanshihlipu on the Liaotung peninsula discloses two forms with and without a spine, which are otherwise identical and thus belonging to one species.

Pygidium is very small, round and apparently has an entire

1) Walcott (1910), Smiths. Misc. Coll., Vol. 53, No. 6.

margin, a pair of strong rib is found along the articulating margin.

It is very interesting to note that *Redlichia* sometimes has a row of pits or tubercles along the marginal groove of cephalon which reminds us of some relationship to the Kainellidae.

Notes on the specific characters:—The previous classification of *Redlichia* was mainly based upon the outline of glabella, course of the facial suture anterior to the eye, shape of the free cheek, and the position of the genal spine. In my observation the shape of the thoracic pleurae, the number of the thoracic segments posterior to the eleventh and the shape of the hypostoma will furnish further good specific distinctions. As to a row of pits or tubercles on the cephalon it is not quite sure if it is a specific character or not, because this feature is, so far as my observation is concerned, confined to fairly large individuals only.

On the ground of these criteria the specific characters and specific alliances are summarized as follows:—

1) *Redlichia mansuyi* Resser and Endo.

Glabella rather cylindrical; facial suture directed antero-laterally from the eyes; thoracic pleura sharply bent at the lateral extremity; (hypostoma in *Redlichia nobilis* pointed at the postero-lateral angles.)

Cephala and detached thoracic segment of *Redlichia noetlingi* (Redlich) and *Redlichia nobilis* Walcott are of this type.

2) *Redlichia chinensis* Walcott.

Glabella conical; anterior branch of the facial suture transverse; thoracic segment like that of *R. noetlingi*; hypostoma with transverse posterior margin.

Redlichia manchuriensis Resser and Endo (Pl. XXI, figs. 6–7,) sometimes has a telson on the fourth segment, but otherwise is extremely close to *R. chinensis*.

3) *Redlichia murakamii* Resser and Endo. (Pl. XXI, fig. 9.)

Cephalon same as that of *Redlichia chinensis*, but with a row of very distinct pits; thoracic segments remarkably falcate backwards; four segments to be counted posterior to the eleventh segment; hypostoma with a short spine on the lateral margin, and rounded at postero-lateral angles.

4) *Redlichia yunnanensis* Resser and Endo is represented only by the thorax and pygidium of *R. murakamii* type, but the outline is expanding more abruptly forward and the four thoracic segments are to be counted posterior to the eleventh.

5) *Redlichia longispinosa* Kobayashi, (new species.)

Glabella conical; anterior branch of the facial suture oblique; some thoracic segments with a node on the axial lobe and a long sharp spine at the extremity of the pleural lobe; six thoracic segments to be counted posterior to the eleventh.

Redlichia carinata Mansuy and *Redlichia walcotti* Mansuy are represented by incomplete cranidia which do not suffice for a precise comparisons.[1]

Redlichaspis, new genus :—Finally it is added here that the latest form, *Redlichia* (?) *finalis* Walcott is, as already suggested by the author of the species, naturally expelled from *Redlichia* s. str., because this species has distinct features, such as those in glabellar furrows, nuchal spine and facial suture which are nothing like those found in *Redlichia* s. str. Its cranidium throws some doubt as to whether it is really a terminus of the *Redlichia* branch or rather that of the *Dolichometopus* branch, or a member of *Saratogia* line. Morphologically, phylogenetically and geologically the species is qualified to stand as a good new genus and here *Redlichaspis* is proposed for it.

PA979-21-3
PA980-21-4
PA981-21-5

Redlichia longispinosa, new species.

Plate XXI, figures 3-5.

In a remarkable contrast to other species of *Redlichia* this one has a pair of long spines on both sides of each thoracic segment. Axial lobe is nearly of subequal length to the pleural lobe exclusive of the spine and frequently has a tiny median node on the posterior margin. The pleural lobe is transverse and its terminal spine is directed postero-laterally; a sharp change of direction is observed between. Spines are longer than the pleural lobes themselves; the former are all nearly of the same length whereas the latter shorten their length considerably from the first to the last

The cephalon has a conical glabella and an oblique anterior branch of facial suture. Pygidium is poorly preserved and hypostoma is unknown.

The holotype consists of a cephalon and ten thoracic segments partly broken; the paratype is composed of fourteen segments with a pygidium. This paratype indicates very clearly that it has six segments

1) Recently Saito described two new species, *Redlichia coreanica* and *Redlichia nakamurai* from North Chosen. K. Saito (1934), Older Cambrian Trilobites and Conchostraca from Northwestern Korea, (Japan. Jour. Geol. Geogr. Vol. XI.)

behind the segment with a big telson.

The specific distinction is therefore in main based upon the unique character of the thoracic spine, and the number of thoracic segments behind the eleventh.

Formation and locality:—Lower Cambrian; Kojo (古場) and Genkoku-ri (元谷里) in Sosan area, North Chosen.

Notes on the Australian *Redlichia*.

Two Australian species of *Olenellus forresti* Etheridge[1] from "River, south of base line", Kimberley District and *Olenellus* (?) sp. by Etheridge[2] from the neighbourhood of Wirrialpa, Flinders Range, South Australia, are correctly referred to *Redlichia* by Walcott. So far as the description and illustrations are concerned, the two might be of the same species of *Redlichia longispinosa* type, but differ from that by the outline of the palpebral lobe which is semi-oval, instead of semi-circular as in *R. longispinosa*.

Walcott referred two more Australian species to *Redlichia*, namely *Redlichia tatei* (Woodward), and *Redlichia thielei* (Chapman). Etheridge identified *Redlichia* (?) *minima*, but from my study on the replicas of these types kept in U. S. National Museum, I am led to believe that the first species is a *Lorenzella*, (see page 209), and the second and third are members of the Dolichometopinae.

Family Zacanthoidae Swinnerton

Zacanthoides Walcott, 1888. (Genotype: *Ogygia* (?) *spinosus* Walcott.)

Albertella Walcott, 1908. (Genotype: *Albertella helena* Walcott.)

Remarks:—This is probably a branch divergent from the Mesonacidae. As is usual in *Mesonacis, Paedeumias*, and *Olenellus, Albertella* has an enlarged third thoracic segment. *Zacanthoides* sometimes has an enlarged third segment on the thorax and a pair of intergenal spines on the cephalon. In this genus a median spine is found on the fifth thoracic segment, while it varies between the fourth or fifth in *Redlichia*.

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1) *Olenellus* (?) *forresti* Etheridge in Ford, Geol. Mag. Dec. 3, 7, 1890, p. 99, Pl. 4, fig. 2. *Protolenus* (?) *forresti* Matthew, Can. Rec. Sci. 5, 1892, p. 253.
Redlichia forresti Walcott, Research in China, 1913, p. 50.
Redlichia forresti Etheridge, Trans. Proc. Royal. Soc. S. Australia, 43, 1919, p. 387.

2) *Olenellus* sp. Etheridge, Trans. Proc. and Rep. Royal Soc. Australia, Vol. 29, p. 247, Pl. 25, fig. 1.

An astonishing resemblance is found between *Zacanthoides* and *Kainella* in their pygidia and cephala, and also the thoracic segments have fairly good alliance to one another. Further discussion along these lines will be found in the chapter on the Kainellidae.

The main generic distinction between *Zacanthoides* and *Albertella* is found in the pygidium. The differences of the facial suture and of the position of the eye referred to the glabella are also important. On the basis of a pair of lateral spines on its pygidium *Albertella* was once grouped in the Ceratopygidae, but as it is clear from comparisons among the Opisthoparian genera with a pair of pygidial spines, that basis is good for marking distinctions among genera but is not sufficient when families are concerned. (See page. 269).

Genus ZACANTHOIDES Walcott, 1888.

1887. *Embolimus*, Rominger, Proc. Acad. Nat. Sci. Phil., p. 16.
1888. *Zacanthoides* Walcott, Amer. Jour. Sci., 3d. ser., p. 165.
1889. *Zacanthoides* Miller, North Amer. Geol. Pal., p. 569.
1897. *Zacanthoides* Matthew, Trans. Roy. Soc. Canada, sec. ser. 3, sec. 4, p. 187, footnote.
1897. *Zacanthoides*, Frech, Leth. geog., 1 Th. Leth. Pal., 2, p. 51.
1901. *Zacanthoides* Lindström, Kongl. Sven. Vet. Akad. Handl., 34, No. 8, p. 16.
1902. *Zacanthoides* Grönwall, Danmarks Geol. Unders., 2 Raekke No. 13, p. 129.
1902. *Embolimus* Woodward, Geol. Mag. Dec. 4, 9, p. 539.
1910. *Zacanthoides* Reed, Mem. Geol. Surv. India., Pal. Indica, ser. 15, 7, Mem. 1, p.9.
1910. *Zacanthoides* Grabau and Shimer, N. A. Index Fossils, 2, p. 273.
1913. *Zacanthoides* Raymond, in Zittel-Eastman's Text-Book of Palaeontology, I, p. 716.
1924. *Zacanthoides* Zittel-Broili, Grundzüge der Palaeontologie, p. 645.

Genotype:—*Olenoides spinosus* Walcott.

Remarks:—By the reason that "the generic name *Embolimus* was given by Westwood[1] to a genus of Hymenoptera in 1833," and "it was spelt *Embolemus* by Westwood, and was corrected by Professor Agassiz to *Embolimus* in his "Nomenclator Zoologicus", Walcott established a new name *Zacanthoides* in 1888, instead of using *Embolimus* Rominger 1887.

Geological and geographical distribution:—Two species of *Zacanthoides*, *Z. eatoni* Walcott and *Z. levis* (Walcott), are known to occur in association with the typical Lower Cambrian fauna containing *Olenellus* in the northeastern part of North America, but both of them are

1) Westwood (1833), Phil. Mag. Brewster, ser. 3, Vol. 2, p. 445.

represented only by cephala which are quite different from that of *Zacanthoides* s. str. *Zacanthoides indicus* Reed is described from Parahio Valley, Spiti, and is composed of six segments of athorax attached to a pygidium. It is certainly similar to *Z. spinosus* Walcott, but further material including a cephalon is needed before its generic reference is ascertained. Except for these, all the described species of this genus are confined to the Middle Cambrian of western North America.

Genus ALBERTELLA Walcott, 1908.

1908. *Albertella* Walcott, Smiths. Misc. Coll. 53, p. 18.
1910. *Albertella* Grabau and Shimer, N. A. Index Fossils, 2, p. 274.
1913. *Albertella* Raymond, in Zittel-Eastman's Text-Book of Paleontology, p. 717.
1924. *Albertella* Zittel-Broili, Grundzüge der Palaeontologie, I, p. 648.

Genotype :—*Albertella helena* Walcott.

Geological and geographical distribution :—As discussed on page 270, *Albertella pacifica* Walcott may not be an *Albertella* s. str. Except for this, all of the known *Albertella* are confined to the Middle Cambrian of western North America.

Family KAINELLIDAE Ulrich and Resser.

Remarks :—In my opinion *Kainella* might be the descendant of *Zacanthoides*, because both genera show remarkable agreements in the outlines of the glabella and free cheek, in the pleural lobe of the thoracic segment and notably in the feature of the pygidium. Eyes are much smaller in *Kainella billingsi* (Walcott) than in normal *Zacanthoides*. The anterior branch of the facial suture is transverse and a row of pits runs along the inner margin of the frontal border. These characters remind me of the Redlichidae, but the facial suture, size of the eyes, and length and outline of the glabella vary among the species of *Kainella* to some degrees, and in looking over a series of *Kainella*, I am impressed more strongly of its relationship to *Zacanthoides* rather than to *Redlichia*.

The main difference from the Zacanthoidae is, however, in the cranidium. *Kainella* has only two pairs of glabellar pits ; and it has a characteristic row of pits and lines or ridges of different strength diverging forward from glabella on the preglabellar field.

In some of these respects the Kainellidae is allied to the Remopleuridae including *Apatokephalus*, while in some other ways it resembles the Richardsonellinae. The chief objection in tying up the Richardsonellinae with this family lies, however, in the glabellar furrows of the dikelocephalid type, and the entire margin and triangular shape of the pygidium in the Richardsonellinae. On the other hand it is obvious that the cranidium of *Apatokephalus* is easily derivable from that of *Kainella* by the fading out of the axial furrow. Other features of *Apatokephalus* and its relatives are quite suggestive of a *Kainella*-alliances. For instance, the pygidia of *Kainella* and *Apatokephalus* have similar outlines with spinose posterior margins, and their axes are conical in addition to needle-shaped ridges behind them. The chief distinction of the Remopleuridae from the Kainellidae is found in the swelling out of the glabella between the palpebral lobes.

It is also interesting to consider the distribution of these families. The Zacanthoidae is, if the dubious species of *Zacanthoides* are omitted, confined to the Middle Cambrian of the Cordilleran trough. The Kainellidae is a characteristic group of western North America in the basal Ordovician period. The discovery of *Kainella* in Argentina[1] extends the distribution along the whole length of the eastern Pacific.

Here it is, however, noted that *Lichapyge* Callaway,[2] 1877, (genotype: *Lichapyge salopiensis* Callaway) might be a member of the Kainellidae. It is very much allied to *Kainella*, but distinguished from that by the outline of pygidium. A similar pygidium is also known from the Tremadoc of Hof under the name of *Lichas primulus* Barrande.[3] If this consideration is correct, the distribution of the family is naturally extended into Northern and Central Europe.

Among the Remopleuridae *Apatocephaloides* is the oldest representative which appears already in the Upper Cambrian of Vermont. *Apatokephalus* is more widely distributed from Europe to Eastern Asia and extended farther to the western portion of North America across the Pacific.

Although the Remopleuridae is considered by some authors to be derived from the Paradoxidae, the evidences here cited appear to indicate to me that it is more natural to trace the phylogenetical relation from the Zacanthoidae to the Remopleuridae as well as Kainellidae on both points of morphology and distribution.

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1) T. Kobayashi (1935), On the *Kainella* Fauna of the Basal Ordovician Age found in Argentina, (Japan. Jour. Geol. Geogr. Vol. XII.)

2) C. Callaway (1877), On a New Area of Upper Cambrian Rocks in South Shropshire, etc. (Q. J. G. S. London, Vol. XXXIII,) pp. 667-668, pl. XXIV, fig. 8.

3) Barrande (1868), Faune Silurienne des Environs de Hof, en Bavière, p. 86, fig. 34.

Finally it is noted here that the denomination of the Kainellidae was already proposed by Ulrich and Resser[1] in 1930 without any family notice.

Family Paradoxidae Emmrich.

Paradoxides, Brongniart, 1822.(Genotype: *Paradoxides tessini* Brongniart.)
Centropleura, Angelin, 1854. (Genotype : *Paradoxides loveni* Angelin.)
Metadoxides, Bornemann, 1891.(Genotype: *Paradoxides torosus* Meneghini.)

Historical Review:—This is the well known family confined to the Middle Cambrian of the Atlantic province. Salter's *Anopolenus*, 1864 (Quart. Jour. Geol. Soc. London, 20, p. 236,) is now understood to be a synonym of *Centropleura*. Matthew established *Catadoxides* and *Anadoxides* for the subgenera of *Metadoxides*, and selected *Metadoxides magnificus* Matthew and *Paradoxides armatus* Meneghini for their types respectively. (Bull. Nat. Hist. Soc. New Brunswick, 17, 1899.)

Barrande's *Hydrocephalus* is considered to be a young form or protaspis of *Paradoxides*, which is particular interesting in its similarity to that of *Olenellus*. [Raymond (1914), Bull. Mus. Com. Zool. LVIII, No. 4.]

Remarks:—Here I recall to attention that those Australian forms named *Bathyuriscus saint-smithii* (Pl. XXI, fig. 8), *Marjumia elegans* (Pl. XXII, fig. 16) and *Dikelocephalus dunstani* (Pl. XXII, fig. 18) by Chapman[2] reveal astonishing agreements with the Paradoxidae in their elongate, forwardly expanded glabella, large semi-circular palpebral lobe, and facial suture widely divergent from the eyes, which features at the same time argue strongly against the reference to *Bathyuriscus*, *Marjumia* and *Dikelocephalus*. Although the illustrations are not clear enough to permit precise observations, their glabellae are furnished with three or four pairs of glabellar furrows in addition to a transverse occipital furrow, and the pygidium is considerably smaller than the cephalon and has two or three pairs of serration on the margin.

The distinction between *Metadoxides* and *Paradoxides* is based upon the outline of glabella; this part of the head-shield in the latter genus is club-shaped whereas in *Metadoxides* it is conical.(Matthew 1899, p.

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1) Ulrich and Resser (1930), The Cambrian of the Upper Mississippi Valley, Pt. I, p. 62.

2) Frederick Chapman, (1929), On some Trilobites and Brachiopods from the Mount Isa District, N.W. Queensland, (Proc. Roy. Soc. Victoria, Vol. XLI, Pt. II, New Series.)

83.) On the other hand *Centropleura* is primarily distinguished from *Paradoxides* upon the aspect of the pygidium; the margin of the pygidium is entire in the latter, whereas it is serrated in the former. If we check the Australian forms by these criteria, it seems that they are most close to *Centropleura*, although it is unknown today just how and where the *Centropleura* fauna could have reached Australia. The migration of such a typical European element into the Pacific is, however, not unexpectable, if we recall the occurrence of *Conocoryphe* in Indochina, Chosen and Manchuria.

Plutonia Hicks[1], 1871 (genotype: *Plutonia sedgwickii* Hicks) is the Paradoxidae having the coarse tubercles or spines on the surface of the carapace. This texture reminds me of the Mesonacidae, but somewhat differs from the texture of the family which in turn is shagreen.

Subfamily Centropleurinae Angelin.

Angelin's family name would be useful for the separation of such a specialized and later form as *Centropleura* from the rest of the Paradoxidae, or the Paradoxinae, (nov.) into a distinct subfamily like in Howell's[2] recent action.

Recently Cobbold[3] established a new genus *Strettonia* on the basis of *Strettonia comleyensis* Cobbold from the late Lower Cambrian of England. Its nearest relative is considered to be probably *Centropleura*, although the true taxonomic position is as yet quite uncertain.

Genus CENTROPLEURA Angelin.

1854. *Centropleura* Angelin, Pal. Scandinavica, p. 87.
1864. *Anopolenus* Salter, Quart. Jour. Geol. Soc. London, 20, p. 236.
1865. *Anopolenus* Salter, Ibid. 21, p. 476.
1865. *Anopolenus* Hicks, Quart. Jour. Geol. Soc. London, 21, p. 477.
1885. *Anopolenus* Zittel, Handbuch d. Pal., 2, Munich, p. 598.
1889. *Anopolenus* Miller, N. A. Geol. and Pal. p. 528.
1896. *Anopolenus* Koken, Die Leitfossilien, Leipzig, p. 16.
1901. *Centropleura* Lindström, Kongl. Sven. Vet. Akad. Handl., 34, No. 8, pp. 16, 24, 49.
1902. *Centropleura* Grönwall, Danmarks Geol. Unders., 2, Raekke, no. 13, p. 122.

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1) H. Hicks (1871), Descriptions of New Species of Fossils from the Lungmynd Rocks, (Q. J. G. S. London, Vol. XXVII,) p. 399, Pl. XV, figs. 1-8.

2) Howell (1932), Bull. Wagner Free Inst. Sci. Phil. Vol. 7, No. 1, p. 6.

3) Cobbold (1931), Q. J. G. S. London, Vol. LXXXVII, p. 471.

Genotype:—*Paradoxides loveni* Angelin.

Geological and geographical distribution:—We have known already for a long time of the distribution of this genus in the Middle Cambrian of Bohemia, Bornholm in Denmark, England, Wales and Newfoundland. Recently Howell[1] reported that the *Centropleura* fauna is also found in the St. Albans formation of Vermont. On the eastern side, Westergård's work has extended the distribution of the fauna to Bennet Island, Arctic Ocean.[2]

Family Remopleuridae Corda.

Remopleurides Portlock, 1843. (Genotype: *Remopleurides colbii* Portlock.)

Caphyra Barrande, 1846. (Genotype: *Caphyra radians* Barrande.)

Apatokephalus Brögger, 1877. (Genotype: *Trilobites serratus* Boeck.)

Robergia Wiman, 1902. (Genotype: *Remopleurides microphthalmus* Linnarsson.)

Teratorhynchus Reed, 1903. (Genotype: *Teratorhynchus bicornis* Reed.)

Apatokephaloides Raymond, 1924. (Genotype: *Apatokephaloides clivosus* Raymond.)

Macropyge Stubblefield, 1927. (Genotype: *Macropyge chermi* Stubblefield.)

Remarks:—It is astonishing to see how *Apatokephaloides* and *Corbinia* Walcott, 1924 (genotype: *Corbinia harato* Walcott) look alike in the cephalon and pygidium. The only differences to be observed between the genotypes are in the features of the preglabellar area and glabellar furrows. In *Corbinia* the glabellar furrows are obsolete on surface, but under the test three pairs of them start from the glabellar margin whereas just two pairs of strong pits are found inside of the glabellar margin in *Apatokephaloides*. The frontal limb is wider in *Apatokephaloides*. The raised border like that of *Corbinia* is not illustrated in Raymond's paper, but according to his description, a narrow raised border is usually broken off. In contrast to such remarkable similarities *Apatokephaloides* is tolerably distinct from the rest of the Remopleuridae in the outline of glabella, small eyes, subparallel course of the facial suture anterior to the eyes, and transverse pygidium.

1) Howell (1932), Bull. Wagner Free Inst. Sci. Philadelphia, 7, No. 1.

2) Holm and Westergård (1930), Mem. Acad. Sci. Leningrad, 8th. ser. 31, No. 8.

From these comparisons one question arises in the mind whether *Apatokephaloides* really belongs to the Remopleuridae line together with *Corbinia* or to an entirely remote line.

Family Olenopsidae, new family.

Since the time Walcott applied the generic name *Olenopsis* for certain American trilobites various forms embracing an extensive range of variation have become included therein. The original *Olenopsis* Bornemann of the Mediterranean region as may be seen in *Olenopsis zoppii* Meneghini, manifested the combined characters of the Paradoxidae and the Ptychoparidae.

Recently Checchia-Rispoli[1] added a new species *Olenopsis broilii* to the Sardinian fauna. *Olenopsis thorali* Cobbold[2] has been described from Southern France and is represented by the cephalon and thorax of the Ptychoparidae type, but nothing is known of the pygidium of the species. *Olenopsis americanus* Walcott of Montana whose pygidium is also yet unknown might belong to the same group with *Olenopsis zoppii*, but is quite distinct in the surface texture. It is also suggested here that in the general outline of the cephalon and thoracic segment *O. americanus* is quite similar to Poulsen's *Kochiella* while *Olenopsis* (?) *argenensis* Walcott from the Mt. Whyte formation of Canada resembles Walcott's *Amecephalus,* although the two pairs are certainly distinct generically.

In contrast to all of these species cited above, *Olenopsis roddyi* Walcott from Pennsylvania is essentially distinct on the point that it shows a combination of the characters of the Paradoxidae and Oryctocephalidae, that is, it has a cephalon of the Oryctocephalidae and a thorax and pygidium of the Paradoxidae. On this account I hesitate to put this species even in the same family with *Olenopsis.* According to Howell and Resser's suggestion the new genus for this species is denominated as *Lancastria.* This would then be in the family Lancastridae (nov.) which I propose here in conjunction with the other new family group the Olenopsidae containing *Olenopsis* s. str.

The Olenopsidae, Lancastridae, Redlichidae and Paradoxidae are supposed to have diverged from the main stock involving the Mesona-

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1) Giuseppe Checchia-Rispoli (1933), Una Nuova Trilobite del Cambriano di Sardegna, (Mem. della Soc. Geol. Italiana, Vol. I.)

2) E. S. Cobbold (1931), Le Genre *Olenopsis* en France, (Bull. Soc. Géol. France, 5e ser. t. I,) p. 564, text-figs. 1-3, Pl. XXVII, figs. 1-13.

cidae directly and probably none of these four was a derivative from any of the others. Pompeckj[1] is of the opinion that *Olenopsis* was derived from *Paradoxides*, but the stratigraphical situation rules out this interpretation, and I rather agree with Walcott.[2]

In the cephalon by itself the Olenopsidae and Lancastridae are quite similar to the Ptychoparidae and Oryctocephalidae respectively. The former are not the ancestors of the latter nor vice versa, because these differ so much in the thorax and pygidium and besides the Ptychoparidae and Oryctocephalidae already appear in the Lower Cambrian.

Family Corynexochidae Angelin.

The comprehensive revision of this family was accomplished by Walcott[3] and then by Raymond.[4] Their scheme of classification is adopted here, in adding Etheridge's *Dinesus*, Delgado's *Hicksia*, Lorenz's *Amphoton*, Raymond's *Acheilus*, Clark's *Denisia*, Poulsen's four genera, Walcott's *Vistoia*, Ulrich's *Acheilops* and one more new genus to this family.

Subfamily Corynexochinae Raymond.

1. *Corynexochus* Angelin, 1854. (*Corynexochus spinulosus* Angelin.)
2. *Hicksia* Delgado, 1904. (*Hicksia elvensis* Delgado.)
3. *Karlia* Walcott, 1916. (*Bathyuriscus* (*Karlia*) *minor* Walcott.)
4. *Bonnia* Walcott, 1916. (*Bathyuriscus parvulus* Billings.)
5. *Acheilus* Raymond, 1924. (*Acheilus marcoui* Raymond.)
6. *Denisia* Clark, 1924. (*Denisia eminens* Clark.)
7. *Vistoia* Walcott, 1925. (*Vistoia prisca* Walcott.)
8. *Ptarmigania* Raymond, 1928. (*Bathyuriscus rossensis* Walcott.)
9. (?) *Vanuxemella* Walcott, 1916. (*Vanuxemella contracta* Walcott.)

So far as I can gather from Delgado's description and illustration,[5] *Hicksia* reveals the diagnostic characters of the Corynexochinae in such

1) J. F. Pompeckj (1901), *Paradoxides* Stufe von La Cabitza in Sardinien, (Zeitschr. deutsch. Geol. Gesell. Bd. 53, Hft. 1,) p. 19.

2) Ch. D. Walcott (1912), Sardinian Cambrian genus *Olenopsis* in America, (Smiths. Misc. Coll. Vol. 57, No. 8,) p. 239.

3) Walcott (1916), Smiths. Misc. Col. Vol. 64, No. 5, p. 310.

4) Raymond (1928), Two New Cambrian Trilobites, (Am. Jour. Sci. 5th ser. no. 88), p. 309.

5) J. F. H. Delgado (1904), Faune Cambrienne du Haut-Alemtejo (Portugal), (Comm. Comm. Serv. Geol. Portugal, Tom. V.)

respects that the long parallel-sided or forwardly expanded glabella without distinct glabellar furrows, small eyes located near the center of the cheeks, anterior facial suture subparallel to the axis of the cephalon and narrow free cheek. It, however, differs from the known genera of the subfamily in the small pygidium with only two or three segments and the number of thoracic segments which attains to nineteen. The surface is smooth or punctated. It is presumably an archaeic form of this subfamily.

Last year Saito[1] established two new species of *Bonnia*, *B. orientalis* and *B. tokunagai* from the Lower Cambrian *Redlichia* shales of North Chosen. For *Bonnia* I have a question, if it might not be a member of the Dorypyginae.

Genus ACHEILUS Raymond, 1924.

1924, *Acheilus* Raymond, Proc. Boston Soc. Nat. Hist., Vol. 37, No. 4, p. 422.

Genotype:—*Acheilus marcoui* Raymond.

Remarks:—The American *Pagodia*, such as *P. seelyi* and *P. thea*, as pointed out already in my previous paper, have no frontal brim at all on which account they are entirely distinct from *Pagodia* s. str. The associated pygidium is much longer in the American than in the Asiatic forms too.

Raymond once referred *Pagodia seelyi* to *Lloydia*, but the absence of the brim and square outline of glabella again object to such a reference. The associated pygidium of *P. seelyi* has, however, something suggestive of *Lloydia*, but this is quite different from that of *P. thea* which shows no distinct brim. Some question is therefore retained for combining the cephalon with the detached pygidium.

So far as the cranidia are concerned, the American *Pagodia* are very close to Raymond's *Acheilus* from which they are distinguished only by the parallel sided glabella, broader fixed cheek and smaller eyes, but these characters vary even among Raymond's species of *Acheilus*. For example, *Acheilus macrops* has an almost square glabella; *Amphion* (?) *matutina* Hall which according to Raymond is an *Acheilus*, has fixed cheeks as wide as those of American *Pagodia*. Therefore *Acheilus* would really be the best genus to which these forms might be assigned.

The subsquare shape of the .glabella, relatively short and wide, would be more important than the slight forword expansion of the glabella for the generic character of *Acheilus*.

1) K. Saito (1934), Older Cambrian Trilobita and Conchostraca from North-Western Korea, (Japan. Jour. Geol. Geogr. Vol. XI,) pp. 226–229, pl. XXVII, figs. 1–15, text-fig. 6.

Subfamily Dolichometopinae Walcott.

Dolichometopus Angelin, 1852. (*Dolichometopus svecicus* Angelin.)
Bathyuriscus Meek, 1873. (*Bathyurus* (?) *haydeni* Meek.)
Dinesus Etheridge, 1896. (*Dinesus ida* Etheridge.)
Amphoton Lorenz, 1906. (*Dolichometopus deois* Walcott.)
Poliella Walcott, 1916. (*Bathyuriscus* (*Poliella*) *anteros* Walcott.)
Anoria Walcott, 1924. (*Dolichometopus tontoensis* Walcott.)
Dolichometopsis Poulsen, 1927. (*Dolichometopsis resseri* Poulsen.)
Glossopleura Poulsen, 1927. (*Dolichometopus boccar* Walcott.)
Clavaspidella Poulsen, 1927. (*Clavaspidella sinupyge* Poulsen.)
Prosymphysurus Poulsen, 1927. (*Prosymphysurus kochi* Poulsen.)
Klotziella Raymond, 1928. (*Bathyuriscus ornatus* Walcott.)
Athabaskia Raymond, 1928. (*Athabaskia ostheimeri* Raymond.)
Acheilops Ulrich, 1930. (*Acheilops dilatus* Ulrich.)
Fuchouia Resser and Endo, (M S.) (*Bathyuriscus manchuriensis* Walcott.)

As to *Dolichometopsis* Poulsen[1] considered that it belonged to the family Zacanthoidae, but even if such a reference of its cephalon and detached pygidium were correct, the entire margin and other features of the pygidium would not permit its grouping with *Alberthella* and *Zacanthoides*. As it manifests various alliance to the *Dolichometopus-Bathyuriscus* group, it is quite possible that it belongs to this subfamily. It is noted here that R. Richter[2] established Bathyuriscidae without any diagnostic description, but it might fall somehow or other into this subfamily.

Genus DINESUS Etheridge, 1896.

1896. *Dinesus* Etheridge J. R. jr., Evidence of the Existence of a Cambrian Fauna in Victoria, (Proc. Roy. Soc. Victoria, New Ser. 8,) p. 56–62, Pl. I, figs. 1–5.
1902. *Dinesus* Geogory, J. W., The Heathcotian –a Pre-Ordovician Series– and its Distribution in Victoria, (Proc. Roy. Soc. Victoria, New Ser. 15,) pp. 154–155.
1905. *Dinesus* Walcott, Cambrian Faunas of China, (Proc. U. S. Nat. Mus.), p. 35.
1913. *Dinesus* Walcott, Cambrian Faunas of China, p. 124.
1917. *Dinesus* Chapman, Report on Cambrian Fossils from Knowley East, near Heatcote, (Records of Geol. Surv. of Victoria, Vol. IV, Pt. 1.)

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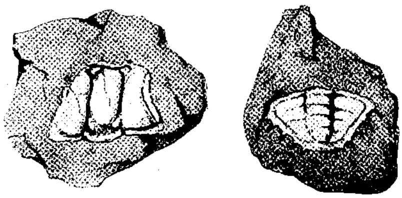
1) Poulsen (1927), The Cambrian, Ozarkian, and Canadian Faunas of Northwest Greenland, p. 335.

2) Rud. Richther, (1932), Crustacea, in Handwörterbuch der Naturwissenschaften, p. 855.

1919. *Dinesus* Etheridge, The Cambrian Trilobites of Australia and Tasmania, (Trans. Roy. Soc. S. Australia, Vol. XLIII,) p. 381.

Genotype:—*Dinesus ida* Etheridge.

Etheridge gave a precise description of the genotype and its generic comparison, instead of presenting a list of strict generic qualifications. He mentions that the all important points to be noted, however, are the facial sutures, simply convex before and behind the eyes, the peculiarly squarish oblong outline of the glabella, triangular fixed cheeks, and very straight run of the axial grooves, together with the entire absence of glabellar grooves. These characters are supplemented by the presence of the anterior and posterior distinctly circumscribed lobes. The eye-lobes are certainly small and non-olenelloid in appearance. Associated with these glabellae are pygidium possessing few segments, and a fimbriated margin. The presence of a pleural groove is questionable." (See Text-fig. 15)



Text-figure 15, *Dinesus ida* Etheridge.
[Reproductions of Etheridge's original figures 4 and 6 on plate 1. (1896)]

Later Gregory, however, upon examination of further new material, claimed that two different forms exist, *Dinesus ida* and *Notasaphus fergusoni* Gregory. The two species are different primarily in the outline of the glabella which is widely expanded in front in *N. fergusoni*, while parallel-sided or contracted forward in *D. ida*. He brought both of them into the family Asaphidae; changed the age of the deposits containing them to the Lower Ordovician from the Cambrian; and assigned the pygidium referred to *D. ida* by Etheridge to *N. fergusoni*.

Walcott, however, believes that "the genus *Dinesus* Etheridge jr. [(1896), p. 56, Plate I, figures 1–5,] appears to be more nearly related to *Dorypyge* Dames than to *Damesella* or *Teinistion* Monke. Its marked characteristics are the elongate, oval glabella with the small, distinct, antero-lateral and postero-lateral lobes, the small palpebral lobes and the large pygidium with a spinose border."

Later on Frederick Chapman studied *Dinesus* and *Notasaphus* and intended to combine a Ptychoparian pygidium with *Dinesus* and he joined the pygidium which was considered to belong to *Dinesus* of Etheridge to *Notasaphus*, as Gregory did. He also put forth an opinion that the fauna containing *Dinesus* is of the Upper Cambrian.

According to David[1] who bases his views upon the palaeontological studies of Whitehouse, however, the *Dinesus* zone is to be brought into the Middle Cambrian and in my belief this is the place where it ought to belong.

As reviewed above, the palaeontology of *Dinesus* and chronology of *Dinesus* zone have been subjects of considerable dispute, but in such a fragmentary state of occurrence, it is almost impossible to tell which pygidium goes to which cranidium. Fortunately, however, Wm. E. Schville procured a complete individual and through the courtesies of Prof. P. E. Raymond and Dr. Schville I had an opportunity to study this and thus learn the answer to this puzzling question. It is to be added that the accompanying fauna is an undoubted Middle Cambrian one. My observations and opinions are given on the following page.

Dinesus ida Etheridge.

Plate XXII, figure 3.

Description:—Trilobites with a large cephalon, eleven thoracic segments and a small wide pygidium.

Cranidium subequally divided into a glabella and two fixed cheeks; glabella convex, elevated, square, twice as long as wide; the first and last pairs of the glabellar furrows cut off small lobes at four corners of the glabella; dorsal and occipital furrows wide and deep; anterior border of the cranidium straight, with a thick rim, but no limb; fixed cheek across the eyes a little narrower than the glabella; eye of medium size, located at the mid-length of the cephalon and connected with the glabella by a transverse eye-ridge; postero-lateral limb of the fixed cheek triangular; free cheek provided with a spine at the genal angle; facial sutures subparallel anterior to the eyes, and diagonal posterior to them and cut the articulating margin just inside of the genal spine.

Thorax four-fifths as wide as the cephalon at the anterior end, but narrows gradually in the posterior half; axial lobe about one-third of the thoracic breadth, but it does not become narrow so abruptly as does

1) T. W. Edgeworth David, (1932), Explanatory Notes to accompany a New Geol. Map of the Commonwealth of Australia

the thorax itself. The axial segment with an articulating half ring at the middle part of the posterior; pleural lobe composed of a strong, transverse anterior rib and posterior groove and terminates in a short spine.

Pygidium twice as wide as long and on it the axis occupies half of the breadth; no segmentation; marginal border seems to be depressed.

Breadth of the trilobites.	28 mm.
Length of the cephalon exclusive of the genal spine.	10.5 mm.
Breadth of the cephalon.	20 mm.
Breadth of the cranidium across the eyes.	12 mm.
Breadth of the cranidium along the base.	18 mm.
Breadth of the glabella at the mid-length of the cephalon	5 mm.
Length of the thorax.	16 mm.
Breadth of the fifth thoracic segment.	16.6 mm.
Breadth of the fifth axial lobe of the thorax.	5.8 mm.
Length of the pygidium.	2 mm.
Breadth of the pygidium.	5.8 mm.
Breadth of the axial lobe on the pygidium.	3.5 mm.

These observations are based upon specimen No. 1853 in Museum of Comparative Zoology, Harvard University.

Comparisons:—The cranidium of *Dinesus*, that of *Notasaphus*, and the detached pygidium which was considered to belong to either one of them have probably nothing to do with one another. *Notasaphus*, judging from the cranidium, might be a form of the *Dorypygé* group; the detached pygidium on the other hand is possibly that of *Kootenia*. The pygidium of *Dinesus* is very small in size.

So far as the cephalon is concerned, *Dinesus ida* looks to me to be of the *Bathyuriscus*-type, especially close to *Klotziella*. The glabella of *Dinesus* has of course, a curious triangular lobe at its four corners, but in *Klotziella* the first or fourth glabellar furrows converge forward or backward so that, if their furrows were to increase in depth, they would easily separate the lobes from the body of the glabella. Careful examination of *Dinesus* reveals traces of the second and third furrows which, however, are represented simply by two pairs of pits on the lateral margin of the glabella. Therefore it is my opinion that the glabella of *Dinesus* was produced by the strengthening of the first and last furrows and weakening of the middle two in *Klotziella*.

The main difficulty to bringing this genus into the Dolichometopinae lies, however, in the tiny pygidium, but it is not a serious objection, because the size of pygidium varies considerably among the genera, and in *Poliella* it is transverse and small, though not quite as small as in *Dinesus*. In this subfamily, *Poliella* is the only genus which has eleven segments in thorax.

Dinesus has characters of both *Poliella* and *Klotziella* and by this reason it is best assigned to this subfamily.

Formation and locality:—Middle Cambrian of Templeton River, Queensland, collected by Wm. E. Schville, and kept in Museum of Comparative Zoology at Harvard University, (No. 1853).

Genus FUCHOUIA Resser and Endo, (MS.)

Genotype:—*Bathyuriscus manchuriensis* Walcott.

Remarks:—Resser and Endo mention in their manuscript that "this genus is proposed for a group of Middle Cambrian trilobites in which the cephalon has an elongate quadrangular glabella, very narrow, concave brim, rather thick, narrow rim and rather narrow fixed cheeks. The pygidium is large, with a strong axis and broad pleural lobes. Pleurae completely fused and with furrows terminate in a somewhat expanded fashion which amounts almost to the formation of a pit."

Raymond[1] once suggested that the genotype of this genus might belong to his genus *Athabaskia*, but *Fuchouia* is distinguished generically from that by the outline of glabella and characters of the pygidium.

The glabella of this genus is parallel-sided and regularly rounded in front, but never expanded in its frontal lobe as in the case of *Athabaskia*. Each pleural rib has a faint pleural furrow whose course is somewhat oblique to that of rib itself and which divides the pleural rib into two triangles as seen in the ribs of *Klotziella*. Walcott's type specimen of the pygidium shows the pleural grooves ending at the pits, but this feature is not usual in my material and I assume that Walcott's material has been depressed secondarily. Therefore these pits are of little value as a distinct generic character.

Fuchouia manchuriensis (Walcott.)

Plate XXII, figure 11.

1911. *Bathyuriscus manchuriensis* Walcott, Smiths. Misc. Coll. Vol. 57, No. 4, pp. 97–99, Pl. 16, fig. 4.

1) Raymond (1928), Am. Jour. Sci. Vol. 15, p. 311.

1913. *Bathyuriscus manchuriensis* Walcott, Research in China, III, pp. 219–220, Pl. 23, figs. 2, 2a-f.

1916. *Bathyuriscus manchuriensis* Walcott, Smiths. Misc. Coll. Vol. 64, No. 5, p. 344, figs. 4, 4-ac.

As this species has been thoroughly described, no further information need be set down here.

Formation and locality:—This species has been described from the chocolate coloured shale, about 130 feet above the white quartzite in Tschang-hsing-tao, Liaotung, (35 o, 36 g & 36 h) in association with *Obolus damesi*, *Agnostus chinensis* (s. l.) and others. In Sosan area, Chosen, the black shale of various localities[1] contains this species usually together with *Agnostus rakuroensis*, *Amphoton deois* and *Dorypyge manchuriensis*.

Genus AMPHOTON Lorenz, 1906.

1906. *Amphoton* Lorenz, Zeitsch. deuts. Geol. Gesell. 58, p. 75.

1913. *Dolichometopus* Walcott, Cambrian Faunas of China, p. 215.

1916. *Dolichometopus* Walcott, (in part) Smiths. Misc. Coll. 64, p. 355.

1928. *Dolichometopus* Raymond, (in part) Am. Jour. Sci. 5th ser. 15, no. 88, p. 310.

Generic diagnosis:—Glabella long, slightly expanded forward; glabellar furrows frequently obsolete; occipital ring with a spine in most species; palpebral lobe large, provided with a thick eye-band and located close to the glabella; frontal border narrow and concave; lateral margin of free cheek rounded, especially so near the genal angle; facial sutures slightly divergent anterior to the eyes, and transverse and cutting the articulating margin just inside of the genal angles.

Thoracic segment pointed back at its pleural extremities and has a spine on its axis.

Pygidium semi-circular, surrounded by a concave border and consists of about four anchylosed segments; axis stout and ends at a broadly rounded extremity; pleural rib strong, swelling into a spindle-shape.

Genotype:—*Dolichometopus deois* Walcott.

Remarks:—*Dolichometopus deois*, *D. derceto*, and *D. dirce*, with a question as to the free cheek of the last species, are included in this genus.

Walcott[2] has already called attention to the fact that "the eastern

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1) 平安北道楚山郡楚山邑暎湖亭
平安北道渭原郡西泰面洛葛峰中腹

2) Walcott (1916), Smiths. Misc. Coll. Vol. 64, No. 5, p. 359.

Asiatic species of the genus (*Dolichometopus*) all differ from the Swedish and American species in their associated pygidium. The latter have fewer segments in the axial lobe and more distinct prolongation of the axial segments in the pleural lobes. The pygidia are more like those of the species of *Bathyuriscus* with small pygidia such as *B.* (*Poliella*) *powersi* and *B.* (*Poliella*) *primus*."

Through the reexamination of their types, Resser and Endo[1] referred these Asiatic species to Poulsen's *Dolichometopsis*, but this again is quite uncertain, because there are considerable differences between the Asiatic and Arctic forms, especially in the features of free cheeks and pygidia. Poulsen's genus is of the Lower Cambrian and is accompanied by the *Olenellus* fauna, whereas this Asiatic one is of the Middle Cambrian and occurs usually with *Dorypyge* and *Fuchouia*. Therefore I am convinced that the Asiatic forms ought to be separated from all of the known genera of the Dolichometopinae.

Finally the separation of the Asiatic *Dolichometopus* forces the revival of Lorenz's *Amphoton* which was united once with *Dolichometopus*.

Geological and geographical distributions:—The early Middle Cambrian of North Chosen, South Manchuria and North China. *Dolichometopus* (?) sp.[2] described from Tonkin is quite uncertain as to whether it falls into the domain of this genus.

Amphoton deois (Walcott.)

Plate XXII, figure 12.

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1905. *Dolichometopus deois* Walcott, Proc. U. S. Nat. Mus. Vol. XXIX, p. 94.

1906. *Bathyuriscus asiaticus* Lorenz, Zeitsch. dentsch. Geol. Gesell. Vol. LVIII, Pt. 2, p. 73, Pl. V, figs. 1–5.

1906. *Amphoton steinmanni* Lorenz, idem. Vol. LVIII, Pt. 2, p. 75, Pl. IV, figs. 15–17.

1913. *Dolichometopus deois* Walcott, Research in China, III, p. 216, Pl. 21, figs. 13, 13a-d; Pl. 22, figs. 1a-h, 2a-b.

1916. *Dolichometopus deois* Walcott, Smiths. Misc. Coll. Vol. 64, No. 5, p. 365, Pl. 54, fig. 1, 1 a-m.

1) Endo (1932), Cambrian, (Iwanami series.)

2) Mansuy (1915), Faunes Cambriennes du Haut-Tonkin, (Mém. du Serv. Géol. de Indochine, Vol. IV, Fasc. II.)

Formation and locality:—This species is common in the black shale of Sosan area,[1] Chosen.

It is also known to be widely distributed in the early Middle Cambrian of Shantung and Liaotung.

Family KOMASPIDAE, new family.

In 1863 *Chariocephalus* was established by Hall[2] on the basis of *Chariocephalus whitfieldi* Hall[3] from the Franconia of Wisconsin, and *Chariocephalus tumifrons* Hall and Whitfield[4] was later added to it. In 1924 Ulrich and Resser[5] established another genus *Irvingella*, taking *Irvingella major* Ulrich and Resser[6] from the Franconia of Wisconsin for the genotype. This is distinguished from the former genus "by its large eyes, usual presence of glabellar furrows sometimes, however, not any more visible than in *Chariocephalus*, large fixed and smaller free cheeks and the better definition of the axis of the pygidia." Walcott and Resser[7] subsequently described *Irvingella septentrionalis* and *Irvingella*(?) *arctica* from the so-called Ozarkian of Novaya Zemlya.

In the second part of this monograph I described *Irvingella* (?) *orientalis*.[8] This differs from both of the Upper Cambrian genera in the feature of glabellar furrows. It has two pairs of furrows converging backward and meeting on the axis in a V-shape. In the ovately triangular outline of the glabella, this form is quite distinct from *Chariocephalus*. I am in doubt that the free cheek provisionally assigned to this species really belongs to it, but if the reference is correct, the cheek is quite different from those of the two Upper Cambrian genera under discussion. Such a clear and prominent distinction on the

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1) 平安北道楚山郡東面建陽洞
楚山郡東面倉坪洞
楚山郡古面月岳洞坪洞
平安北道渭原郡西泰面鷲岩洞北坂中腹
渭原郡西泰面洛葛峰南坂及ビ北坂

2) Hall (1863), 16th Ann. Rep. N. Y. State Cab. Nat. p. 175.

3) Hall (1863), Op. cit. p. 175, Pl. 6, figs. 47–51; Pl. 10, fig. 20.

4) Hall and Whitfield (1877), U. S. Geol. Expl. 40th Parl. p. 224, Pl. 2, fig. 38.

5) Ulrich and Resser (1924), in Walcott's Cambrian and lower Ozarkian Trilobites, p. 68.

6) Ulrich and Resser (1925), in Walcott's Cambrian and Ozarkian Triobites, p. 98, Pl. 15, figs. 26–29.

7) Walcott and Resser (1925), Trilobites from the Ozarkian Sandstone of the Island of Novaya Zemlya, p. 10, Pl. II, figs. 32–33.

8) Walcott and Resser (1925), Op. cit. p. 10, Pl. II, figs. 34–37.

cephalon provides sufficient basis to separate *Irvingella*(?) *orientalis*[1] from *Irvingella* to the generic rank and I propose a new name *Irvingelloides* for it. This separation is also founded upon the time and areal displacements involved, *Irvingelloides* coming from the Lower Ordovician of South Chosen.

Here I have to establish another genus, *Komaspis* which is the Middle Cambrian representative of this family. *Irvingella* is advanced from this in its extraordinarily large eyes, while *Chariocephalus* differs in the obsolecence of glabellar furrows. Other generic values of *Komaspis* are the outline of glabella, wide fixed cheek and also the frontal brim and limb.

Finally it is noted that the oldest representative of this family will be *Bathynotus* Hall whose genotype is *Bathynotus holopyge* Hall. Beecher grouped this genus in the Conocoryphidae, but the presence of a long eye is a valid reason for rejecting this classification. Raymond placed this next to *Triarthrus* Green in the Olenidae, but no genus of the Olenidae nor of the Ptychoparidae has such a long eye. The third glabellar furrow across the glabella is characteristic of the Komaspidae, very rare in the Oleninae, and never present in the Ptychoparidae s. str. If the Olenidae branch came from *Liostracus*, as is believed by Westergård, the occurrence of *Bathynotus* only in the Lower Cambrian is an objection for this family grouping. In such a situation it is clear that *Bathynotus* is much better explained as an early form of the Komaspidae.

Here the family diagnosis, distinguishing characters of the genera and their genotypes will be added.

Family diagnosis :—Cephalon short, with conical or square glabella ; posterior one or two glabellar furrows run across the glabella ; little or no brim ; fixed cheek narrow ; eyes large.

1) *Bathynotus* Hall, 1860. (Genotype : *Bathynotus holopyge* Hall.) Glabella conical, not very convex ; eyes as long as the glabella ; thorax composed of thirteen segments ; its axis wide.
2) *Komaspis*, new genus. (Genotype : *Komaspis typa*, new species.) Cephalon with a narrow brim ; fixed cheek of medium breadth ; eyes medium sized.
3) *Chariocephalus* Hall, 1863. (Genotype : *Chariocephalus whitfieldi* Hall.) Glabella square ; eye anterior and medium sized ; fixed cheek narrow. (Text-fig. 16 a)

1) Kobayashi (1934), Second Part of this Monograph, p. 566, Pl. VIII, figs. 5–6.

4) *Irvingella* Ulrich and Resser[1], 1924. (Genotype: *Irvingella major* Ulrich and Resser.) Cephalon without brim; dorsal and glabellar furrows very strong; eyes posterior and very large; fixed cheek narrow. (Text-fig. 16 b.)

5) *Irvingelloides*, new genus. (Genotype: *Irvingella* (?) *orientalis* Kobayashi.) Glabella semi-ovate with two V-shaped glabellar furrows running across it.

Text-figure 16.

(a) *Chariocephalus whitfieldi* Hall, the genotype of *Chariocephalus*. [From Hall (1863), 16th Ann. Rept. Univ. State New York etc. Appendix D, Pl. X, fig. 21.]

(b) *Irvingella major* Ulrich and Resser, the genotype of *Irvingella*. [From Walcott (1924), Cambrian and lower Ozarkian Trilobites, Pl. 10, fig. 3.]

Genus KOMASPIS, new genus.

Komaspis typa, new species. V

Plate XVI, figures 4-5.

Description:—Cephalon semi-circular, convex toward the axis; glabella conical, rounded in front and well defined by a strong dorsal furrow; anterior two pairs of glabellar furrows disconnected in the middle and located close to each other; the second glabellar lobe sub-elliptical, larger than the others; third and occipital furrows very strong and run entirely across the glabella, the latter transverse, while the former broadly convex backward; fixed cheek inclined laterally and relatively wider than those of other genera of this family, especially in the anterior portion; palpebral lobe located a little anterior to the mid-length of the cranidium; eye-band thick; frontal limb and rim narrow and of subequal length; facial suture somewhat diagonal, dire-

1) C. J. Stubblefield communicated me that *Irvingella nuneatonensis* (Shorma) occurred in the Outwoods shales (Maerterog) of Nuneaton, (Summary of Progress for 1731, pt. 1.); according to Westergård's information a trilobite similar to *Irvingella* except a narrow brim of cephalon is found in the *Peltura* zone or *Dictyonema* zone of Kärbacken, Sweden

cted inward anterior to the eye and outward posterior to that; surface smooth.

Formation and locality:—*Olenoides* zone of Neietsu.

Komaspis (?) *convexa*, new species.

Plate XVI, figure 3.

Description:—Cranidium subtrapezoidal; glabella as long as wide, considerably convex, elevated high up the cheeks, and surrounded by a narrow but fine dorsal groove; two anterior pairs of glabellar furrows represented by weak and short grooves, while the third and occipital furrows are very strong, transverse and mark off the narrow third glabellar and occipital lobes; fixed cheek subtriangular, gently convex and inclined outward; eyes relatively large on both sides of the middle of the cranidium; frontal brim narrow, close to the glabella; surface smooth.

Comparisons:—By the transverse cranidium, short and elevated glabella this species escapes readily from confusion with *Komaspis typa*. This is more similar to *Chariocephalus* (?) *tumifrons*, but the primary distinction is in the profile of glabella, i. e., the glabella is pushed forward and produced beyond the frontal brim in *C.* (?) *tumifrons*.

Formation and locality:—*Olenoides* zone of Neietsu.

Family Telephidae Angelin.

Ulrich[1] recently claimed that the *Telephus* group came from certain Upper Cambrian and early Ozarkian trilobites such as *Irvingella* and *Chariocephalus*. Because both of these groups of trilobites manifest fairly good accordances in the large glabella, narrow cheeks, large eyes and in other respects, this interpretation might be right. However, there is still a remarkable difference between the two groups in the mode of glabellar furrows, development of the eyes and in other features and the gap matches the displacement in their distribution. The *Telephus* group ranges from the Middle Ordovician to early Silurian on both sides of the Atlantic, while the *Irvingella* group originated in the Lower Cambrian of North America and later on spread out to the

1) E. O. Ulrich (1929), Ordovician Trilobites of the family Telephidae and Concerned Stratigraphic Correlation, (Proc. U. S. Nat. Mus. Vol. 76, Art. 21,) p. 7.

Island of Novaya Zemlya and Eastern Asia. The distribution of the groups does not stand as convincing evidence for the contention that the Cambrian and Ozarkian representatives of the Telephidae originated in the Arctic region as insisted by Ulrich.

Family Oryctocephalidae Raymond.

In his "Outline of a natural Classification of the Trilobites," Beecher[1] first established Oryctocephalinae as the second subfamily of the Olenidae, stating that it included "*Oryctocephalus, Ctenopyge, Olenoides,* and *Parabolina,* with large pygidia and all but the last one or two pleural elements continued into spines; also *Eurycare, Angelina, Peltura,* and *Protopeltura,* with smaller and shorter pygidia and denticulations of the margins corresponding to the pleural divisions."

This subfamily was promoted to the family rank in the revision of Zittel-Eastman's Text-Book[2] with some emendation of the diagnosis as follows:—

"Opisthoparia with large cephalon and smaller pygidium, palpebral lobes long and connected with the glabella. Pygidium of six to nine segments, which end in spine."

On that occasion the family included four genera, *Oryctocephalus, Zacanthoides, Olenoides,* and *Neolenus.* Walcott[3] later described *Vanuxemella, Karlia* and *Hanburia* and grouped them in this family.

In Zittel-Broili's Grundzüge der Palaeontologie,[4] it is brought into the Mesonacidae with some hesitation and *Dorypyge, Tsinania, Redlichia,* and *Olenoides* are also contained in it.

As discussed in the chapter on the Tsinanidae, it is clear that the family is a descendant from the Asaphiscidae and therefore it can not be retained here. *Hanburia* bears many aspects suggestive of an Ogygiocarinae-alliance. Walcott questioned the presence of the facial suture on *Hanburia.* In examining the type specimens under the high magnification with crossed light, they are seen to have the same kind of facial suture and eyes as *Ogygiopsis*; the misunderstanding must have arisen simply out of materials not well preserved enough to retain these features. (Plate XIV, figure 15.)

1) Beecher (1897), Outline of a Natural Classification of the Trilobites, (Am. Jour Sci. Vol. III,) p. 192.

2) Raymond (1913), in Zittel-Eastman's Text-Book, p. 716.

3) Walcott (1916), Smiths. Misc. Coll. Vol. 64, No. 3, pp. 220-228.

4) Zittel-Broili (1924), Grundzüge der Palaontologie, I, p. 645.

Karlia is certainly allied to *Bathyuriscus* and *Corynexochus*, but differs in its small eye lobes, the wide fixed cheek and entire margin of the pygidium. Through *Karlia* and *Tonkinella* two families, Corynexochidae and Oryctocephalidae, are connected.

Olenopsis was considered by Walcott[1] and others to be related to *Holmia* and *Redlichia*[2] to a descendant of mesonacids. It is, however, quite uncertain, if *Olenopsis* and *Redlichia* fall within the domain of the Oryctocephalidae.

Vanuxemella is similar to *Albertella*, as claimed by Walcott, on one hand; it is also allied to the Corynexochinae on the other. The true phylogenetical position is in question, but probably the genus is located in the immediate vicinity of *Karlia*.

Arthricocephalus Bergeron,[3] 1899, which is based on *A. chauveaui* Bergeron reveals something allied to the Oryctocephalidae, although its true taxonomic position is not yet certain.

As a result of the above discussions the following seven genera are seen to belong to this family and are to be subdivided into two subfamilies as follows:—

Subfamily Oryctocephalinae Beecher.

Glabella long, square, with three pairs of glabellar pits or transverse furrows; fixed cheek wide; thorax of six to eleven segments; pygidium smaller than the cephalon, with an entire or spinose margin.

1) *Oryctocephalus* Walcott, 1886. Oryctocephalinae with a spinose pygidium; surface smooth.
2) *Oryctocare* Walcott, 1908. Pygidium with an entire margin; its each pleural lobe divided into two ribs; surface granulated.
3) *Tonkinella* Mansuy, 1916. Pygidium with an entire margin; pleurae fused; surface smooth.

Subfamily Dorypyginae, new subfamily.

Glabella wide, parallel sided or expanded forward; glabellar furrows more or less obliterated; a pair of pits on both sides of the front lobe of

1) Walcott (1912), The Sardinian Cambrian Genus *Olenopsis* in America, (Smiths. Misc. Coll. Vol. 57, No. 8,) p. 239.

2) Walcott (1910), *Olenellus* and other Genera of the Mesonacidae, (Smiths. Misc. Coll. Vol. 53, No. 6,) p. 253.

3) J. Bergeron (1899), Étude de quelques Trilobites de Chine, (Bull. de la Soc. géol. de France, 3 ser. vol. 27, No. 5,) pp. 514–516, text-fig. 9.

the glabella; fixed cheek medium sized; seven to eight thoracic segments; pygidium as large as the cephalon, with spines on the margin.

4) *Olenoides* Meek, 1877. Pygidial pleurae separate, divided unequally by the grooves; marginal spines of equal length; surface smooth.
5) *Dorypyge* Dames, 1883. Pleurae of pygidium fused; one or two pairs of posterior spines longer than the others; surface frequently granulated.
6) *Kootenia* Walcott, 1888. Pleurae of pygidium fused; marginal spines of equal length; surface mostly smooth.
7) *Holteria* Walcott, 1924. Cephalon without brim; glabella projected forward; pygidium subquadrate with divided pleurae which are produced into spines of different length.

Subfamily Oryctocephalinae Beecher.

1. *Oryctocephalus* Walcott, 1886. (Genotype: *Oryctocephalus primus* Walcott.) (Pl. XV, fig. 1.)
2. *Oryctocare* Walcott, 1908. (Genotype: *Oryctocare geikiei* Walcott.)
3. *Tonkinella* Mansuy, 1916. (Genotype: *Tonkinella flabelliformis* Mansuy.)

This group has a unique outline and lobation of the glabella. Its cranidium has a rather straight frontal margin and wider fixed cheeks than that of *Olenoides* group, in which regard it is rather closer to *Damesella* group, but the alliance to *Olenoides* is undeniable in the pygidium of *Oryctocephalus*, especially in such a form as *O. reynoldsi*. As noticed by Matthew, the pygidium of *O. primus* appears similar to that of *Cheirurus foveolatus* Ang. But this represents nothing more than a homoeomorphic resemblance.

Oryctocare has the same type of cranidium as *Oryctocephalus*, but differs from the latter primarily in the entire margins of its thorax and pygidium. It, however, still retains the interpleural grooves on the pygidium. As suggested by Walcott[1], its pygidium is certainly allied to that of *Bathyuriscus*.

The pygidium of *Tonkinella* has an entire margin and no interpleural grooves, but at the same time the general feature is quite different from any pygidium of the Corynexochidae. *Tonkinella flabelliformis* and *Oryctocephalus primus* are in good accordance with each other except for the spines on the pygidium.

1) Walcott (1908), Smiths. Misc. Coll. Vol. LIII, p. 23.

Genus ORYCTOCEPHALUS Walcott, 1886.

1886. *Oryctocephalus* Walcott, Second Contribution to the Studies on the Cambrian Faunas of North America, (Bull. U. S. Geol. Serv. 30,) p. 210.
1889. *Oryctocephalus* Miller, North Amer. Geol. & Pal. p. 558.
1899. *Oryctocephalus* Matthew, Trans. Royal Soc. Canada, 2nd. Ser. 5, Sec. 4, p. 63.
1901. *Oryctocephalus* Lindström, Kongl. Sven. Vet. Akad. Handl. 34, No. 8, p. 22.
1910. *Oryctocephalus* Reed, Cambrian Fossils of Spiti, p. 10.
1913. *Oryctocephalus* Raymond, in Zittel-Eastman's Text-Book of Paleontology, Vol. I, p. 716.
1924. *Oryctocephalus*, Zittel-Broili's Grundzüge der Palaeontologie, p. 645.

Remarks:—Reed's elaborate review of the previous works gives a good idea of this genus.

Hitherto four species were described as follows:—

1. *Oryctocephalus primus* Walcott,[1] 1886, from the Middle Cambrian of Nevada.
2. *Oryctocephalus reynoldsi* Reed,[2] 1899, from the Stephen formation of British Cambrian and Idaho.
3. *Oryctocephalus walkeri* Matthew,[3] 1899, from the Stephen formation of British Columbia.
4. *Oryctocephalus salteri* Reed,[4] 1910, from the Middle Cambrian of Spiti.

The second and third species were established almost simultaneously from the Stephen formation and both are much alike, but the distinction is given in Matthew's paper which appeared a little later than Reed's: "it (*O. reynoldsi*) has shorter genal spines and broader movable cheeks; the pygidium is longer, is composed of more numbers of somites, and has a pair of spines that much exceed the others in length. The species also is somewhat longer than Mr. Walker's."

Lately Saito[5] described *Oryctocephalus* cf. *reynoldsi*, *O. orientalis* and *O. kobayashii* from the Middle Cambrian *Ptychoparia* beds of North Chosen.

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1) Walcott (1886), Bull. U. S. Geol. Surv. 30, p. 210, Pl. XXIX, figs. 3, 3a.

2) Cowper Reed (1889), Woodwardian Museum Notes; A few Trilobites from Mount Stephen, Field, B. C., (Geol. Mag. New Ser. Dec. 4, 6,) pp. 359–361, fig.

3) Matthew (1899), Trans. Roy. Soc. Canada, 2nd. ser. 5. Sec. 4, pp. 60–61, Pl. III, fig. 2.

4) Reed (1910), Mem. Geol. Surv. Pal. Indica, Ser. 15, 7, p. 11, Pl. I, figs. 16–21.

5) K. Saito (1934), Older Cambrian Trilobita and Conchostraca from North-eastern Korea, (Japan. Jour. Geol. Geogr. Vol. XI), pp. 230–232, pl. XXV, figs. 17–25, pl. XXVII, figs. 16–20.

The occurrences of this genus in India and western North America through Chosen are very important for the consideration of the problems of correlation and faunal migration.

Walcott simply referred this genus to the family Olenidae; Mathew reaffirmed the view, stating that "*Oryctocephalus* is evidently related to *Parabolina* and *Parabolinella* of the European Upper Cambrian." Cowper Reed, however, pointed out the resemblance of the pygidium to that of certain species of *Olenoides*, although the cephalon, particularly in the lobation of the glabella, shows distinct and unique features.

Genotype:—*Oryctocephalus primus* Walcott. (Plate XV, figure 1.)

Geological and geographical distribution:—Middle Cambrian; Southern and eastern Asia and western North America.

Genus TONKINELLA Mansuy, 1916.

1916. *Tonkinella* Mansuy, Faunes Cambriennes de l'Extrême Orient Méridional, p. 43.

Remarks:—In describing *Tonkinella flabelliformis*, Mansuy established a new genus *Tonkinella*. Though he depicted the genotype in detail, he gave no generic diagnosis.

In U. S. National Museum is kept an undescribed species of *Tonkinella* collected from the Stephen formation of British Columbia which is represented by several specimens, one being nearly complete except for the free cheeks. It is denominated here as *Tonkinella tephensis*. Because this species gives a more exact concept of the genus *Tonkinella*, especially in the thoracic characters, diagnosis of this genus is outlined here, based not only upon *Tonkinella flabelliformis* but also upon *Tonkinella stephensis*.

Generic diagnosis:—Cranidium subtrapezoidal; glabella and fixed cheek of subequal size; glabella long, parallel sided or expanded forward, convex, elevated above the cheeks..frontal margin of the glabella rounded and overlapping upon the frontal brim; three pairs of glabellar furrows transverse, dividing the glabella into four lobes of subequal lengths; the first and second pairs of the furrows disconnected in the middle of the glabella, but the third pair crosses the glabella with a weak backward convexity; occipital lobe on the axis and cheeks narrow, but clearly defined by a groove; fixed cheek slightly convex; palpebral lobe opposite the midpoint of the cephalic length; eye-line entirely obsolete; facial suture nearly straight; frontal brim narrow, flat and rather horizontal. Nothing is as yet known about the free cheek or hypostoma.[1]

The axial lobe of the thorax as broad as one-fourth the thoracic breadth, and elevated above the flat pleurae; pleural lobe transverse and its terminal portion descending and sharply pointed postero-laterally; pleural groove crosses the pleural portion diagonally with a transverse median course. (Six thoracic segments are counted in one specimen of *Tonkinella stephensis* 8 mm. long; axial lobe cylindrical, slightly expanded in the middle. In another specimen the feature of each segment is well observed.)

Pygidium semi-circular; axial lobe conical, narrow, and divided into five to seven rings in addition to an articulating half ring; pleural lobes radiate from the axis and are truncated at the extremities; five to six pairs of pleural lobes counted in addition to a posterior lobe and an articulating segment.

Still another new species of *Tonkinella* has been found in the Korean collection. The occurrences of *Tonkinella* on both sides of the Pacific Ocean is very important for the correlation of the Middle Cambrian.

Comparisons:—As to the generic characters Mansuy gave the following information in describing the genotype:—

"Ce Trilobite offre la plus grande ressemblance avec les formes pour lesquelles Walcott a créé le genre *Karlia* et provenant du Cambrien moyen du Newfoundland et du Mont Stephen: cette ressemblance est particulièrement frappante avec les formes jeunes de l'une des espèces attribuées à ce nouveau genre: *Karlia minor* Walcott. Les proportions de la tête et de la glabelle des individus incomplètement développas de *K. minor* sont presque identiques à celles de nos fossiles. L'un des exemplaires figurés par Walcott (pl. XXXVI, fig. 7b) possède un pygidium dont les segments montrent une disposion radiaire, de même que chez notre espèce. Walcott a reconnu des affinités marquées entre le genre *Karlia* et le genre *Bathyuriscus* Meek, dans la forme et les proportions du bouclier céphalique. *Karlia* se sépare de *Bathyuriscus* par le nombre plus réduit de segments thoraciques. La disposition rayonnante des segments latéraux du pygidium de *Tonkinella* nov. gen. rappelle, jusqu'à un certain point, le pygidium des *Bronteus* Goldfuss, mais les segments, dans ce dernier genre, montrent une inflexion inverse; l'axe du pygidium est rudimentaire.

1) The hypostoma of *Tonkinella breviceps* has been found and described in my paper; Middle Cambrian Fossils of Kashmir, (Am. Jour. Sci. Vol. XXVII, 1934).

Malgré les étroites affinités reconnues entre l'espèce décrite ici et les formes jeunes du genre *Karlia*, il semble, en raison de la segmentation très accusée de la glabella et du pygidium, que nos individus représentent une forme adulte, nettement differenciée du genre *Karlia* par les caractères du pygidium, chez les individus entièrement développés.

Bien que des têtes fragmentées, d'un tout autre type, d'ailleurs tout à fait indéterminables, aient été recueillies avec les têtes et les pygidiums rapportés à *Tonkinella flabelliformis* nov. gen., nov. sp., il ne saurait subsister le moindre doute, à notre sens, en raison des affinités démontrées du genre *Karlia* avec le genre *Tonkinella* nov. gen. dans les caractères de la tête et du pygidium, que les têtes et les pygidiums isolés dont nous venons de donner la description ne proviennent des mêmes individus."

Karlia including the cited species was once considered by Walcott himself to be a synonym of *Corynexochus*.[1)]

In the outline of the glabella, features of the glabellar furrows, and wide fixed cheek *Tonkinella* differs both from the *Corynexochus* series as well as the *Bathyuriscus* series. To me the more intimate relation is found to exist between *Tonkinella* and *Oryctocephalus*. In comparing three species of *Tonkinella* to *Oryctocephalus primus*, the genotype, differences are found only in the following respects in the latter :—

1) Glabella marked by four transverse furrows that terminate in little pits within the margin of the glabella.
2) Distinct ocular ridge connecting the large eye with the axial furrow at about the first glabellar furrow.
3) In *Oryctocephalus* the pleural segments of pygidium are produced into sharp spines, while in *Tonkinella* there are no spines and in a well preserved specimen of *T. orientalis*, the margin of pygidium has a very narrow but fine brim.

Genotype :—*Tonkinella flabelliformis* Mansuy.

Geological and geographical distribution :—Middle Cambrian ; southern and eastern Asia and western North America.

Tonkinella stephensis, new species.

PA986-15-2
PA987-15-3
PA988-15-4
PA989-15-5

Plate XV, figures 2-5.

Description :—Carapace elliptical; thorax shorter than the cephalon or pygidium. Cranidium subtrapezoidal ; the frontal margin broadly

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1) Walcott (1916), Cambr. Geol. & Paleont. III, 5, Cambrian Trilobites, p. 309.

rounded; glabella expanded forward regularly; three pairs of glabellar furrows all rather strongly depressed at a short distance inside from the lateral margin; the first and second pairs disconnected at the middle and at one-third of the breadth; the third pair traverses the middle and turns forward on both sides; faint furrows found on the frontal lobe originating at the junctions of the dorsal and frontal furrows; dorsal furrow distinct; glabella elevated above the cheek and overlapped on the horizontal front brim.

Thorax consists of six segments; axis about one-fourth the breadth of the thorax, cylindrical and narrowing slightly anteriorly and posteriorly; axial ring has a distinct semicircular articulating half ring; pleural lobe flat, transverse, triangularly produced postero-laterally at the extremity; pleural groove crosses the lobe from the antero-inner corner to the lateral spine.

Pygidium semi-elliptical in outline; axial lobe has about one-fourth the breadth and one-third the length of the pygidium, and is divided into an articulating half ring, five ordinal axial rings and a triangular terminal lobe, which in turn is also faintly subdivided into two parts; pleurae divided into thirteen radial lobes and two articulating half segments.

Comparisons:—Owing to the incomplete state of preservation of *Tonkinella flabelliformis*, the exact comparison between the cranidia of that and the present species cannot be undertaken, but they are very much alike in their gross features.

The main specific distinction lies in the pygidium. In *T. flabelliformis* the axial lobe consists of five segments, instead of seven. And also the anterior margin of the pygidium is nearly transversely straight in *T. stephensis* while broadly rounded in *T. flabelliformis*.

Formation and locality:—Stephen formation of Mt. Stephen, British Columbia, Canada.

Tonkinella breviceps, new species.

Plate XV, figures 6, 8–9.

This is represented by a single cranidium. The cranidium is short; glabella also short and expanded forward; glabellar furrows represented by three pairs of pits inside of the glabellar margin which become shallow laterally and are connected with the dorsal furrows; the first pair disconnected in the middle, but the second and third pairs extend across the glabella; fixed cheeks and frontal brim of characteristic *Tonkinella* type; surface roughened by punctae.

Pygidium triangularly semi-ovate; axial lobe relatively narrow, slender, and divided into seven rings; pleurae wide and consisting of fifteen radial lobes.

Comparisons:—The pygidia of *Tonkinella stephensis* and *T. breviceps* are very much alike, although minor differences are to be recognized in the outline of the pygidium and relative size of the axial lobe. The cranidium of this species is especially interesting, because its glabellar characters tend to merge from the *Tonkinella* type to the *Oryctocephalus* type.

Formation and locality:—*Olenoides* zone of Neietsu.

Tonkinella orientalis, new species.

Plate XV, figure 7.

Description:—Cranidium subtrapezoidal, a little arched on the frontal margin; glabella two and half times as long as wide, well defined by parallel dorsal furrows which are somewhat depressed at the anterior ends and subsequently continue to the round frontal margin; three pairs of glabellar furrows of *Tonkinella* type; frontal lobe a little longer than the other lobes and on it a pair of weak and short accessory furrows are found at a short distance from the frontal margin; occipital lobe relatively long; fixed cheek almost the same breadth as the glabella along the basal margin, and less convex than the glabella; palpebral lobe opposite the middle of the cranidium; facial sutures nearly straight.

Surface of the test smooth.

Comparisons:—In the cranidium, however, this and the preceding species are quite different in the outline of the glabella, through which they escape perfectly from being confused with each other.

Formation and locality:—*Olenoides* zone of Neiestu.

Subfamily Dorypyginae, new subfamily.

1. *Olenoides* Meek, 1877. (Genotype: *Paradoxides* (?) *nevadensis* Meek.)
2. *Dorypyge* Dames, 1883. (Genotype: *Dorypyge richthofeni* Dames.)
3. *Kootenia* Walcott, 1888. (Genotype: *Bathyuriscus* (*Kootenia*) *dawsoni* Walcott.)

4. *Holteria* Walcott, 1924. (Genotype: *Ogygia* (?) *problematica* Walcott.)

The anterior margin of the cranidium is narrower and more rounded than that of Oryctocephalinae. The glabella is elongately ovate to elliptical with forward expansion to various degrees and overlapping upon the brim. In *Holteria* it is projected far beyond the brim. A pair of strong depressions are found on both sides of the frontal lobe in *Dorypyge*. The glabellar furrows are obsolete in most forms of this group. The fixed check is relatively narrow. The ocular band and line are distinct. Facial suture is subparallel in front of the eyes and cuts the posterior margin of the cephalon at a varying distance from the glabella. In *Olenoides* it is extended far outside of the cephalon and tends to approach the Proparian-like course, but never cuts the lateral margin in front of the genal spine.

The thoracic and pygidial segments sometimes have axial spines. Interpleural groove on the thoracic pleura varies in its course from transverse to somewhat oblique. Pleural lobes of the pygidium are usually produced into spines. The pygidium of *Oryctocephalus reynoldsi* Reed is quite allied to that of *Olenoides* in possessing interpleural furrows. These furrows, however, vary in their strength and, when they are exceedingly weak, the pygidium of *Olenoides* is not far different from that of *Kootenia*.

Kootenia ranges from Lower to Middle Cambrian; *Olenoides* and *Dorypyge* are limited to the Middle Cambrian; and *Holteria* is the Upper Cambrian derivative of *Olenoides*.

Genus OLENOIDES Meek, 1877.

1877. *Olenoides* Meek, U. S. Geol. Expl. 40th Parl. 4, p. 25.
1886. *Olenoides* Walcott, Bull. U. S. Geol. Surv. 30, p. 180.
1888. *Olenoides* Walcott, Proc. U. S. Nat. Mus. II, p. 442.
1889. *Olenoides* Miller, North Amer. Geol. & Pal. p. 557.
1890. *Olenoides* Matthew, Trans. Royal Soc. Canada, p. 557.
1890. *Olenoides* Matthew, Trans. Royal Soc. Canada, 7. sec. 4, p. 160, foot-note.
1896. *Olenoides* Koken, Leitfossilien, Leipzig, p. 16.
1899. *Olenoides* Toll, Mém. l'Acad. Imp. Sci. St. Petersbourg, 8 ser., No. 10, p. 35.
1899. *Neolenus* Matthew, Trans. Royal Soc. Canada, sec. ser., 5, sec. 4, p. 52.
1902. *Neolenus* Grönwall, Danmark Geol. Unders. 2 Raekke, No. 13, p. 129.
1906. *Olenoides* Lorenz, Zeitsch. dents. geol. Gesell. 58, Hft. 1, pp. 68–69.
1910. *Olenoides* Grabau and Schimer, N. A. Index Fossils, 2, p. 272.
1910. *Neolenus* Grabau and Schimer, ibid. 2, p. 270,

1913. *Olenoides* Raymond, in Zittel-Eastman's Text-Book of Palaeontology, Vol. I, p. 716.
1913. *Neolenus* Raymond, ibid. p. 716.
1924. *Olenoides* Zittel-Broili, Grundzüge der Palaeontologie, 1. Abt. p. 645.
1924. *Neolenus* Zittel-Broili, ibid. p. 645.

Genotype:—*Paradoxides* (?) *nevadensis* Meek.

Remarks:—In 1877 Meek proposed a generic name *Olenoides* in describing *Paradoxides* (?) *nevadensis* Meek. Walcott first gave the following generic diagnosis of this genus in 1886, basing upon *O. nevadensis* and *O. typicalis* Walcott, latter of which was, however, afterward transferred to *Zacanthoides*

"General outline ovate. Head large, semi-circular. Glabella straight or slightly expanded in front, marked by three pairs of furrows in *O. typicalis*. Eyes elongate. The facial sutures extend obliquely outward from the anterior base of the eyes and cut the frontal margin; posteriorly they cut the margin at the pleural angle and run subparallel to the margin to the posterior end of the eye.

Thorax with eight or more segments; axis strong and pleural lobes well defined; pleural groove broad.

Pygidium marked by transverse furrows on the axis, and the lateral segments are directed backwards."

Walcott referred the genus to the family Paradoxidae, but Beecher brought it to the family Oryctocephalidae.

In 1899, Matthew established *Neolenus*, stating that "one of the distinctions is in the pleural furrow. In *Olenoides* (*Dorypyge* ?) it is a straight broad furrow going out well to the extremity of the pleura. In *Zacanthoides* it is also a wide furrow, but it has a heavy shoulder in the middle at its connection with the ring of the rachis. In this group (*Neolenus*) the furrow is narrow and oblique, as in *Paradoxides*."

Matthew's *Neolenus* was based upon *Ogygia serrata* Rominger. Grabau and Shimer perceived a distinction in the fact that *Neolenus* "differs from *Olenoides* in the strong tapering of the axial lobe from the anterior portion of the glabella to its posterior portion in the pygidium (in *Olenoides* the width for the entire distance is nearly unvarying); also differs in the more distinct segments of the pygidium, the more triangular outline of the cephalon and the narrow pleural grooves."

In a number of species of *Olenoides-Neolenus* series, these distinctions are hardly to be supported and it is very difficult to find out any morphological gap of generic value. Meek's type specimen of *O. nevadensis* preserved only the occipital segment of the cephalon, eight thoracic segment, of which both lateral margins are broken, and about two-thirds of the pygidium. Such an incomplete state does not permit very accurate comparison, especially in the characters of the cephalon between *O. nevadensis* and *N. serratus*, but, as far as these genotypes are concerned, it will be more natural to recognize them as distinct species of the same genus rather than two members of independent genera.

Among the described species of *Neolenus, Neolenus inflatus* is rather different. It has a glabella considerably projected beyond the frontal brim, in which regard, as noticed by Walcott,[1] its cranidium is generically indistinguishable from that of *Holteria problematica* of the Upper Cambrian of Nevada. Therefore the main generic difference between them lies in the pygidia.

The described species referrable to *Olenoides* are :—

Olenoides nevadensis (Meek). [Acadian (Wheeler) of Utah.]
Olenoides curticei Walcott. [Acadian (Conosauga) of Alabama.]
Olenoides inflatus (Walcott.). [Acadian (Marjum) of Utah.]
Olenoides intermedius (Walcott). [Acadian (Marjum) of Utah.]
Olenoides pugio (Walcott). [Acadian (Marjum) or Utah.]
Olenoides serratus (Rominger). [Acadian (Stephen & Burgess shale) of British Columbia.]
Olenoides superbus (Walcott) [Acadian (Marjum) of Utah.]
Olenoides granulatus (Matthew). [Acadian (Stephen) of British Columbia.]

Here is added a species of *Olenoides, O. asiatica,* from the Middle Cambrian of South Chosen. It is very interesting to discover a representative of such an important Middle Cambrian genus in Eastern Asia.

Genotype :—*Paradoxides* (?) *nevadensis* Meek.

Geological and geographical distribution :—Middle Cambrian of Chosen and North America.

Olenoides asiaticus, new species.

Plate XIV, figure 23 ; Plate XV, figures 10-12, ? 13.

Description :—Cranidium convex with a drooping frontal margin ; glabella almost parallel-sided, but slightly expanded forward, well defined by distinct dorsal furrows and rounded in front, convex, elevated above the cheeks ; three pairs of glabellar furrows unusually strong and

1) Walcott (1925), Cambrian and Ozarkian Trilobites, p. 91.

all discontinuous at the middle of the glabella; the first and second pairs transverse, but the third pair at first transverse and then turned back, making obtuse angles; occipital furrow strong; fixed cheek as wide as the glabella along the basal margin; palpebral lobe medium sized and opposite the mid-length of the cranidium; ocular band and ridge strong; facial sutures diagonal behind the eyes and subparallel in front of them.

Pygidium exclusive of the spines semi-circular; axial lobe conical, elevated, as wide as one-fourth to one-fifth the breadth of the pygidium, and divided into about five rings and a terminal lobe; pleural portion flat, consisting of four ribs; each rib accompanies an accessory posterior rib and a wide groove between; the main rib is interrupted at the marginal brim, but is produced into a spine after passing the brim.

Surface smooth.

Comparisons:—The proparian like feature of the facial suture which is common in the *Olenoides* group is not clear in the specimens in hand. The unusual strength of the glabellar furrow is a very distinct feature, but it is, I think, of no more than specific value, because the glabellar furrows are fairly distinct even in *O. serratus* (Rominger) and some other species, and the course of these furrows are all identical, although the third pair of the glabellar furrows rather abruptly changes its direction subrectangularly. In many cases these furrows are oblique and convergent.

The most easily recognized specific character in this genus is the number of the marginal spines on each side of the pygidium. There are eight pairs in *O. inflatus*; five to six in *O. intermedius*; five in *O. serratus* and *O. granulatus*; and four in *O. curticei* and *O. pugio*. The present species also has four pairs of spines. The main differences from *O. curticei* and *O. pugio* are as follows:—

1) This Oriental form has a more transverse outline.
2) Its axial lobe is much narrower and conical.
3) The lateral extremity of the articulating margin is sharply angulated and the first marginal spine is directed more posteriorly; in this feature this species is more like *O. intermedius*.

Formation and locality:—*Olenoides* zone of Neietsu; same zone of Chuwa, Heian-nan-do, Chosen. (平安南道中和郡中和大洞.)

Genus KOOTENIA Walcott, 1899.

Genotype:—*Bathyuriscus* (*Kootenia*) *dawsoni* Walcott.[1]

Remarks;—Basing upon the species just mentioned, Walcott proposed a new name *Kootenia* as a subgenus of *Bathyuriscus*, but did not give any information about the subgeneric characters at that time. The genotype was later referred to *Dorypyge* by Matthew.[2]

Walcott[3] first gave the generic distinction in 1918 stating that "this species (*Kootenia dawsoni*) combines characters of *Dorypyge*, *Olenoides* and *Neolenus*. It has the slightly expanded subquadrilateral glabella of *Olenoides* and *Neolenus* with the unfurrowed, fused pygidial segments of *Dorypyge*. The fringing spines of the pygidium are similar to those of the two former genera and quite unlike those of *Dorypyge*. The glabella of *Kootenia* differs from that of *Dorypyge* in form."

In 1925 he[4] gave further information that "*Neolenus* lacks the flat border, has the individual pleurae separate enough to be readily distinguishable and from three to nine spines on either side. *Kootenia* is distinguished by the fusion of the pleurae to the extent that the boundary between them is only rarely discernible, and then with great difficulty. The pleural furrows, as in the foregoing genera, are quite deep. *Kootenia* has usually four or five spines to a side, but they may vary in length from mere scallops to long, heavy spines equal to the length of the pygidium."

It is certain that *Kootenia* takes an intermediate position between *Olenoides* and *Dorypyge*. In addition to the distinctions pointed out by Walcott, in *Dorypyge* a pair of strong constrictions are found on both sides of the frontal lobe of the glabella which are caused by deep depressions on the dorsal furrows. The test of the carapace is frequently ornamented by distinct granulations.

Dorypyges which hold these characters are so far limited in their distribution to the Middle Cambrian of North China, South Manchuria and North Chosen.

Grönwall's two species, *Dorypyge danica* and *D. oriens* from the Middle Cambrian of Bornholm appear rather similar to *Dorypyge* s. str.

1) Walcott(1889), Proc. U. S. Nat. Mus. Vol. XI, p. 446.

2) Matthew(1899), Trans. Roy. Soc. Canada, 2d. ser. Vol. V, sec. IV, p. 56, Pl. 3, fig. 1.

3) Walcott(1918), Appendages of Trilobites, (Smiths. Misc. Coll. Vol. 67, No. 4,) p. 131.

4) Walcott (1925), Smiths. Misc. Coll. Vol. 75, No. 3, p. 92.

in the presence of long posterior spines on the pygidium, but still the surface of the test is smooth; outline of the glabella in *D. danica* has no strong frontal constrictions; and *D. oriens* which is simply represented by pygidia has a spine on the axial segments. These aspects are more likely to be found in *Kootenia* than in *Dorypyge*. There is a possibility that the two types may represent parallel branches which sprang earlier from a common stock rather than stages in the same evolutional line.

Most species of *Dorypyge* known from North America, Greenland, and Siberia seem to me to have more possibility of belonging to *Kootenia*; and *Dorypyge* specified by *D. richthofeni* is an Oriental branch from *Kootenia-Olenoides* series and the two Baltic species signifies another branch from the same series. [See page 160.]

PA999-15-14
PA1000-15-15.16
PA1001-15-17
PA1002-15-18
PA1003-15-19
PA1004-15-20
PA1005-15-21

Kootenia punctata, new species.

Plate XV, figures 14—21.

Description:—Glabella convex, parallel-sided except at the very front where it is remarkably constricted and then rounded forward; three pairs of glabellar furrows short, but sometimes strong; the first pair originated from the depressions on the dorsal furrow located just behind the frontal groove; the second pair most indistinct; the third pair strong and obliquely backward; dorsal and occipital furrows strong; occipital lobe produced back into a spine, but the spine differs in size, sometimes very narrow, but sometimes stout and consequently the occipital lobe takes a subtriangular shape; fixed cheek nearly as wide as the glabella along the base, but is only of a half breadth of the glabella in front of the eye; the palpebral lobe medium sized and located at the mid-length of the cheek; eye-line narrow, not strong, but still well observable, and lies diagonally across the fixed cheek from the anterior end of the eye to the lateral extremity of the glabellar front; frontal brim flat and inclined backward, rather broad on the cheek, but narrowed in the middle through the overlapping of the glabella; surface of the test roughened by punctation, but frequently the punctae are worn down to some extent.

Pygidium exclusive of the spines subtrapezoidal; articulating margin turns back on the lateral half of the pleural portion; axial lobe subcylindrical, slightly narrowing back, ending in a rounded back and divided into four rings and a semi-circular terminal lobe; pleural lobe consists of four strong ribs and grooves, the former of which almost die out on the marginal border, but are recognized again by the projection of spines corresponding to them; six marginal spines counted on each side of the pygidium and nearly of equal length; the first spine directed postero-laterally, but from anterior to posterior the spines change their direction and the posterior two or three are directed posteriorly.

Comparisons:—Among the Oriental *Dorypyge* *D. laevis* which is represented by the cephalon only, is most close to this species, but the position of the eye is more posterior in this species, and if the punctation is well preserved, there should be no trouble making specific distinctions. In the presence of frontal constrictions on the glabella this species seems to be somewhat related to *Dorypyge* s. str., but in the parallel-sided glabella and equal length of the pygidial spines it is more allied to *Kootenia*. The outline of the glabella together with the three pairs of the glabellar furrows and six pairs of the subequal spines, and the absence of axial spines on the pygidium are the distinguishing specific characters.

Formation and locality:—*Olenoides* zone of Neietsu.

PA1006-18-11

PA1007-18-12,13

Kootenia damesi, new species.

Plate XVIII, figures 11—13.

The cranidium in hand is fragmentary, but it bears several marked characters. The glabella is considerably convex and elevated above a slightly convex fixed cheek; dorsal furrow subparallel, a little sinuated just behind the frontal brim; anterior half of the fixed cheek narrower than half breadth of the glabella; eye-band distinct, marked by a groove inside; eye-ridge highly oblique and lies across the fixed cheek; frontal margin of the cranidium arched in the middle, frontal brim convex and thick but flattens out inwardly; surface smooth.

The pygidium exclusive of the spine semi-elliptical; axial lobe conical, consists of six lobes and five grooves; pleura divided into five ribs and four grooves; the ribs produced into spines and do not weaken near the margin; the spine nearly of equal length and directed more postero-laterally than those of *Kootenia punctata*. the pleural groove remarkably deepened at a short distance within the margin.

Formation and locality:—*Megagraulos* zone of Doten.

PA1008-22-5

PA1009-22-6.

Kootenia asiatica, new species.

Plate XXII, figures 5—6.

Description:—Glabella roundly elevated, parallel-sided and rounded in front; axial furrows fairly strong; the first and second lateral furrows indicated simply by pits along the axial furrows; the third furrows short and transverse; occipital furrow strong, and neck-ring triangular, pointed back; fixed cheek less convex than the glabella, its breadth across the eye about half that of the glabella; palpebral lobe of medium size, located at the mid-length of the cephalon and distinctly elevated; palpebral ridge diagonally across the cheek from the eye to the antero-lateral corner of the glabella; the frontal brim convex forward, relatively thick and wire-like; facial sutures anterior to the eyes parallel to each other and those posterior to the eyes diagonal with a little convexity; surface has irregular and fine wrinkles.

Pygidium semi-circular; axis composed of an articulating segment, four rings and a terminal lobe; articulating segment narrow and strong on the pleural portion, crosses the marginal border and is produced into a short spine; the rest of the pleura divided into three ribs by grooves which end inside of the marginal border which in turn is defined by a groove inside, broadened posteriorly and serrated; the margin is distinctly sinuated inward behind the axial lobe; surface smooth.

Comparisons:—This species is very close to *Kootenia ellsi* (Walcott)[1] of the Lower Cambrian near Quebec and *Kootenia serrata* (Meek)[2] of the Middle Cambrian of Montana. Walcott's species, however, differs from this species in possessing a sharp occipital spine and a pair of pits at the anterior end of the axial furrows and its frontal brim is not as strong as that of this species. The pygidium of his species has one segment more and lacks sinuation of the margin posterior to the axial lobe. Meek's species is distinguished from this by its narrower glabella, and transverse posterior margin of the occipital ring. The margin of its pygidium is not so deeply serrated as that of this species and has no posterior sinuation.

This differs from *Kootenia punctata* Kobayashi from the *Olenoides* zone of Neietsu, South Chosen and *Kootenia damesi* Kobayashi from the *Megagraulos* zone of Doten, South Chosen primarily in the mode of serration of the margin of the pygidium. *Kootenia damesi* also has very narrow fixed cheeks.

Formation and locality:—A boulder of light gray limestone found in a valley east of Chuwa, Heian-nan-do, Chosen. As the valley is covered by the *Redlichia* shales only, the boulder is supposed to come from the Lower Cambrian strata.

1) *Olenoides ellsi* Walcott(1880), 10th Ann. Rep. U. S. Geol. Surv. p. 642.
2) *Bathyuriscus serratus* Meek(1878), 6th Ann. Rep. U. S. Geol. Surv. Terr. p. 480.

Genus DORYPYGE Dames, 1883.

1883. *Dorypyge* Dames, in Richthofen's China, 4, Berlin, p. 23
1885. *Dorypyge* Zittel, Handbuch d. Palaeont., 2, München, p. 596.
1886. *Dorypyge* Walcott, Bull. U. S. Geol. Surv. 30, p. 221.
1889. *Dorypyge* Walcott, Proc. U. S. Nat. Mus. 11, p. 443.
1897. *Dorypyge* Matthew, Trans. Royal Soc. Canada, sec. ser. 3, sec. 4, p. 186.
1899. *Dorypyge* Toll, Mém. l'Acad. Imp. Sci. St. Petersbourg, ser. 8, No. 10, p. 35.
1901. *Dorypyge* Lindström, Kongl. Sven. Vet. Akad. Handl. 34, No. 8, p. 22.
1902. *Dorypyge* Grönwall, Danmarks Geol. Unders., 2, p. 126.
1913. *Dorypyge* Walcott, Research in China, 3, p. 107.
1924. *Dorypyge* Zittel-Broili, Grundzüge d. Palaeont. I Abt. p. 645.
1926. *Dorypyge* Lermontova, Bull. Com. Goel. Leningrad, 43, No. 9, p.1104.

Genotype:—*Dorypyge richthofeni* Dames.

For the generic remarks see page 145.

A comment as to *Dorypyge danica* and *D. oriens* has been given on page 156. Among the European species *Dorypyge* cf. *richthofeni* by Nicholas[1] and *D. aenigma* (Linnarsson)[2] have the diagnostic characters of this genus. The latter has first been assigned as Trilobita *aenigma*, but referred by Westergård[3] to *Dorypyge*. This occurs in the *Paradoxides forchhammeri* beds.

PA1010-22-9
PA1011-22-10.

Dorypyge manchuriensis Resser and Endo (MS).

Plate XXII, figures 9-10.

1913. *Dorypyge richthofeni* Walcott (partim), Research in China, 3, p. 108, (not illustrated.)

The Sosan collection contains a number of *Dorypyge* which do not fit well with *Dorypyge richthofeni* Dames. The most noticeable difference is in the outline of glabella which is parallel-sided or rather expanded forward in the Korean specimens while it is expanded most at the mid-length of the glabella in *D. richthofeni* s. str. Careful comparisons between the two forms reveal further distinctions. In the Korean form the depressions on both sides of the frontal lobe of the glabella are not so pronounced; fixed cheek wider; anterior branches of the

1) T. C. Nicholas (1915), Notes on the Trilobite Fauna of the Middle Cambrian of the St. Tudwal's Peninsula, Carnarvonshire, (Q. J. G. S. London, Vol. LXXI,) p. 465, pl. XXXIX, figs. 10-11.

2) J. G. O. Linnarsson (1869), Om Vestergötland Cambriska och Siluriska Aflagrinar, (Kongl. Svenska Vetenskaps-Akad. Handl. Bd. 8, Nio 2,) p. 83, Taf. II, figs. 63-64.

3) G. Lundgvist, A. Högbom, and A. H. Westergård, Beskriving till Karblat Lugnas, (Sveriges Geol. Undersok. Ser. Aa, Nio 172,) p. 44.

facial sutures parallel to each other; frontal brim and eye-ridge narrow, but usually strong; occipital ring provided with a long spine. The pygidium is not very different from that of *D. richthofeni*, but the terminal lobe of the axis is relatively large and the marginal border is more pronounced.

These differences are enough to separate this form from Dames' species. Resser and Endo have proposed in their manuscript a specific name *Dorypyge manchuriensis* for the same type of *Dorypyge* as this Korean one. The specimen was collected from the chocolate coloured shale 24 meters above the white quartzite in the Fuchou series on Tschang-hsing-tao, Liaotung (35 p) and had been reported as *Dorypyge richthofeni* by Walcott but without any illustration. Here their manuscript name is adopted.

Resser and Endo are also of the opinion that Walcott's *Damesella* sp. from 35o [Walcott (1913), p. 180, Pl. 9, fig. 12,] belongs to this new species. In looking over Walcott's type, the question seems to hinge upon the length of the fifth spine which is too short for this species, though the spine seems to manifest the original shape and is whole.

Formation and locality:—This is widely distributed in Liaotung and Sosan area,[1] Chosen.

Family Pagodidae, new family.

Diagnosis:—Small trilobites with a long glabella of nearly square shape; glabellar furrows obliterated; fixed cheek of medium breadth; small and middle eyes; thick frontal rim, close to glabella; facial sutures subparallel or convergent anterior to the eyes and diagonal posterior to them; pygidium small and convex; marginal border narrow or lacking; surface smooth, punctated or granulated.

Remarks:—In my previous paper[2] I compared the *Lisania-Pagodia* group to the Leiostegidae, and insisted that there was a gap no less than of the subfamily rank between the two. They are really distinct in the size of carapace, eyes, facial suture and pygidium.

Between *Lisania* and *Pagodia* there are again so many distinctions such as the convex and elevated glabella with a large occipital ring, narrow fixed cheek, large eyes and flat rim of *Lisania*, which in turn shows many agreements with the Asaphiscidae in the cranidium and free

1) 平安北道楚山郡東面倉坪洞　楚山郡東面白壁洞　楚山郡東面建陽洞
楚山郡古面月岳洞坪洞　楚山郡古面燕頭峯　渭原郡西泰面洛葛峰北坂
渭原郡西泰面鷲岩洞北方坂路中腹

2) Kobayashi (1933), Upper Cambrian of the Wuhutsui Basin, etc. p. 105.

cheek except for the long glabella, and make it certain that *Lisania* does not belong to the Pagodidae.

Resser and Endo's *Aojia* (MS) (Pl. XXIV, figs. 3–4,) is extremely close to *Lisania*. Among the majority of *Lisania-Aojia* series the frontal limb varies little to none in size, and accordingly this series in my guess might have been introduced from the Asaphiscidae stock by the elongation of the glabella.

One more genus which probably belongs to this family is Walcott's *Hardyia*, 1924, which is based on *Hardyia metion* Walcott from the Upper Cambrian of Utah. This differs from *Pagodia* in the larger occipital ring, anterior position of the eyes, broader fixed cheeks, and convergent anterior facial sutures.

Phylogenetically the Pagodidae is probably related to the Oryctocephalidae most of whose members have a spinose pygidium, though in *Tonkinella* the pygidium is entire. The obscure glabellar furrows of *Pagodia* recalls to me some resemblance to *Avalonia*.

Pseudolisania, new genus :—Incidentally the American *Lisania* (?) *breviloba* Walcott[1] is totally different from *Lisania* s. str. in the concave frontal border, anterior eyes, narrow occipital ring, large postero-lateral limb of the fixed cheek, large pygidium with a wide concave border, and each of its pleura separated into two ribs by a groove. The Asiatic species of *Lisania* are all small trilobites of the Middle Cambrian. This American form is three times as large as the larger forms of the Asiatic *Lisania* and it is known from the Upper Cambrian of eastern North America. These reasons will be sufficient for the generic separation at least, and a new name *Pseudolisania* is proposed here, with *Lisania* (?) *breviloba* Walcott selected for the genotype. The Proparian-like facial suture of *Pseudolisania* which was already discussed in page 94 is a very significant feature. (Pl. XXII, fig. 4.)

Genus PAGODIA Walcott, 1905.

PA1012 *Pagodia shumardoides*, new species.

Plate V, figure 10.

Description :—Cranidium convex, subtrapezoidal in outline; glabella suboblong, contracted at the mid-length ; dorsal furrows subparallel, slightly divergent backwards from the point of contraction, but broadly forward from that point ; practically no glabellar furrows ; occipital

1) Walcott. (1916), Smiths. Misc. Coll. Vol. 64, No. 5, p. 404, Pl. 66, figs. 3-3c.

furrow distinct; median longitudinal ridge more or less prominent; frontal brim wire-like, narrow; eyes small, opposite the contraction in the glabella; fixed cheek narrow anterior to the eye, and rather large and triangular posterior to it; anterior branches of the facial sutures subparallel and their posterior branches divergent diagonally; surface smooth.

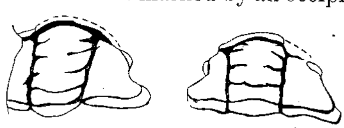
The holotype cranidium measures 3.3 mm. in length; its glabella exclusive of the neck ring 2.7 mm. in length and 2 mm. in breadth; the distance between the eyes is 3.6 mm.

Comparisons:—*Pagodia* is rather rare in South Chosen. In the present collection only two cranidia are found which at first might be surmized by their subtrapezoidal outline, strong convexity, obsolete glabellar furrows and smooth surface as being *Pagodia lorenzi*,[1] but one distinguishing feature is the striking contraction at the mid-length of the glabella and the accompanying forward expansion from that point toward the position where the maximum breadth of the glabella is located. Such a character is really unique among the known species of *Pagodia*. In *P. bia*, *P. damesi* and *P. buda* the glabella is rather strongly contracted at its middle portion, but usually the maximum breadth of the glabella is situated behind the contraction.

Formation and locality:—*Dictya* zone of Kasetsu-ji and Doten.

Genus CHEIRUROIDES, new genus.

Generic diagnosis:—Cranidium with a long glabella which is parallel sided and marked by an occipital and four pairs of glabellar furrows, the fourth pair of which is joined together on the axis; eye anterior, connected with the glabella by an ocular furrow; postero-lateral limb of the facial suture cuts the lateral margin in front of the genal angle which in turn has no spine.



Text-figure 17.
Atops orientalis
Resser and Endo, the genotype of
Cheiruroides new genus.

(R)

Genotype:—*Atops orientalis* Resser and Endo. (Pl. XXII, figs. 1–2; text–fig. 17) PA4192-22-1 PA4193-22-2

Remarks:—Endo[2] noticed the significant resemblance between *A.*

1) Kobayashi (1933), Upper Cambrian of the Wuhutsui Basin, etc. p. 112, pl. X, fig. 15.

2) R. Endo (1932), Cambrian, (Iwanami Series), p. 80.

orientalis and *A. trilineatus* Emmons. Because it possesses a distinct eye, however, this species cannot be referred to the genus *Atops*. It is more allied to *Avalonia manuelensis* in the anterior eye, ocular furrow and the posterior limb of the facial suture, but *Avalonia* is easily distinguished from this new genus by the furrowed glabella. In the general aspect *Cheiruroides* is more similar to the Cheiruridae, especially to *Cyrtometopus* and *Cheirurus*, but in addition to the occipital furrow it has several pairs of glabellar furrows and the fourth pair is united. The absence of the genal spine and the presence of the ocular furrows are also distinguishing characters. I am unable to decide as yet whether this genus belongs to the Cheiruridae, Pagodidae, Oryctocephalidae or some other family.

Arthricocephalus (?) *primigenius* Saito[1] from the *Redlichia* shale of North Chosen is quite allied to *Cheiruroides orientalis* (Resser and Endo), although the eyes of the latter is smaller than and more anterior to those of the former.

Family Damesellidae, new family.

Diagnosis:—Cephalon broad; glabella truncato-conical with three pairs of glabellar furrows of different strength; the third pair oblique, marking off triangular lobes; facial sutures subparallel anterior to the eyes and transverse posterior to them; thoracic segment provided with a long transverse groove on the pleura; pygidium with various number of spines.

The genera concerned are confined in their distribution to Eastern and Southern Asia.

Subfamily Damesellinae, new subfamily.

Damesellidae with many spines on the pygidium. (All of late Middle Cambrian of Eastern and Southern Asia.)

Stephanocare Monke, 1903.
Damesella Walcott, 1903.
Blackwelderia Walcott, 1906.

Subfamily Dorypygellinae, new subfamily.

Damesellidae with large eyes and distinct eye-ridges; pygidium with a pair of long anterior spines sprung out from the articulating

1) K. Saito (1934), Older Cambrian Trilobita and Conchostraca from North-Western Korea, (Japan. Jour. Geol. Geogr. Vol. XI,) p. 232, pl. XXV, figs. 26–29.

segment and with a serrated posterior margin between. (All of late Middle Cambrian of Eastern and Southern Asia.)

Drepanura Bergeron, 1899.

Dorypygella Walcott, 1905.

Subfamily Kaolishaninae, new subfamily.

Damesellidae with only a pair of long spines which are sprung out from the first segment on the pygidium.

Kaolishania Sun, 1924. (Middle Upper Cambrian of Eastern Asia.)

(?) *Chosenia* Kobayashi, 1934. (Lower Ordovician of South Chosen.)

Mimana, new genus. (Late Upper Cambrian of South Chosen.)

Remarks:—As it is in *Oryctocephalus*, the anterior margin of the cranidium in this family is mostly transverse. The glabella is long, conical and tapering forward. The strength of the glabellar furrows and ocular line varies with the genera. Fixed cheek is moderately wide. Palpebral lobe is medium sized, and located at about the mid-length of the cranidium. The median ridge sometimes crosses the marginal brim of the free cheek obliquely (in *Damesella* and *Stephanocare*). In *Damesella* the facial suture takes the Proparian-like course in cutting the lateral margin anterior to the extremity of the articulating margin, but never anterior to the genal spine as in the case of the real Proparian suture. *Stephanocare* and *Blackwelderia* are allied to *Kootenia* and *Dorypyge* in the pygidium.

The primary distinction from the preceding family is found in the outline of the glabella. Except for *Damesella*, complete fossils have never been found, and therefore we are not sure as to the number of the thoracic segments. According to Airaghi,[1] *Damesella paronai* has twelve thoracic segments.

The subfamily division is mainly based upon the marginal spines of the pygidium. In Walcott's types of *Drepanura* the anterior portion of the cranidium is covered by the matrix, but Monke shows the features of this portion which are of the Damesellidae type.

In *Chosenia* the glabellar outline is subelliptical and on this account the genus is unique in this family and rather similar to *Dorypyge*.

Walcott[2] once considered the Kushan genera, such as *Damesella*, *Stephanocare*, *Blackwelderia* and others as a whole being related to the

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1) Airaghi (1902), Di Acuni Trilobiti della Cina, p. 12.

2) Walcott (1913), Cambrian Faunas of China, p. 53.

Olenoides-Dorypyge group. When we take into consideration the dominance of that group as well as of *Oryctocephalus-Tonkinella* group in the various horizons of the Middle Cambrian on both sides of the Pacific, it appears at present that the best interpretation would be to recognize this family as a derivative of either one of these groups.

As suggested by Sun[1], *Kaolishania* in the middle Upper Cambrian is possibly a descendant of *Blackwelderia* or its allied genera.

Subfamily Damesellinae, new subfamily.

Genus STEPHANOCARE Monke, 1903.

1903. *Stephanocare* Monke, Jahrb. Königl. Preuss. Geol. Landesanstalt, Vol. 23, Pt. I, p. 136.

1913. *Stephanocare* Walcott, Research in China, 3, Carnegie Inst. 54, p. 113.

Genotype:—*Stephanocare richthofeni* Monke.

Remarks:—Monke included the generic discussion in the description of the type species. Walcott referred certain species of his *Damesella* to *Stephanocare*. The generic comparison, however, was never carried out.

The carapace of *Stephanocare richthofeni* is elegantly ornamented, most conspicuously at the indented anterior and posterior margins of the cephalon. In the essential features, however, this cephalon is not different from that of *Damesella*. The distinction will be found rather in the pygidium.

In the pygidium of *Stephanocare* no trace of marginal border can be observed from the dorsal side; the marginal thickening is found only in the ventral view. The marginal spines are directly produced from the pleural ribs without any interruption, while in *Damesella* and *Blackwelderia* the brim is fairly clear, and the pleural grooves usually end inside of it.

In North China *Stephanocare richthofeni* is usually accompanied by *Drepanura*, *Blackwelderia* and others, while in South Chosen, the *Stephanocare* zone is found below the zone containing *Drepanura*, *Damesella*, *Blackwelderia* and others and the association includes only *Agnostus* and *Eodiscus*. With such a situation it has been proved that Monke combined the detached portions of *S. richthofeni* correctly.

Geological and geographical distribution:—Late Middle Cambrian of Chosen, Manchuria and North China.

1) Sun (1924), Contribution to Cambrian Faunas of North China, p. 53.

Stephanocare richthofeni Monke.

PA1013-13-4
PA1014-13-5
PA1015-13-6,7.

Plate XIII, figures 4–7.

1903. *Stephanocare richthofeni* Monke, Beiträge zur Geologie von Schantung, 1, Obercambrische Trilobiten von Yen-tsy-yai, p. 136, Pl. VIII, figs. 1–17.
1905. *Damesella chione* Walcott, Proc. U. S. Nat. Mus., Vol. XXIX, p. 40.
1905. *Olenoides richthofeni* Woodward, Geol. Mag. New Ser. Dec. V,2, p. 254, Text-fig. 2, Pl. 13, figs. 1, 2, 6.
1913. *Stephanocare richthofeni* Walcott, Cambr. Faunas of China, Vol. III, p. 114, Pl. VII, figs. 17, 17 a-f.
1915. *Stephanocare richthofeni* Mansuy, Faunes Cambriennes du Haut-Tonkin, p. 2. (Listed).
1916. *Stephanocare richthofeni* Mansuy, Faunes Cambriennes de l'Extrême-Orient Méridional, p. 19.
1922. *Stephanocare richthofeni* Sun, Cambrian Faunas of North China, p. 32, Pl. II, figs. 5 a-c.
1931. *Stephanocare richthofeni* Kobayashi, Japan. Jour. Geol. Geogr. Vol. VIII, p. 174, Pl. XX, fig. 2.

Formation and locality:—This species is widely distributed in the Kushan beds and its equivalents in China and Manchuria. In South Chosen it occurs at Shokudo, Kasetsu-ji and Saisho-ri in the *Stephanocare* zone, below the *Drepanura* zone, while in the other regions this species is frequently found in association with *Drepanura* and others.

Stephanocare (?) *quinquespina*, new species.

PA1016-12-14.

Plate XII, figure 14.

Description:—Pygidium semi-circular; axial lobe cylindrical, rounded at the posterior end and divided into five rings; pleura divided into five lobes which are produced into spines; the fifth pleural lobe is, however, to be perceived in the marginal spine only; surface smooth.

This pygidium like that of the preceding species, consists of five segments, but is to be distinguished from that by its stout axis and pleural lobes and by the directions of the spines which are divergent in this species, while all directed backward in that one.

Formation and locality:—*Drepanura* zone of Shokudo.

Stephanocare bergeroni, new species.

PA1017

Plate XI, figure 9.

1903. *Teinistion sodeni* Monke, (partim), Obercambrische Trilobites von Yen-Tsy-yai, p. 123, Pl. 5, figs. 3–4.

Description:—Pygidium of moderate size, roundly triangular with serration on the margin; axis conical, rounded at the posterior end; axis and pleurae divided into five fused segments; five spines corresponding to the pleural lobes prominent and all directed backward; the first and fifth spines longer than the other three between them; surface smooth.

Comparisons:—A pygidium designated by Monke as *Teinistion sodeni*, (pl. 5, fig. 4,) is almost identical with this. For the distinction from the pygidium of *Teinistion lansei* he mentions that "ein wesentlicher Unterschied besteht darin, dass sich das Pygidium nicht aus 6, sondern nur aus 5 Pleuren aufbaut."

To combine the detached parts of trilobites into species is a dubious task and frequently we see quite unexpected combinations when the complete carapace is found. Since Monke's study was completed, Walcott undertook a more closer research and, though still tentative, he tied another type of pygidium with a pair of long spines with the cephalon of *Teinistion*. It is true that the pygidia of *Teinistion sodeni* as well as *T. lansei* are so close to that of *Stephanocare richthofeni* in the fundamental features that they may quite possibly be congeneric with it; therefore, in agreeing with Walcott's idea, this pygidium is here assigned to *Stephanocare*, with a new name. *T. sodeni* should be limited to the form represented by its cephalon, (Monke, Pl. 5, figs. 1–2.)

Formation and locality:—*Drepanura* zone of Saisho-ri.

Genus DAMESELLA Walcott, 1905.

1905. *Damesella* Walcott, Proc. U. S. Nat. Mus. 29, p. 34.
1913. *Damesella* Walcott, Research in China, 3, p. 123.

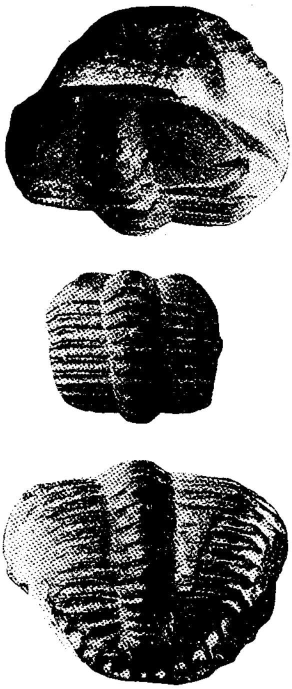
Genotype:—*Cheirurus paronai* Airaghi, (i. e. *Damesella blackwelderi* Walcott.)

Remarks:—Since Walcott's elaborate study, the generic research of *Damesella* has not proceeded much further. Unfortunately, however, he failed to refer to Airaghi's paper of 1902[1] which is of the prime importance in any consideration of *Damesella*. (See Text-fig. 18.)

Airaghi's *Cheirurus paronai* is a unique complete specimen of *Damesella blackwelderi* with the aid of which we are able to see that Walcott's combination of detached carapaces is correct in the main, only a slight doubt as to the pygidium, whether the first and fifth pairs

1) Carlo Airaghi (1902), Di Alcuni Trilobiti della Cina, (Atti della Sociatà Italiana di Scienze Naturali, Vol. XLI.)

of the pygidial spines are so prominent or not, remaining, because Airaghi's specimen does not have the ends of the spines. Twelve thoracic segments are counted on Airaghi's specimen.



Text-figure 18.
Damesella paronai (Airaghi).
[Reproductions of Airaghi's original figures 29, 29 a & 30, on plate I, (1902).]

As noticed by Walcott, *Damesella* and *Blackwelderia* are certainly much alike in the thorax and pygidium, but he suggested distinguishing points, stating that the latter differed "in having a flat, straight groove on the pleural lobe of the segments of the thorax, proportionately broader furrows on the pleural lobe of the pygidium, and a concave frontal limb on the cephalon with a narrow rim."

As yet we really do not know what kind of the pygidium belongs to *Blackwelderia*. However, if we assume Walcott's combination of the detached carapace to be correct, it can be said that most pygidia of *Damesella* are transversely semi-elliptical, while those of *Blackwelderia* are more triangular, and the glabellae and axial lobes on the pygidia of the latter are tapering more rapidly than those of the former, and the posterior end of the axial lobes are sometimes pointed back, as seen on the pygidia of *Stephanocare*. Finally it is noted that the specific name of the genotype *Damesella blackwelderi* Walcott 1905, is to be changed to *Cheirurus paronai* Airaghi, 1902, because of priority; *Damesella chione* Walcott, 1905, also to *Stephanocare richthofeni* Monke, 1903, for the same reason.

Damesella cf. *brevicaudata* Walcott.

1905. cf. *Damesella brevicaudata* Walcott, Proc. U. S. Nat. Mus. Vol. XXIX, p. 39.
1913. cf. *Damesella brevicaudata* Walcott, Cambrian Faunas of China, p. 128, Pl. 9, fig. 9.

1915. cf. *Damesella speciosa* Mansuy, Faunes Cambriennes du Haut-Tonkin, p. 13, Pl. II, fig. 5.

1915. cf. *Damesella dongvanensis* Mansuy, ibid. p. 13, Pl. II, fig. 7.

1916. cf. *Damesella brevicaudata* Mansuy. Faunes Cambriennes de l'Extrême-Orient méridional, p. 21, Pl. I, fig. 31; Pl. II, fig. 1 a-z.

Walcott established this species with only the pygidium as the basis. Mansuy found the cranidium and cheek of *Damesella* from Tonkin and, in distinguishing two forms, called them by the names, *D. speciosa* and *D. dongvanensis*. Through further study he found these species were synonymous with *D. brevicaudata*.

In comparing with Walcott's and Mansuy's *D. brevicaudata* the first and fifth pairs of the marginal spines on the present specimen are not so much produced and the surface of the test is smooth. Therefore, further study may separate this form specifically. This is easily distinguished from *Damesella paroni* (Airaghi) by the number of marginal spines which is twelve, instead of fourteen, in Airaghi's species.

It is noted that the cranidium of *D. brevicaudata* is very close to *Kaolishania*, although the associated pygidia of both genera are quite distinct from each other.

Formation and locality:—*Drepanura* zone of Kasetsu-ji and Saisho-ri. This species is also known from the *Drepanura* zone of China and Tonkin.

PA1018-11-1
PA1019-11-2
PA1020-11-3
PA1021-12-17

Damesella octaspina, new species.

Plate XI, figures 1-3; Plate XII, figure 17.

In the essential features this pygidium is the same as that of *Damesella brevicaudata*, but simply differs from that in the number of marginal spines. This pygidium has eight, instead of seven, pairs of spines among which the first and sixth pairs are longer than the others and also the axial lobe is tapering a little more acutely and is less rounded at the posterior end than it is in *D. brevicaudata*. The surface is entirely smooth.

Formation and locality:—*Drepanura* zone of Shokudo and Kasetsu-ji.

Genus BLACKWELDERIA Walcott, 1906.

1906. *Blackwelderia* Walcott, Proc. U. S. Nat. Mus. 30, p. 573.

1913. *Blackwelderia* Walcott, Research in China, 3, p. 116.

Genotype:—*Calymene* (?) *sinensis* Bergeron.

It is interesting to notice that this cephalon is allied to certain forms of *Chuangia*, (see *Chuangia* cf. *batia*, p. 190,) especially in the presence of a concave frontal limb. The main distinction from *Chuangia* is found in the furrowed glabella, absent eye-ridge, and granulation on the carapace of some species. The most related genera are *Damesella* and *Kaolishania*. The comparisons to *Damesella* has already been made on page 168. From *Kaolishania* this genus is distinguished simply by the absence of the palpebral ridge and also by the variant features in the associated pygidium, but otherwise both genera are very close.

Walcott brought two different kinds of free cheeks into this genus, the one is represented in figure 5c, plate 9 and the other in figure 6a on the same plate, (Walcott, 1913, Op. cit.) In the latter type a sharp ridge crosses the marginal brim obliquely and it looks similar to the cheek of *Chuangia*, or its allied genera. Most cheeks found in association with *Blackwelderia* cranidium in the Korean collection are of the former kind and it is doubtful, that such different types of cheeks should belong to the same genus. It is most likely that the former type will be found to be the real *Blackwelderia*-cheek.

PA1022-11-10
PA1023-11-11
PA1024-12-10
PA1025-12-11
PA1026-12-12

Blackwelderia sinensis (Bergeron).

Plate XI, figure 11; Plate XII, figures 10–12.

1899. *Calymene* (?) *sinensis* Bergeron, Bull. Soc. géol. de France, 3d. ser. Vol. XXVII, p. 500, Pl. 13, figs. 1–2, text-figs. 1–2.

1899. *Olenoides leblanci* Bergeron, ibid. p. 506, Pl. 13, figs. 5–6; text-figs. 5–6.

1903. *Stephanocare sinensis* Monke, Jahrb. königl. Preuss. Geol. Landesanstalt u. Bergakadamie, XXIII, Pt. II, p. 142.

1906. *Blackwelderia sinensis* Walcott, Proc. U. S. Nat. Mus. Vol. XXX, p. 573.

1913. *Blackwelderia sinensis* Walcott, Cambrian Faunas of China, p. 121, Pl. 9, figs. 5, 5a–g.

1915. *Blackwelderia sinensis* Mansuy, Faunes Cambriennes du Haut-Tonkin, p. 10, Pl. II, figs. 2a–b.

1916. *Blackwelderia sinensis* Mansuy, Faunes Cambriennes de l'Extrême Orient Méridional, p. 20, Pl. II, figs. 6a–c.

A cranidium and cheek in slate (pl. XII, figs. 10–11) are strongly depressed, but it is clear that the cephalon of this species has rounded palpebral lobes. The cranidia on plate XI, figure 11 and a cheek on plate XII, figure 12 still retain the convexity. The posterior margins of the cranidia have distinct indentation, as seen on *Stephanocare richthofeni*.

Formation and locality:—*Drepanura* zone of Kasetsu-ji, Saisho-ri and Doten. This species is widely distributed in the same zone from Manchuria to Tonkin through China.

Blackwelderia cf. *sinensis* (Bergeron)

PA1027

Plate XII, figure 9.

The pygidium in hand is quite similar to Walcott's pygidium of this species illustrated in figure 5 g on plate 9, except for one point that this pygidium has seven pairs of lateral spines in addition to a posterior spine. Walcott combined smooth thoracic segment and pygidium with a strongly granulated cephalon, but this is questionable.

Formation and locality:—*Drepanura* zone of Kasetsu-ji.

Blackwelderia paronai (Airaghi).

PA1028

Plate XII, figure 13.

1902. *Olenoides paronai* Airaghi, Di Alcuni Trilobiti della Cina, (Atti Soc. Italiana Sci. 41), p. 20, Pl. I, figs. 1–21.
1905. *Olenoides* (?) *cilix* Walcott, Proc. U. S. Nat. Mus. Vol. XXIX, p. 27.
1906. *Blackwelderia cilix* Walcott, Proc. U. S. Nat Mus. Vol. XXX, p. 573.
1913. *Blackwelderia cilix* Walcott, Cambrian Faunas of China, p. 119, pl. 9, figs. 6, 6a-c.
1915. *Blackwelderia cilix* Mansuy, Faunes Cambriennes du Haut-Tonkin, p. 11, Pl. II, fig. 3.
1916. *Blackwelderia cilix* Mansuy, Faunes Cambriennes de l'Extrême-Orient Méridional, p. 20.

Airaghi's figures 16–16e clearly show the identity between his and Walcott's species. Both have the same outline, five pairs of short lateral spines, the long sixth pair of spines and a pair of short posterior spines. According to the rule of priority Walcott's well known name should be changed to *Blackwelderia paronai* (Airaghi).

Formation and locality:—*Drepanura* zone of Kasetsu-ji and Saishorí; this has an extensive distribution in the Kushan beds in Eastern and Southern Asia.

Blackwelderia cf. *alastor* (Walcott.)

PA1029

Plate XII, figure 8.

1905. cf. *Dorypygella alastor* Walcott, Proc. U. S. Nat. Mus. 29, p. 31.
1913. cf. *Blackwelderia alastor* Walcott, Research in China, 3, p. 117, Pl. 9, fig. 7.
1915. cf. *Blackwelderia alastor* Mansuy, Faunes Cambriennes du Haut-Tonkin, p. 12, Pl. II, figs. 4a-b.
1916. cf. *Blackwelderia alastor* Mansuy, Faunes Cambriennes de l'Extrême-Orient Méridionale, p. 20, Pl. II, figs. 5a–b.

The pygidium in hand is very close to this species, but it has only six pairs of marginal spines and its outline is transverse with a straight frontal margin, whereas the spines come in seven pairs and the outline is more triangular with convex anterior margin in *B. alastor*. For these reasons I hesitate to make the definite specific identification.

Formation and locality:—*Drepanura* zone of Kasetsu-ji.

Subfamily Dorypygellinae, new subfamily.

Genus DORYPYGELLA Walcott, 1905.

1905. *Dorypygella* Walcott. Proc. U. S. Nat. Mus. 29, p. 29.
1913. *Teinistion* Walcott, (in part) Research in China, 3, p. 109.

Genotype:—*Dorypygella typicalis* Walcott.

See the remarks on *Teinistion* on page 254.

Genus DREPANURA Bergeron, 1899.

1899. *Drepanura* Bergeron, Bull. Soc. Géol. de France, 3d. ser. Vol. XXVII, p. 509.
1903. *Drepanura* Monke, Jahrb. Königl. Preuss. Geol. Landesanstalt und Bergakademie, Vol. XXIII, Pt. I, p. 124.
1913. *Drepanura* Walcott, Cambr. Faunas of China, p. 129.
1924. *Drepanura* Zittel-Broili, Grundzüge d. Palaeont. Abt. 1, p. 646.

Remarks:—Basing upon the pygidium of *Drepanura premesnili*, Bergeron established this genus; and Monke found the cephalon of the genotype species and added another species *Drepanura ketteleri*. The genus and species have been fully discussed by Bergeron, Monke and Walcott.

The pygidium of *Drepanura* is much allied to that of *Dorypygella* in its long lateral spines originating from the articulating segment and in its serrated margin between the spines. If the hypostoma illustrated in figure 20 on plate 10 in Walcott's monograph really does belong to *Drepanura*, then the difference is very profound. But the cephalon of *Drepanura ketteleri* described and illustrated by Monke and Walcott are not very far from those typical in the Damesellinae.

It is noted that the cranidium of *Drepanura premesnili* is quite allied to that of *Ambonolium lioderma* Raymond.

Genotype:—*Drepanura premesnili* Bergeron.

Geological and geographical distribution:—Kushan beds and its equivalents of Eastern Asia. Mansuy assigned a form from *Ptychaspis angulata* zone as *Drepanura* (?) sp., but it is more possible to be a pygidium of *Kaolishania*, because the margin has no deticulation and its lateral spines are located at the middle of the lateral margin.

PA1030-11-7
PA1031-11-8
PA1032-12-7

Drepanura premesnili Bergeron.

Plate XI, figures 7-8; Plate XII, figure 7.

1899. *Drepanura premesnili* Bergeron, Bull. Soc. Géol. de France, 3d. ser. Vol. XXVII, p. 509. Pl. 13, fig. 8.
1902. *Drepanura premesnili* Airaghi, di Alcuni Trilobiti della Cina, p. 24, Pl. I, figs. 31.
1903. *Drepanura premesnili* Monke, Jahrb. Königl. Preuss. Geol. Landesanstalt u. Bergakademie, Vol. XXIII, Pt. I, p. 124, Pl. 5, figs. 5–9; Pl. 9, No. 4.
1905. *Drepanura premesnili* Woodward, Geol. Mag. New Ser. 2, p. 253, fig. 1, Pl. 13, fig. 3.
1913. *Drepanura premesnili* Walcott, Cambrian Faunas of China, p. 129, Pl. 10, figs. 2, 2a–d; Pl. II, figs. 1–5.
1916. *Drepanura* cf. *premesnili* Mansuy, Faunes Cambriennes de l'Extrême-Orient Méridional, p. 23, Pl. II, fig. 8; Pl. III, fig 1.
1931. *Drepanura premesnili* Kobayashi, Japan. Jour. Geol. Geogr. Vol. VIII, p. 175, Pl. XX, fig. 19.

Airaghi's pygidia in figure 31, Pl. I, are safely identified to this species, but the pygidium in figure 32, on the same plate has too widely divergent lateral spines for this species and appears to be closer to *Drepanura ketteleri* Monke.

Formation and locality:—This species is widely distributed in the *Drepanura* zone of Manchuria, Chosen, and China; The form from Chang-poung described by Mansuy carries some doubt as to its exact identity because "les denticules marginaux du pygidium ne sont pas conserves."

PA1033-12-15
PA1034-12-16

Drepanura ketteleri Monke.

Plate XII, figures 15-16.

1902. *Drepanura premesnili* Airaghi, di Alcuni Trilobiti della Cina, Pl. I, fig. 32, only.
1903. *Drepanura ketteleri* Monke, Obercambrische Trilobiten von Yen-Tsy-Yai, p. 132, Pl. 6, figs. 1–14; Pl. 9, No. 5.
1905. *Drepanura ketteleri* Woodward, Geol. Mag. New Ser. 2, Pl. 13, fig. 4.
1913. *Drepanura ketteleri* Walcott, Cambrian Faunas of China, p. 129, Pl. 20, figs. 3, 3a–c.
1916. *Drepanura ketteleri* Mansuy, Faunes Cambriennes de l'Extrême Orient Méridional, p. 23, Pl. II, fig. 7.

Formation and locality:—This is a well known species from China. It is also common in the *Drepanura* zone of South Chosen, found at Kasetsu-ji, Saisho-ri and Doten.

Subfamily Kaolishaninae, new subfamily
Genus KAOLISHANIA Sun, 1924.

1924. *Kaolishania*, Sun, Contributions to the Cambrian Faunas of North China, p. 52.

1933. *Kaolishania*, Kobayashi, Upper Cambrian of the Wuhutsui Basin, etc. p. 103.

Genotype:—*Kaolishania pustulosa* Sun.

Remarks: – *Kaolishania* of the middle part of the Upper Cambrian, *Mimana* of the late Upper Cambrian and *Chosenia* of the Lower Ordovician are mutually related in the glabella, medium sized palpebral lobes at the mid-length of the cephalon and thick marginal brim. The pygidium usually has a pair of lateral spines which spring from the second pleural lobes. *Mimana*, however, differs from *Kaolishania* primarily in the course of the facial suture and other respects; *Chosenia* differs from *Kaolishania* as well as *Mimana* by the rounded outline of its glabella and broad fixed cheeks.

In the general feature the *Kaolishania* group is, as noticed by Sun,[1] very close to the *Blackwelderia* group of the Kushan shale, and it is quite possible that the former group was derived from one genus of the latter or had branched off from the same stock as the latter group.

Albertella of the Ptarmigan is another genus which suggests a relationship with the *Kaolishania* branch and this is the reason why I[2] once tentatively put *Kaolishania* in the Ceratopygidae. Close comparisons with *Ceratopyge*, however, reveals quite a difference in the configuration of the cranidium, *Ceratopyge* having a forward expanded, oblong glabella, three pairs of glabellar furrows which are divergent from side to axis, median pustule on the posterior portion of the glabella, triangular side lobes on both sides of the glabellar lobe, relatively wide frontal limb and so on. Although the pygidium of *Ceratopyge* is somewhat similar to those of the *Kaolishania* group, I deem it wise to abandon the search for an actual relationship between the two groups.

PA1035-8-9
PA1036-8-10
PA1037-8-11
PB913 =PA1038-9-14
PB913 =PA1039-9-15

Kaolishania granulata Kobayashi.

Plate VIII, figures 9—11; Plate IX, figures 14—15.

1913. cf. *Teinistion* (?) sp. undt. Walcott, Cambrian Faunas of China, p. 222, pl. 9, fig. 4.

1933. *Kaolishania* (?) *granulosa* Kobayashi, Upper Cambrian of the Wuhutsui Basin, etc. p. 104, Pl. XI, figs. 19—20.

1) Sun (1924), Cambrian Faunas of North China, p. 5.
2) Kobayashi (1933), Upper Cambrian of the Wuhutsui Basin, etc. p. 103.

Description:—Cranidium broad, somewhat trapezoidal and strongly convex; glabella conical, well defined by the deep furrow and truncated by a frontal groove; occipital furrow and lobe strong, transversal, turning obliquely forward at both sides; three pairs of glabellar furrows quite strong among which the first and second pairs are almost transverse, but the third pair converges obliquely backward; fixed cheek strongly convex, bent down toward the front as well as toward the back from the palpebral lobe; eye-ridge prominent, starting at the point about at the second glabellar furrow and directed postero-laterally; eye elevated and located at the mid-length of the cranidium, frontal brim slightly convex forward, elevated and separated from the glabella by a narrow groove.

Free cheek convex, bordered by a strong brim and groove; the groove ends at a short distance from the genal end; the central portion of the cheek convex and continues to the genal spine; occipital groove strong and oblique and, although narrowing, is continuously extended into the genal spine. Facial sutures diagonal posterior to the eyes and almost parallel in front of the eyes.

Pygidium much shorter than that of *K. pustulosa*; frontal margin nearly straight; axis conical, gradually tapering back and ending at a round extremity just inside of the marginal groove; the axis divided into about seven rings, the posterior three being poorly defined; both extremities of the articulating margin roundly rectangular; first pleural lobe quite prominent, turning postero-laterally across the marginal border, and produced back into a long lateral spine; behind this lobe three smaller lobes are to be counted; marginal groove and border strong.

Whole surface of the cephalic shield and pygidium ornamented rather uniformly by granulation and under the test by punctation.

The figured specimens give the following dimensions;

Cranidium.	Specimen 1. (pl. VIII, fig. 9.)	Specimen 2. (pl. IX, fig. 15.)
Length of the cranidium.	11 mm.	8.8 mm.
Breadth of the cranidium.	18.5 mm.	
Length of the glabella.	9 mm.	7.8 mm.
Breadth of the glabella.	7 mm.	6 mm.
Distance between the eyes.	13 mm.	13 mm.
Basal breadth of the fixed cheek.	7 mm.	

Pygidium	specimen. (pl. XVIII, fig. 14.)
Length of the pygidium exclusive of the spine.	6 mm.
Breadth of the pygidium.	Ca. 10 mm.
Length of the axis.	5.2 mm.
Breadth of the axis.	4 mm.

Comparisons:—Walcott figured *Teinistion* (?) sp. undt. from the *Tsinania* zone of Shantung, (locality C_{54}). In comparing the specimen in U. S. National Museum with the present material from South Chosen I failed to find any considerable difference except for a point that in the Shantung species the tail has a weaker posterior brim than that of the Korean species. If *Teinistion* (?) sp. undt. from Shantung does not belong to this species, it is at least a species of *Kaolishania* closely related to this species. Based upon an incomplete cranidium from the *Kaolishania* zone of Paichia-shan, Wuhutsui basin, Liaotung I distinguished this form from *Kaolishania pustulosa* by the density of surface granulation and other characters. In examining further material from South Chosen, I find that *K. granulosa* is quite different from *K. pustulosa* by its strongly convex glabella, broad fixed cheek, deep frontal groove and thick frontal brim; however, both species are much allied in the cephalon. In the pygidium, on the other hand, they are quite distinct from each other. The pygidium of *K. granulosa* has a deep marginal groove inside of the border. In this respect it is more similar to the associated pygidium of *Kaolishania orientalis*, although it is much more transverse in outline.

Formation and locality:—Very common in the red sandstone and limestone at the middle portion of the Upper Cambrian; Doten and Saisho-ri; *Kaolishania* zone of the Wuhutsui basin, Liaotung.

(12)

Kaolishania obsolata Kobayashi. cf.

PA1040-9-17
PA1041-9-18
PA1042-9-16

Plate IX, figures 17–18, 16 (?)

1933. *Kaolishania* (?) *obsolata* Kobayashi, Upper Cambrian of the Wuhutsui Basin, etc.p.104, Pl.XI, figs. 15–16.

In the cephalon this species is quite similar to *Kaolishania granulosa* and *Kaolishania pustulosa*, but the surface is smooth and the palpebral lobe is located close to the glabella. In the red shale of the Sosan area, North Chosen, this species is associated with a pygidium which is considerably different from those of both allied species.

Formation and locality:—*Kaolishania* zone of Saisho-ri; red micaceous shale of Sankirei, Sosan area, Heian-hoku-do, Chosen.

PA1043

Kaolishania orientalis (Grabau).

Plate XII, figure 12.

1923. *Ceratopyge orientalis* Sun, Upper Cambr. of Kaiping Basin, (Bull. Geol. Soc. China, Vol. II,) p. 98, (listed).

1924. *Mansuyia orientalis* Sun, Cambrian Faunas of North China, p. 50, Pl. III, figs. 7a-h, (not 7i-j).

The pygidium here illustrated is very close to those illustrated in fiugures 7 g-h, on plate III, in Sun's paper, although its outline is a little more transverse than that of Sun's specimens.

In a great deal of Manchurian and Korean material the pygidia of *Prochuangia*, *Kaolishania* and *Mansuyia* look very much alike and at the same time no complete individual of these genera has yet been found. Therefore the reference of the detached parts of these trilobites bears considerable uncertainty. In the case of the present pygidium there is no difficulty in identifying it to Sun's pygidium, but it is a question after that, whether the pygidium actually belongs to *Mansuyia* or not, because in South Chosen no cranidium of *Mansuyia* has yet been found in association with it; instead there occur several different cranidia of *Kaolishania*.

Judging from this situation in the beds of South Chosen, it seems more possible that the pygidium belongs to a certain form of *Kaolishania*.

Formation and locality:—*Kaolishania* zone; Saisho-ri.

PA1044

Kaolishania sp.

Plate IV, figure 13.

An incomplete pygidium in hand is roundly subquadrate; rachis cylindrical, distinctly divided into several segments and elevated above the pleurae; pleural portion flat, divided into unequal ribs by narrow grooves; the second rib strong and produced into a lateral spine; marginal border smooth, undefined by any groove.

In the subquadrate outline this pygidium escapes any confusion with other described pygidia of *Kaolishania*.

The pygidium referred to *Mansuyia orientalis* by Sun[1] (fig. 7 i-j, not 7f-h) is similar to this, but differs by its larger axis and smooth pleurae.

Formation and locality:—*Kaolishania* zone; Saisho-ri.

1) Sun (1924), Cambr. Faunas of North China, pl. III, figs. 7i-j.

Kaolishania (?) sp.

Plate VIII, figure 13.

In the truncato-conical glabella, strong dorsal, glabellar, and occipital furrows, large triangular limb of the fixed cheek and other features this cranidium is quite suggestive of *Kaolishania.*

Although the specimen is imperfect, it deserves to be noticed, because it was collected from the *Dictya* zone, next higher than the *Kaolishania* zone.

In comparing with other cranidium of *Kaolishania* this cranidium is seen to be less convex; its eye relatively large and located very close to the glabella; and the surface entirely smooth.

Formation and locality:—Dictya zone; Doten.

Genus MIMANA, new genus.

Remarks:—This genus is similar to *Kaolishania* and *Chosenia.* It differs, however, from *Kaolishania* in its expanded facial suture, median and large eyes and in the features of the free cheek on the one hand, from *Chosenia* in its truncato-conical glabella and narrow cheek on the other.

Genotype:—Mimana eurycephala, new species.

Geological and geographical distribution:—Late Upper Cambrian; South Chosen.

Mimana eurycephala, new species.

Plate VIII, figure 7.

Description:—Cephalon broad, convex; glabella truncato-conical, elevated; three pairs of glabellar furrows V-shaped and disconnected in the middle; median longitudinal ridge moderately distinct; occipital furrow and lobe strong, slightly convex backwards; fixed cheek narrow, convex, bent down anterior to the eye; eye large, located at the mid-length of the cranidium; eye-ridge oblique, started from the first pair of glabellar furrow; frontal brim wire-like, marked by a groove inside and convex forward; facial suture posterior to the eye transverse and sharply bent back at the lateral end; its anterior branch diagonal in front of the eye, but in crossing the frontal groove, is recurved inward abruptly; surface granulated.

Formation and locality:—Dictya zone; Doten.

Mimana (?) sp.

Plate V, figure 12.

The cranidium is imperfect, but its subconical glabella, large middle eyes close to the glabella, and other features remind me of *Mimana eurycephala*. Yet this form differs from *M. eurycephala* in its elongate outline, the more transverse glabellar furrow and smooth surface.

As the frontal portion is not preserved, the generic position cannot be determined exactly.

Formation and locality:—*Dictya* zone; Doten.

Genus CHOSENIA Kobayashi, 1934.

1934. *Chosenia* Kobayashi, Cambro-Ordovician Formations and Faunas of South Chosen, Palaeontology, Part. II, Lower Ordovician Faunas, p. 567.

Genotype: *Chosenia laticephala* Kobayashi.

For this genus, see the description in the cited paper.

Family Lloydidae, new family.

Diagnosis:— Cephalon with a subtriangular to subtrapezoidal glabella; third glabellar lobes triangular and well marked off by furrows; eyes anterior to middle; fixed cheek narrow anterior to the eye, and large and triangular posterior to the eye; frontal limb little or none; thorax composed of nine segments; pygidium semi-circular and convex; surface smooth.

All genera are, so far as is known, confined to North America.

Lloydia Vogdes, 1890. (Genotype: *Bathyurus bituberculatus* Billings.)

Glabella strongly convex, well defined by dorsal furrows and projected upon the rim; pygidium with a distinct convex border defined by a marginal groove. (Lower Ordovician of North America.)

Ambonolium Raymond, 1924. (Genotype: *Ambonolium lioderma* Raymond.)

Cranidium with a narrow frontal limb; eyes anterior; pygidium without marginal border. (Upper Cambrian of eastern North America.)

Cheilocephalus Berkey, 1898. (Genotype: *Cheilocephalus st.-croixensis* Berkey.) (Pl. XXIV, fig. 20.)

Glabella subtrapezoidal, elevated above the cheek, and gently sloping forward; glabellar furrows all obscure; the third pair oblique; eyes small and anterior; frontal border flat and narrow. (Upper Cambrian of Minnesota.)

In many respects this family resembles the Leiostegidae, but the essential difference is found in the aspects of glabella. This family in my opinion may have been derived from the Kaolishaninae through a loss of spines on the pygidium, this being a conspicuous tendency in the evolution of the whole Damesellidae from the Middle Cambrian to the Lower Ordovician.

Genus LLOYDIA Vogdes, 1890.

1890. *Lloydia* Vogdes, Bull. U. S. Geol. Surv. No. 63, p. 17.
1913. *Lloydia* Raymond, Victoria Mem. Mus. Bull. No. 1, p. 66.

In applying Vogdes' name, Raymond gave the diagnosis based upon *Bathyurus bituberculatus* Billings.

Later on, he[1] put this genus in his Asaphiscidae, but with the members of that family some space of the frontal limb is usually left between the glabella and marginal border. Such a strong convex border as is exhibited by *Lloydia* is also never found on the pygidium of any genus in the Asaphiscidae.

Raymond referred three species of Billings' *Bathyurus* to this genus ;—*Bathyurus bituberculatus*, *B. saffordi*, and *B. solitarius* ; Bradley[2] added three new species —*L. amplimarginata*, *L. pinguis*, and *L. obscura* from the Beekmantown of Philipsburg Region, Quebec. Judging from the parallel sided glabella and other features, *L. pinguis* is undoubtedly a *Leiostegium*.

L. obsoletus Phleger[3] from the Mazourka (Chazyan) formation of Inyo Mountain, California, might be the latest representation of this genus, but the parallel sided, oblong glabella, wide and gently convex marginal border, and eight, instead of nine, thoracic segments throw doubts upon the generic reference.

Family Leiostegidae Bradley.

Diagnosis :—Trilobites with long and square glabella; eye medium and about middle to posterior; frontal rim narrow and strong; pygidium wide, short and convex; no concave border.

Remarks: —This is a large and well defined family starting from Middle Cambrian and terminating in the Lower Ordovician and distributed in South and Eastern Asia, North and South America to Novaya Zemlya and northern Siberia across the Atlantic Ocean.

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1) Raymond (1924), Op. cit. p. 408.

2) J. H. Bradley, jr. (1925), Trilobites of the Beekmantown in the Philipsburg region of Quebec, (Canadian Field-Natural. Vol. XXXIX, No. 1,) pp. 7-8.

3) Fred B. Phleger jr. (1933), Notes on Certain Ordovician Faunas of Inyo Mountains, California, (Bull. Southern California Acad. Sci Vol. XXXII.)

The divisions of subfamily are based upon the breadth of the fixed cheek and position of the eyes, presence or absence of spines on the pygidium and texture of the carapace.

Subfamily Eochuanginae, new subfamily.

Leiostegidae with a broad, fixed cheek, posterior axial spine on the pygidium and granulated surface. (Middle Cambrian of Eastern Asia.)
Eochuangia, new genus. (Genotype : *Eochuangia hana,* new species.)

Subfamily Leiosteginae, new subfamily.

Leiostegidae with a broad to medium fixed cheek, middle eyes, no pygidial spine except in *Prochuangia* ; surface smooth. (Upper Cambrian to Lower Ordovician.)

1. *Chuangia* Walcott, 1911.(Genotype: *Ptychoparia*(?)*batia* Walcott.)
2. *Leiostegium* Raymond, 1913. (Genotype : *Bathyurus quadratus* Billings.)
3. *Koldinia* Walcott and Resser, 1924. (Genotype : *Koldinia typa* Walcott and Resser.)
4. *Leiostegioides* Kobayashi, 1934. (Genotype : *Leiostegioides raymondi* Kobayashi.)
5. *Prochuangia,* new genus. (Genotype : *Prochuangia mansuyi,* new species)
6. *Chuangiella,* new genus. (Genotype : *Chuangiella elongata,* new species.)

Subfamily Illaenurinae Raymond.

Narrow fixed cheek, and middle to posterior eyes are the distinguishing characters. Surface smooth or granulated. (Upper Cambrian to Lower Ordovician of North America.)

Illaenurus Hall, 1863.(Genotype : *Illaenurus quadratus* Hall.) (Upper Cambrian.)

Platycolpus Raymond, 1913.(Genotype : *Bathyurus capax* Billings.) (Upper Cambrian.)

Cholopilus Raymond 1924. (Genotype : *Cholopilus vermontanus* Raymond.) (Lower Ordovician.)

Subfamily Eochuanginae, new subfamily.

Genus EOCHUANGIA, new genus.

Generic diagnosis :—Cephalon, excepting a pair of stout spines, semi-circular surrounded by a striated strong brim ; cranidium like that of *Chuangia*, but has no frontal limb at all; glabella quadrate, convex and elevated; fixed cheek narrow, its breadth across the eyes corresponding to nearly half the breadth of the glabella; free cheek wide; genal spine strong, produced postero-laterally; marginal and occipital grooves end on both sides of the spines.

Pygidium subtriangular, convex; axial lobe conical, elevated above the cheek, divided into more than five rings and produced back into a long spine; pleural lobe bent down near the margin and distinctly divided into about four ribs and grooves; the margin entire, without any border.

Surface of the cephalon and pygidium granulated.

Remarks:—In the cranidium this genus certainly resembles the members of the *Chuangia* group of the Upper Cambrian, but as far as the described species of *Chuangia*, *Prochuangia* and *Chuangiella* are concerned, such a granulated test has never been found in the group. In the free cheek of *Chuangia* a sharp ridge runs across the brim obliquely and marks off the transversely lined outer slope from the smooth inner one. The pygidium of this genus exclusive of the posterior spine is not essentially different from that of *Chuangia*, but the prominent feature of the spine, which appears somewhat similar to that of *Symphysurina* serves for ready generic distinction.

Genotype:—*Eochuangia hana*, new species.

Geological and geographical distribution:—Middle Cambrian of Chosen.

Eochuangia hana, new species.

Plate XVI, figures 10–17.

The general description and generic comparisons have already been given above.

Observations:—This is a very common species in the *Olenoides* fauna of Chosen. Among the material in hand two or three forms may possibly be distinguished. The first form has a very wide, quadrate glabella; the glabella of the second one is also quadrate, but much narrower; and the glabella of the third one is distinctly conical. In most pygidia the axial lobe is as broad as one-fourth the pygidium, but in one specimen the lobe is parallel sided and nearly one-third the breadth of the pygidium; the outline is also much more transverse than with the others. Additional research upon the *Eochuangia* may spread these forms into distinct species, but as the specimens now available for study are somewhat secondarily deformed, and as these forms themselves seem to be interconnected by some intermediate ones, further separation is not attempted here. Therefore the third type of cranidium only will be isolated from the others as a new variety.

One thing to be noted here is that the pygidium has a quite distinct feature under the test. The pleural ribs are normal on the surface, but under the test they exhibit remarkable flanges on both sides and each space between the edges is flat or a little concave.

Formation and locality:—*Olenoides* zone of Neietsu.

Eochuangia hana, var. *conica*, new variety.

Plate XVI, figures 7-9.

This variety is to be recognized by the conical outline of the glabella. The pygidium possibly belonging to this has a more transverse outline and a cylindrical axis.

Formation and locality:—Same as the type form.

Subfamily Leiosteginae, new subfamily.

The general outline of the cranidium is very much allied to that of the preceding subfamily. The frontal brim is thick and transverse or broadly rounded (in *Chuangiella*). The axial lobe is long, conical or cylindrical and frequently truncated in front. In the latter forms a pair of depressions are found on both sides of the frontal lobe. Glabellar furrows and ocular line weak or obsolete. Palpebral lobe differs in size, but usually is located near the mid-length of the cranidium. A sharp ridge crosses the brim of free cheek obliquely.

Pygidium subtriangular to semi-circular, *Prochuangia* has a pair of lateral spines sprung out from the first pleural lobes; other described genera have entire margins. Surface smooth.

In my previous paper I presented an opinion that there was an intimate relation between *Chuangia* and *Leiostegium*, but at that time the matter of distribution introduced some uncertainty, because the former genus occurs in the early Upper Cambrian of Eastern Asia and the latter in the Lower Ordovician of North America.

In the extensive collections from South Chosen are contained several new forms which fill up the gaps in the chain of evidence and introduce further evidence for the evolutional series. They are *Prochuangia* from the base of the Upper Cambrian, *Chuangiella* from the late Upper Cambrian and *Leiostegioides* from the Lower Ordovician.

Prochuangia and *Chuangia* are quite similar in the cephalon, but different in the pygidium, *Prochuangia* having a pair of long lateral spines on it. Generally the frontal border of *Chuangia* is sharply ridged into a roof-shape and the lateral extension of this ridge crosses the marginal border obliquely on the free cheek, but in *Prochuangia* the marginal border is usually rounded.

Chuangiella would be a link between the early Upper Cambrian and the Lower Ordovician genera. In this genus the glabella and fixed cheek have approximately the same breadth, but the fixed cheek is considerably narrower than the glabella in *Leiostegium*. Neverthless both genera are quite close in the thick frontal brim, glabella overlapping on the brim and strong depressions at the frontal ends of the dorsal furrows.

Leiostegioides has these strong depressions close to the front of the glabella, but is to be distinguished from *Leiostegium* by the broad cheek and from *Chuangia* by the straight frontal margin. The anterior eye and outline of the glabella are also distinguishing characters.

Koldinia would be a branch of this family manifesting advanced smoothing.

The family Leiostegidae represents an evolutional line branched from the Oryctocephalidae or perhaps tracing a course parallel to it, having sprung from a common stock in a previous epoch.

Genus PROCHUANGIA, new genus.

Remarks:—This genus is similar to *Chuangia*, but the pygidium has a long lateral spine on each side in which respect it resembles *Kaolishania*; yet it differs from it in the absence of convex border and deep groove on the posterior margin. As in *Chuangia* the glabellar furrows of this genus is entirely obsolete, but under the test three pairs of glabellar furrows are rather distinct, having features similar to those of *Kaolishania*. Frontal brim is usually not so acutely edged as that of *Chuangia*. Further observations will bé found in the description of the genotype.

Genotype:—*Prochuangia mansuyi*, new species, (ie. *Chuangia nais* Mansuy, not Walcott.)

Geological and geographical distribution:—The early Upper Cambrian; South Chosen and Tonkin. King[1] reported that cranidia,

1) W. B. R. King, (1930), Notes on the Cambrian Faunas of Persia, (Geol. Mag. Vol. LXVII,), p. 320, Pl. XVII, figs. 6-7.

hypostoma and pygidium comparable to Mansuy's *Chuangia nais* occur in Persia.

VIII

Prochuangia mansuyi, new species.

Plate VII, figure 8 ; Plate X, figures 1-7.

1915. *Chuangia nais* Mansuy, Faunes Cambriene du Haut-Tonkin, (Mém. du Serv. Géol. de l'Indochine, Vol. IV, fasc. II,) p. 20, Pl. II, figs. 14a–g.

Description:—Cephalon slightly convex ; glabella slowly tapering forward and much broader than the fixed cheek ; glabellar furrows practically obsolete, but under the test three pairs of lateral furrows are impressed ; the first and second pairs transverse and disconnected, but the third pair at first lateral and then bent back ; dorsal and occipital furrows strong ; palpebral ridge oblique and moderately strong ; palpebral lobe small, semi-circular, situated just at middle ; frontal brim, transverse, slightly convex forward, and sharply edged ; anterior slope of the brim striated by transverse lines. Free cheek a little broader than fixed cheek, slightly convex and the marginal brim and furrow not very distinct ; genal spine short ; fine irregular lines radiating from the eye. Facial sutures diagonal behind the eyes and almost parallel, but only a little divergent in front of the eyes.

Hypostoma elongately ovate, rounded back and produced into wings at both extremities of the anterior margin ; body of the hypostoma oval, convex, elevated and defined by a furrow ; a small depression located at the postero-lateral corner.

Pygidium transversely semi-circular ; axial lobe cylindrical tapering back a little, ending at a short distance from the posterior margin and divided into five rings ; pleural portions flat, and smooth except for the first segment which is large and well defined by a groove ; lateral spine produced in a postero-lateral direction from the middle of the lateral margin without any border or groove ; the margin simply sloping down.

The following dimensions were secured from the figured cotype specimens.

Cranidium.	A specimen (fig. 1.)	Another specimen (figs. 4–5.)
Length.	14 mm.	16.5 mm.
Breadth.	22 mm.	ca. 27. mm.
Length of the glabella.	12 mm.	14.5 mm.
Breadth of the glabella.	8 mm.	ca. 9. mm.

Pygidium.	A specimen (fig. 6.)	Another specimen (fig. 7.)
Length of the pygidium exclusive of spines.	7.5 mm.	7.4 mm.
Breadth of the pygidium on the articulating margin.	12.4 mm.	ca. 10.5 mm.
Length of the axial lobe.	6.4 mm.	5.5 mm.
Breadth of the axial lobe.	4.3 mm.	5.0 mm.

Comparisons:—Mansuy described *Chuangia nais* from the Upper Cambrian of Tonkin which certainly belongs to this new species, because its cranidium has a narrow fixed cheek and its pygidium a long lateral spine on each side.

King's *Chuangia nais*[1] from the limestone of Narghum (pl. XVII, fig. 6,) is very close to this species, but the other cranidium and pygidium from the limestone of Kuh-i-Namak (Pl. XVIII, fig. 7,) are quite distinct from it; on the other hand the pygidium suggests closer resemblance to *Kaolishania vulgaris*.

The cranidium of *Chuangia nais* Walcott is closely allied to that of this species, but it has a broader fixed cheek and its glabella is slightly contracted at a point a little anterior to its middle. It is also similar to *Chuangia kawadai*, but the cheek of this species differs from that of *Chuangia kawadai* by its more obsolete marginal border and stout genal spine. The pygidium of this species escapes absolutely from being confused with the *Chuangia* species of North China, North Chosen and South Manchuria. In regard to the tail this species approaches *Kaolishania*, especially *Kaolishania vulgaris*. The latter species, however, is distinctly segmented in the pygidium as well as in the cephalon while the present form is smooth. The glabella of the present species is certainly of the *Chuangia* type; still the glabellar furrows seen under the test suggest some similarity to those of *Kaolishania*.

Formation and locality:—*Prochuangia* zone of Saisho-ri; early Upper Cambrian of Tonkin.

Prochuangia posterospina, new species.

Plate X, figure 8. PA 1064

Description:—This species is represented only by a pygidium which is similar to that of *Prochuangia mansuyi*, but it is quite distinct in its elongate form and backward directed lateral spines. Axial lobe is

1) King (1930), Op. cit.

cylindrical; articulating segment large, divided into an anterior half ring and a large posterior ring by a groove; the rest of the axis divided into three rings of approximately same size and a terminal lobe. Pleural portion consisting of an articulating segment and a large swelling body which is produced backwards at a postero-lateral point into a long spine.

Comparisons:—The general form of this pygidium resembles *Blackwelderia cilix*[1] somewhat, but the margin is entire except for two long lateral spines.

Two pygidia (pl. III, figs. 7 i–j) of *Mansuyia orientalis* (Grabau)[2] described from Kaolishan limestone at Kaolishan, Shantung, are entirely different from those of *Mansuyia orientalis* s. str. (pl. III, figs. 7 f–g), but are rather closely allied to the present pygidium. In the Kaolishan specimens, however, the lateral margins are practically parallel to each other, whereas they narrow backward in the present species.

Formation and locality:—*Prochuangia* zone; Saisho-ri.

Prochuangia angusta, new species.

Plate IX, figure 12.

Description:—Cranidium comparatively long for this genus; glabella long, cylindrical, strongly elevated above the cheeks, slightly expanded in the posterior half, rounded at the anterior margin and well defined by the dorsal furrow; no furrow on the glabella except for the distinct neck furrow; neck-ring moderately convex backwards; frontal brim almost straight and behind it there is a broad transverse groove of moderate depth; fixed cheek narrow and slightly convex; eye-ridge strong and a large palpebral lobe located posterior to the middle of the glabella; postero-lateral limb of the cheek small; posterior branch of the facial suture transverse and turns back gently; the anterior branch of the suture cutting the frontal margin in front of the eye; surface smooth.

The holotype cranidium measures 13.5 mm. in length in which the glabella inclusive of the neck-ring occupies 11. 3 mm. The glabella and the free cheek are 7 mm. and 6 mm. broad on the basal margin respectively.

Comparisons:—The elongated cranidium with a long cylindrical glabella, broad frontal groove and posteriorly placed eyes are the important specific characters. As the pygidium of this species has not yet

1) Walcott (1913), Cambrian Faunas of China, p. 119, Pl. 9, figs. 6b–c.
2) Sun (1924), Cambrian Faunas of North China, p. 50, Pl. III, figs. 7a–j.

been found, it remains indecisive whether it is a *Prochuangia* or a *Chuangia*, but the frontal brim is not sharply angulated in the middle as is usually the case with *Chuangia*. Merely for this reason this species is provisionally referred to *Prochuangia* instead of *Chuangia*.

Formation and locality:—A single specimen found in the *Chuangia* zone of Saisho-ri.

Genus CHUANGIA Walcott, 1911.

Chuangia nitida Walcott.

Plate X, figure 17.

1911. *Chuangia nitida* Walcott, Smiths. Misc. Coll. Vol. 57, No. 4, pp. 85–86, pl. 15, fig. 6.

1913. *Chuangia nitida* Walcott, Cambrian Faunas of China, p. 172, Pl. 17, fig. 21.

The truncato-conical glabella, narrow fixed cheek, small postero-lateral limb, distinct palpebral ridge, large eye, and narrow and straight frontal groove and brim are the distinguishing characters of this species.

In the precise comparison the Korean form has a more convex glabella and less marked palpebral ridge than the holotype, in which regards it is somwhat similar to *Chuangia batia* and *Chuangia nais*, but it is far distant from them in its broad glabella, large eye, and small postero-lateral limb of the fixed cheek.

Formation and locality:—*Chuangia* zone of Kasetsu-ji and Doten.

Chuangia taihakuensis, new species.

Plate X, figures 10–16.

Comparisons:—This species is most closely allied to *Chuangia kawadai*,[1] but many differences of small magnitude are to be recognized between them. The general form of their cephala are quite similar, but the cranidium is relatively wider and the free cheek narrower in this species; the glabella is not as distinctly elevated above the cheek as that of *C. kawadai*; dorsal, occipital, and marginal furrows almost obsolete, and only recognized under the test; the frontal brim gently inclined forward with the edge close to the posterior margin of the brim, while in *C. kawadai* the brim highly elevated and acutely edged in the middle. The pygidia of the two are almost indistinguishable. The only difference lies in the fact that the axial lobe is narrower and

1) Kobayashi (1933), Upper Cambrian of the Wuhutsui Basin, Liaotung, etc. p. 106, pl. XI, figs. 1–3.

comparatively well defined in the present species. The axial lobe is divided into five rings and a terminal lobe under the test.

Dimensions :—

Cephalon.	Holotype (Figs. 10–11.)	Paratype (Fig. 15.)	Another Paratype (Fig. 16.)
Length.	8 mm.	8.3 mm.	17.5 mm.
Breadth.	ca. 16.3 mm.	ca. 17 mm.	
Distance between the eyes.	11.8 mm.	11 mm.	25 mm.
Length of the glabella.	7.3 mm.	7.7 mm.	15.5 mm.
Breadth of the glabella.	6.2 mm.	5.6 mm.	13 mm.

Pygidium.	Paratype (Fig. 13.)	Another paratype (Fig. 14.)
Length.	9 mm.	6 mm.
Breadth.	22 mm.	13 mm.
Length of the axial lobe.	7.5 mm.	4.7 mm.
Breadth of the axial lobe.	6.3 mm.	3.6 mm.

Formation and locality :—*Chuangia* zone ; Kasetsu-ji and Saisho-ri.

PA1073-9-8
PA1074-9-9
PA1075-9-10
PA1076-9-11
PA1077-10-9

Chuangia aff. *batia* (Walcott.)

Plate IX, figures 8–11; Plate X, figure 9.

1905. aff. *Ptychoparia* (?) *batia* Walcott, Proc. U. S. Nat. Mus. Vol. XXIX, p. 75.

1911. aff. *Chuangia batia* Walcott, Smiths. Misc. Coll. Vol. 57, No. 4, p. 84, pl. 15, figs. 3, 3 a.

1913. aff. *Chuangia batia* Walcott, Cambrian Faunas of China, p. 170, Pl. 17, figs. 20, 20 a-d.

1933. aff. *Chuangia batia* Kobayashi, Upper Cambrian of the Wuhutsui Basin, p. 107.

At Doten this form is quite common in the *Chuangia* zone from which many cranidia, cheeks and pygidia have been collected. In comparing with the type form of *C. batia*, the marginal brim is rather concave forward, instead of convex, and the palpebral lobes are more elevated in the Korean form, but otherwise no significant difference can be discerned. The associated pygidium is also quite similar to that of *C. batia*, but the axial lobe is more slender in this form.

Formation and locality :—*Chuangia* zone ; Doten and Kasetsu-ji.

Genus CHUANGIELLA, new genus.

Remarks:—This genus is definitely allied to *Chuangia* Walcott of the early Upper Cambrian of Eastern Asia on the one hand and to *Leiostegium* Raymond of the Lower Ordovician of North America on the other. Comparisons with both genera reveal that this genus has a more elongated cranidium, ie. its glabella and fixed cheeks are relatively longer. It differs also from *Chuangia* in having nearly parallel sided and strongly convex glabella and narrow cheek, obsolete eye-ridge and course of the facial suture. In these respects it rather agrees with *Leiostegium*, in which, however, as seen in *L. quadratus* (Billings), the glabella is much broader than the fixed cheeks and is remarkably elevated above the cheeks and extended forward overlapping upon a part of the frontal brim. As the horizon out of which it was collected is the late Upper Cambrian, it might possibly be an intermediate link between *Chuangia* and *Leiostegium*.

Genotype:—*Chuangiella elongata*, new species.

Geological and geographical distribution:—Late Upper Cambrian of Chosen.

Chuangiella elongata, new species.

Plate X, figure 18.

Description:—Cranidium convex, slightly broader than long; glabella cylindrical, defined by deep subparallel dorsal furrows; no furrow on the glabella itself except the occipital furrow; occipital ring short and convex backwards; fixed cheek narrow; palpebral lobe distinct, somewhat elevated; frontal rim moderately round, narrowing toward the extremities. Facial sutures diagonal behind the eyes and curving slightly outward in front of the eyes.

Surface smooth.

The holotype cranidium measures 7.7 mm. long and 9 mm. broad; glabella is 7 mm. long; occipital ring 1 mm. long and 3.5 mm. broad. The distance between the eyes is 7.5 mm.

Comparisons:—Among the species of *Leiostegium*, *L. oblongatus*[1] is quite similar to this species, but the glabella of that form is considerably elevated, the dorsal furrow not so deep, frontal brim thick and eyes smaller in that species.

Formation and locality:—*Eoorthis* zone; Doten.

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1) Billings (1865), Paleozoic Fossils, Vol. I, p. 412, fig. 394.

Subfamily Illaenurinae Raymond.

Remarks:—This subfamily was established by Raymond as a division of the Dikelocephalidae Miller; and *Illaenurus* Hall 1863, *Platycolpus* Raymond 1913, and *Cholopilus* Raymond 1924, were grouped into it. As reviewed elsewhere,[1] *Illaenurus* was compared to *Illaenus*, *Symphysurus* or to the dikelocephalids by Hall, Brögger, Walcott and Raymond; it appears also similar to the *Tsinania*-group, but as discussed later, the Tsinanidae is related to the Asaphiscidae and probably a descendant of the latter.

The important characters of *Illaenurus* are the course of the facial suture, position of the eyes, narrow fixed cheek, wide and round free cheek without genal spines, striated flat rim in the cephalon; very wide thoracic axis (eleven thoracic segments are counted in *I. quadratus* but ten in *I. calvini*)[2]; and broad semi-circular pygidium.

Among these characters the thick, flat striated rim on the cephalon and the outline of the pygidium exclude this genus from the domain of the Dikelocephalidae, but force it into the neighbourhood of the Leiosteginae. Most genera of that series differ somewhat from *Illaenurus* in the course of the facial suture, smoothing of the glabella and breadth of the fixed cheek. But the smoothing is considerably advanced in *Koldinia typa* too.

Careful observation upon Walcott's type[3] of *Illaenurus quadratus* Hall reveals that the outline of the glabella is subquadrate and its straight anterior margin crosses the point about four-fifths of the length of the cephalon from the posterior margin. In other words, a short space of the frontal limb is left between the glabella and marginal brim as in the case of *Koldinia* and some species of *Chuangia*.

In my opinion the Illaenurinae branched off from the Leiostegidae-stock, most probably from somewhere near *Koldinia*. Here the subfamily name is valid, because in the outline of cheeks, position of the palpebral lobes and in the breadth of the axis occurs a fairly big morphological gap between the Illaenurinae and the Leiosteginae.

Genus ILLAENURUS Hall, 1863.

1863. *Illaenurus* Hall, 16th Ann. Rept. New York State Cab. Nat. Hist., p. 176.
1867. *Illaenurus* Hall, Trans. Albany Inst. 5, p. 167.

1) Kobayashi (1933), Upper Cambrian of the Wuhutsui Basin, Liaotung, etc. p. 131.

2) O. T. Walter (1926), Trilobites of Iowa and Some Related Paleozoic Forms, (Iowa Geol. Surv. Vol. XXXI,) p. 189, pl. XI, figs. 15-20.

3) Walcott (1916), Smiths. Misc. Coll. 64, Pt. 45, fig. 1c, (U.S. Nat. Mus. Catalogue No. 62616.)

1885. *Illaenurus* Zittel, Handb. d. Pal. 2, p. 612.

1889. *Illaenurus*, Miller, N. A. Geol. Pal. p. 550.

1916. *Illaenurus* Walcott, Smiths. Misc. Coll. 64, p. 404.

1924. *Illaenurus* Zittel-Broili, Grundzüge d. Palaeont. I, p. 651.

Genotype:—*Illaenurus quadratus* Hall.

Remarks:—The generic characters and the phylogenetical relationships of *Illaenurus* have been thoroughly discussed in the preceding pages. Eliminating the Asiatic species of *Illaenurus* which have been reassigned to *Tsinania* and *Dictya*,[1] the following species are retained in this genus.

1) *Illaenurus quadratus* Hall. Common in the Upper Cambrian of Wisconsin (Norwalk sandstone), Minnesota, and Iowa; it occurs also in zone 3 of the Milton formation of Vermont.

2) *Illaenurus breviceps* Raymond. Zone 3 of the Milton of Vermont.

3) *Illaenurus laevis* Raymond. Locality is the same as *I. breviceps*.

4) *Illaenurus calvini* Walter. Trempealeau (Lodi shale) of Iowa.

This species is also found in the St. Lawrence formation; a specimen is illustrated in figure 8, plate XXII. A new species *Illaenurus montanensis*[2] is also added to them.

Illaenurus (?) *bia* Walcott[3] from the Upper Cambrian (Wilbernis ?) of Morgans Creek, Burnet Co. Texas, is questioned, because the glabella is well defined by the axial furrows across the cephalon and the facial sutures are divergent from the eyes. Walcott himself[4] was once inclined to refer it to *Nileus*.

I have an opinion that *Illaenurus* sp.[5] from Bache Peninsula is most probably a *Symphysurina*.

Geological and geographical distribution:—Upper Cambrian of Vermont, Minnesota, Wisconsin, Iowa and Montana.

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1) Kobayashi (1933), op. cit. p. 132.

2) T. Kobayashi, (1935), *Briscoia* Fauna of the Late Upper Cambrian in Alaska, etc. (Japan. Jour. Geol. Geogr. Vol. XII.)

3) Ch. D. Walcott (1890), Description of New Forms of Upper Cambrian Fossils, (Proc. U. S. National Mus. Vol. XIII,) p. 277, Pl. 20, fig. 6.

4) Walcott (1914), Smiths. Misc. Coll. 57, p. 359. (Generic reference).

5) O. Holtedahl (1913), The Cambro-Ordovician beds of Bache Peninsula, (Second Norwegian Expedition in the "Fram" 1898-1902, No 28,) p. 8, pl. IV, fig. 4.

Genus PLATYCOLPUS Raymond, 1913.

1913. *Platycolpus* Raymond, A Revision of the Species which have been referred to the genus *Bathyurus*, (Victoria Mem. Mus. Bull. No. 1,) p. 63.

Genotype:—*Bathyurus capax* Billings.

Remarks:—Except the genotype from the Levis conglomerate this genus includes so far the following other species:—

Platycolpus eastoni (Whitfield) from the magnesian limestone of the Devils Lake district, Baraboo, Wisconsin.

Platycolpus dubius (Billings) from the Levis conglomerate, Quebec, Cowhead of Newfoundland, and zone 3 of the Milton of Vermont.

Platycolpus barabuensis (Whitfield) from the same locality as *P. eastoni*.

Platycolpus marcoui Clark from the Levis conglomerate of Quebec.

Geological and geographical distribution:—This genus is distributed from Wisconsin to Newfoundland in the Upper Cambrian series. *P.* (?) *granulatus* Kobayashi[1] is known to occur in the Wanwankou dolomite of South Manchuria, but it might be distinguished from *Platycolpus* generically, when better material will be found.

Genus CHOLOPILUS Raymond, 1924.

1924. *Cholopilus* Raymond, New Upper Cambrian and Lower Ordovician Trilobites from Vermont, p. 447.

Genotype:—*Cholopilus vermontanus* Raymond.

Remarks:—I have observed upon the genotype that the specimen has a strong rim in front of the glabella, as typically seen in all others of the Leiostegidae, although it is neither described nor represented in the illustration. As suggested by Raymond, it is certian that this form is a member of the Leiostegidae close to *Platycolpus*, and that feature just mentioned militates against putting this genus in the Komaspidae or its neighbourhood.

Family Ellipsocephalidae Matthew.

Remarks:—Raymond applied Matthew's name in grouping *Ellipsocephalus*, *Agraulos* and *Strenuella* with the following diagnosis:—

Opisthoparia with narrow free cheeks, small eyes, smooth unfurrowed glabella, twelve to sixteen thoracic segments and small pygidium.

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1) T. Kobayashi (1933), Faunal Study of the Wanwanian, etc. p. 281, pl. VI, figs. 2—3.

Kiaer[1] suggested that *Protolenus, Micmacca, Mohicana, Inouyia* and probably *Levisia* are also referrable to this family; Raymond established *Plethopeltis* and *Stenopilus* as new genera of this family, but later Ulrich spread the former genus into *Plethopeltis* and *Plethometopus* and considered their family undetermined; Clark added one more genus *Leiocoryphe* to the Ellipsocephalidae; recently Cobbold has discovered another, *Blayacina.*

With *Ellipsocephalus hoffi,* the genotype, and with many protolenoids, however, the eye is long and posterior. Generally speaking, it may be said to range in size from small to medium in this family, and located at about the mid-length of the cephalon. The fixed cheek is mostly wide, but it is narrow in *Plethopeltis.* If *Protolenus* and *Lorenzella* (i. e. Walcott's *Inouyia* in part) are admitted into this family, the glabellar lobes may be said to be fairly well marked by furrows. Thoracic segments are reduced in the *Plethopeltis* group,—ten in *Plethometopus* and eight in *Leiocoryphe.* Therefore the family diagnosis should be so emended nowadays to include these variations therein.

One of the most significant characters is the absence of the concave, or depressed frontal limb. The frontal limb and rim are frequently so poorly defined that they conform a single convex border. This feature is common among all genera and through it this family is distinguished from the Ptychoparidae, Asaphiscidae and other allied families.

According to the breadth of the cheek and size and position of the eyes this family will be subdivided here into three subfamilies. Further, the feature of the marginal border, outline, convexity and demarcation of the glabella, shape of the occipital ring, absence or presence of the genal spine, and other features furnish generic characters.

Subfamily Ellipsocephalinae, new subfamily.

Ellipsocephalidae with broad cheeks and large posterior eyes.

1) *Ellipsocephalus* Zenker, 1833. (Genotype: *Ellipsocephalus hoffi* Schlotheim.)

   Cephalon with simple convex border; glabella cylindrical, obtusely angular in front.; no genal spine; thoracic segments 12—14.

This is a well known Middle Cambrian genus of the Atlantic province, occurring in Norway, Sweden, Poland, Bohemia and Spain and appearing in New Brunswick across the Atlantic.

1) Kiaer (1916), Lower Cambrian *Holmia* Fauna at Tomten in Norway, (Vidensk. Skrift. I, Mat. Naturv. Kl. No. 10, Christiania,) pp. 53—54.

Ellipsocephalus nordenskioldi Linnarsson[1] from the *Holomia* shale and *Ellipsocephalus latus* Wiman[2] from a boulder of Aland Island are the exceptionally archaic members of the genus.

2) *Ellipsocephaloides*, new genus. (Genotype : *Ellipsocephalus curtus* (Whitfield.[3]) (Text-fig. 19 ; Pl. XXIII, figs. 11—12.)) PA4196-23-11 PA4197-23-12

Text-figure 19.
Ellipsocephalus curtus Whitfield, the genotype of *Ellipsocephaloides*, new genus. [From Whitfield's Geol. of Wisc. Vol. IV, (1873—79.) Pl. I, fig. 18.]

Similar to *Ellipsocephalus*, but the cephalon broader, glabella not angulated in front, glabellar furrows observable in the mature stage, ocular ridge merging into a narrow convex frontal border, the fixed cheek behind the ocular ridge usually depressed and facial suture incurved in front of the eye. Associated pygidium relatively large, broad, surrounded by a narrow convex brim; axis elevated, and divided into about three segments. Upper Cambrian of the Upper Mississippi Valley.

3) *Kingaspis*, new genus. (Genotype : *Anomocare campelli* King.) (Pl. XXIII, figs. 9—10.)) PA4198-23-9 PA4199-23-10

Similar to *Ellipsocephalus*, but the cranidium is entirely smooth on the surface, and the marginal limb and rim are subequally divided under the test. Middle or Upper Cambrian of Palestine.

4) *Protolenus* Matthew, 1892. (Genotype : *Protolenus paradoxides* Matthew.)

Cephalon bordered by a narrow brim ; glabella convex, conical or cylindro-conical with three pairs of glabellar furrows ; distinct eye-ridge across the wide fixed cheek ; free cheek narrow, with a genal spine.(For the distribution see page 204.)

Subgenus *Bergeronia* Matthew, 1895, was established on the basis of *Bergeronia elegans* Matthew. The difference is found simply in the aspect of thoracic pleura which is strongly grooved and geniculated in *Bergeronia*, while it is flat with a diagonal furrow in *Protolenus* s. str.

Matthew laid particular stress upon such a thoracic character, because the thoracic pleura of *Bergeronia* is of the *Ptychoparia* type whereas that of *Protolenus* s. str. is of the Olenidae type.

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1) Linnarsson (1882), Sverges Geol. Unders. Ser. C, No. 54, p. 20, Pl. 4, fig. 1. Kiaer (1917), Skrifter Vidensk. Kristiania, 1, Mat. Naturv. Kl. Vol. 2, p. 41, Pl. 6, figs. 7—8; Pl. 5, figs. 11—31,

2) Wiman (1902), Bull. Geol. Inst. Upsala, 6, p. 44, Pl. 1, figs. 22, 24.

3) Whitfield (1878), Ann. Rep. Wisc. Geol. Surv. p. 58; (1882), Geol Wisc. 4, p. 191, Pl. I, figs. 18.

5) *Micmacca* Matthew, 1895. (Genotype: *Micmacca matthevi* Matthew.)

Similar to *Protolenus*, but the glabella is convex, long, conical; glabellar furrows obscure; no frontal limb; no genal spine; facial sutures anterior to the eyes parallel, while divergent in *Protolenus*. Lower Cambrian of New Brunswick, Newfoundland and England.

Matthew compared this genus to *Zacanthoides*, but it is quite distinct from that in the breabth of fixed cheek and course of facial suture.

6) *Mohicana* Cobbold, 1910. (Genotype: *Mohicana lata* Cobbold.)

Similar to *Micmacca*, but cephalon gently convex, in slight relief, dorsal furrow shallow, glabellar furrows obscure, ocular ridge slight or wanting, anterior margin with a narrow indistinct fold or none, free cheek small, pointed or spined.

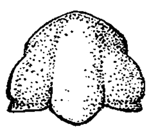
7) *Blayacina* Cobbold, 1931. (Genotype: *Blayacina miqueli* Cobbold.)

Similar to *Protolenus* and *Ellipsocephalus*, but distinguished on such accounts as,[1], "le cranidium aplati, le bord postérieur non géniculé, et la glabelle tronquée relativement courte qui s'élargit aux lobes de base." Lower Cambrian (Grès de Marcory); Montagne Noire, France.

8) *Palaeolenus* Mansuy, 1912. (Genotype: *Palaeolenus douvillei* Mansuy.)

Similar to *Protolenus*, but glabella less convex, parallel sided or slightly expanded forward; glabellar furrows transversal, among which the third one runs across the glabella. This differs principally from *Micmacca* and *Mohicana* in the presence of the frontal limb. Thorax composed of fourteen segments or more. Lower Cambrian of Yunnan.

9) *Protagraulos* Matthew, 1895. (Genotype: *Protagraulos priscus* Matthew.)



Text-figure 20.
Protagraulos priscus Matthew, mut. [From Matthew (1898), Trans. Roy. Soc. Canada, Sec. Series, Vol. IV, sect. IV, Pl. I, fig. 5.]

Similar to *Protolenus*, but glabellar furrows and ocular ridgies are obscure. Matthew mentions that the preglabellar area is partly broken off in the hologenotype, (Trans. N. Y. Acad. Sci. XIV, 1895, p. 139, Pl. VIII, fig. 1,) and he presented a more complete cranidium in his paper in 1898. (*Protagraulos priscus* Matt. Trans Royal Soc. Canada, sec. ser. IV, sec. IV, p. 134, Pl.

1) Cobbold (1931), Le Genre *Olenopsis* en France, (Bull. Soc. Géol. France, 5e ser. t. I,) p. 569.

I, fig. 5.) I studied the clay-cast from the original of the latter form kept in U. S. National Museum and found that by its large posterior eye it is absolutely distinct from either *Agraulos* or *Holocephalina* to which it was compared by Matthew, but is rather closely related to *Protolenus* from which it may be derived simply by the obliteration of the surface relief. It is also added here that the glabella is quite conical in the cast and somewhat unlike the illustration. Lower Cambrian of New Brunswick.

10) *Strenuella* Matthew, 1887.(Genotype: *Agraulos strenuus* Billings.)

Cephalon with a simple, convex rim; glabella convex, parallel-sided, rounded in front and pointed back; glabellar furrows obscure; eyes long, posterior connected with the glabella by the ocular ridge, fixed cheek wide.

This is a characteristic member of the Lower Cambrian fauna of the Atlantic province spread out in Norway, Sweden, Poland, England, Newfoundland and New Brunswick. Lately it has been found in Greenland by Poulsen.[1] Hedström[2] described *Strenuella subgotlandica* from a core of a drill in Gotland which is the only exception to be found in the Middle Cambrian.

Cobbold[3] distinguished two groups typified by *Strenuella strenua* (Billings) and *Strenuella linnarssoni* Kiaer. The former group has a distinct nuchal spine, smooth glabella, and swollen raised rim in front of the glabella; the latter has distinct glabellar furrows and the preglabellar area which is gently convex but descending all the way to the margin. According to Cobbold's reference, the former group is distributed over England and eastern North America, while the latter is confined to Europe, i. e. to England and Baltic region.

Inouyia divi from the early Middle Cambrian of Shantung has diagnostic features of *Strenuella*, excepting such points as the smaller and middle eye and absent genal spine. *Strenuella* is confined, so far, to the Lower Cambrian of the Atlantic province, but for *Strenuella subgotlandica* Hedström which was secured from a well core in Gotland and is considered to be from the Middle Cambrian.

Under such a situation the difference between this Asiatic Middle Cambrian form and *Strenuella* might be worth more than of a specific value.

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1) Poulsen (1927), Meddles Greenland, 70, pp. 253—254, Pl. 14, figs. 24—25.

2) Hedström (1923), Sveriges Geol. Unders. ser. C, no. 314, p. 14, Pl. 2, fig. 6.

3) Cobbold (1331), Additional Fossils from the Cambrian Rocks of Comely, Shropshire, (Q. J. G. S London, Vol. XXXVII,) pp. 482—483.

Subfamily Agraulinae Raymond.

Ellipsocephalidae with medium to wide fixed cheek, and small to medium eyes located at about the mid-length of the cephalon or a little posterior to that.

Matthew,[1] when he established the Ellipsocephalidae, brought in *Agraulos* as a remote relative of *Ellipsocephalus* as in the following pattern :—

Ptychoparidae.	....	*Agraulos.*
	Ptychoparinae.	*Liostracus.*
		Ptychoparia.
		Solenopleura
	Ellipsocephalidae.	*Ellipsocephalus.*

Although the *Agraulos* and *Ellipsocephalus* groups are accepted as components of one family, really each in itself is fairly distinct in certain respects and in my opinion the two need to be distinguished at least to the subfamily rank. The name Agraulidae[2] once suggested by Raymond, is here reemployed as a group term of the subfamily rank, separating the *Plethopeltis* group as another subfamily.

1) *Agraulos* Corda, 1847. (Genotype: *Arion ceticephalus* Barrande.)

Cephalon gently convex, in slight relief; glabella semiovate, faintly outlined; neck ring of equal breadth; eyes small and median; fixed cheek wide; no concave or rimmed border; surface smooth or punctate; thoracic segments sixteen. (For the distribution see page 206.)

2) *Metagraulos*, new genus. (Genotype : *Agraulos nitida* Walcott.)

Differs from *Agraulos* by its convex truncato-conical glabella, neck ring broadened in the middle or produced back into a spine; medium sized eye. No ocular ridge and surface smooth or punctate.

3) *Megagraulos*, new genus. (Genotype: *Megagraulos coreanicus*, new species.)

The generic characters are truncato-conical glabella defined by the deep dorsal groove, no glabellar furrows, the middle and medium eye accompanied by an ocular ridge and the border faintly divided by a groove into two convex rim and limb. Surface smooth or punctate.

4) *Chondroparia* Lorenz, 1906. (Genotype : *Agraulos* (?) *pusillus* Matthew.)

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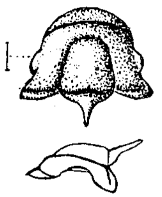
1) Matthew (1887), Illustrations of the Fauna of the St. John Group, No. IV, (Trans. Roy. Soc. Canada, sec. IV,) p. 161.

2) Raymond (1913), Victoria Mem. Mus. Bull. 1, p. 64.



Text-figure 21.
Agraulos (?) *pusillus* Matthew, the genotype of *Chondroparia* Lorenz. [From Matthew, (1897), Trans. Royal Soc. Canada, Sec. Series, Vol. III, sect. IV, Pl. II, fig. 6.]

Similar to *Metagraulos*, but the frontal limb and rim are more or less divided, glabella is convex, elevated, and the surface is marked by granulation to which in turn Lorenz attached generic significance. From *Megagraulos* this is distinguished by the absence of preglabellar boss and by the surface texture. Lorenz's woodcut shows a remarkable divergence of the facial sutures anterior to the eyes, but in the original figure of *Agraulos* (?) *pusillus* a convergence is seen. Middle Cambrian of New Brunswick.

5) *Proampyx* Frech, 1897. (Genotype: *Anomocare acuminatum* Angelin.)

Agraulinae with relatively large eyes and acuminate frontal border which is produced into a spine in the genotype. The neck ring frequently accompanied by a median tubercle or nuchal spine.

Frech established this genus on account of the frontal spine, but such form as *Anomocare difformis* Angelin has been included in this genus, by the reason that it manifests specialization in the same direction but one step removed from *A. acuminatum.*

This genus is typically developed in the Middle Cambrian of the Baltic region and Bennett Island. *Proampyx burea* Walcott has been described from the early Upper Cambrian of Shantung, but unfortunately the median portion of the frontal border is not preserved, so the frontal margin cannot be exactly figured out. Judging from the direction of the preserved portion of the margin this species seems to have a transverse front. Its dorsal furrow is also too strong and its fixed cheek is too narrow for this genus and therefore it is my belief that it cannot be called a *Proampyx.*

6) *Proliostracus* Poulsen, 1932. (Genotype: *Proliostracus strenuelliformis* Poulsen.)

Differs from *Megagraulos* by its broader cephalon, four pairs of distinct glabellar furrows, and inward turned anterior branch of the facial suture. Further comparisons to the other genera of the Ellipsocephalidae are made by the author.[1] Hence it is simply added here that *Inouyia* (?) *regularis* Walcott is remarkably allied to this genus, but for the obscure glabellar furrows and boss in front of the glabella. *Prolio-*

1) Poulsen (1932), Lower Cambrian Faunas of East Greenland, p. 48.

stracus is found in Greenland in association with the typical *Olenellus* fauna, while *Inouyia* (?) *regularis* is accompanied by *Blackwelderia*. Owing to these circumstances the generic reference of the latter causes some hesitation.

7) *Lorenzella*, new genus. (Genotype: *Agraulos abaris* Walcott.)

Glabella truncato-conical, convex, with three pairs of oblique glabellar furrows, neck ring broad in the middle or produced back into a spine; fixed cheek of medium breadth; eyes medium sized and located at about middle to the posterior; ocular ridge fairly distinct; frontal rim more or less distinct from the limb, but both convex, especially raised in front of the glabella in a boss-shape.

Subfamily Kingstoninae Kobayashi.

Ellipsocephalidae with a subsquare, relatively large glabella, narrow fixed cheeks and mostly small or no eyes; little or no relief on the carapace.

Formerly this subfamily was established only to embrace *Kingstonia*, *Ucebia* and *Bynumia*.[1] These do not, however, differ essentially from the *Plethopeltis-Plethometopus* group, although their eyes are rather anterior, and therefore all are now grouped in one subfamily.

Once I was[1] inclined to group the *Plethopeltis-Plethometopus* series in the Tsinanidae, but I now believe that it should come here. The chief objections of placing it in the Tsinanidae arise from the small eyes and transverse pygidium. The problem of the taxonomy of the smooth trilobites is further discussed on page 303.

1) *Kingstonia* Walcott, 1924. (Genotype: *Kingstonia apion* Walcott.)

Small trilobites with little and anterior eyes; dorsal furrows observable only in the posterior part; facial sutures parallel anterior to the eyes and diagonal posterior to the eyes, embracing large triangular fixed cheeks inside of them. Pygidium relatively large, without segmentation except for the articulating segement; its margin convex, without border.

Upper Cambrian and Basal Ordovician; North America and Eastern Asia.

2) *Ucebia* Walcott, 1924. (Genotype: *Ucebia ara* Walcott.)

Similar to *Kingstonia*, but having a longer and broader glabella surrounded by a shallow dorsal furrow.

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1) T. Kobayashi (1933), Upper Cambrian of the Wuhutsui Basin, Liaotung, etc. (Japan. Jour. Geol Geogr. Vol XI,) p. 133

Upper Cambrian of Appalachian region.

3) *Triarthrella* Hall, 1863. (Genotype: *Triarthrella auroralis* Hall.)

Quite close to *Ucebia*. This is, however, distinguished from that by its narrow frontal limb.

Upper Cambrian of the Upper Mississippi Valley.

Text-figure 22. *Triarthella auroralis* Hall. [From Hall's 16th Ann. Rep. Univ. State New York, etc. (1863), Pl. IX, fig. 13.]

4) *Bynumia* Walcott, 1924. (Genotype: *Bynumia eumus* Walcott.)

Differs from the preceding two by the deeper dorsal furrow and prolonged triangular frontal limb.

Upper Cambrian of British Columbia, Tennessee, and Vermont.

5) *Wongia* Sun, 1924. (Genotype: *Wongia triangulata* Sun.)

Small trilobite similar to *Kingstonia*, but differing by its relatively large eyes, frontal boss and Proparian like facial suture.

Late Middle Cambrian of Chihli.

6) *Plethopeltis* Raymond, 1913, em. Ulrich, 1931. (Genotype: *Agraulos saratogensis* Walcott.)

Cranidium strongly convex; glabella sub-oblong, defined by a dorsal furrow; two pairs of glabellar furrows sometimes present; occipital ring widest at the center, but no spine; palpebral lobe small, slightly anterior to the mid-length; frontal border simply convex; free cheek with a short genal spine. Pygidium small, convex, wider than long, without border; axis with about five segments.

This genus occurs in the Hoyt limestone of New York, and in the Eminence dolomite of Missouri; two species have been found in the Wanwankou dolomite of South Manchuria.[1]

7) *Plethometopus* Ulrich, 1931. (Genotype: *Bathyurus armatus* Billings.)

Similar to *Plethopeltis*, but dorsal and glabellar furrows obscure, eyes small, neck ring triangular, pointed back, without segmentation on the pygidium except for the articulating segment. Ten segments are to be counted on the thorax.

This genus is distributed in the Milton of Vermont and Eminence of Missouri.

8) *Stenopilus* Raymond, 1924. (Genotype: *Stenopilus pronus* Raymond.)

Differs from *Plethometopus* in the absence of the nuchal spine and

1) T. Kobayashi (1933), Faunal Study of the Wanwanian, etc. p. 280.

dorsal furrows which are still faintly retained in the posterior course in *Plethometopus*.

Raymond[1] considered that there is a continuous series of evolution from *Plethopeltis* s. l. to *Stenopilus*. *Stenopilus* is found in the Milton of Vermont, Eminence of Missouri and Wanwankou dolomite of South Manchuria.

9) *Leiocoryphe* Clark, 1924. (Genotype: *Leiocoryphe gemma* Clark.)

Similar to *Stenopilus*, but with neither eyes nor a facial suture. Thorax consists of eight segments with a broad axis.

As suggested by Clark,[2] this represents the terminus of the *Plethopeltis* evolution. The genotype is from a boulder out of the Levis conglomerate, Quebec, presumed to be of the Upper Cambrian age.

10) *Camaraspis* Ulrich and Resser, 1924. (Genotype: *Arionella convexus* Whitfield. Text-fig. 23, Pl. XXIII. figs. 7–8.)

Text-figure 23. *Arionellus convexus* Whitfield, the genotype of *Camaraspis* Ulrich and Resser. [From Whitfield's Geol. Wisc. Vol. IV, (1873-1879), Pl. I, fig. 17.]

Differs from *Plethopeltis* in the large and more posterior eyes, elevated truncato-conical smaller glabella and faintly divided frontal limb and rim. The latter two characters vary among the species and individuals and obviously merge into obsoletion of surface relief like in *Plethopeltis* (*Camaraspis* ?) *arencola* Raymond. Such a form cannot be separated generically from *Tsinania* by the cranidium only, so I had once suggested its reference to that genus, but the associated pygidium of *Camaraspis convexus* has a transverse outline, cylindrical elevated axis and narrow depressed border which preclude its assignment to *Tsinania*.

Agraulos hemisphericus Berkey[3] from the Upper Dresback will be another species which possibly belongs to this genus.

This genus is known to occur in the Upper Cambrian of the Upper Mississippi valley.

Subfamily Ellipsocephalinae, new subfamily.

Genus PROTOLENUS Matthew, 1892.

1892. *Protolenus* Matthew, Bull. Nat. Hist. Soc. N. B. No. 10, p. 34.
1892. *Protolenus* Matthew, Canadian Rec. Sci., 5, p. 248.

1) Raymond (1924), Proc. Boston Soc. Nat. Hist. Vol. 37, No. 4, p. 420.
2) Clark (1924), Bull. Am. Pal. Vol. 10, No. 41, p. 21.
3) Berkey (1998), Geology of the St. Croix Dalles, p. 289, Pl. XX, figs. 14-15

1894. *Protolenus* Matthew, Trans. Roy. Soc. Canada, 11, sec. 4, p. 100.
1895. *Protolenus* Matthew, Trans. New York Acad. Sci. 14, p. 144.
1896. *Protolenus* Matthew, Rep. 66th Meeting Brit. Assoc. Adv. Sci., p. 786.
1901. *Protolenus* Pompeckj, Zeits. Deutsch. Geol. Gesll. 53, p. 17.
1904. *Protolenus* Matthew, Bull. Nat. Hist. Soc. New Brunswick, 5, p. 246.
1910. *Protolenus* Grabau and Schimer, N. A. Index Fossils, 2, p. 265.
1924. *Protolenus* Zittel-Broili, Grundzüge d. Palaeont. I, p. 646.
1931. *Protolenus* Cobbold, Quart. Jour. Geol. Soc. London, 87, p. 486.

Genotype:—*Protolenus paradoxides* Matthew.

Since this genus was originally described from New Brunswick, Cobbold discovered it in Comley, Shropshire in England; Czarnocki[1] found it in St. Croix in Poland and added three new species, *Protolenus* (*Bergeronia*) *radegasti*, *Protolenus bodzanti* and *Protolenus percuñi*, but all as yet undescribed.

Recently Saito[2] described a new species, *Protolenus coreanicus* from Chuwa area, North Chosen where the *Protolenus* shale is found underneath the *Redlichia* shale with the Bunsanri quartzite between.

Matthew once referred *Olenellus* (?) *forresti* Woodward from Australia to *Protolenus*, but in accordance with Walcott's and Etheridge's opinion I believe it to be a *Redlichia*, (see p. 122).

The age of the *Protolenus* faunas has been set upon debatable grounds. It is yet a question whether it should be called the base of the Middle Cambrian or the top of the Lower Cambrian. But I incline to believe that the latter alternative will be the case. Such a world wide distribution here cited and the situation observed by Saito are important facts worthy of consideration in this matter.

Genus PALAEOLENUS Mansuy, 1912.

1912. *Palaeolenus* Mansuy, Mém. du Serv. Géol. de l'Indochine, 1. p. 27.

Genotype:—*Palaeolenus douvillei* Mansuy.

Mansuy compared *Palaeolenus* to *Olenus*, *Bathyuriscus* (ex. *B. ornatus*,) *Olenoides* (*O. spinosus*), *Neolenus*, *Albertella* and *Zacanthoides*, but he failed to consider *Ellipsocephalus* and *Protolenus*. The genotype of *Ellipsocephalus*, *E. hoffi*, reveals quite distinct features, especially in its outline and obsoletion of glabellar furrows, but some species of *Ellipsocephalus* such as *E. grandis* and *E. galeatus* from the *Protolenus* fauna are very

1) J. Czarnocki (1927), le Cambrien et la Fauna Cambrienne de la Partie Moyenne du Massif de Swiety Krzyz (Ste. Croix), (Comte-Rendu XIVe Congres Géol. Intern. 1926.)

2) Kazuo Saito (1933), Cambrian Formations in the Chungwa District, western North Korea, (Jour. Geol. Soc. Tokyo, Vol. XL): (1933) the Occurrence of *Protolenus* in the Cambrian Rocks of North Korea, (Japan. Jour. Geol. Geogr. Vol. X.)

close to this in the outline of glabella, wide fixed cheek, position and strength of palpebral lobe and ridge, but are distinguished from this by the obsolete glabellar furrows and the absent rudimentary frontal brim. In regard to these characters the genus is rather allied to *Protolenus* and *Bergeronia,* but they have conical, instead of cylindrical, glabella and more posterior palpebral lobe, and a little narrower fixed cheek.

Geological and geographical distribution:—Lower Cambrian of Yunnan.

Subfamily Agraulinae Raymond.

Genus AGRAULOS Corda, 1847.

1846. *Arion* Barrande, Nat. Prelim. Syst. sil. Bohème, p. 13.
1846. *Ellipsocephalus* Barrande (part), Not. Prelim. Syst. sil. Bohème, p. 12.
1847. *Arionides* Barrande, Neues Jahrb. f. Min. etc. p. 391, footnote.
1847. *Agraulos* Corda, Abhandl. d. k. böhmischen Gesell. d. Wiss. 5, p. 142.
1847. *Herse* Corda, Abhandl. d. k. böhmischen Gesell. d. Wiss. 5, p. 135.
1850. *Ellipsocephalus* Barrande, Neues Jahrb. f. Min. etc p. 779.
1850. *Arionellus* Barrande, Neues Jahrb. f. Min. etc. p. 779.
1852. *Arionellus* Barrande, Syst. Sil. du Centre Bohème, I, p. 404, pl. 10.
1854. *Arionellus* Pictet, Traite de Pal. 2nd ed. 2, p. 491.
1860. *Arionellus* Billings, Canadian Nat. Geol. 5, p. 313.
1865. *Arionellus* Billings, Pal. Fossils, 1, Geol. Surv. Canada, p. 405.
1865. *Agraulos* Meek and Hayden, Pal. Upper Missouri, Smiths, Contr. Knowl. 14, No. 172, p. 7.
1876. *Arionellus* Kayser, Beitr. Geol. Pal. Argentinishen Republik, Palaeontogr. Suppl. 3, p. 7.
1884. *Arionellus* Walcott, Science 3, p. 281.
1885. *Arionellus* Zittel, Handb. d. Pal. 2, p. 601.
1887. *Agraulos* Matthew, Trans. Royal Soc. Canada, 4, p. 151.
1887. *Agraulos* Matthew, Canadian Rec. Sci. 2, p. 357.
1888. *Agraulos* Matthew, Trans. Royal Soc. Canada, 5, p. 129.
1889. *Agraulos* Miller, North, Amer. Geol. Pal. p. 527.
1896. *Arionellus* Koken, Die. Leitfossilien, Leipzig, p. 21.
1896. *Agraulos* Beecher in Zittel-Eastman's Text-Book of Paleontology, Vol. I, p.628.
1901. *Arionellus* Lindström, Kongl. Svensk. Vet. Akad. Handl. 34, pp. 22, 25.
1906. *Agraulos* Lorenz, Zeits. deut. geol. Gesell. 58, p. 67.
1910. *Agraulos*, Reed, Mem. Geol. Surv. India, Pal. Indica, ser. 15, 7, Mem. 1, p. 41.
1910. *Agraulos*, Grabau and Shimer, N. A. Index Fossil. 2, p. 278.
1913. *Agraulos* Walcott, Research in China, 3, Carnegie Inst., p. 155.
1924. *Agraulos* Zittel-Broili, Grundzüge d. Pal. 1, p. 646.
1932. *Agraulos* Lake, Mon. British Camb. Tril., Pal. Soc. part. 7, p. 155.

Genotype:—*Arion ceticephalus* Barrande.

i. e. *Agraulos delphinocephalus* Corda.

Remarks:—The above citation gives the references for this well known genus. Therefore I shall only include here a question from Lake's remarks concerning the various changes which the generic name has undergone:—

"This genus has been very unfortunate in its name. It was first called *Arion* by Barrande, but that name was already in use. Corda accordingly substituted *Agraulos*, but he separated youthful individuals as a distinct genus to which he gave the name of *Herse*. Barrande rejected Corda's emendation, on the ground that the similar name *Agraulis* had been applied to one of the *Lepidoptera*, and he altered his original name to *Arionellus*. This was the name most widely used throughout the later half of last century. Now, however, a similarity such as that between *Agraulos* and *Agraulis* is not considered a sufficient reason for the rejection of either, and under that condition Corda's name must stand."

Geological and geographical distribution:—*Agraulos* s. str. is very common in the Middle Cambrian of the Atlantic Province, occurring in Bohemia, the Baltic region, England, Spain, Newfoundland and New Brunswick.

The following Lower and Upper Cambrian species from North America are exceptions and might require a revisional study:—

Agraulos charops Walcott, Lower Cambrian (Mount Whyte) of Mount Stephen near Field, British Columbia.

Agraulos (?) *globosus* Walcott, Upper Cambrain (St. Croixan) of Eureka District, Nevada.

Agraulos levis Walcott, Upper Cambrian of Yellow Stone Park.

Agraulos planus (Shumard) Miller, Upper Cambrian of Morgans Creek, Burnet Co. Texas.

Agraulos redpathi Walcott, Lower Cambrian of St. Simon, Quebec.

Agraulos stator Walcott, Acadian of British Columbia.

Agraulos (?) *unca* Walcott, Lower Cambrian of British Columbia.

Most of the Asiatic species have been transferred outside of *Agraulos* s. str. (See page 207).

Notes on the Asiatic species of *Agraulos*.

As a result of this study I believe that there is no real *Agraulos* in Asia. The various changes of the generic references are indicated below:—

Specific name.	Present generic reference.
Agraulos abrota Walcott.	*Metagraulos.*
Agraulos dirce Walcott.	*Metagraulos.*
Agraulos dolon Walcott.	*Metagraulos.*
Agraulos dryas Walcott.	*Metagraulos* (?)
Agraulos (?) *fervidus* Reed	*Chondroparia.*
Agraulos nitida Walcott.	*Metagraulos,* (see note 1.)
Agraulos obscura Walcott.	*Megagraulos,* (see note 2.)
Agraulos aff. *roberti* Matthew.	*Chondroparia,* (see note 3.)
Agraulos (?) *similans* Reed.	*Chondroparia.*
Agraulos sorga Walcott.	*Megagraulos* (?)
Agraulos tonkinensis Mansuy.	*Lorenzella.*
Agraulos uta Walcott.	*Megagraulos.*
Agraulos vicina Walcott.	*Megagraulos.*

Note 1. In my observation on the holotype the granulation on *Agraulos nitida* is not as clear as Walcott described it.

Note 2. The ocular ridge is to be observed on the holotype *Agraulos obscura,* especially distinct on its left cheek.

Note 3. *Agraulos roberti* has a punctate surface, while *Agraulos* aff. *roberti* Reed has a finely granulated one. On this account the latter is distinct from the former, at least specifically, and a new name, *Chondroparia reedi* is here given for the latter.

PA1079-18-5
PA1080-18-6
PA1081-18-7
PA1082-18-8
PA1083-18-9
PA1084-18-10
PA1085-23-15

Genus MEGAGRAULOS, new genus.

Megagraulos coreanicus, new species.

Plate XVIII, figures 5—10 ; Plate XXIII, figure 15.

Description :—Cranidium subquadrate, broadly rounded along the anterior margin ; glabella truncato-conical, convex, large, defined by a wide dorsal groove ; parctically no glabellar furrows except for the occipital one ; occipital lobe large on the axis, but quite narrow on the cheek; preglabellar area and fixed cheeks all gently convex, nearly of equal breadth, and a little narrower than the breadth of the glabella ; palpebral lobes located on both sides of the middle of glabella ; eye-band rather longitudinal, only slightly convex outward; ocular ridge strong, crosses the fixed cheek obliquely from the the anterior end of the eye-band to a point a short distance behind the antero-lateral angle ; preglabellar area simply convex, but by the crossed light the division of the frontal rim and limb is observable on its lateral portions; facial suture steeply oblique behind the eyes and rounded in front of the eye.

Free cheek relatively broad, with genal spine.

Thoracic segments with falcate lateral extremities.

Pygidium accompanying cranidium semi-circular; posterior end a little sinuated and elevated; axial lobe strong, elevated, short, cylindrical, rounded at the posterior end; pleural lobes convex, inclined from axis to margin; axial and pleural lobes consist of three sets of segments in addition to an articulating one; marginal border narrow and not well defined; pleural lobes and grooves strong, but fade out in passing the border; surface smooth.

Under the high magnifying lens very fine inosculating lines are found on the frontal limb under the test.

Comparisons:—*Agraulos ceticephalus* (Barrande)[1] has a semi-ovate glabella and its palpebral lobe is smaller than this species. Among the North Chinese faunas, *Metagraulos abrota* (Walcott)[2] and *Metagraulos dirce* (Walcott)[3] are more or less allied to this species, but *M. abrota* is a small trilobite which has a short and considerably elevated glabella in which respects the present species is quite distinct. *M. dirce* is closer to this, but it has a larger preglabellar field and a more smooth glabella which almost merges into the preglabellar field forward.

Except the texture of the carapace the most closely allied species is *Chondroparia simulans* (Reed)[4] from the Himalayas. It agrees with this species in the truncato-conical glabella surrounded by a deep dorsal furrow, distinct eye-ridge across the fixed cheek, strong occipital furrow, and preglabellar field of moderate size which is somewhat differentiated into a frontal limb and rim. However, the Indian species is to be distinguished from this Korean one by the rapid narrowing glabellar outline, smaller palpebral lobe and larger postero-lateral limb of the fixed cheeks of the former. *Ptychoparia* (?) *himalaica* Reed[5] from the same locality and horizon is also very close to *Megagraulos coreanicus* and *Chondroparia simulans* in the general outline of the cranidium and glabella and the position of the palpebral lobe, although *P.* (?) *himalaica* has a strong frontal brim and a furrowed glabella.

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1) Barrande (1852), Syst. Sil. de Bohème, Vol. I, p. 404, Pl. 10, figs. 14–15, (*Arionella ceticephalus* Barr.)

2) Walcott (1913), Cambrian Faunas of China, p. 155, Pl. 15, fig. 3.

3) Walcott (1913), Op. cit. p.156, Pl. 15, fig. 5.

4) Reed (1910), Cambrian Fossils of Spiti, p. 43, Pl. V, fig. 22.

5) Reed (1910), Op. cit. p. 35, Pl. IV, fig. 27, Pl. V, fig. 1–3, ? 4.

This Korean species is, in general form of the cranidium, also very close to *Proliostracus* which was recently established by Poulsen, but it does not agree with that genus in its obsolete glabellar furrows and *Proliostracus*[1] for the most part has a more transverse outline and approaches the ptychoparids.

Formation and locality:—*Megagraulos* zone of Doten. This occurs also in the early Middle Cambrian green shale at 1 km. south of Nankaso in Sosan area, North Chosen, in association with *Agnostus rakuroensis*, *Acrothele* sp. and *Acrotreta* sp. (平安北道楚山郡南面南下倉)

Genus LORENZELLA, new genus.

Genotype:—*Agraulos abaris* Walcott.

Remarks:—This is a characteristic Cambrian genus of the Western Pacific. For the generic characters and specific reference see pages 201, 207, and 253.

Lorenzella tatei (Woodward).

Plate XXIV, figure 17.

1884. *Dolichometopus tatei* Woodward, Geol. Mag. I, p. 343, Pl. II, fig. 3.
1892. *Microdiscus subsagittatus* Tate, Trans. Roy. Soc. S. Australia, 15, p. 187, Pl. 2, fig. 12.
1892. *Olenellus pritchardi* Tate, ibid. p. 187, Pl. 2, fig. 1.
1909. *Dolichometopus tatei* Basedow, Zeits. d. d. geol. Gesell. 61, p. 313.
1909. *Microdiscus subsagittatus* Basedow, ibid. p. 313.
1916. *Redlichia tatei* Walcott, Smiths. Misc. Coll. 64, p. 359.
1919. *Ptychoparia* (?) *tatei* Etheridge, Trans. Proc. Roy. Soc. S. Australia, 43, p. 382, Pl. 39, fig. 2, 3.
1919. *Ptychoparia* (?) *subsagittatus* Etheridge, ibid. p. 383, pl. 39, fig. 4–5.

Here are noted Australian representatives of *Lorenzella* which bear the names of *Dolichometopus tatei*, *Microdiscus subsagittatus* and *Olenellus pritchardi* and which have been referred variously to *Microdiscus*, *Olenellus*, *Redlichia*, *Dolichometopus* and *Ptychoparia*. A stuty of their replicas, however, has convinced me that these three species, as suggested by Etheridge, might be united into one or two which, however, in my opinion do not belong to any one of these genera, but is most probably a *Lorenzella*. The position of the eye is rather posterior, but this varies among the species of *Lorenzella* to a great degree and on that account it will be comparable to such a form as *Lorenzella melie*.

1) Poulsen (1932), Lower Cambrian Faunas of East Greenland, p. 48.

Formation and locality:—Middle Cambrian (Parara limestone) of Curramulka, Yorke Peninsula, South Australia.

Lorenzella quadrata, new species.

Plate XII, figures 2-5; Plate XIII, figures 2-3.

Description:—Cranidium subquadrate, broadly rounded on the frontal margin; glabella as wide as fixed cheek, convex, truncato-conical, unfurrowed except for the occipital groove; occipital ring semi-circular; dorsal furrow very strong; frontal limb and the fixed cheeks approximately the same in breadth and convexity; eyes posterior, opposite the middle of the glabella; occipital lobe on the cheek very narrow.

In some specimens a pair of grooves are observed which cross the frontal limb obliquely from the antero-lateral corners of the glabella.

Free cheeks which possibly belong to this species are convex and pointed at the genal end into a short spine.

Associated pygidium is semi-ovate, convex, and bent down to the margin; its anterior margin broadly rounded; if the specimen were not broken, the posterior margin would be deeply sinuated; axis a little wider than the pleura, tapering back rather abruptly and ending in a narrow longitudinal ridge across the margin; axis divided into five rings and a triangular lobe; five pleural ribs counted among which the first one is considerably strong; actually no marginal border; surface smooth.

Comparisons:—The distinguishing characters are the subquadrate outline of the cranidium, truncato-conical glabella surrounded by a deep dorsal furrow, the convex frontal limb and fixed cheeks, and posterior eyes. Among the species of *Lorenzella* in North China, *L. acella* (Walcott)[1] is most close to this species, but this is distinct from that Chinese species in its wider outline and more posterior eyes. That species also manifests an unusual swelling in the frontal limb.

Another allied species is *Lorenzella tonkinensis* Mansuy[2] which simply differs from this species in the presence of a short pointed occipital spine.

Formation and locality:—*Drepanura* zone; Shoku-do and Kasetsu-ji.

1) Walcott (1913), Cambrian Faunas of China, p. 150, Pl. 14, figs. 15, 15 a.

2) Mansuy (1915), Faunes Cambriennes du Haut-Tonkin, p. 19, Pl. II, figs. 13a-c; (1916), Faunes Cambriennes de l'Extrême Orient méridionale, p. 31, Pl. V, figs. 5a-d.

Family Shumardidae Lake.

Blind trilobites similar to the Eodiscidae in size and in cephalon, but having six segments on the thorax and different shape of the glabella.

Shumardia has been compared variouly to *Agnostus, Conocoryphe*, the Olenidae and the Trinucleidae, but not one of them is close enough in resemblance to bring this genus into its folds. At the same time it cannot be a larval stage, because none of the trilobites found in association with it has been proved to be its mature form. Accordingly this is separated as a distinct family.

The family includes the following genera among which the generic distinction is to be made primarily on the shape of the glabella.[1]

Shumardia Billings, 1865. (Genotype : *Shumardia granulosa* Billings.)
Idiomesus Raymond, 1924. (Genotype : *Idiomesus tantillus* Raymond.)
Koldinoidia Kobayashi, 1930. (Genotype : *Koldinioidia typicalis* Kobayashi.)
? *Acanthopleurella* Groom, 1902. (Genotype : *Acanthopleurella grindrodi* Groom.)

Lake[2] suggested that the apparent absence of the frontal limb in *Acanthopleurella*[3] is probably the result of inrolling. Out of *Conophrys salopiensis* Callaway was establshed *Conophrys* by Callaway,[4] but it loses its standing, since the genotype is a synonym of *Shumardia pusilla* (Sars).

Shumardia is a wide spread Tremadoc fossil distributed in Europe, North and South America, and Eastern Asia.

Shumardia sp. undt. which is represented only by the pygidium was reported from the Middle Cambrian of Shantung by Walcott[5]; *Shumardia* cf. *granulosa*[6] and *Shumardia orientalis*[7] have been described from the Upper Cambrian of Tonkin and the *Ptychaspis walcotti* zone of Li-konan-ku by Mansuy ; and *Shumardia pellizzarii* from South Chosen.

1) T. Kobayashi (1933), Upper Cambrian of the Wuhutsui Basin, etc. p. 99.
2) P. Lake (1907), Monogr. Brit. Cambr. Tril. Pt. II, p. 42.
3) T. T. Groom (1902), On a Trilobite from the *Dictyonema*-shales of the Malvern Hills, (Geol Mag. Dec. IV, 9,) pp. 70-72, text-figs. 1-4.
4) C. Callaway (1877), On a new Area of Upper Cambrian Rocks in South Shropshire, etc. (Q. J. G. S. London, Vol. XXXIII.)
5) Walcott (1913), Cambrian Faunas of China, Pl. 7, fig. 9.
6) Mansuy (1915), Faunes Cambriennes du Haut Tonkin, p. 9.
7) Mansuy (1916), Faunes Cambriennes de l' Extrême Orient Méridional, p. 18, Pl I, figs. 28 a-e.

Idiomesus is known from the Upper Cambrian of Vermont and *Koldinioidia* from the Upper Cambrian and Basal Ordovician of Manchuria.

Family Conocoryphidae Angelin.

Historical Review:—In 1881, Zittel[1] placed the *Conocoryphe* group under Salter's Conocephalitidae with *Liostracus, Anomocare, Arionellus* (i. e. *Agraulos*), *Ellipsocephalus, Corynexochus, Ptychaspis* and many others. This family, however, lost its standing not only by its own heterogeneity but by the circumstance of Barrande's usage of *Conocephalites* which was applied by the author in the sense that it united Corda's three genera, *Conocoryphe, Ctenocephalus* and *Ptychoparia.*

Matthew[2] recognized the Conocoryphine for the eye-less trilobites with long thoraces and included *Conocoryphe* and *Ctenocephalus* in it. Before that, he[3] subdivided each one of these genera into two subgenera. The key for his Conocoryphea (or Conocoryphinae) is as follows:—

A. Species with frontal lobes as well as glabella and having a small pygidium. ············ *Ctenocephalus* Corda.
  A 1. Species having a wall-like front to the cheeks and frontal lobe. ············ *Ctenocephalus* s. str.
  A 2. Species having a sloping front to the cheeks and frontal lobe. ············ *Hartella,* subgenus.

B. Species with glabella only, with larger pygidium. ············ *Conocoryphe* Corda.
  B 1. Species having a suture that runs along the outer edge of the marginal fold. ············ *Conocoryphe,* s. str.
  B 2. Species having a suture that cuts off the lateral third of the marginal fold. ············ *Bailiella,* subgenus.

Matthew's study of the classification and ontogeny was criticized by Pompeckj[4] who claimed, however, that "Aus den Kopfschildern erwachsener Formen möchte ich eine scharfe Trennung zweier Gattungen: *Conocoryphe* (sammt *Bailiella*) und *Ctenocephalus* (sammt *Hartella*) nicht befürworten," and Matthew himself did not later recommend at least

1) Zittel (1881), Handbuch d. Palaeontologie, p. 600.

2) J. W. Matthew (1887), Illustrations of the Fauna of the St. John group, No. IV, (Trans. Roy. Soc. Canada, Sec. IV.)

3) Matthew (1885), Illustrations of the Fauna of the St. John Group, *Conocoryphe* and *Paradoxides,* (Trans. Royal Soc. Canada, Vol. 2, sect. 4,) p. 103.

4) Pompeckj (1896), Die Fauna des Cambrium von Tejrovic and Skrej in Böhmen, p. 535.

these subgenera *Bailiella* and *Hartella* be maintained as distinct divisions of *Conocoryphe* and *Ctenocephalus* respectively.

In 1897, Beecher[1] was of the belief that Angelin's Conocoryphidae represented the most primitive family of Opisthoparia on account of the presence of nepionic characters of *Ptychoparia* and *Sao* in the adult stage and included the following genera in it :—

Conocoryphe Howle and Corda, 1847. (Genotype : *Trilobites sulzeri* Schlotheim.)

Aneucanthus Angelin, 1852, (=*Acontheus* Angelin, 1852.) (Genotype : *Acontheus actuangulus* Angelin.)

Atops Emmons, 1844. (Genotype : *Atops trilineatus* Emmons.)

Avalonia Walcott, 1889. (Genotype : *Avalonia manuelensis* Walcott.)

Bailiella Matthew, 1865. (Genotype : *Conocephalites baileyi* Hart.) [=*Erinnys* Salter, 1865, (genotype : *Erinnys venulosa* Salter,) and *Salteria* Walcott, 1884, (genotype: *Erinnys venulosa* Salter.)]

Bathynotus Hall, 1880. (Genotype : *Peltura* (*Olenus*) *holopyge* Hall.)

Carausia Hicks, 1872. (Genotype : *Carausia menevensis* Hicks.)

Carmon Barrande, 1872. (Genotype : *Trilobites mutilus* Barrande.)

Ctenocephalus Howle and Corda, 1847. (Genotype : *Ctenocephalus barrandei* Howle and Corda.)

Dictyocephalites Bergeron, 1895. (Genotype : *Dictyocephalites villebruni* Bergeron.)

Elyx Angelin, 1852, (i. e. *Eryx* Angelin, not *Eryx* Swains.) (Genotype : *Elyx laticeps* Agelin.)

Harttia Walcott, 1884. (Genotype : *Harttia matthewi* Walcott.)

Toxotis Wallerius, 1805. (Genotype : *Toxotis pusilla* Wallerius.)

Next year Cowper Reed presented a paper on the " Blind Trilobits " in which he suggested the synonymy of *Carausia* with *Erinnys* and of *Dictyocephalites* with *Harpides*. But he[2] proposed Beecher's suggestion of synonymy between *Bailiella* and *Erinnys*. The latter genus on the other hand agrees with *Harpides* in every respects but that *Harpides* has eye-spots whereas *Erinnys* possesses only branching nervures on the cheeks.

The type of *Carausia* is so strongly deformed secondarily by the lateral compression that it cannot be made sure whether the frontal glabellar furrows and the basal side lobes are the original characters, or

1) Beecher (1897), Outline of a Natural Classification of the Trilobites, (Am. Jour. Sci. Vol. III.)

2) F. R. Cowper Reed (1898), Blind Trilobites, (Geol. Mag. New Ser. Dec. 5,) pp. 494-495.

due to the secondary modification. So far as I can see, a significant distinction is that *Carausia* has a genal spine, but *Erinnys* not. On this account and in the shape of the glabella *Carausia* is somewhat similar to *Hartshiella*, but the latter has no marginal brim.

As noticed by Reed, *Avolonia* and *Bathynotus* are not blind. Raymond later on placed the latter genus in the Olenidae, but its large eyes and furrows across the glabella appear quite suggestive of the Komaspidae-relationship. It might be an ancestral form of the Komaspidae and Telephidae. (See p. 140.)

Avalonia is quite allied to the Oryctocephalidae and Pagodidae in its square, long glabella and similar course of the facial suture, although the glabella is smooth and small eye is connected with the glabella by a groove, instead of a ridge. (See page 162.)

Carmon is represented so far by only two species, *C. mutilus* from Etage Dd5 and *C. primus* from Etage Dd1. The former has no eyes nor a facial suture, whereas *C. primus* possesses both. Barrande considered these differences to be of the specific importance and Zittel placed this in the family Proetidae. By the reason mentioned above *Avalonia, Bathynotus, Carausia, Carmon* and *Dictyocephalites* are here excluded from the family Conocoryphidae.

Elyx laticeps, the genotype, was later referred to *Ctenocephalus* by Grönwall.[1] In the outline of the cephalon *Elyx* is, however quite distinct from other genera of the Conocoryphidae, and hence I incline to believe that it stands as a valid genus. Howell[2] has the same opinion and described *Elyx americanus* from Vermont.

So far as I am aware, no study on *Aneucanthus* and *Toxotis* has been presented since the authors' descriptions excepting brief notes upon the terminology by Barrande[3] and Westergård.[4]

During my visit to Stockholm Westergård suggested me that *Toxotis* might be an immature form of *Acrocephalites* and *Aneucanthus* that of *Conocoryphe*.

In regard to Walcott's *Harttia* the criterion serving to distinguish it from *Conocoryphe* is a lobe or elevation in front.

1) Grönwall (1902), Bornholm Paradoxideslag og deres Fauna, p. 101.

2) B. F. Howell (1932), Two New Cambrian Trilobites from Vermont, (Wagner Free Inst. Sci. Phil. 7, no. 1,) p. 6, fig. 1.

3) Barrande (1856), Parallèle entre les dépôt siluriens de Bohême et de Scandinavie, (Abhandl. der kgl. Böhm. Gesell. der Wiss. Folge. 5, Bd. 9,) S. 20.

4) Westergård (1910), Index to N. P. Angelin's Palaeontologia Scandinavica, pp. 12–13.

Matthew[1] in 1899 established five divisions of the Conocoryphinae, viz. *Conocoryphe, Ctenocephalus, Erinnys, Atops,* and *Cainatops* Matthew, 1899. (Genotype: *Conocoryphe pustulosus* Matthew.) Modifying this opinion, Grönwall[2] in 1902 recognized the four subgenera of *Conocoryphe,* namely *Conocoryphe, Erinnys, Ctenocephalus,* and *Liocephalus* Grönwall 1902, with *Conocoryphe impresus* Linnarsson for the type of the last subgenus. Cowper Reed[3] and Grönwall suggested that *Holocephalina* Saltar, 1864, (genotype: *Holocephalina primordialis* Saltar) needs probably to be referred to this family. Lately Raymond[4] in 1924 added a new genus *Phoreotropis,* (genotype: *Phoreotropis puteatus* Raymond), but this has small eyes.[5]

In Zittel-Broili's Grundzüge,[6] the family was again expanded and made to hold *Hartshillia* Illings, 1915, (genotype: *Holocephalina inflata* Hicks), *Alokistocare* Lorenz, 1906, (genotype: *Conocephalites subcoronatus* Hall and Whitfield), *Acrocephalites* Wallerius, 1895, (genotype: *Solenopleura ? stenometopa* Angelin) and Walcott's Menomonidae; but *Alokistocare* and *Acrocephalites* are not blind and the Menomonidae is recognized as an independent family by Clark,[7] Richter[8] and others and its members are not blind either.

In 1927 Stubblefield and Bulman[9] established two new genera, *Hospes,* (genotype: *H. clonograpti* S. & B.) and *Myinda,* (genotype: *M. uriconii* S. & B.) from the Shineton shales and placed them provisionally in the Conocoryphidae. They might be the latest representatives of the family.

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1) G. F Matthew (1899), Studies on Cambrian Faunas, No. 4, Fragments of the Cambrian Faunas of Newfoundland, (Trans. Roy. Soc. Canada, 2 ser. sec. IV, Vol. V, p. 88.)

2) Karl A. Grönwall (1902), Bornholms Paradoxideslag og deres Fauna, (Danmarks geologiske undersøgekse II, 13,) p. 213.

3) Reed (1898), Op. cit. p. 497.

4) P. E. Raymond (1924), New Upper Cambrian and Lower Ordovician Trilobites from Vermont, (Proc. Boston Soc. Nat. Hist. Vol. 37, No. 4,) p. 33.

5) In the same year T. H. Clark established *Bienvillia* for the cranidium of *Dikelocephalus corax* Billings, (Pal. Foss. p. 334,) and placed it in the Olenidae in his description (Beekmantown series at Levis, Quebec, p. 21), but set it in the next place to *Phoretropis* in the Conocoryphidae on the table, (ibid. p. 12). The presence of the eyes, however, rejects the latter case. Incidentally, the congenity between the pygidium *D.* (?) *corax* and *Metopolichas* (?) *martellii* Kobayashi was suggested on p. 565 in the 2nd part of the palaeontology of this monograph.

6) Zittel-Broili (1924), Grundzüge der Palaeont. I, p. 647.

7) Clark (1924), Op. cit. p. 35.

8) Rudolf Richter (1933), Crustacea, in Handwörterbuch d. Naturwissenschaften, p. 854.

9) C. J. Stubblefield and O. M. B. Bulman (1927), The Shineton Shales of the Urenkin District, (Q. J. G. S. London, Vol. LXXXIII,) pp. 128-131, pl. IV, figs. 2-3.

Distinctions of the Concoryphid Genera:—According to Matthew, Grönwall, and others, the generic distinction is based upon 1) the outline of the cephalon and glabella, 2) relative size of glabella, 3) depth of the dorsal furrow, 4) presence or absence of the preglabellar lobes, 5) course of the facial suture, 6) size of the pygidium and 7) texture of the carapace; among these the 1st to 4th and 7th criteria are especially important.

The principal characters of the genera are summarized below:—

1) *Conocoryphe* Corda (s. str.)
   Glabella well defined, medium to large; shell mostly granulated. (For distribution see page 217.)
2) *Liocephalus* Grönwall. (Middle Cambrian of England and Baltic region.)
   Glabella large, poorly defined; shell smooth or shagreened.
3) *Atops* Emmons. (Lower Cambrian of Eastern North America.)
   Cephalon with a shortened ocular crest near the front margin; glabella long and well defined.
4) *Cainatopsis* Matthew. (Middle Cambrian of New Brunswick.)
   Glabella large and well defined; apical spine produced from the front margin.
5) *Erinnys* Salter. (Middle Cambrian of England.)
   Glabella well defined, small; cheek wide; nerve-like impressions highly conspicuous on the cheeks.
7) *Ctenocephalus* Corda. (Middle Cambrian of Bohemia, Southern France, Denmark, Sweden, Norway, England, Newfoundland, and New Brunswick.)
   Glabella small and defined; cheeks divided by the preglabellar lobe; shell granulated.
7) *Elyx* Angelin. (Middle Cambrian of Vermont and Baltic Region.)
   Similar to *Ctenocephalus*, but has a quadrate outline of the cephalon.
8) *Holocephalina* Salter. (Middle Cambrian of England.)
   Glabella obscure, tapering forward.
9) *Hartshillia* Illings. (Middle Cambrian of England and Newfoundland.)
   Glabella obscure; differs from *Holocephalina* by the large convex glabella widening forward and by the large nuchal spine.

Notes on the phylogenetical position:—That the absence of the eyes signifies primitiveness was Beecher's principal standpoint upon which he grouped most of the blind Opisthoparian genera in this family, and placed it at the top of that Order. But it is now generally accepted that the blindness is a sign of degeneracy, and the group of blind trilobites is considerd to be polyphyletic. It might be probable that *Carmon* is derived from the *Proetus*-stock and *Leiocoryphe* Clark from the Ellipsocephalidae-stock. If this idea is correct, as a consequence it becomes more probable that the Conocoryphidae divided off from the Ptychoparidae, in direct opposition to Beecher's, Swinnarton's and others' views which had explained the evolution in the reverse way. (See pages 76 and 114.)

Genus CONOCORYPHE Hawle and Corda, 1847.

1847. *Conocoryphe* Hawle and Corda, Abh. d. k. böhmisch. Gesell. d. Wiss., 5, p. 139.
1864. *Conocoryphe* Salter, Mem. Geol. Surv. United Kingdom, Dec. 11, p. 3, pl. 7.
1877. *Conocoryphe* Hall and Whitfield, U. S. Geol. Expl. 40th, Parl. 4, p. 209.
1878. *Conocoryphe* Angelin, Pal. Scand. 3d. ed. p. 62.
1885. *Conocoryphe* Matthew, Trans, Royal Soc. Canada, 2, sec. 4, p. 103.
1888. *Conocoryphe* Woodward, Quart. Jour. Geol. Soc. London, p. 77.
1889. *Conocoryphe* Miller, North American Geol. Pal., p. 539.
1895. *Conocoryphe* Wallerius, Unders. ofver. Zonen med *Agnostus laevigatus* i Vestergotland. Lund. p. 48.
1896. *Conocoryphe* Pompeckj. Jahrb. d. k. k. Geol. Reichsanst. 45, p. 531.
1897. *Conocoryphe* Beecher, Amer. Jour. Sci. 4th ser., 3, p. 104, Pl. 3, fig. 15.
1898. *Conocoryphe* Reed, Geol. Mag., Dec. 4, 5. p. 494.
1899. *Conocoryphe* Matthew, Trans. Royal Soc. Canada, 2 4, p. 88.
1900. *Conocoryphe* Reed, Geol. Mag., Dec. 4, 7, p. 250.
1901. *Conocoryphe* Lindström, Kongl. Sven. Vet. Akad. Handl., 34, No. 8, p. 10.
1902. *Conocoryphe* Grönwall, Danmarks Geol. Unders., 2, pp. 82, 84, 213.
1910. *Conocoryphe* Grabau and Shimer, N. A. Index Fossils, 2, p. 260.
1924. *Conocoryphe* Zittel-Broili, Grundzüge d. Palaeont. I, p. 647.

Genotype:—*Trilobites sulzeri* Schlotheim.

Remarks:—The distribution of *Conocoryphe* which is found throughout the whole Atlantic province during the Middle Cambrian age is very interesting. It is well known to occur in England, Baltic area, Bohemia, Southern France, Iberian peninsula and Sardinia. It has lately been found in Poland by Samsonovicz[1]; it reached across the Atlantic to Newfoundland, but never extended farther into the American continent, nor into the Arctic region. So far as I am aware, there is no record of its occurrence in Siberia.

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1) J. Samsonovicz (1920), Sur la Stratigraphie du Cambrien et l'Ordovicien dans la Partie Orientale des Montagnes de Sainte Croix, Palogne Centrale, (Bull. Serv. Géol. de Pologne, Vol. I, Livr. 1.)

Without any connection between, it reappears in a certain horizon of the Middle Cambrian in Yunnan and the Taitzu area in South Manchuria and North Chosen. It is known also to be listed from Australia,[1] but I have never seen any full description or illustration.

In such a situation the occurrence of *Conocoryphe* suggests a faunal connection between Europe and Eastern Asia at a certain time in the the Middle Cambrian wherever the route of migration may have been. If we recall the wide extension of the *Redlichia* in the Himalayan trough from Yunnan to Persia, the southern channel presents itself as the most probable avenue.[2]

PA1091-23-13
PA1092-23-14

Conocoryphe lantenoisi Mansuy.

Plate XXIII, figures 13–14.

1916 *Conocoryphe lantenoisi* Mansuy, Faunes Cambr. de l' Extrême-Orient Méridional, p. 30, Pl. IV, fig. 6a-g, 7 ; Pl. V, fig. 3.

1924. *Conocoryphe lantenoisi* Hayasaka, Brief Note on the Cambrian Fossils from Chin-chia-cheng-tzu, Huhsien and Liaotung, South Manchuria, (Jour. Geogr. Tokyo. Vol. XXXV, No. 412,) p. 209.

Original description was given by Mansuy as follows :—

" Ce Trilobite, d'assez grande taille, une contre-empreinte presque complète mesurant : longueur 60 mm., largeur au milieu de la longueur 38 mm., présente un contour ovale. La tête est arrondie surbaissée, sa longueur est un peu inférieure à deux fois sa largeur et elle égale le tiers de la longueur totale. Glabelle peu saillante, triangulaire, arrondie en avant ; sa largeur à la bass égale le tiers de la largeur de la tête ; sa lobation est à peine visible, chez les individus les mieux conservés. On observe deux lobes inférieurs latéraux triangulaires, séparés du reste de la glabelle par des sillons très obliques ; les lobes antérieurs sont réduits à de faibles ondulations. Joues fixes grandes, assez renflées. Les joues mobiles, sans doute très étroites et situées très latéralement, sont détruites chez tous nos individus. Aucune trace d'appareil oculaire. Limbe décrivant une concavité assez accusée dans sa région frontale ; cette concavité s'atténuant latéralement. Bourrelet occipital élevé et large, un peu infléchi en arrière, séparé de la glabelle par un sillon accusé ; bourrelets latéraux plus bas et plus étroits, disparaissant près de l'angle génal ; le sillon qui les précède est très large et assez profond.

Thorax composé de quatorze segments. Le rachis est assez saillant,

1) Gürich (1901), N. Jahrb. Min. Beil-Bd. 14, p. 500.

2) Reed recently described *Conocoryphe frangtengensis*, *Conocoryphe sejuncta* und *Conocoryphe* (*Ctenocephalus*) sp. from Kashmir, (Palaeont. Indica, New Ser. Vol XXI ,Mem. No. 2, 1934.)

à section courbe ; sa largeur égale environ les deux tiers de la largeur des lobes pleuraux. Les plèvres montrent une inflexion assez accusée, elles sont sillonnées ; le sillon qui les parcourt est très large, oblique ; pointes pleurales courtes, arrondies, non incurvées en arrière.

Pygidium arrondi très surbaissé. Axe large et peu saillant. Segments obsolètes ; les trois segments antérieurs sont encore discernables, les segments postérieurs entièrement effacés."

He described this species from the *Conocoryphe lantenoisi* horizon of Tien-fong along with *Anomocare minus.* Subsequently Hayasaka identified this species in Aoji's collection from Liaoyang. The horizon where the fossil came from was later reported upon in detail by Aoji[1] who stated that the *Conocoryphe* shale is greyish green shale intercalating limestone, 12 meters thick, and is located in the lower portion of the Middle Cambrian. The shale bed was recently designated by the name of Tangshih by Endo.

In their Manchurian collection Resser and Endo[2] found *Conocoryphe* and gave a new specific name *C. ulrichi* without any reference to *C. lantenoisi,* but between both of them no conspicuous difference can be made out. This species is distributed in the Taitzuho trough from Liaoyang area to Sosan area through the Huolienchai area on the one hand, and at Tien-fong of Indochina on the other. Nowadays we know no connection between, and such curious occurrences seem to suggest endemism, but it is really hard to recognize any morphological difference of specific value between the southern and northern forms.

This species is first distinguished easily from the granulated forms of *Conocoryphe.* Among the smooth forms this is fairly close to *C. sulzeli* (Schlotheim) as compared by Mansuy, but the boss is not so clearly defined and the lateral furrows of the glabella are much weaker in this species than in that genotype one. On these accounts this is still closer to *C. glabrata* Angelin,[3] but its glabella is much narrower and slender than that of the Baltic species.

Formation and locality:—Early Middle Cambrian of Sosan area, North Chosen. (古場東北東四粁月岳洞坪洞) Mansuy's specimens collected from the *Conocoryphe* zone of Tien-fong.

1) O. Aoji, (1927), Explanatory Text to the Geological Map of Manchuria, Feng-Huang-Cheng, p. 7.

2) R. Endo, (1932), Cambrian, in the Iwanami Series.

3) Angelin (1878), Pal. Scan. p. 72, Pl. XXXVII, fig. 8.

Genus ATOPS Emmons, 1844.

1844. *Atops* Emmons, Taconic System, p. 20.
1846. *Atops* Emmons, Nat. Hist. New York, Agriculture, 1, p. 64.
1848. *Atops* Haldeman, Amer. Jour. Sci., 2d. ser., 5, p. 107
1889. *Atops* Miller, North Amer. Geol. & Pal. p. 532.
1890. *Atops* Walcott, Rep. U. S. Geol. Surv., 30, p. 205.
1890. *Atops* Walcott, 10th Ann. Rep. U. S. Geol. Surv., p, 643, footnote.
1892. *Atops* Cole, Natural Science, 1, p. 340.
1895. *Atops* Oehlert, Bull. Soc. Géol. de France, 3 Ser., 23, 319, footnote.
1897. *Atops* Beecher, Amer. Jour. Sci., 4th ser., 3, p. 104, Pl. 3, fig. 14; p. 189, footnote.
1899. *Atops* Matthew, Trans. Roy. Soc. Canada, (2), 5, p. 88.
1910. *Atops* Grabau and Shimer, N. A. Index Fossils, 2, p. 261.
1924. *Atops* Zittel-Broili, Grundzüge d. Palaeont. I, p. 647.

Genotype:—*Atops trilineatus* Emmons.

Remarks:—*Atops* was recognized as a synonym of *Conocoryphe* by Walcott[1] and as a subgenus of *Conocoryphe* by Matthew.[2] Beecher and others accepted it as an independent genus as Emmons established it. The main distinctions from *Conocoryphe* are a cylindrical and long glabella with a crest in front of it, seventeen thoracic segments and smaller pygidium.

Except for the genotype, *Atops trilineatus* Emmons, only *Conocoryphe reticulata* Walcott has been referred to this genus and that by Matthew. The former species is known to be distributed in the Lower Cambrian from New York to Newfoundland through Vermont and Quebec and the latter is known only from New York.

Lately Resser and Endo referred a trilobite from the *Redlichia* zone of Liaotung to this genus of such a limited distribution. This attracted my attention and I have made an exacting study of the original specimen. My observations reveal that *Atops orientalis* Resser and Endo has a fairly large eyes opposite and close to the first glabellar lobes and thereby it is certainly out of the Conocoryphidae. Further notes will be given on page 163.

Family Ptychoparidae Matthew.

Historical Review:—Matthew[3] distinguished the Ptychoparinae and Conocoryphinae on the basis of the presence or absence of eyes, but

1) Walcott (1886), U. S. Geol. Surv. Bull. 30, p. 203.
2) Matthew (1899), Trans. Roy. Soc. Canada, 2d. ser. Sec. IV, Vol. V, p. 89.
3) Matthew (1887), Trans. Roy. Soc. Canada, Sec. IV.

since Beecher[1] had put the various kinds of trilobites including *Ptychoparia* into the family Olenidae Salter, the validity of the Ptychoparidae was not seriously considered for a long time. Later on, the Olenidae, however, was defined in a more limited sense by Raymond[2] and others, and in consequence the Mesonacidae, Paradoxidae, Solenopleuridae, Oryctocephalidae, Ellipsocephalidae and Dikelocephalidae became separated from Beecher's Olenidae. The Olenidae is, however, still large, and Swinnerton,[3] Poulsen,[4] Richter[5] and others are of the opinion that it is necessary to separate the Ptychoparidae from the Olenidae s. str. with which idea I am in agreement by the reasons that the Ptychoparidae is well defined and readily distinguishable from the Olenidae s. str. on one hand, and that the Olenidae evolution was traced by Westergård[6] up to *Liostracus* on the other. In my belief the Ptychoparidae is one of the ancestral stocks from which various evolutional lines branched off. Here, the Ptychoparidae s. str. (or Ptychoparinae) will be defined in the following way.

Family diagnosis:—Cephalon large, transverse; glabella small, truncato-conical; eyes small to medium, about at the mid-length; frontal limb and free cheeks marked by irregular radiating lines; facial sutures more or less divergent anterior to the eyes; thorax composed of numerous segments, (fourteen in the genotype of *Ptychoparia*, but twenty-four in *Chancia evax*); its axis narrow; pygidium smaller than the cephalon and without spine.

The main distinctions which set apart the Olenidae s. str. are found in the anterior eyes, square preglabellar area and large postero-lateral limb of the fixed cheek of the Olenidae. The axial lobe of the thorax is mostly much broader in the Olenidae than in the Ptychoparidae.

The Asaphiscidae is distinguished from the Ptychoparidae by its broad axis, narrow fixed cheek, obliteration of the radiating lines on the preglabellar area, fewer thoracic segments, larger pygidium with a distinct concave border and in most cases larger eyes and weaker ocular ridges.

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1) Beecher (1897), Am. Jour. Sci. Vol. III; (1900), in Zittel-Eastman's Text-Book of Palaeontology.

2) Raymond (1913), in Zittel-Eastmen's Text-Book of Palaeontology.

3) Swinnerton (1915), Suggestions for a Revised Classification of Trilobites, (Geol. Mag. New Ser. Dec. 6, Vol. 2.)

According to Swinnerton, the Ptychoparidae includes *Ptychoparia, Protypus, Euloma, Sao, Trianthrus, Liostracus, Bavarilla* and *Neseuretus*, (p. 540).

4) Poulsen (1927), Cambrian, Ozarkian, and Canadian Faunas of North Greenland.

5) Richter (1933), Crustacea, in Handwörterbuch d. Naturwissenschaften.

6) Westergård (1922), Sveriges Olenidskiffer, p. 188.

The Solenopleuridae differs by its large oval glabella, thick brim and strong relief upon the cephalon.

Notes on the Ptychoparid Genera:—As *Ptychoparia* itself has been a sort of a waste-basket, a thorough revision of the genus is required. Walcott, Mansuy, Poulsen and others have already attempted to subdivide it into subgenera or spread it out into several genera. As a result of their studies the following genera and subgenera have been introduced:—

Ptychoparia Corda, 1847.(Genotype: *Conocephalus striatus* Emmrich.)
Alokistocare Lorenz, 1906. (Genotype: *Conocephalites subcornatus* Hall and Whitfield.)
Emmrichella Walcott, 1911. (Genotype: *Ptychoparia theano* Walcott.)
Annamitia Mansuy, 1916. (Genotype: *Ptychoparia* (*Annamitia*) *spinifera* Mansuy.)
Amecephalus Walcott, 1924. (Genotype: *Ptychoparia piochensis* Walcott.)
Chancia Walcott, 1924. (Genotype: *Chancia ebdome* Walcott.)
Elrathia Walcott,1924. (Genotype: *Conocoryphe* (*Conocephalites*) *kingi* Meek.)
Amecephalina Poulsen, 1927. (Genotype: *Amecephalina mirabilis* Poulsen.)
Elrathiella Poulsen, 1927. (Genotype: *Elrathiella obscura* Poulsen.)
Inglefieldia Poulsen, 1927. (Genotype: *Inglefieldia porosa* Poulsen.)
Kochiella Poulsen, 1927. (Genotype: *Kochiella tuberculata* Poulsen.)
Ptychoparella Poulsen, 1927. (Genotype: *Ptychoparella brevicauda* Poulsen.)
Mapania Resser and Endo (MS). (Genotype: *Mapania typus* Resser and Endo.)

Lorenz established *Trachyostracus* Lorenz[1] without selection of the genotype and included *Solenopleura* (?) *howleyi* Walcott and *Ptychoparia limbata* Matthew in it. The latter species belongs to *Ptychoparia* and the former probably *Protolenus* or its allied genus.

The generic characters are based variously by these authors on the breadth of the fixed cheek, convexity of the brim, the boss in front of the glabella, number of thoracic segments, relative size of the carapace and so on.

Ptychoparia s. str. has a broad fixed cheek, anterior branches of the

1) Th. Lorenz (1906), Beiträge zur Geologie und Palaeont. von Ostasien II, (Zeitsch. deut. geol. Gesell., Bd. 58,) p. 74.

facial sutures widely divergent in front of the eyes and marginal along the brim, distinct irregular lines radiating outside of the palpebral lobe, strong, convex rim and relatively large pygidium.

It is to be noted that the Solenopleuridae probably sprang out from this type of ptychoparid.

Poulsen's *Ptychoparella* differs in the pygidium from *Ptychoparia* merely "in being extremely short and in having a short axis with but four segments and a well differentiated border." [Poulsen (1927), ibid. p. 280.]

Elrathia Walcott is distinguished from *Ptychoparia* primarily by its narrow fixed cheek, less convex and broad rim, intramarginal course of the facial suture and relatively smaller pygidium. The genotype has thirteen thoracic segments. *Armonia* Walcott from the Upper Cambrian of southern Appalachian will be a descendant of the *Elrathia*-line. Poulsen's *Elrathiella* differs from *Elrathia* "in its much narrower cranidium, wider rim, narrower frontal limb, and unusually long, narrow glabella." [Poulsen (1927), ibid. p. 276.] This genus contains a single species represented only by cranidia. If in addition to the above characters its large eyes and smooth texture is taken into account, it may be suggested that *Manchuriella* is a synonym of *Elrathiella*.

Resser and Endo's *Mapania* is characterized by a long glabella, narrow fixed cheek, large eye and posteriorly projected frontal rim.

The *Elrathia-Mapania* line possibly runs into the Asaphiscidae through *Manchuriella* and *Proasaphiscus* without any large gaps, and so after all the family boundary ought to be arbitarily drawn.

Chancia and *Inglefieldia* form another group of ptychoparids. *Chancia* is characterized by a wide axial lobe, narrow fixed cheek, subequally divided frontal limb and rim, numerous thoracic segments (20–24), and very small pygidium. Both genera are known to be distributed in the late Lower and Middle Cambrian of North America and Greenland.

Inglefieldia porosa and *Chancia ebdome*, both genotypes, are so close that the former is a synonym or a subgenus of the latter. The only distinction recognizable between them is the outline of glabella which is longer and tapering more slowly in the former and, if this is enough for generic distinctions, *Chancia evax* will be an *Inglefieldia* and not a *Chancia*.

The fourth group containing *Alokistocare* s. str., *Amecephalus* and *Amecephalina* usually has a wide concave border on the cephalon in contract to the convex ones of the preceding forms. *Alokistocare* of the

Lower Cambrian and *Amecephalus* of the Middle Cambrian might merge one into the other gradually. The comparison of the genotypes, however, reveals some differences such as small glabella and eyes, long preglabellar area and postero-lateral limb, and stronger boss in front of the glabella in *Amecephalus piochensis*. This form also has 19 segments and a very small pygidium. *Ptychoparia defossa* Reed[1] from the horizon 6 of the Parahio series in Spiti bears all of the characteristics of *Alokistocare* excepting the nuchal spine.

Poulsen's *Amecephalina* from the Middle Cambrian of Greenland is a good genus which stands apart on its intramarginal facial suture, and eyes close to the glabella, and large associated pygidium.

I presume that *Pterocephalia-Coosia* s. str. group might be located in this neighbourhood. (See the Pterocephalinae on page 230.)

The fifth group contains *Kochiella* and its allied forms from the late Lower to Middle Cambrian of North America and Greenland, and distinguished from all of the preceding ones by the granulation, that is, *Kochiella* is a granulated *Amecephalus*. Some species of Walcott's *Acrocephalites*, such as *A. americanus* belong here.

Incidentally Walcott's *Acrocephalites* and *Alokistocare* are composite genera which call for a thorough revision. As excellently illustrated by Westergård (Westergård (1922), ibid. Pl. I, figs. 21 a-b), *Acrocephalites stenometops* (Angelin), the genotype, is quite different from most of the American species of *Acrocephalites* which have commonly broad cranidia, transverse frontal brims, distinct ocular ridges and divergent facial sutures in front of the eyes.

Asteraspis, new genus:—For such an unusual form as *Acrocephalites*(?) *aster* Walcott there is no need of hesitation in establishing a new genus and I propose the name *Asteraspis* here. The generic characters are triangular glabella, transverse frontal rim, axial ridge across the frontal limb, small eyes and diagonal facial sutures posterior to them, and granulate surface.

Finally two subgenera of *Ptychoparia* are known from the Middle Cambrian of the Orient. Walcott's *Emmrichella* is established on the basis of *Ptychoparia theano*. In my observation this genus is well characterized by the narrow cylindrical glabella, wide fixed cheek, large posterior eyes, flat depressed rim, very narrow occipital lobe, and so forth. With such a combination of characters *Emmrichella* escapes

1) Cowper Reed (1910), Cambrian Fossils of Spiti, p 29, Pl. III, figs. 26–28; Pl. IV, fig. 1.

from confusion with any described genera and at the same time it falls outside of the Ptychoparidae, because no member of the family has such a cylindrical glabella and posterior eyes which are actually or almost in contact with the occipital lobe. Led by such unique features, I group this with *Liostracina* Monke in the Emmrichellidae, new family. Incidentally *Ptychoparia* (*Emmrichella*) *mantoensis* is an *Elrathia* or a *Manchuriella*; *Ptychoparia* (*Emmrichella*) *bronus* is undoubtedly a *Changshania*. (See plate XXIII, figure 16.)

Mansuy's *Annamitia* is certainly a distinct genus, but its large eyes, facial sutures convergent anterior to the eyes and intermarginal on the frontal rim, wide axial lobe of the thorax with a long spine on the eleventh preclude the inclusion of this genus in the Ptychoparidae.

The last mentioned character is strongly suggestive of the *Redlichia* alliance. The square glabella, occipital spine and other characters of the cranidium reveal good agreement with those of *Redlichaspis*. Another line which might be suggested is the Olenidae which also has the square preglabellar area and spines on the axial segments of the thorax and other characters in common with *Annamitia*.

Subfamily Ptychoparinae Matthew.

Genus PTYCHOPARIA Corda, 1847.

Ptychoparia kochibei Walcott.

Plate XXIV, figure 24.

1911. *Ptychoparia kochibei* Walcott, Smiths. Misc. Coll. Vol. 57, No. 4, pp. 78–79, Pl. 14, figs. 10–10a.

1913. *Ptychoparia kochibei* Walcott, Cambrian Faunas of China, p. 132, Pl. 12, figs. 15, 15a–e.

This is a common and well known fossil of the Fuchou series in Liaotung. Its primary difference from *Elrathia kingi* lies in the broad fixed cheek, narrow convex rim and marginal facial suture. It is, however, different again from *Ptychoparia striata* in the size of the pygidium and in which respect this species is very similar to the Indian ptychoparids, such as *Ptychoparia spitiensis*[1] and *P. stracheyi*.[2]

Formation and locality:—The figured specimens were collected from the Sosan area, North Chosen. (平安北道楚山郡東面倉坪洞)

1) Reed (1910), Cambrian Fossils of Spiti, p. 18, Pl. I, figs. 25–31; Pl. II, figs. 1–5, 6 ? 7 ?

2) Reed (1910), ibid. p. 21, Pl. II, figs. 8–13

PA1094-23-3
PA1095-23-4

Ptychoparia (?) *coreanica*, new species.

Plate XXIII, figures 3-4.

Description:—Cephalon broad; glabella, conical, rounded in front; dorsal and glabellar furrows narrow, but distinct; eyes medium sized, at about the middle and connected with the glabella by an oblique and straight ocular ridge; fixed cheek measured across the eyes narrower than the glabella at the same point; frontal limb long and rim narrow and convex; irregular lines divergent from the palpebral lobes; free cheek broad, with a short genal spine.

Thorax composed of eleven segments; axial lobe as wide as one-fifth the thorax.

Pygidium of moderate size, subtrapezoidal in outline; posterior margin slightly sinuated; axis and pleurae divided into six segments; axial lobe relatively short; each pleura divided by a furrow.

The holotype is 16 mm. long; its cephalon, thorax and pygidium are 5.6 mm., 7.7 mm., and 3.7 mm. in length respectively.

Comparisons:—The relatively large glabella and narrow fixed cheek are suggestive of *Elrathia*, but excepting these, this species is provided with all the diagnostic characters of *Ptychoparia* s. str. It stands between *Elrathia* and *Ptychoparia*, but is closer to the latter.

Formation and locality;—Sendo, Heian-nan-do, North Chosen. (平安南道大同郡栗里 隱松里 泉洞)

PA1096-18-2
PA1097-18-3
PA1098-18-4

Genus ELRATHIA Walcott, 1924.

Elrathia taikiensis, new species.

Plate XVIII, figures 2-4.

Description:—Cephalon semi-circular with a distinct marginal border which is produced back into genal spines; glabella conical, rounded in front, marked off by a distinct dorsal furrow and bluntly keeled along the axis; glabellar furrows almost obscure except for the occipital furrow; fixed cheek flat or slightly convex; palpebral lobe large, a little posterior to the middle of the glabella; ocular band and ridge vary in strength; frontal limb gently convex and inclined forward; frontal rim and groove strong; fine irregular lines diverge outward from the frontal margin of the glabella and from the ocular ridge and band and are distributed on the frontal limb and also on the central body of the free cheek; anterior branches of facial sutures do not extend outward from the parallels passing the eyes; they obliquely cross the brim to the center of the anterior margin after meeting with the marginal groove; posterior branch of the suture almost transverse and turns back near the lateral end of the postero-lateral limb of the fixed cheek.

Comparisons:—The narrow, fixed cheek and intramarginal facial sutures suggest that this species is closer to *Elrathia* than *Ptychoparia* s. str., although its glabella is relatively long and frontal limb short. *Elrathia kingi* (Meek), the genotype, has a much smaller and less elevated glabella and narrower fixed cheek.

Among the Oriental ptychoparids this species is quite close to *Ptychoparia acilis* Walcott on one hand and to *Ptychoparia* (*Emmrichella*) *mantoensis* Walcott on the other. From *P. acilis*, however, it is distinguished by its unfurrowed and more conical glabella and absent occipital spine. Its only unmistakable difference from *P.* (*E.*) *mantoensis* lies in the strength of the frontal brim and eye-ridge which is considerably reduced in Walcott's species.

Formation and locality:—*Elrathia* zone of Taiki.

Elrathia kikkawai, new species.

Plate XXIII, figure 2.

This species quite resembles the preceding in the general outline, but is distinguished by its convex glabella provided with three pairs of furrows, and clear cut ocular ridge and inosculating lines covering the frontal limb.

Another allied species is *Ptychoparia consocialis* Reed[1] from the horizon 9 of the Parahio series in Spiti from which this is distinguished by the surface texture. The Spiti species has very fine granulations on the head-shield.

In comparing with *Elrathia kingi*, the frontal rim is seen to be fairly convex, but otherwise no difference of the generic value is found.

Formation and locality:—Sho-ryu-san, Heian-nan-do, North Chosen, (小龍山 南谷).

Elrathia chuwaënsis, new species.

Plate XXIII, figure 1.

Description:—Glabella truncato-conical, two-thirds as long as the cranidium; dorsal furrows strong, but the glabellar furrows very weak;

1) Reed (1910), Cambrian Fossils of Spiti, p. 24, Pl. II, figs. 17–21.

eyes medium sized, and located at the mid-length of the cranidium ; no distinct ocular ridge ; fixed cheek measured across the eyes as wide as the glabella ; frontal limb moderately convex and frontal rim flat and depressed, divided by a transverse groove between ; facial sutures slightly divergent anterior to the eyes and then take the intramarginal course on the rim ; they are diagonal posterior to the eyes.

Thorax composed of fourteen segments ; axial lobe as broad as one-fourth the thorax.

Pygidium small, semi-circular, divided into five segments or so.

The holotype is 16 mm. in length. Its cephalon, thorax, and pygidium are 6 mm., 8 mm., and 2 mm. long respectively.

Formation and locality ;—*Elrathia chuwaensis* zone ; west of Chuwa, North Chosen.

Genus MAPANIA Resser and Endo (MS.)

Remarks :—Resser and Endo intend to establish this genus on the basis of their *Mapania striata*(nov.), namely Walcott's *Ptychoparia typus*,[1] (1913, Pl. 12, figs. 14a–c and not fig. 14 and not Dames' *Conocephalites typus*.)

According to them *Mapania* resembles *Anomocarella*, but differs from the latter in the well defined glabellar furrows, a heavier eye-line, and relatively small eyes in the cephalon. *Mapania* has a posterior projection on the marginal brim, as seen in *Anomocarella*, which often reaches to the glabella. The pygidium of *Mapania* is similar to that of *Anomocarella*, but somewhat larger and has interpleural furrows.

Those distinctions from *Anomocarella* seem to me to point the relationship of this genus to ptychoparids. It might be an intermediate link between ptychoparids and *Anomocarella*.

It is noted that *Anomocare conjunctiva*[2] from Spiti has this kind of a brim, furrowed glabella, strong eye-line and pygidium with interpleural furrow and it may come within the fold of *Mapania* or at least its close neighbourhood. The rather important characteristics which this Indian species possesses, are, however, the convex anterior margin of the pygidium and a tubercle on each axial ring.

Here it is noted that Poulsen's *Polypleuraspis*[3] has this last character.

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1) Walcott (1913), Research in China, 3, p. 134, Pl. 12, figs. 14a–c.
2) Reed (1910), Cambrian Fossils of Spiti, p. 45, Pl. V, figs. 23–25.
3) Poulsen (1927), Cambrian, Ozarkian and Canadian Faunas of N. W. Greenland, p. 270.

Genotype:—*Mapania striata* Resser and Endo, (i. e. *Ptychoparia typus* Walcott.)

Geological and geographical distribution:—Middle Cambrian of Eastern Asia.

Mapania beihoensis, new species.

Plate XX, figures 8–10.

Description:—Cranidium subtrapezoidal; glabella truncato-conical, distinctly defined by a strong dorsal furrow and elevated above the flat cheeks and preglabellar area; three pairs of glabellar furrows not very strong, disconnected in the middle, and transverse except for the third pair which is a little oblique backward; occipital furrow strong; occipital lobe broadened and convex backward in the middle; the breadth of fixed cheek nearly equal to that of the glabella; palpebral lobe medium sized and located at the mid-length of the cranidium; eye-band continues to the eye-ridge which in turn crosses the fixed cheek toward the first glabellar furrow; preglabellar area almost same as the glabella in width, and divided into the limb and rim of subequal length by a deep and narrow groove; frontal rim broadly rounded along its anterior margin and transverse along the posterior, but near the middle produced back along the axis.

Free cheek curving conspicuously along the antero-lateral margin, but subsequently running rather straignt; marginal brim narrow, but thick and after joining with the occipital brim produced back into a spine.

Surface smooth.

Comparisons:—The general aspect of this cranidium reminds me first of Walcott's *Conocephalina vesta*, but this palpebral lobe is much smaller and the posterior margin of the frontal brim is pointed back at the middle and these characters bring this species to the new genus *Mapania* proposed by Resser and Endo. They selected *Mapania striata* as the genotype which is identical with Walcott's *Ptychoparia typus* illustrated on plate 12 in figures 14a–c and not in fig. 14. Comparisons reveal that this Korean form has a broader fixed cheek and a weaker eye band and ridge. In the free cheek the exterior margin and the direction and strength of the genal spine also distinguish these species.

Formation and locality:—*Mapania* zone of Doten.

Subfamily Pterocephalinae, new subfamily.

The phylogenetical relation of *Pterocephalia* has been discussed by various authors; Shumard[1], Hall and Whitfield[2] sought its relationship toward *Conocephalites* of Zenker; Miller[3] grouped *Pterocephalia* into the Dikelocephalidae; Ulrich and Resser[4] combined it with *Hungaia, Burnetia* and *Elkia* and removed Raymond's Hungaiinae from the Dikelocephalidae as a distinct family.

Through the comparison of the cephala and pygidia it will be easy to arrive at the heterogeneity of their Hungaiidae. But there are certain reasons that *Pterocephalia* should be referred to the Dikelocephalidae, because *Pterocephalia* manifests the combined characters of *Amecephalus* and *Saukia*,—precisely speaking, it has a cephalon of the former type and a pygidium of the latter. But as no complete individual of *Pterocephalia* has ever been found, it cannot be proved that this combination of the cephalon and pygidium is correct, even though it is quite possible. In this situation the cephalon naturally bears more weight than the pygidium, because the genus was originally found by Roemer[5] upon that part.

The essential differrences between the cephalon of *Pterocephalia sancti-sabae* and *Amecephalus piochensis* are found in the longer preglabellar area and strong depressions on both sides of the frontal lobe of the glabella in the first genus. The prolongation of the preglabellar area involves the concave border and not the frontal limb, because the limb marked by radial nerve-like striations in the same way as in *Amecephalus* is not very large, but the concave area in front of the limb is smooth, or marked by an irregular transverse striation probably caused by the doublure and if the length of its area is reduced to half, the resulting cephalon would have the same outline as that of *Amecephalus*. Therefore there is no need for hesitation in grouping *Pterocephalia* in the *Amecephalus* line, so far as the cephalon is concerned.

The only point which would raise a question as to this interpreta-

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1) B. F. Shumard, (1861), Primordial zone of Texas with Descriptions of New Fossils, (Am. Jour. Sci. 2d. ser. Vol. 32,) p. 214.

2) James Hall, and R. P. Whitfield (1877), Exp. 40th Par. Vol. 4, Geol. p. 221.

3) S. A. Miller, (1889), N. A. Geol. and Pal. p. 564.

4) Ulrich and Resser (1930), Cambrian of the Upper Mississippi Valley, Pt. I, p. 12–15.

5) Roemer (1849), Texas, Bonn, p. 412; (1852), Die Kreidebildungen von Texas, p. 92, Pl. II, figs. 1 a-d.

tion lies in the remarkable difference of the pygidium, but the size and features of the pygidium are fairly apart even between *Amecephalus* and *Amecephalina,* and the pygidium of *Amecephalina mirabilis* is not very different from that of *Pterocephalia sancti-sabae* excepting the wide concave margin of the latter. Therefore this point may be explained by assuming a later development of the pygidium.

When the two or three links now missing will brought to light, it is expected that *Amecephalus, Amecephalina* and *Pterocephalia* will be found to constitute a beautiful evolutional series, for which a name Pterocephalinae is suggested here, and which will probably comprise also *Alokistocare* and *Coosia* by the reasons mentioned in pages 223–224.

Two remarks are to be added at the end.

I) Hall and Whitfield used the name *Pterocephalus,* instead of *Pterocephalia,* and Walcott[1] followed them, but *Pterocephalus* and *Pterocephalia* are synonymous and thereby the first one is invalid.

II) Three species of *Pterocephalia* have been described from Eastern Asia by Walcott among which *P.* (?) *liches* was selected by Resser and Endo for the genotype of their *Kolpura,* new genus, and *P. busiris* should go into the group of *Lioparia* or somewhere else. *Pterocephalus asiaticus* is the only one which is probably referrable to the genus with certainty.

Genus COOSIA Walcott, 1911.

Coosia coreanica, new species.

Plate XIX, figures 11–12.

Description:—Glabella gently tapering forward, its frontal margin transverse, and its length corresponding to two-thirds the length of the cephalon; dorsal furrow fairly clear on the lateral sides of the glabella, but fainted out on the anterior one; glabellar furrows obsolete; occipital furrow strong and occipital ring widened in the middle; frontal limb and rim not well differentiated and they all together make a gentle concavity; fixed cheek narrow; palpebral lobe opposite the middle of the glabella, semi-circular and surrounded by a broad ocular band; postero-lateral limb not well preserved; facial suture describing a semi-circle in front of the eye; surface smooth.

Comparisons:—*Coosia superba* Walcott,[2] the genotype, from the

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1) Walcott (1884), Palaeontology of Eureka District, (U. S. Geol. Surv. Monogr. 8,) pp. 58–59; (1913), Cambrian Faunas of China, p. 146.

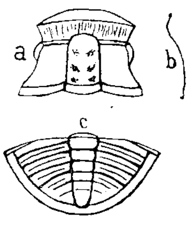
2) Walcott (1911), Smiths. Misc. Coll. Vol. 57, No. 4, pp. 94–97, Pl. 16, fig. 1, 1 a.

Middle Cambrian of Alabama differs from this species in the length and outline of the glabella and position of the eye, i. e. the glabella is shorter, more triangular and broadened backwards and the palpebral lobe is located at the mid-length of the cephalon, instead of at the mid-length of the glabella, in the former species.

Among the Oriental faunas this species is more closely allied to the southern forms than to the north Chinese ones. Mansuy's *Coosia deprati*[1] and *Coosia asiatica*[2] are quite similar to this in many respects, however, *C. deprati* is distinguished by its large eye and large occipital ring, while *Coosia asiatica* may be told apart by its glabella which attains only half the length of the cephalon.

Formation and locality:—*Solenoparia* zone of Doten.

Notes on the Liostracidae Angelin.



Text-figure 24.
Liostracus costatus Angelin [From Ivar D. Wallerius (1895), Undersökningar öfver zonen med *Agnostus lævigatus* i Vestergötland, p. 55.]

Angelin established this family and included therein *Liostracus* and *Anomocare*, while Poulsen[3] proposed the Anomocaridae recently for the latter genus together with his *Glyphaspis* which will be discussed later.

The genus *Liostracus* itself has again long stood on debatable grounds. *Liostracus aculeatus* (Angelin) whose description just follows Angelin's diagnosis was recognized as the genotype by Miller,[4] Walcott[5] and most authors, since the time Matthew[6] studied *Liostracus*, but Brögger[7] and some Scandinavian authors are wont to secure Angelin's idea of the genus from *Liostracus costatus* Angelin and *L. microphthalmus* Angelin, which were, however, excluded by Matthew from *Liostracus*. If distinct

1) Mansuy (1915), Faunes Cambr. du Haut-Tonkin, p. 27, Pl. III, fig. 4 a-g.

2) Mansuy (1916), Faunes Cambr. de l'Extrême-Orient Méridionale, p. 40, Pl. VII, fig. 6 a-b.

3) Poulsen (1927), Cambrian, Ozarkian and Canadian Faunas of NW Greenland, p. 325.

4) Miller (1889), North Am. Geol. & Pal., p. 555.

5) Walcott (1913), Cambrian Faunas of China, p. 137.

6) Matthew (1888), Trans. Roy. Soc. Canada, 5, Sec. 4, p. 134.

7) Brögger (1878), Nyt. Mag. for Naturv. 24, p. 49.

elements as *Liostracus aculeatus*, *L. costatus*, and *L. microphthalmus* are combined in one genus, the genus cannot help but fall into confusion. *Liostracus costatus* and *L. microphthalmus* bear many alliances to *Ptychoparia*, s. l. and this might be one reason why Walcott[1] and Reed[2] considered *Liostracus* as a subgenus of *Ptychoparia* and Pompeckj[3] took it as a synonym of *Ptychoparia*.

The different opinions had been probably due to the incompleteness of the original generic diagnosis, which, however, already has been checked carefully by Matthew from his viewpoint. If we start from *A. aculeatus* as Matthew did, *Liostracus* will, however, be a well defined genus. It is to be distinguished from *Ptychoparia* by the elongate outline of carapace, absence of genal spine, elevated glabella with obscure furrows, aculeate occipital rings, concave frontal limb with a raised rim, rounded end of thoracic pleura, and so on. Surface of the carapace is smooth or finely punctated, but the value of the punctation as a diagnostic feature was doubted by Walcott. In comparison with *Ptychoparia* s. str. the pygidium is smaller and less segmented, but this character varies considerably even among the Ptychoparidae. Among the species of *Liostracus* which fall in the above defined category it is possible to distinguish two distinct groups, the one is *Liostracus* s. str. and the other *Liostracus* typified by such a form as *Liostracus plathyrrhinus* Grönwall[4] whose cranidium is remarkably constricted between the eyes, as also seen in *Idahoia*, and for that I suggest a new generic name *Grönwallia*. As this species is known only from the cranidium, the other characters cannot be brought into consideration; but except for the nuchal spine the form is quite simillar to *Liostracus microphthalmus*. The latter has a distinct genal spine on the free cheek, and the convex shape of the frontal border is quite different from that in *Liostracus* s. str. Under the test irregular lines radiate outside of the palpebral lobe as in ptychoparids.

I presume *Liostracus* is related to *Idahoia* and *Saratogia* through *Grönwallia* on one hand and probably to *Anomocare* through *Glyphaspis* on the other and the two lines run parallel to *Inouyella-Kokuria* and *Eymekops-Haniwa* lines in the Pacific respectively.

It is quite possible that each pair appears to reveal a set of parallelism, but it is not yet clear, whether each pair was derived from the

1) Walcott (1884), Bull. U. S. Geol. Surv. 10, p. 36.
2) Reed (1910), Cambrian Fossils from Spiti, pp. 14-16.
3) Pompeckj (1896), Jahrb. kais. kön. geol. Reichsanstalt, Wien, XLV, pp. 543-545.
4) Grönwall (1902), Bornholms Paradoxideslag og deres Fauna.

same stock, or not. Through comparisons among these four lines I can present the following pertinent facts:—

1) *Idahoia-Saratogia* group bears in most cases conspicuous nuchal spines, while these are totally absent in the *Inouyella-Kokuria* group. Moreover the latter group has little or no frontal brim whereas this feature is distinct in the former.

2) *Anomocare-Glyphaspis* group frequently has an extra-furrow probably caused by the doublure on the border of the cephalon, and broad concave border gradually merging from the pleural lobes on the pygidium, while *Eymekops-Haniwa* group has no extra-furrow on the border on the cephalon and the border on the pygidium is narrower, well defined, and of the Asaphiscidae type.

3) *Idahoia-Saratogia* group is distributed in the Middle Cambrian of the Baltic region and the Upper Cambrian of eastern North America excepting *Lonchocephalus tellus* from the late Middle Cambrian of Shantung which is not a *Lonchocephalus*, but belongs to an undescribed genus of this group, if not an *Annamitia*.

4) In the *Anomocare-Glyphaspis* group, *Glyphaspis* is distributed in the Middle Cambrian of Greenland, Montana and Shantung. *Anomocare latelimbatum* and *Anomocarella thraso* are the representatives in Eastern Asia, from the former of which Lorenz, however, already had established a new genus *Lioparia* and this suggests that Poulsen's *Glyphaspis*, 1927 might be a synonym of Lorenz's *Lioparia*, 1906. At least it can be said that *Glyphaspis perconcava* is closer to *Anomocare latelimbatum* in the outline of glabella and extra-ridge on the frontal margin and to *Anomocarella thraso* in the aspects of pygidium than to *Asaphiscus* (?) *capella*, the genotype of *Glyphaspis*.

These morphological distinctions are, however, not wide departures, but simply suggest the general tendencies, and the facts of geological distributions do not spread these lines out. I do not think that the evidences so far we know are sufficient to permit tracing these lines like regular chain of links, but in my belief, *Grönwallia-Saratogia* line and *Inouyella-Kokuria* line are fairly distinct from each other. *Anomocare-Glyphaspis* and *Eymekops-Haniwa* groups might on the contrary be united into one for the time being.

Conokephalina is first proposed by Brögger[1] as a subgenus between *Dikelocephalus* and *Conokephalites* and he included *Dikelocephalus osceola*

1) W. C. Brögger (1886), Om alderen af *Olenellus* zonen i. Nordamerika, (Geol. Foren. i Stockholm Förhandl. Bd. VIII,) pp. 205–206.

Hall, *D. misa* Hall and *D. spinger* Hall besides *Conokephalites ornatus*, the genotype. The first species is the genotype of *Osceolia* Walcott, the third that of *Calvinella* Walcott[1] and the second that of *Prosaukia* Ulrich and Resser.[2] Walcott[3] described *Conokephalina whitehallensis*, but this again might be a Saukinae. Two Asiatic species of *Conokephalina* have already been transferred into *Wuhuia* (p. 283). Thus the genus is confined in the Cambrian of northern Europe, including *C. abdita* (Salter), *C. invita* (Salter), and *C. lata* (Lake) of England, *C. olenorum* Westergård of Sweden and others.

This genus is quite distinct from the Dikelocephalidae by some characters such that the third glabellar furrow are not united in the middle of the glabella. The large eyes and subquadrate glabella are quite suggestive of the Anomocaridae, although the true taxonomic position is not yet certain.

As a result, I suggest here the following scheme, modifying the conventional names of Angelin's Liostracidae and Poulsen's Anomocaridae.

Subfamily Liostracinae Angelin.

1) *Liostracus* Angelin, 1852. (Genotype: *Liostracus aculeatus* Angelin.)
2) *Saratogia* Walcott, 1916. (Genotype: *Conocephalites calciferus* Walcott.)
3) *Idahoia* Walcott, 1924. (Genotype: *Idahoia serapio* Walcott.)
4) *Grönwallia*, new genus. (Genotype: *Liostracus platyrrhinus* Grönwall.)

Subfamily Anomocarinae Poulsen.

1) *Anomocare* Angelin, 1854. (Genotype: *Anomocare laeve* Angelin.)
2) *Lioparia* Lorenz, 1906. (Genotype: *Anomocare latelimbatum* Dames.)
3) *Dolgaia* Walcott and Resser, 1924. (Genotype: *Dolgaia megalops* Walcott and Resser.)

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1) C. D. Walcott (1914), *Dikelocephalus* and other genera of the Dikelocephalinae, (Smiths. Misc. Coll. Vol. 57, No. 13.)

2) E. O. Ulrich and C. E. Resser (1933), The Cambrian of the Upper Mississippi Valley, Pt. II, Trilobita, Saukinae, (Bull. Publ. Mus. City Milwaukee, Vol. 12, No. 2.)

3) C. D. Walcott (1912), New York Potsdam-Hoyt Fauna, (Smiths. Misc. Col. Vol. 57, No, 9.)

4) *Glyphaspis* Poulsen, 1927. (Genotype: *Asaphyscus* (?) *capella* Walcott.)
5) *Haniwa* Kobayashi, 1933. (Genotype: *Haniwa sosanensis* Kobayashi.)
6) *Haniwoides*, new genus. (Genotype: *Haniwoides longus*, new species.)
7) *Eymekops* Resser and Endo (MS). (Genotype: *Anomocarella hermias* Walcott.)

Subfamily Yokuseninae, new subfamily.

1) *Yokusenia*, new genus. (Genotype: *Yokusenia vulgaris*, new species.)
2) *Kokuria*, new genus. (Genotype: *Kokuria typa*, new species.)
3) *Inouyella* Resser and Endo (MS). (Genotype: *Inouyella peiensis*, Resser and Endo (MS). (Pl. XXIV, fig. 1.)

Liostracus pusillus Westergård[1] from the *Parabolina spinulosa* zone is the latest representative of the genus which, however, rather distinct from *Liostracus* s. str. *Liostracus* (?) *superstes* Linnersson is an interesting species. So far as I can see on the Westergård's type specimen, it appears to suggest something of the Asaphidae, notably the doublures apparently join to each other in a longitudinal line and the thoracic segments are to be counted eight as typical in the family.

Finally a brief note is to be added for the Asiatic and some other forms known outside of the Atlantic province. *Liostracus* was first introduced into Eastern Asia by Dames[2] whose idea of the genus seems to have been based on *Liostracus costatus*. Among his two species, *L. megalurus* and *L. talingensis*, the former was transferred to *Anomocare* by Walcott and then Walcott's *A. megalurus* in turn was recently moved into *Manchuriella* by Resser and Endo. (See page 288.)

Lorenz[3] added *Liostracus latus* from Shantung. The holotype of the Lorenz's species is represented by an anterior portion of a cranidium which seems to have a relatively narrow frontal border. More material is required for a further generic discussion, but the form is not a *Liostracus*.

1) A. H. Westergård (1922), Sveriges Olenidskiffer, (Sver. Geol. Undersök, Ser. Ca, Nio 18.)
2) Dames (1883), Richthofen's China, 4.
3) Lorenz (1906), Zeits. d. d. Geol. Gesell. 58, Hft. 1.

Reed found one species from the Parahio series of Spiti, but he recognized *Liostracus* as a subgenus of *Ptychoparia*, and consequently it was named *Ptychoparia* (*Liostracus*) *civica*. The glabella of this species has usually distinct furrows on it. For the Siberian form of *Liostracus*, *L.* (?) *maydelli* I have suggested a new name, *Tollaspis*, (see page 263).

Two species *L. steinmanni* and *L. ulrichi* are described by Kayser[1] from Argentine. Their anterior eyes and square preglabellar area are, however, quite suggestive of the Olenidae, notably of *Angelina* Salter. Two other species are known from North America, –namely *Liostracus panope* (Walcott)[2] from the St. Croixan of South Dakota and *Liostracus parvus* Walcott[3] from the St. Croixan of Yellowstone Park. The former has a narrow fixed cheek and relatively large eyes; the latter has the facial sutures bent directly inward in front of the eyes; and both species have no spine on the occipital ring.

In addition to the preceding species there are many others of *Liostracus* which have been already transferred into other genera and if eliminate them, *Liostracus* s. str. will be confined to the Middle Cambrian of the Atlantic Province, being typified by *L. aculeatus* in the Baltic region and *L. ouagodianus* (Hartt) in eastern North America, both of which are condsidered to be identical species by Strand[4] and others.

Subfamily Anomocarinae Poulsen.

Genus ANOMOCARE Angelin, 1878.

1878. *Anomocare* Angelin, Pal. Scand. 3d. ed. Holminae, p. 24.
1885. *Anomocare* Zittel, Handb. Pal. 2, p. 601.
1896. *Anomocare* Matthew, Trans. Royal Soc. Canada, 9, sec. 4, p. 60.
1906. *Anomocare* Lorenz, Zeits. d. d. geol. Gesell. Bd. 58, Hft. 1, p. 62.
1910. *Anomocare* Reed, Mem. Geol. Surv. India, Pal. Indica, ser. 15, Mem. 1, p. 44.
1911. *Anomocare* Walcott, Smiths. Misc. Coll. 57, p. 87.
1913. *Anomocare* Walcott, Research in China 3, p. 187.
1924. *Anomocare* Zittel-Broili, Grunzüge d. Palaeaont. 1, p. 648.

Genotype :—*Anomocare laeve* Angelin.

In 1878, Angelin established *Anomocare* with the following diagnosis :—

Corpus oblongum, convexum, distincte longitudinaliter trilobum, crusta lævi, excavato-punctata, aciculata vel alutacea tectum.

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1) Kayser (1897), Zeitsch, Deutsch. Geol. Gesell. XLIX.
2) Walcott (1890), Proc. U. S. Nat. Mus. 13, p. 275, Pl. 21, fig. 13.
3) Walcott (1899), Monogr. U. S. Geol. Surv. 32, Pt, 2, p. 463, Pl. 62, fig. 6.
4) Strand (1929), Norsk geol. tidsskr. Vol. X, p. 351.

Caput semilunare, sagittatum, margine plano sulcoque intramrginali aut immarginatum ; anguli exteriores producti, acuminati. Frons subangusta, ovata vel oblongula, marginem apicalem haud attingens, utrinque lineis impressis lobata: lobis decrescentibus. Oculi majusculi, distantes medium versus frontis siti, loboque orbitali marginato præditi. Sutura facialis postice ab oculis oblique ad marginem basalem anticeque ad marginem apicalem decurrens.

Thorax constat e segmentis 10– angustatis, sulco pleurico extrorsum evanescente canaliculatis, apice obtusiusculis; rachis angusta, convexa.

Abdomen rotundatum, plerumque impressione intramarginalis lata præditum : rachis distincta, angusta, ante apicem scuti desinente : costis lateralibus ante marginem evanescentibus.

Remarks :—Angelin[1] brought the genus into the family Liostracidae and at the same time named seven species, including *Anomocare laeve*, the genotype ; but later *A. aculeatum*, *A. acuminatum* and *A. microphthalum* became changed in their references to *Liostracus*, *Agraulos* or somewhere else.[2] *Anomocare angelini* and *Anomocare excavatum dentata* were described from Bornholm by Grönwall[3] and *Anomocare pusillum* from Sardinia by Meneghini ;[4] *Anomocare balticum* from Gotland by Hedström[5]; and *Anomocare sibiricum* from Bennett Island by Holm and Westergård.[6] Cobbold's *A.* (?) *pustulatum* and *A. platycephalum*[7] were brought into *Strenuella*.[8]

Conokephalina suecicus Wallerius[9] is more or less allied to *Anomocare* (s. l.) except for the outline of the glabella ; its associated pygidium[10] is, however, resembling that of saukids.

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1) Angelin (1878), Pal. Scad. 3d. ed. p. 24.

2) A. H. Westergård, (1910), Index to N. P. Angelin's Palaeontol. Scandinavica.

3) Grönwall (1902), Danmarks Geol. Unders.

4) Meneghini (1884), Soc. Tosc. di Sc. Nat. Proc. Verv. 4; (1888) Mem. Alla Desc. della Carta Geol. d. Italia, 3.

5) Hedström (1923), Sveriges Geol. Unders. Ser. Ct. no. 314, p. 13, Pl. 2, fig. 4.

6) Holm and Westergård,(1930), Mem. Acad. Sci. Leningrad, 8th ser. 31, no. 8, p. 17, pl. 2, fig. 15–20; Pl. 3, fig. 1.

7) Cobbold (1910), Q. J. G. S. London, 66.

8) Lake (1932), Mon. British Cambr. Tril. (Pal. Soc.) Part. 7.

9) I. D. Wallerius (1895), Undersokningar ofver Zonen med *Agnostus laevigatus* Vestergotland, p. 50, fig. 4, text-fig. 4.

10) I. D. Wallerius (1930), Fran Vastergotland Mellan-Kambrian, (Meddelanden fran Lund Geologisk-Mineralogiska Institution, Nio 42,) p. 60, fig. 9

Vogdes[1] records several American species in his catalogue; Weller[2] described *Anomocare parvula* from the Upper Cambrian of New Jersey; Billing's *Conocephalites teurer*[3] was referred to *Anomocare* by Matthew[4]; and Walcott established *Wilbernia*[5] for *Anomocare* (*Ptychoparia*) *pero*.

Since the genus *Anomocare* first found use with Asiatic materials at the hands of Dames in 1883, many species have been added by Schmidt and Toll from Siberia, by Wallcott and Lorenz from North China, by Mansuy from South China and adjacent area of Tonkin, by Cowper Reed from India and by King from Palestine.

Further discussion on the European and American forms will not be undertaken here, but one thing in particular must be added to the attention of Oriental students, viz., the similarity and difference between *Anomocare laeve* and Asiatic species of *Anomocare* together with *Anomocarella*. As discussed below, many species, however, bear sufficiently distinct characters as to require generic separation from both of these genera. Generally speaking, not only *Anomocare laeve*, but also other European species, have the narrow brim and wide preglabellar area, and their glabellae are mostly elongato-conical and have distinct glabellar furrows. *A. laeve* has a distinct occipital spine, but no spine is found on the Asiatic forms excepting *Anomocare* (?) sp. from Spiti by Reed.[6] *Anomocare latelimbatum*, *A. lisani*, *A. ephori* and *A. daulis* are rather close to *Anomocare* s. str., but they are distinguished by smaller eyes, shorter glabella and other features. *Eymekops* and *Haniwa* have large eyes like those of A. *laeve*, but in them the frontal area is equally divided into limb and rim, and also the quadrate glabella of *Haniwa* and the smooth glabella of *Eymekops* easily distinguish these genera from *Anomocare* s. str. Thus it becomes a question if any Eastern Asiatic species is safely referrable to the genus under discussion.

Genus LIOPARIA Lorenz, 1906.

1906. *Lioparia* Lorenz, Zeits. deuts. geol. Gesell., Bd. 58, p. 73.

Genotype:—*Anomocare latelimbatum* Dames.

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1) Vogdes, (1893), Catal. Palaeoz. Crust. (Calif. Acad. Sc. Occasional papers, IV,) p 270.

2) Weller, (1903), Geol. Surv. New Jersey, Pal. 3, p 120, pl. 3, fig. 12.

3) Billings (1861), Geol. Vermont, 2, p. 951, fig.356; (1865), Paleoz. Foss. p. 13, fig. 16

4) Matthew (1897), Trans. Royal. Soc. Canada, sec. ser. 3, sec. 4, p. 198, Pl. 4, fig. 8.

5) Walcott, (1924), Cambrian and lower Ozarkian Trilobites, p 75.

6) Reed (1910), Cambrian Fossils of Spiti, p. 16, Pl. VI, fig. 1.

Lorenz mentions "*Lioparia* nov. gen. steht zwischen *Ptychoparia* und *Liostracus*. Mit beiden hat sie die mittelgrossen Augen gemein. Sie teilt allein die tiefe Dorsalfurche mit *Ptychoparia*. Im Hinblick anf die Schalenstruktur und den flachen Randsaum steht sie auf der Seite von *Liostracus*. Nach richtigen Abwagen muss man gestehen, dass *Liostracus* der Gattung *Lioparia* näher steht als der Gattung *Ptychoparia*."

He selected two species, *Anomocare latelimbatum* Dames and *Lioparia blautoeides* Lorenz for the types and referred *Conocephalites minutus* Hall to this species.

Walcott referred the third species to *Lonchocephalus* and suggested that the first and second are synonymous, but so far as the illustrations are concerned, these two are not same. To escape from such a confusion the one designated *A. latelimbatum* Dames is selected here for the genotype.

The chief generic characters are the short truncato-conical glabella, large frontal limb and narrow rim, wide fixed cheek and medium sized posterior eyes provided with the ocular ridges, and relatively small pygidium with the pleural furrows running across the flat border.

In Walcott's *A. latelimbatum*, inosculating radial lines are faintly observable in the preglabellar area and on the free cheeks outside of the eyes.

One thing very remarkable in *A. latelimbatum* is the feature of the fixed cheek. There is a line along the middle of the marginal border like in *Yokusenia vulgaris* of the Upper Cambrian. If the facial suture would take a more intramarginal course and swell up a little bit along the axial plane, then the form acquired would be *Yokusenia*. It is also notable that the pygidia of *Yokusenia* and *Lioparia* are very much alike.

Lioparia expansus, new species.

PA1105 V

Plate XIX, figure 13.

Description:—Glabella short, conical, narrowing forward rather abruptly and rounded in front, its length corresponding to about two-fifths the length of the cranidium; dorsal furrow and occipital furrows distinct; neck ring narrow; median ridge fairly strong; three pairs of glabellar furrows narrow, faint and a little oblique backwards; palpebral lobe large, semicircular, opposite the second and third glabellar lobes and associated with a broad eye-band; preglabellar area large and broad, expanded forward from the eyes; frontal limb and rim well differentiated, the former being three times as long as the latter; surface poorly pustulated.

Comparisons:—The outline of the glabella, long frontal limb and posterior eye point the species toward *Lioparia*, but the palpebral lobe is relatively large, in comparison to *Lioparia latelimbata*.

Formation and locality:—*Solenoparia* zone of Doten.

Lioparia (?) *longifrons*, new species.

Plate XVII, figure 15.

Description:—Cranidium subquadrate; glabella quadrate, as long as two-thirds the length of the cranidium, convex, elevated above the flat sides which gently slope to the margin; glabellar furrows obsolete; fixed cheek of moderate breadth; eye rather small, slightly posterior to the mid-length of the cranidium; frontal limb very long and inclined forward; marginal brim convex, strong, elevated and narrows laterally.

Comparisons:—The distinguishing characters of this form are its short quadrate and obscure glabellar furrows, relatively wide fixed cheek crossed by an eye-ridge, small middle eyes and wide frontal limb.

This combination of characters seems to bring the species into the neighbourhood of *Koptura* and *Lioparia*, but it differs from *Koptura* by its strong frontal brim and straight anterior branch of the facial suture and from *Lioparia* by the quadrate outline of its glabella.

Formation and locality:—*Olenoides* zone of Neietsu.

Genus EYMEKOPS Resser and Endo (MS).

Remarks:—With *Anomocarella hermias* Walcott as the basis Resser and Endo[1] established this genus because of its large eye. Another distinguishing character from *Anomacarella* Walcott is found in the absence of the posterior arching of the inner margin of the frontal rim which has never been found in *Eymekops*.

Haniwa Kobayashi from the Upper Cambrian is quite similar to this genus in the general outline of the cranidium, but considerably different in the convexity. In *Haniwa* the glabella is not strongly convex and its outline is quadrate in the typical forms. Nevertheless *Eymekops* and *Haniwa* are quite allied and possibly the latter may have been a descendant of the former.

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1) Resser and Endo, Cambrian and Ozarkian Strata of South Manchuria, (MS).

Reed's *Anomocare* sp.[1] from Himalaya which was first compared with *Anomocare excavatum* Angelin and later with *Dolichometopus deois* Walcott by Reed has many features agreeing with this genus. A distinct character of the Himalayan species is, however, that "the occipital ring is produced into a short stout spine."

Genotype:—*Anomocarella hermias* Walcott.

Geological and geographical distribution:—Middle Cambrian of Chosen, Manchuria, and possibly the Himalayas.

Eymekops hermias (Walcott).

Plate XIX, figures 14–15.

1911. *Anomocarella hermias* Walcott, Smiths. Misc. Coll. Vol. 57, No. 4, p. 92, Pl. 15, fig. 10.

1913. *Anomocarella hermias* Walcott, Cambrian Faunas of China, p. 202, Pl. 20, figs. 5.–5a.

Through its truncato-conical glabella, large semi-circular palpebral lobe almost attached to the glabella, thick eye-band, the drooping frontal limb and rim and punctated surface the Korean specimen is safely identifiable to this species. In comparing with the types in U. S. National Museum, the frontal rim and limb is rather clearly differentiated and the glabellar furrows perfectly obsoleted in the Korean form.

The free cheek associated with the cranidium is rather flat; the marginal border broad and horizontal, and only the central portion gently convex and elevated. The facial suture and the margin of the large posterior eye suggest strongly that the cheek is that of this species.

Formation and locality:—*Solenoparia* zone of Doten, South Chosen; Middle Cambrian Mapan beds of Tschang-hsing-tao, Liaotung.

Genus HANIWOIDES, new genus.

Remarks:—The observations which I am able to present at this time will be given in the description of the genotype. The distinguishing characters are an oblong glabella, obscure glabellar furrows, long concave preglabellar area and semi-circular posterior palpebral lobes which are located close to the glabella.

This cranidium resembles *Eymekops* and *Haniwa*, but it differs from

1) Reed (1910), Cambrian Fossils of Spiti, p. 16, Pl. VI, fig. 1; p. 69.

both of them in its smooth glabella, smaller palpebral lobe without any distinct ocular band, and concave front which is not divided into limb and rim.

Genotype:—*Haniwoides longus*, new species.

Geological and geographical distribution:—Middle Cambrian of Chosen.

Haniwoides longus, new species.

PA1109-17-2
PA1110-17-3

Plate XVII, figures 2–3.

Description:—Cranidium long; glabella oblong, rounded in front, unfurrowed; occipital lobe narrow, defined faintly by a transverse furrow; frontal area as long as one-third the length of the cranidium, narrow, slightly expanded forward and then rounded, concave and elevated near the margin; palpebral lobe small, close to and opposite the middle one-third of the glabella; postero-lateral limb of the fixed cheek short and transverse; surface smooth.

The holotype cranidium is 6.4 mm. long; the glabella inclusive of the neck lobe 4.4 mm. long and 2.3 mm. broad; the distance across the eyes 6 mm.

A detached free cheek which possibly belongs to this species, is relatively broad and flat. It has a posterior and medium sized eye and very wide border and doublure; the posterior branch of the facial suture transverse along the occipital groove and turns back quickly at the end; its anterior branch directed antero-laterally, curved inward near the margin, meets its fellow below at the middle of the frontal margin and crosses the long doublure longitudinally; occipital lobe very short; articulating margin swings back near the lateral end.

The course of the facial suture fits well with *Haniwoides longus*, but differs in the convexity. The cheeks of *Shantungia spinifera* (Walcott, 1913, Pl. 14, fig. 6a) and of *Koptura lisani* (Walcott, 1913, Pl. 18, fig. 4 b) are also very similar to this. Further material is required for the final settlement.

Formation and locality:—*Olenoides* zone of Neietsu.

Haniwoides concavus, new species.

PA1111-17-1
PA1112-17-16
PA1113-17-17

Plate XVII, figures 1, 16–17.

Description:—Glabella subquadrate, rounded on the anterior margin; no furrows on the glabella except for the occipital furrow which is marking off a very narrow neck lobe; a longitudinal line faintly marked on the axis; palpebral lobes with ocular bands large, attached on both sides of the glabella; frontal area about one-third the length of the cranidium, expanded forward and remarkably concave, bending up near the anterior margin; postero-lateral limb of the fixed cheek short and transverse; surface smooth.

Associated pygidium transversely semi-elliptical, flat; axis narrow, conical, ends inside of a broad margin and divided into seven rings and a terminal lobe; pleural portion gently convex. Surface smooth.

Comparisons:—This cranidium and pygidium are very much allied to those of *Anomocare sibiricum* Holm and Westergård[1], but the Siberian species has a furrowed and forward narrowing glabella and wider occipital lobe; in its pygidium the pleural ribs extend into the border.

Formation and locality:—*Olenoides* zone; Neietsu.

PA1114-7-1
PA1115-7-2
PA1116-7-5
PA1117-7-6
PA1118-7-19
PA1119-7-20

Genus HANIWA Kobayashi, 1933.

Haniwa quadrata Kobayashi.

Plate VII, figures 1-2, 5-6, 19-20,

1933. *Haniwa quadrata* Kobayashi, Upper Cambrian of the Wuhutsui Basin, etc. p. 149, Pl. XV, figs. 7-8.

The quadrate glabella, large, semi-circular palpebral lobes, depressed frontal area, and divergent anterior branch of the facial suture indicate the identity of the Korean form with this species.

In the precise comparisons with the holotype, the median longitudinal ridge is weak, the palpebral lobe somewhat larger and the marginal rim not so well differentiated in the Korean forms as in the Manchurian ones. In the cited paper I stated that only two pairs of glabellar furrows were observed on the holotype, but in examining new material, I found that three pairs are clearly impressed under the test, as shown in figure 19, on plate VII. In Chosen free cheeks have been also collected which are exactly alike the cheeks of *Haniwa sosanensis* except for the anterior branch of the facial suture.

Formation and locality:—Common in the *Dictya* zone of Kasetsu-ji, South Chosen; *Tsinania canens* zone of Paichia-shan, Wuhutsui basin, Liaotung.

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1) G. Holm and A. H. Westergård (1930). Middle Cambrian Faunas from Bennet Island, (Mèm. de l'Acad. des Sci. de l'URSS, VIIIe, Série Classe Physico-Mathèmatique Vol. XXI, No. 8, p. 17, Pl. II, figs. 15-20; Pl. III, fig. 1, (2?). Toll (1899), Beiträge zur Kenntnis der Sibirischen Cambrium, p. 30, Pl. II, fig. 11. (*Banthyuriscus howelli.*)

Haniwa convexa, new species.

Plate VII, figure 3.

1933. *Haniwa* sp. Kobayashi, Upper Cambrian of the Wuhutsui Basin, etc. p. 149, Pl. XV, fig. 16.

Description:—Cranidium moderately convex; glabella oblong, convex, elevated above the cheeks; three pairs of pits located inside of the dorsal furrow indicate the position of the glabellar furrows; the first pairs very faint; the second pair transverse and third oblique backwards, the latter two pairs strongly impressed; occipital furrow strong, transverse, bent forward near both ends; neck ring large, narrowing laterally; preglabellar area relatively narrow; palpebral lobe large, semi-circular, in contact with the glabella; eye-band thick; posterior limb of the fixed cheek triangular, rather large; facial sutures slightly divergent anterior to the eyes and almost diagonal posterior to them.

The holotype cranidium is 5.4 mm. long; glabella 2.9 mm. broad and 4.3 mm. long on which the neck ring occupies a distance of 1.2 mm. posterior limb of the fixed cheek about 2.5 mm. broad.

Comparisons:—An incomplete cranidium from the *Tsinania canens* zone of Hsi-shan, Wuhutsui basin, Liaotung designated as *Haniwa* sp. probably belongs to this species.

The strong convex and oblong glabella, two pairs of strong glabellar pits, thick neck-ring, narrow frontal area and comparatively large posterior limb of the fixed cheek in subtriangular outline are the distinguishing characters of this species.

Formation and locality:—*Dictya* zone of Doten, South Chosen; *Tsinania canens* zone of the Wuhutsui basin, Liaotung.

Haniwa conica, new species.

Plate VII, figure 4.

Description:—Glabella narrow, truncato-conical, well defined by the dorsal furrow and elevated; glabellar furrows represented by three pairs of depressions; the first pair almost obsolete; the second and third strong; preglabellar field concave with a narrow and poorly defined brim; palpebral lobes large, semi-circular, close to the glabella; eye-band broad; surface smooth.

The holotype cranidium measures 6 mm. in length; glabella inclusive of the neck-ring 4.5 mm. long and its breadth tapers regularly from 3 mm. to 2 mm.

Comparisons:—The narrow conical glabella and concave preglabellar field are the distinct specific characters through which this species escapes from being confused with other *Haniwa*.

Formation and locality:—*Dictya* zone of Doten.

PA1122-7-14
PA1123-8-14

Haniwa oblongata, new species.

Plate VII, figure 14; Plate VIII, figure 14.

Description:—Cephalon semi-circular, with sharp genal spines; glabella roundly oblong, broadest in the middle, well defined by dorsal furrows; glabellar furrows all obscure; occipital furrow strong; occipital furrow and lobe gently convex backwards; eye-band broad, semi-elliptical, embracing a narrow palpebral lobe inside; preglabellar area flat, inclined gently forward; free cheek wide, moderately convex, bordered by a strong groove and brim; brim produced into a genal spine.

Pygidium flat, somewhat lenticular in outline; axis elevated, conical; three pleural ribs and grooves subparallel to the articulating margin. Surface smooth.

Comparisons:—This species is well characterized by the outline and obsoletion of the glabellar furrows, narrow palpebral lobe, strong marginal brim of the cephalon and transverse form of the pygidium.

Formation and locality:—Black slate in a frequent alternation of slate and limestone, west of Kasetsu-ji, approximate equivalent of the *Dictya* zone.

Haniwa sp.

PA1124-7-21,22.

Plate VII, figures 21–22.

This cranidium is quite distinct from others by its narrow palpebral lobe and large, flat preglabellar field with an elevated frontal margin. The glabella is moderately convex, elevated, parallel sided, and rounded in front; the glabellar furrows, even the first one, moderately impressed and relatively long.

This is certainly a distinct species, but a specific designation must be postponed until better specimens become available.

Formation and locality:—*Dictya* zone of Kasetsu-ji.

Haniwa (?) sp.

Plate IV, figures 3-4.

The cranidium flat with a subquadrate glabella and large semi-circular palpebral lobe, is quite similar to *Haniwa quadrata*, but the glabella is more expanded backwards than is the case with *H. quadrata*. Cheeks probably belonging to this species are quite long in outline.

Formation and locality:—*Eoorthis* zone of Doten.

Subfamily Yokuseninae, new subfamily.

Geuus YOKUSENIA, new genus.

Remarks:—The distinguishing characters of this genus are the triangular cranidium with a large convexo-concave preglabellar field, rather longitudinal eye, distinct eye-ridge and the transverse outline of the pygidium with a cylindrical and elevated axis and a wide, flat marginal border.

In the cranidium, Walcott's *Inouyia* appears somewhat similar to the genus, but the deep concavity it has in front of the glabella is quite distinct. This genus is closely related to *Inouyella* Resser and Endo from the Taitzu beds of Manchuria in the general form of the head and tail, especially in the triangular outline of cranidium. But in this genus the palpebral lobes are located close to the glabella. Another important difference lies in the preglabellar field where in *Inouyella* there is a strong convex fold at the middle. In *Yokusenia* the preglabellar field is regularly concave and also much longer. *Yokusenia* was an early Upper Cambrian genus, while *Inouyella* lived in the Middle Cambrian.

Further detailed characters of this genus will be seen in the description of the genotype.

Genotype:—*Yokusenia vulgaris*, new species.

Geological and geographical distribution:—Early Upper Cambrian; South Chosen.

Yokusenia vulgaris, new species.

Plate IX, figures 1-7.

Description:—Cranidium somewhat triangular; glabella conical, elevated above the cheeks, rounded in front, as long as two-thirds the length of the cranidium; dorsal, glabellar and occipital furrows strong;

first and second pairs of glabellar furrows nearly transverse and the third pair oblique, all of which are disconnected at the middle of the glabella; a narrow median longitudinal ridge somewhat distinct and extended through the preglabellar field; preglabellar area deeply concave and triangularly produced in front; no marginal brim; fixed cheek narrow at the eye; eye-ridge started at a point slightly posterior to the antero-lateral angle of the glabella and gently oblique backwards; eye posterior to the mid-length of the cephalon, long and longitudinally semi-elliptical; postero-lateral limb of the fixed cheek subtriangular.

Free cheek large; its body strongly convex, bordered by a wide and concave marginal band which continues to the preglabellar area and is produced back into a long genal spine; the border divided behind into a concave band on the outside and a convex band on the inside defined by two grooves which, however, faint out from the genal angle to front.

Facial suture posterior to the eye diagonal, and turns to the longitudinal direction in passing the occipital lobe; anterior branch directed a little outward from the eye, but does not extend beyond the parallel across the eye and recurves sharply inward, forming an angle of about 115 degrees with its fellow at the front.

Pygidium transversely semi-circular; axial lobe cylindrical, truncated back, strongly elevated from the sides and divided into five distinct lobes by strong grooves; pleural portion slightly convex; first and second pleural furrows rather strong, but the rest almost obsolete; marginal border concave.

Formation and locality:—*Chuangia* zone; Kasetsu-ji.

Yokusenia obsoleta, new species.

Plate V, figures 18–19.

Desciption:—Cranidium subtriangular, raised toward the axis; glabella relatively large, subquadrate, gently tapering forward and rounded in front; dorsal furrow distinct; no furrows on the glabella except for the occipital one; frontal limb and border convexo-concave from inside to outside, with no boundary between them: axial ridge not strong but still perceptible across the whole length of the glabella; palpebral lobe medium sized and opposite the anterior part of glabella; postero-lateral limb of the fixed cheek large, triangular; surface smooth.

The holotype cranidium is 7 mm. long and 8.5 mm. broad; its glabella 4.4 mm. long and 3.8 mm. wide; the distance between the eyes is 5.9 mm.

Comparisons:—The general feature of this form is decidedly of the *Yokusenia* type, but it differs from *Yokusenia vulgaris* in the large and smooth glabella and small preglabellar field.

Formation and locality:—*Kaolishania* zone of Saisho-ri.

Genus KOKURIA, new genus.

Remarks:—In general form this genus is quite similar to *Saratogia* Walcott,[1] especially in the outline and in the convexity of glabella, concave frontal limb and border with longitudinal striation on the limb, and large eyes, but differs from *Saratogia* in the obsolete glabellar furrows, broad fixed cheek, absent occipital spine and the granulated surface.

Raymond's *Onchonotus*[2] apparently resembles the present genus, but is quite different in its strongly swelling glabella, small eye and distinct marginal brim.

Among the Asiatic trilobites *Yokusenia* looks somewhat like this genus, but may be distinguished by the large convexo-concave preglabellar field which is crossed longitudinally by the median ridge, smaller eyes and other features.

Genotype:—*Kokuria typa*, new species.

Geological and geographical distribution:—Upper Cambrian of Chosen.

Kokuria typa, new species.

Plate V, figure 17.

Description:—Glabella conical, rounded in front, elevated above the cheeks and distinctly defined by a dorsal furrow; glabellar furrows entirely obsolete, but occipital furrow and lobe distinct; fixed cheek of

1) Walcott (1916), Cambrian Geology and Paleontology, p. 195. Walcott indicated the concave curvature of the frontal limb and border as a generic character of *Saratogia*, but among the species referred to *Saratogia* by him all have convex limb and border, even the genotype *Saratogia calcifera*, and the limb and border are clearly divided by a marginal groove. *Saratogia tellus* from Middle Cambrian of Shantung is distinguishable from *Saratogia* by its fairly well differentiated frontal limb and border.

2) Raymond (1924), New Upper Cambrian and Lower Ordovician Trilobites from Vermont, p. 405.

moderate breadth; eye semi-circular, medium sized, posterior to the middle of the cranidium; preglabellar field considerably concave, with no distinct line dividing it into the limb and border, but the margin is transversely striated, while the portions within are marked longitudinally; facial sutures anterior to the eyes subparallel, and curved inward near the margin; the posterior branches short and diagonal; surface granulated.

The holotype cranidium measures 6. 4 mm. long and about 9 mm. broad; glabella 4 mm. broad and 5.2 mm. long in which the occipital ring occupies 1 mm. in length; the distance between the eyes is 8 mm.

Formation and locality:—*Kaolishania* zone; Doten.

Family Emmrichellidae, new family.

Family diagnosis:—Cephalon wide, glabella cylindrical, narrow; eyes middle to posterior; (breadth of the fixed cheeks varies considerably according to the subfamilies); pygidium wide with an entire concave border; axis narrow and conical.

Remarks:—This is a group of curious trilobites probably derived from the Ptychoparidae stock and developed on both sides of the northern Pacific. The main evolutional line is represented by *Probowmania* and *Bowmania*, the latter being brought forth from the former simply by the shortening of the glabella and backward shifting of the eyes. In the Middle Cambrian three additional lines diverge from it, *Utia-*, *Emmrichella-*, and *Changshania*-groups. The direction of the specialization is the swelling up of the frontal border in the first group, obliteration of the ocular ridge in the second, the narrowing of the fixed cheek in the third (see Text-figure 25). It is significant that the inosculating lines divergent outside of the palpebral lobes are just as well preserved in *Bowmania* and *Utia* as seen in *Ptychoparia*. Further details of evolution will be understood from the following descriptions:—

Subfamily Bowmaninae, new subfamily.

Emmrichellidae with a furrowed glabella, broad fixed cheek, distinct ocular ridge, convex frontal limb; flat, depressed rim, and facial sutures divergent in front of the eyes.

Probowmania, new genus. (Genotype: *Ptychoparia ligea* Walcott. Plate XXIII, fig. 5.)

Probowmaninae with a long cylindrical and relatively little convex glabella and middle eyes. Lower Cambrian of Shantung.

Bowmania Walcott, 1925. (Genotype: *Arethusina americana* Walcott.)

Bowmaninae with a short convex glabella, posterior eyes and narrow rim. Differs from *Inouyia* s. str. by the posterior eyes, ocular ridge running backward and absent preglabellar boss.
Upper Cambrian of Nevada.

Subfamily Utianae, new subfamily.

Emmrichellidae with a square glabella, median medium sized eyes accompanied by ocular ridges in the Middle Cambrian genera, wide fixed cheek and elevated frontal border.

Utia Walcott, 1924. (Genotype: *Utia curio* Walcott.)

Utianae with a vertical frontal limb with irregular lines of *Ptychoparia* type. Similar to *Inouyia* s. str., but differs from that by the downward drooping of the frontal border.
Middle Cambrian of Idaho.

Inouyia Walcott, 1911. (Genotype: *Agraulos ? capax* Walcott.)

Utianae with a preglabellar boss.

The genotype is different from all other species of Walcott's *Inouyia* by its cylindrical glabella, wide fixed cheek, transverse ocular ridge and inward bending of the facial suture anterior to the eyes. Such a sum of difference will be sufficient to call for a new generic distinction.

Phoreotropis Raymond, 1924. (Genotype: *Phoreotropis puteatus* Raymond.)

Utianae with a convex border and without an ocular ridge. Upper Cambrian of Vermont and Tremadocian of England.

Subfamily Emmrichellinae, new subfamily.

Emmrichellidae with middle or posterior eyes of medium to large size, fixed cheek moderate to wide, its postero-lateral limb small and triangular, pygidium with a conical axis and flat border.

Emmrichella Walcott, 1911. (Genotype: *Ptychoparia theano* Walcott.)

Emmrichellinae with large eyes located far back and marginal border depressed. Middle Cambrian of Shantung.

Liostracina Monke, 1903. (Genotype: *Liostracina krausei* Monke.)

Emmrichellinae with a longitudinal groove across the frontal limb and a pair of small lobes on both sides of the glabella.

Late Middle Cambrian of Shantung, South Manchuria and South Chosen.

Subfamily Changshaninae, new subfamily.

Emmrichellidae with a cylindrical to truncato-conical and unfurrowed glabella, large and posterior eyes, narrow fixed cheek, broad transverse postero-lateral limb and raised frontal rim.

Teinistion Monke, 1903. (Genotype: *Teinistion lansei* Monke.)

Changshaninae with a cylindrical glabella and without frontal limb. Late Middle Cambrian of S. Manchuria and Shantung.

Changshania Sun, 1924. (Genotype: *Changshania conica* Sun.)

Changshaninae with a truncato-conical glabella and a flat frontal limb and rim. Early Upper Cambrian of Shantung, Chihli and Chosen, (see page 225.)

Shantungia Walcott, 1905, not *Schantungia* Lorenz,[1] 1906. (Genotype: *Shantungia spinifera* Walcott.)

Changshaninae with a truncato-conical glabella and sloping frontal border which is produced forward into a long spine.

Late Middle Cambrian of Shantung and Liaotung.

Raymond's *Phylacterus* and *Leptopilus* are between the Emmrichellinae and Changshaninae, but probably outside the spheres of both.

Raymond's *Leptopilus*[2] has a cylindrical glabella on which account it cannot be placed in the domain of the Styginidae, because the family has a "glabella greatly expanded at the front", as originally defined.[3] *Leptopilus* resembles *Changshania* in the cylindrical narrow glabella and large posterior eyes close to the glabella, but differs from the latter by the convex frontal limb and depressed marginal border on which respect it is similar to *Emmrichella*.

A very interesting example of the longitudinal preglabellar ridge is found in Raymond's *Phylacterus*[4] from the Upper Cambrian Milton formation of Vermont. In looking over the types of *Phylacterus saylesi* I have noticed that a narrow longitudinal ridge across the frontal limb is provided with a narrow groove on each side on one specimen [Raymond, (1924), Pl. 12, fig. 14], while only a linear furrow is found at the same position on another specimen (Pl. 12, fig. 18), and also on the type of *Phylacterus fraternus*. In the latter case the longitudinal marking coincides exactly with that of *Liostracina*. The narrow glabella,

1) Lorenz's *Schantungia buchruckeri*, the genotype of his genus, was, according to Walcott, *Chuangia nitida*. (Walcott (1913), ibid. p. 7.)

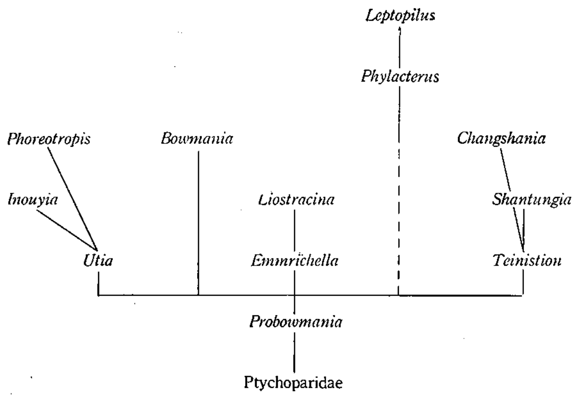
2) Raymond (1924), ibid, p. 430.

3) Raymond (1920), Bull. Mus. Comp. Zool. Vol. LXIV, No. 2, p. 282.

4) Raymond (1924). Proc. Boston Soc. Nat. Hist. Vol. 37, No. 4, p. 403.

small eye, thick brim and other features of *Phylacterus* are fairly well allied to those of *Liostracina,* although the fixed cheek is narrower and eye is more anterior in *Phylacterus.* It might be closer to the Liostracinae rather than to the Olenidae.

Asteraspis, new genus also has an axial ridge which coincides with that of *Liostracina* in position, but the ridge in this case appears to be derived from the preglabellar boss by an extreme specialization. It cannot yet be stated conclusively whether these longitudinal elevation and depression arê simply analogous, or whether they bear further meaning in respect to the phylogeny or something else. (See page 224.)



Text-figure 25.

Subfamily Utianae, new subfamily.

Genus INOUYIA Walcott, 1911.

1911. *Inouyia* Walcott, Smiths. Misc. Coll. Vol. 57, No. 4, pp. 80–81.
1913. *Inouyia* Walcott, Cambrian Faunas of China, p. 149.

Genotype:—*Agraulos* (?) *capax* Walcott.

Remarks:—As to the generic characters see page 251.

Here are listed the present generic references of various forms hitherto assigned to Walcott's *Inouyia.*

Specific name.	Present generic reference.
Inouyia abaris (Walcott).	*Lorenzella.*
Inouyia (?) *acalle* (Walcott).	*Lorenzella.*
Inouyia (?) *armata* (Walcott).	*Lorenzella.*

Inouyia capax (Walcott).	*Inouyia*.
Inouyia divi (Walcott).	*Strenuella* (?)
Inouyia (?) *inflata* (Walcott).	*Lorenzella*.
Inouyia (?) *meglitzkii* (Toll)[1]	*Lorenzella* (?) or *Strenuella* (?)
Inouyia melie (Walcott).	*Lorenzella*.
Inouyia (?) *regularis* (Walcott).	*Inouyia* (?)
Inouyia simulator (Hall and Whitfield)[2]	*Lorenzella* (?)
Inouyia thisbe (Walcott).	*Lorenzella* (?)
Inouyia titiana (Walcott).	*Tollaspis* (?)

Subfamily Emmrichellinae, new subfamily.

Genus LIOSTRACINA Monke, 1903.

PA1134-12-6
PA968-13-9

Liostracina krausei Monke.

Plate XII, figure. 6; Plate XIII, figure 9.

1903, *Liostracina krausei* Monke, Obercambrische Trilobiten von Yen-tsy-yai, p. 114, Pl. 3, figs. 10–17.
1905. *Ptychoparia ceus* Walcott, Proc. U. S. Nat. Mus. Vol. XXIX, p. 76.
1913. *Liostracina krausei* Walcott, Cambrian Faunas of China, p. 143, Pl. II, fig. 8, Pl. 14, figs. 2, 2a.

So far as I am aware, this is a unique genus and species in the Opisthoparia, and, as noticed by Walcott, it has on the other hand some similarity to the agnostids, especially in the strong longitudinal groove in front of the glabella. Under the test the cylindrical glabella is divided into three unequal lobes, and also a pair of side lobes on both sides of the base of the glabella have been recognized by Monke and Walcott; cheeks simply convex and surrounded by a strong marginal brim.

Formation and locality:—*Drepanura* zone of Saisho-ri; common in the Kushan shale in Shantung and South Manchuria.

Subfamily Changshaninae, new subfamily.

Genus TEINISTION Monke, 1903.

1903. *Teinistion* Monke, Jahrb. Königl. Preuss. Geol. Landesanstalt, 23, p. 117.
1913. *Teinistion* Walcott (in part), Research in China, 3, p. 109.

Genotype:—*Teinistion lansi* Monke.

Remarks:—The description of this genus was included by Monke in that of the type species. Walcott in 1905, independently established

1) Walcott (1914), Smiths. Misc. Coll. Vol. 64, No. 1, p. 72.
2) Walcott (1916), Smiths. Misc. Coll. Vol. 64, No. 3, p. 204.

Dorypygella on the basis of *Dorypygella typicalis* and added two more species, *Dorypygella alstor* and *Dorypygella alcon*, but later he found that *Teinistion* and *Dorypygella* were congeneric, and also changed generic reference of *D. alastor* to *Damesella*. As a result of his restudy he secured the following species :—

Teinistion alcon (Walcott).
Teinistion lansi Monke.
Teinistion sodeni Monke.
Teinistion typicalis (Walcott).
Teinistion sp.

Sun[1] added one new species, *Teinistion subconica*, to them.

But upon making comparison between *T. lansi* and *T. typicalis* remarkable differences are recognized. In the cephalon *T. typicalis* is not essentially different from *Blackwelderia* except for its distinct eye-ridge and absent frontal limb. From the minute size of *T. typicalis* it is even reasonable to suppose that the species might represent an immature stage of a certain *Blackwelderia*. On the other hand *T. lansi* is quite different from *T. typicalis* as well as *Blackwelderia*. It has a narrow cylindrical unfurrowed glabella, small posterior eye, and transverse posterior branch of the facial suture. If we compare the cheeks, *T. lansi* and *T. typicalis* are so distant that they can hardly be brought into the same genus. Therefore *T. lansi* is rather isolated and *T. typicalis* bears more possibility of being referred to *Blackwelderia* than to *Teinistion.*

As to the associated pygidium our knowledge in regard to *Teinistion, Dorypygella* and *Blackwelderia* does not as yet stand on sound ground, but if Walcott's combination is correct, *T. typicalis* and *Blackwelderia* are quite different in the pygidium and, if we consider in addition the distinctions on the cephalon, *T. typicalis* does not agree with either *Blackwelderia* or *Teinistion* (s. str.), therefore I inclined to recognize the validity of *Dorypygella* at least in the present state of knowledge. *T. typicalis* and probably *T. alcon* should be brought back to *Dorypygella*.

Teinistion sp. from the Upper Cambrian is, as discussed already, synonymous with *Kaolishania vulgaris*. Consequently *T. lansi, T. subconica* and probably *Teinistion sodeni* (cephalon only) will be retained in this genus, but the pygidium of *T. sodeni* will be distinguished as *Stephanocare bergeroni* here described.

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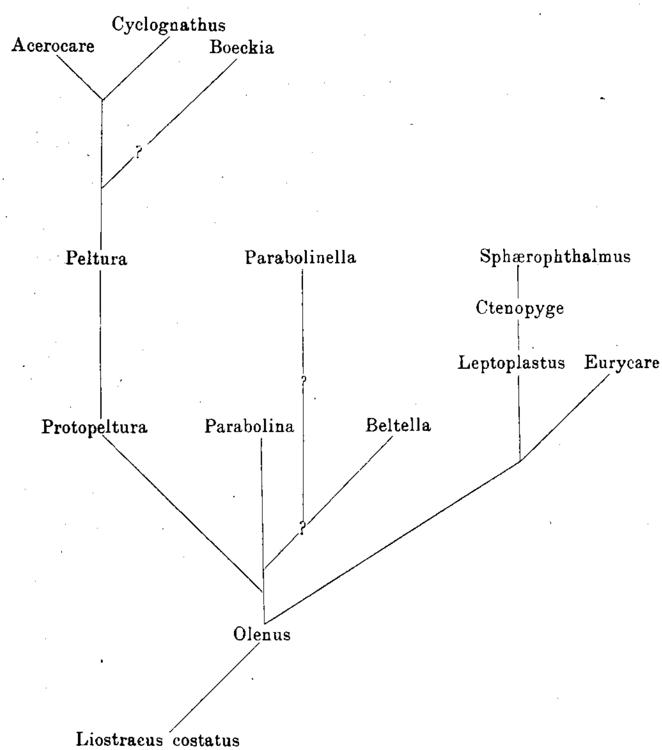
1) Sun (1924), Palaeont. Sinica, B. I, 4, p. 31, Pl. II, fig. 4.

Family Olenidae Burmeister.

Remarks:—Through the Swedish material from the *Olenus* shale, Westergård was able to trace the phylogeny of this family thoroughly as quoted here from his text on page 188.[1]

Stamträd för Olenus s. l.



Text-figure 26.
Westergård's genealogical tree of the Olenidae. [From Westergård's Sveriges Olenidskiffer, (Sver. Geol. Unders. Ser. Ca, Nio 18, 1922,) p. 188]

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1) A. H. Westergård (1922), Sveriges Olenidskiffer, (Sveriges Geologiska Undersökning, ser. Ca, Nio. 18).

Lately Ulrich[1] established a new family, Triarthridae, comprised of *Triarthrus*, *Parabolinella*, *Peltura*, *Protopeltura*, *Acerocare* and *Cyclognathus* and more doubtfully *Triarthropsis* and *Stenochilina*. Except for the dubious reference of Ulrich's two genera, the others from the Atlantic province reveal that this proposed family corresponds nearly to the left hand branch of Westergård's genealogical tree.

Angelin on the other hand already established the Leptoplastidae to include *Leptoplastus*, *Eurycare*, *Sphaerophthalmus*, *Anopocare* and *Acerocare*. According to Linnarsson[2], however, *Anopocare pusillum*, the genotype, was based on the head of *Sphaerophthalmus alatus* and the tail of *Peltura scarabœoides*. It is presumed that *Anopocare* is at any rate an immature form of a certain Olenidae. Therefore, if the last two genera are excluded, Angelin's name will be valid for the right hand branch of Westergård's diagram. Here the family Olenidae is understood in the following way :—

Subfamily Oleninae, new subfamily.

Olenus Dalman, 1827. (Genotype : *Entomostracites gibbosus* Wahlenberg.)

Parabolina Salter, 1849. (Genotype : *Entomostracites spinulosus* Wahlenberg.)

Parabolinella Brögger, 1882. (Genotype : *Parabolinella limitis* Brögger).

Parabolinopsis Hoek, 1912. (Genotype : *Parabolinopsis mariana* Hoek.)

Beltella Lake, 1919. (Genotype : *Ellipsocephalus depressus* Salter.)

Angelina Salter, 1864. (Genotype : *Angelina sedgwicki* Salter.)

Subfamily Leptoplastinae Angelin.

Leptoplastus Angelin, 1854. (Genotype : *Leptoplastus stenotus* Angelin.)

Eurycare Angelin, 1854. (Genotype :—*Eurycare brevicauda* Angelin.)

Ctenopyge Linnarsson, 1880. (Genotype : *Olenus* (*Sphaerophthalmus*) *pecten* Salter.)

Sphaerophthalmus Angelin, 1854. (Genotype: *Sphaerophthalmus flagellifer* Angelin.)

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1) Ulrich (1931), in Bridge's Geology of the Eminence and Caradoreva Quadrangles.

2) Westergård (1910), Index to N. P. Angelin's Palaeontologia Scandinavica, pp. 16-17.

Subfamily Triarthrinae Ulrich.

Protopeltura Brögger, 1882. (Genotype: *Protopeltura acanthura* Brögger, i. e. *Protopeltura præcururrsor* Westergård.)

Peltura Milne-Edwards, 1840. (Genotype: *Entomostracites scaraboeoides* Westergård.)

Acerocare Angelin, 1885. (Genotype: *Acerocare ecorne* Angelin.)

Cyclognathus Linnarsson, 1875. (Genotype: *Cyclognathus micropygus* Linnarsson.)

Westergardia Raymond, 1924. (Genotype: *Boeckia scanica* Westergård).

Boeckia Brögger, 1882. (Genotype: *Boeckia hirsuta* Brögger.)

Triarthrus Green 1832. (Genotype: *Triarthrus beckii* Green.)

Klouček[1] established a new genus, *Holubia*, out of *H. bohemica* Klouček and suggested its similarity to some olenids, such as *Cyclognathus costatus* and *Olenus* (*Parabolinella*) *frequens*.

One very important thing is that the real representative of this family is extremely rare or none in the Upper Cambrian of Southern and Eastern Asia, Australia, Arctic region and western North America.

Family Solenopleuridae Angelin.

Remarks:—The members of this family are well characterised by a strongly convex glabella of subovate to oblong outline, surrounded by a deep dorsal furrow, well defined occipital lobe, small middle eyes, relatively small free cheeks, wire-like rim frequently bent up at the middle of the front, short pygidium of few segments, and generally granulated surface.

The generic characters are the strength of the glabellar furrow and ocular ridges, length of the frontal limb, nuchal spine and so forth. (See text-figure 29.)

1) *Solenopleura* Angelin, 1854. (Genotype: *Solenopleura holometopa* Angelin.)

Solenopleuridae with ocular ridges and little or no frontal limb; surface mostly with granulation.

2) *Lonchocephalus* Owen, 1852. (Genotype: *Lonchocephalus chippewaensis* Owen.)

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1) C. Kluček (1931), *Orometopus* et Autres Fossiles Nouveaux dans le da² d'Olešná, (Zvláŝuní Otisk z Věstníku Státního Geologického Ústav Československé Republiky Roč VII., Č. 4-5,) pp. 7-8, Pl. I. 1-4.

Solenopleuridae with an occipital spine; frontal limb short; ocular ridge present; and surface granulate. Thorax composed of six to seven segments.

Hall considered this genus as a synonym of *Conocephalites.* Walcott compared it to *Liostracus* Angelin on account of the nuchal spine except for which, however, it is entirely different from *Liostracus* by its short convex semiovate glabella, two pairs of strong glabellar furrows, narrower fixed cheek, wire-like brim, facial suture and surface granulation. These characters are on the other hand decidedly suggestive of the Solenopleuridae. Upper Cambrian of New York, Upper Mississippi valley, and Utah. As noticed by Walcott, *Lonchocephalus appalachia* Walcott is more related to *Saratogia* than to *Lonchocephalus* and therefore it is omitted from this genus.

3) *Solenoparia,* new genus. (Genotype: *Ptychoparia* (*Liostracus*) *toxeus* Walcott.)

Solenopleuridae with a narrow frontal limb but without ocular ridge. Surface granulated or smooth. Most species of Asiatic *Solenopleura* occur in the Middle and Upper Cambrian. (See page 289.)

4) *Menocephalites,* new genus. (Genotype: *Menocephalus acanthus* Walcott.)

Solenopleuridae without frontal limb and ocular ridge. Surface granulated. Most *Menocephalus* of Eastern Asia occur in the Middle Cambrian. (See page 268.)

5) *Hystricurus* Raymond, 1913. (Genotype: *Bathyurus conica* Billings.)

Similar to *Solenopleura,* but glabella unfurrowed; surface granulated. Lower Ordovician of Eastern Asia, Arctic region and North America.

In seeing *Ptychoparia* sp.[1] from Bache Peninsula, I am strongly impressed that it may be a *Hystricurus.*

6) *Crusoia* Walcott, 1924. (Genotype: *Crusoia cebes* Walcott.)

Solenopleuridae with a short triangular glabella, anterior eye, transverse ocular ridge, up and backwardly bent frontal rim; cheeks without genal spines and widely separated in front of the glabella. Thorax composed of 16 segments; axis wide. Pygidium small.

This might be related to some American *Acrocephalites,* such as *A. insignis* and *A. multisegmentus,* the latter of which is most probably a member of my new genus, *Asteraspis.* Middle Cambrian of Montana.

7) *Levisia* Walcott, 1911. (Genotype: *Agraulos agenor* Walcott.)

Solenopleuridae with a subelliptical, convex glabella provided with

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1) O. Holtedahl, (1913), The Cambro-Ordovician Beds of Bache Peninsula, (Report of the Second Norwegian Expedition in the 'Fram," 1898-1902, No. 28.)

a blunt occipital spine, convex elevated free cheeks widely separated in front of the glabella, and convex sharply raised brim. Surface smooth or granulated.

Two species *Levisia agenor* (Walcott) and *L. adrastia* (Walcott) are known from the Middle Cambrian of Shantung. Walcott[1] suggested that "*Ptychoparia czekanowskii* von Toll is exceedingly close to *Levisia agenor.*"

8) *Onchonotus* Raymond,[2] 1924. (Genotype: *Menocephalus globosus* Billings.) (Text-figure 27.)

Text-figure 27.

Menocephalus globosus Billings, the genotype of *Onchonotus* Raymond. [From Billings (1865), Pal. Foss. Vol. I, (Geol. Survey, Canada,) p. 407, fig. 388.]

Solenopleuridae with a bulbous almost unfurrowed glabella, no nuchal spine, wide drooping cheeks, nastute brim, and small eyes at about the median position. Surface smooth or granulate.

Three species known from the Upper Cambrian of Vermont and Quebec. This occurs also in the Lower Ordovician of South Chosen.

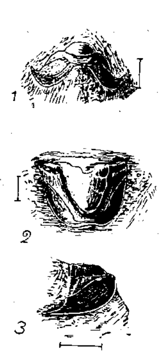
9) *Clelandia* Cossmann, 1902. (Genotype: *Harrisia parabola* Cleland.) (Text-figure 28.)

Similar to *Onchonotus,* but the free cheeks meet in front of the glabella, and eyes are far forward, opposite the anterior end of the glabella.

As Cleland's name *Harrisia* was preoccupied, Cossmann renamed the genus. Single species known from the Lower Ordovician of Tribes Hill, N.Y.

10) *Ischyrotoma* Raymond, 1925. (Genotype; *Ischyrotoma twenhofeli* Raymond.)

Small sized Solenopleuridae with long convex glabella without distinct glabellar furrows, small



Text-figure 28.

Harrisia parabola Cleland, the genotype of *Clelandia* Cossmann. [From Cleland, (1900), Bull. Am. Paleont. No. 13, Pl. 16, figs. 1-3.]

1) Walcott (1914), Cambrian Faunas of Eastern Asia, p. 72.

2) As suggested by various authors, the Cyphaspidae may be linked from such genera as *Onchonotus* and *Clelandia* of the Solenopleuridae through *Tornquistia* Reed.

eyes close to the glabella, steeply inclined cheeks without genal spines and with granulated surface.

Chazyan of Newfoundland and Quebec.

11) *Solenopleurella* Poulsen, 1927. (Genotype: *Solenopleurella ulrichi* Poulsen.)

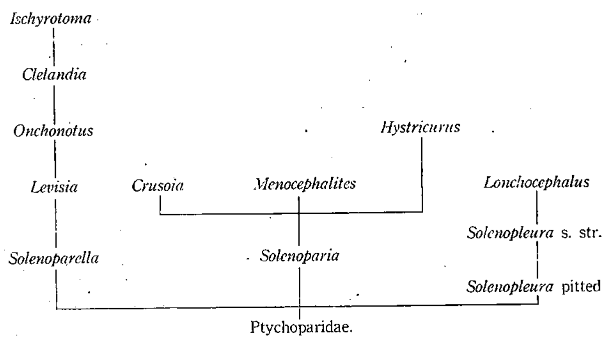
Small sized Solenopleuridae with an oblong convex glabella with three pairs of glabellar furrows; narrow glabella, small eyes, oblique ocular ridges and granulated surface. Middle Cambrian of Greenland.

Some doubt is yet entertained as to the family reference on account of the outline of glabella and transverse glabellar furrows.

Pesania Walcott and Resser[1] (genotype: *P. exsculpta* W. & R.) is in good accordance with *Solenopleurella* in the outline of the glabella, arched thick frontal brim and other respects. This might be an offshoot from this evolutional branch.

Sao Barrande was previously referred to the Ptychoparidae or Olenidae, but it is really intermediate between the Ptychoparidae and Solenopleuridae, probably closer to the latter than to the former. It agrees with the former family in the outline of the glabella, but the facial suture and texture of the carapace are quite suggestive of the alliance to the latter family.

T. H. Clark[2] established *Dipharus* as a new genus of the Solenopleu-



Text-figure 29.

1) C. D. Walcott and C. E. Resser (1924), Trilobites from the Ozarkian Sandstone of the Island of Novaya Zemlya, (Report of the Sci. Result of the Norwegian Expedition to Novaya Zemlya, 1921, No. 24,) p. 9

2) T. H. Clark (1923), New Fossils from the Vicinity of Boston, (Proc. Boston Soc. Nat. Hist. Vol. 36, No. 8, pp. 478-479.)

ridae out of his *Dipharus inspectus*. According to his opinion this curious minute cephalon is a neanic stage of a trilobite. But most features of this species look to me to be quite suggestive of an agnostid except the presence of prominent eyes and of the facial suture on the dorsal shield. Its relationship to the Solenopleuridae is quite uncertain. (See page 112.)

Subfamily Solenopleurinae, new subfamily.

Genus SOLENOPLEURA Angelin, 1854.

1854. *Solenopleura* Angelin, Pal. Scandinavica, 3d. ed. Holmiae, p. 26.
1866. *Solenopleura* Salter, Mem. Geol. Surv. Great Britain, 3, p. 305.
1881. *Solenopleura* Salter, ibid, 2d. ed. p. 499.
1884. *Solenopleura* Walcott, Bull. U. S. Geol. Surv., 10, p. 36.
1887. *Solenopleura* Matthew, Canadian Rec. Sci., 2, p. 357.
1888. *Solenopleura* Matthew, Trans. Roy. Soc. Canada, 5, p. 134, 152.
1889. *Solenopleura* Miller, N. A. Geol. Pal., p. 567.
1895. *Solenopleura* Beecher, Am. Geol. 16, p. 178.
1896. *Solenopleura* Koken, Die Leitfossilien, Leipzig, 189, p. 21, Text-fig. 13, figs. 3, 4.
1896. *Solenopleura* Œhlert, Bull. Soc. Géol. France, 24, p. 111, fig. 18.
1896. *Solenopleura* Pompeckj, Jahrb. d. k. k. geol. Reich. 45, p. 546.
1901. *Solenopleura* Lindström, Kongl. Sven. Vet. Akad. Handl. 34, No. 8, p. 25.
1910. *Solenopleura* Grabau and Shimer, N. A. Index Fossils, 2, p. 227.
1924. *Solenopleura* Zittel-Broili, Grundzüge der Palaeont. p. 648.
1931. *Solenopleura* Lake, Mon. British Cambrian Tril. Part. 6, p. 133.

Genotype:—*Solenopleura holometopa* Angelin.

Remarks:—*Solenopleura* s. str. displays a great development in the Middle Cambrian of the Atlantic province,–Norway, Sweden, Denmark, Poland, France, Spain and England in Europe, and Newfoundland, Nova Scotia and New Brunswick in North America.

It is an extraordinary fact that real *Solenopleuras* may be possibly proved to occur in Australia in forms such as are at present known by the names *Conocephalites australis* Woodward and *Ptychoparia* (?) *howchini* Etheridge. On the contrary all of Chinese *Solenopleura* from the Middle and Upper Cambrian rocks are distinct from *Solenopleura* s. str. and their generic names should be changed into *Solenoparia*, new genus.

Tollaspis, new genus:—As to the Siberian form, *Solenopleura* (?) *sibirica* (Schmidt), the taxonomic position was greatly disputed. Schmidt originally described it as a *Cyphaspis* and Tschernyschew recognized it as a new genus together with another Devonian cyphaspoid, and called it *Schmidtella*, but the name was preoccupied by

Ulrich's Ostracoda genus. Toll[1] made a new genus, *Tschernyschewiella*, for the Devonian form from the Urals and referred the Siberian one to *Solenopleura* with some uncertainty on account of the fact that it had a "Trapezförmiger Raum" in front of the glabella. This feature is never found in *Solenopleura* s. str, but coincides with the case of *Anomocare pawlowskii* Schmidt and *Liostracus* (?) *maydelli* Schmidt. After all, the three ought to be distinguished from all of the other *Solenopleura*, *Anomocare* and *Liostracus* and to be grouped into a new genus. This genus would be set apart by the "Trapezförmiger Raum" in the convex frontal limb marked by nerve-like lines, in addition to a large, oblong and furrowed glabella, large middle eyes accompanied by an ocular ridge and widely separated free cheeks in front of the glabella. *Tollaspis* is here suggested for the group, in which *Anomocare pawlowskii* Schmidt is selected for the genotype.

Out of the Lower Cambrian four species of *Solenopleura* have been described from Greenland by Poulsen and several dubious species from eastern North America by Matthew and Walcott. Among the Arctic *Solenopleura*, *S. borealis* has a truncato-conical glabella and transverse third glabellar furrows. Therefore it will presumably be something other than *Solenopleura* s. str. The other three are rather typical except for the pitted, instead of granulated, surface.

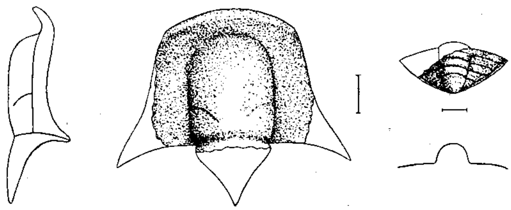
Solenopleura bombifrons Matthew, *Solenopleura* (?) *howleyi* Walcott and *Solenopleura harveyi* Walcott from Newfoundland and *Solenopleura* (?) *nana* Ford and *Solenopleura* (?) *tumida* Walcott from New York are decidedly outside of the Solenopleuridae. The second and third species probably belong to *Protolenus* or its ally. *S. tumida* is probably a Corynexochidae, and the associated pygidia of *S.* (?) *nana* are of the *Kootenia* type. The cranidia of *S. nana* and *S. bombifrons* [Walcott (1891), Pl. XCVIII, fig. 5 only,] fall probably into the *Strenuella* series.

So far as I am aware, no species has yet been found in the Upper Cambrian, or later, of the Atlantic province, but one species *Solenopleura arctica* Walcott and Resser is known from the so-called Ozarkian of Novaya Zemlya.

Two more doubtful species of *Solenopleura* are known from the St. Croixan of North America, namely *Solenopleura jerseyensis* (Weller)[2] from New Jersey and *Solenopleura* (?) *weedi* Walcott[3] from Wyoming.

Welleraspis, new genus :—

1) Toll (1899), Beitr. zur Kenntniss d. Sibir. Cambr. p. 37.
2) Weller (1903), Geol. Surv., New Jersey, Pal. 3, p. 119, Pl. 2, figs. 1–8.
3) Walcott (1899), Mon. U. S. Geol. Surv. 32, Pt. II, p. 464, Pl. 65. figs. 9, 9a.



Text-figure 30.
Solenopleura jerseyensis Weller, the genotype of *Welleraspis*, new genus. [From Weller's Palaeozoic Faunas Rept. on Paleontology, Vol. III, Geol. Surv. New Jersey, 1903, Pl. II, figs. 1-2, 7-8.]

Weller's species has an oblong glabella rather tapering to the back and two pairs of glabellar furrows, the anterior ones remarkably transverse, extraordinarily large occipital ring triangularly pointed back into a spine, narrow fixed cheek, triangular flat pygidium with an elevated conical axis and a different course of the facial suture from *Solenopleura*. (See Text-figure 30.) These distinctions will be sufficient to separate this species as a distinct genus. *Wellerapsis* is proposed on the basis of this species. This is not unlike the Kingstoninae in the general outline, but the presence of the raised convex brim does not admit it into that group. This is most closely related to *Levisia* and its allied genera, but the presence of glabellar furrows and nuchal spine, the less convex glabella and fixed cheeks, and probably, free cheeks which are widely separated in front of the glabella set it apart.

Walcott's species *S.* (?) *weedi* has a truncato-conical glabella and long frontal limb through which it is expelled from *Solenopleura* s. str. Walcott suggested its resemblance to *Bathyurus conica* Billings and *Crepicephalus* (*Loganellus*) *maculosus* Hall and Whitfield.[1] The former is now the genotype of *Hystricurus* which is quite distinct from *S.* (?) *weedi* in the outline of glabella, obsolesence of the glabellar furrows and absence of the ocular ridge, but the latter is congeneric with *S.* (?) *weedi*.

Clark's *Solenopleura laflammei*[2] and *S. truncata*[3] from the Upper Cambrian (?) boulders of Levis, Quebec are also dubious. The former might be an *Ambonolium*, and the latter a *Loganellus* or something else.

1) Hall and Whitfield (1877), U. S. Geol. Exploration of the 14th Parallel. p. 215, Pl. II, figs. 24, 25, & 26 ?

2) Clark (1924), Bull. Am. Pal. X, 41, p. 26, Pl. 4, fig. 1.

3) Clark (1924), ibid, p. 26, Pl. 4, fig. 2.

Plaster
PA1135-24-18
PA1136-24-19

Solenopleura australis (Woodward).

Plate XXIV, figures 18-19.

1884. *Conocephalites australis* Woodward, Geol. Mag. 1, (3), p. 344, Pl. XI, figs. 2a-b.
1888. *Ptychoparia howchini* Etheridge, Trans. Roy. Soc. S. Austr. XXII, p. 2, Pl. IV.
1915. *Ptychoparia* (?) *australis* Etheridge, Trans. Roy. Soc. S. Austr. XLIII, p. 384, Pl. XXXIX, fig. 6.
1915. *Ptychoparia* (?) *howchini* Etheridge, ibid. p. 385, Pl. XL, fig. 7.

The large convex glabella, small frontal limb, eyes accompanied by an ocular ridge, strong frontal brim, and granulated surface signify that this species is an undoubted *Solenopleura*.

The two species *S. australis* and *S. howchini* might be the same, as suggested by Etheridge.

Formation and locality:—Parara limestone (Middle Cambrian) of York Peninsula, South Australia.

Genus SOLENOPARIA, new genus.

Solenoparia agno (Walcott).

PA1137-19-2
PA1138-19-7,8.

Plate XIX, figures 2, 7-8.

1905. *Solenopleura agno* Walcott, Proc. U. S. National Museum, Vol. XXIX, p. 89.
1913. *Solenopleura agno* Walcott, Cambrian Faunas of China, p. 167, Pl. 17, fig. 15.

The present species is well characterized by the short, conical glabella, short preglabellar area, distinct eye-band, dense pustules on the surface and other characters.

In comparing with the holotype in U. S. National Museum the surface pustules are a little indistinct, but otherwise the Korean form is identical with the Shantung one.

Formation and locality:—Very common in the *Solenoparia* zone of Doten; this species was originally described from the Middle Cambrian of Shantung.

Solenoparia beroe (Walcott).

PA1139.

Plate XIX, figure 1.

1905. *Solenopleura beroe* Walcott, Proc. U. S. Nat. Mus, Vol. XXIX, p. 41.
1913. *Solenopleura beroe* Walcott, Cambrian Faunas of China, p. 188, Pl. 17, fig. 17, (not 14, 14a.)

Walcott distinguished this species from *Solenoparia agno* stating that "it differs from the latter in its broader fixed cheeks, shorter frontal limb, more clearly marked glabellar furrows, and minutely pustulose surface."

Walcott, however, included three different species in *Solenoparia beroe*. The cranidium illustrated in figure 14 on plate 17 by Walcott is quite distinct in the outline of glabella, length of the frontal limb. Another cranidium illustrated in figure 14a on the same plate is far more distinct and may be a *Conocoryphe*. Therefore the specific name should be limited here the form represented in figure 17 on plate 17 only, and the two other forms from the Fuchou series ought to be removed.

Formation and locality:—Walcott's holotype specimen was collected from the Upper Cambrian of Shantung, while this Korean form was secured from the *Solenoparia* zone of the Middle Cambrian age at Doten.

PA1140-19-3
PA1141-19-4
PA1142-19-5
PA1143-19-6

Solenoparia (?) *deprati*, new species.

Plate XIX, figures 3-6.

1916. *Solenopleura* (?) sp. Mansuy, Faunes Cambriennes de l'Extrême Orient Méridionale, p. 30, Pl. V, fig 6.

Description:—Cranidium broad; glabella elongately ovate, convex, distinctly defined by the dorsal furrow which joints with the frontal groove in front of the glabella; neck ring well marked off by an occipital furrow; glabellar furrows obsolete excepting the posterior pair which mark off a pair of triangular lobes on both sides of the glabella; fixed cheeks wide; palpebral lobe nearly straight and long; palpebral ridge crosses the fixed cheek from the eye to the antero-lateral angle of the glabella with moderate strength; frontal brim a little convex and transversely subcrescentic in outline; facial sutures obliquely divergent behind the eyes, subparallel in front of them and abruptly incurved after joining the frontal groove; surface very coarsely granulated.

Pygidium subtriangular, convex, with poorly defined marginal border; axial lobe subcylindrical, rounded near the posterior end; axial and pleural portions divided; articulating segment short and the first segment exceedingly strong; the rest of the segments decrease in strength from anterior to posterior.

Comparisons:—Mansuy described *Solenopleura* (?) sp. from the *Anomocare* cf. *latelimbatum* horizon at Siao-pin-tchai. This cranidium bears the characteristics of this species, such as transverse outline of the cranidium, crescentic, rather flat frontal border and so on. It is noted that

Mansuy's *Ptychoparia* (*Emmrichella*) cf. *theans*[1] from the same zone is also very closely allied to this species.

In comparing with *Solenopleura holometopa* Angelin, the frontal brim of this species is not wire-like as in that Scandinavian form. The difference is more profound in the features of the associated pygidia.

Formation and locality:—Very common in the *Solenoparia* zone of Doten; it occurs also in the *Anomocare* cf. *latelimbatum* zone of Siao-pin-tchai.

Solenoparia (?) sp.

Plate XIX, figure 9.

PA 1144

This pygidium is quite similar to those of *Solenoparia agno* and *Solenoparia* (?) *deprati*, but differs from both of them in its triangular outline, rapidly tapering conical axis and narrow marginal border. The axis is pointed back at the extremity, while rounded in both of them.

Formation and locality:—*Solenoparia* zone of Doten.

Genus MENOCEPHALITES, new genus.

1913. *Menocephalus* Walcott, Cambrian Faunas of China, p. 172.

Genotype: *Menocephalus acanthus* Walcott.

Remarks:—Owen's *Menocephalus*[2] is invalid, because the type was lost in a fire, and the description and illustration are not sufficient for purposes of comparison. But judging from *Menocephalus minnesotensis* Owen on which the genus was based the specimen illustrated was probably a fragment of the cranidium of Owen's *Dikelocephalus granulosus*.

Several species of *Menocephalus* were described from America by Billings and others, but reexamination always has proved they are something else. Walcott introduced this generic name to the Asiatic Cambrian fauna, but the Asiatic forms have nothing in common with any of the so-called American *Menocephalus*. Therefore not only no means exist of identifying *Menocephalus* with certainty, but the use of this name leads us to a precarious assumption that the genus is distributed on both sides of the northern Pacific.

So as to escape such a misunderstanding a new name is proposed here to include the Asiatic species of *Menocephalus*. The distinguishing generic characters are the semi-ovate strongly convex glabella, with the

1) Mansuy (1916), Op. cit. p. 24, Pl. III, fig. 3.
2) Owen (1852), Geol. Surv. Wisconsin, Iowa, and Minnesota, p. 577.

deep dorsal and oblique third glabellar furrows, fixed cheek of moderate breadth, eyes median and medium sized, absent ocular ridge, straight and thick frontal rim without any space of frontal limb, subtriangular pygidium composed of about six segments, and granulated surface.

This genus differs from *Solenopleura* in the absence of the ocular ridge, from *Solenoparia* in the absence of the frontal limb, and from *Hystricurus* in the furrowed glabella.

The change of the generic reference of *Menocephalus* will be summarized here as follows :—

Menocephalus species.	Present generic reference.
Menocephalus abderus (Walcott).	*Menocephalites.*
Menocephalus acanthus (Walcott).	*Menocephalites.*
Menocephalus acerius Walcott.	*Menocephalites.*
Menocephalus acidalia (Walcott).	*Menocephalites.*
Menocephalus acis Walcott.	*Menocephalites.*
Menocephalus admeta Walcott.	*Menocephalites.*
Menocephalus adrastia Walcott.	*Levisia.*
Menocephalus agave Walcott.	*Menocephalites.*
Menocephalus belenus Walcott.	*Lisania* (?)
Menocephalus (?) *depressus* Walcott.	*Pagodia.*
Menocephalus globosus Billings.	*Onchonotus.*
Menocephalus minnesotensis Owen.	(?) *Dikelocephalus.*
Menocephalus salteri Devine.	*Corynexochus* (*Bonnia*) *parvulus* (Billings).
Menocephalus salteri Rominger.	*Corynexochus stephensis* Walcott.
Menocephalus sedgwicki Billings.	*Solenopleura.*

Subfamily Dokimocephalinae, new subfamily.

1) *Acrocephalites* Wallerius, 1895. (Genotype : *Solenopleura* (?) *stenometopa* Angelin.)
   Middle Cambrian (*Agnostus laevigatus* zone) and early Upper Cambrian (*Agnostus pisiformis* zone) of Sweden.
2) *Burnetia* Walcott, 1924. (Genotype : *Ptychoparia* (?) *urania* Walcott.) Upper Cambrian of Texas.
3) *Dokimocephalus* Walcott, 1924. (Genotype: *Ptychoparia pernasuta* Walcott.) Upper Cambrian of Nevada.
4) *Iddingsia* Walcott, 1924. (Genotype: *Ptychoparia similis* Walcott.) Upper Cambrian of Nevada.
5) *Elkia* Walcott, 1924. (Genotype: *Dikelocephalus nasutus* Walcott.) Upper Cambrian of Nevada.

This subfamily is proposed to include *Dokimocephalus*, *Burnetia*, *Iddingsia*, and probaly *Elkia* and *Acrocephalites* s. str., separating them from the rest of the Solenopleuridae or Solenopleurinae (nov). The specialization which this subfamily underwent is comparable to that of *Proampyx* in the Ellipsocephalidae in some sense.

Cephalon in strong relief; glabella large, very convex, truncato-conical, surrounded by a deep dorsal furrow and strong occipital furrows; fixed cheek narrow; eyes medium sized, opposite the middle of the glabella; frontal border pointed or produced into a spine; facial sutures divergent in front of the eyes; surface granulated.

The characters are common to both *Dokimocephalus* and *Burnetia*. The chief generic difference between the two are found in the convexity of the glabella and in the character of the marginal border, in which respect *Dokimocephalus* and *Elkia*, and *Burnetia* and *Iddingsia*, are similar pairs.

In comparison to *Burnetia*, *Iddingsia* has a longer frontal limb, round frontal margin, less convex glabella and smooth surface. But both genera are not very different in their gross configuration. It cannot be overlooked that the associated pygidium of *Iddingsia* is semi-circular and composed of a few segments as commonly seen among the solenopleurids.

Elkia is more allied to *Dokimocephalus* than to *Iddingsia*. As the eyes are, however, in such a posterior position and so close to glabella, the cranidium is narrowed down in its frontal half.

Ulrich and Resser once suggested that *Elkia* and *Burnetia* should be tied up with *Hungaia* and *Pterocephalia* in a distinct family, but the Hungaiinae including *Hungaia*, *Dikelokephalina* and *Asaphopsis* is a branch of the Dikelocephalidae and *Pterocephalia* is a relative of *Amecephalus* and *Amecephalina*.

Acrocephalites differs from the two in a wide fixed cheek, smaller and more anterior eyes, longer frontal limb, convergent facial suture anterior to the eyes and in the nuchal spine. But the gross configuration is not very far from that of *Dokimocephalus*.

Comparisons of some Opisthoparian genera having a pair of pygidial spines.

From the Middle Cambrian to the Lower Ordovician there occur a number of Opisthoparian genera with a pair of marginal spines on the pygidia. These forms having sprung forth from various different evolutional stocks manifest important peculiarities in their spines. In the family Corynexochidae the spines usually project out from the articulating segment. Most of them are very tiny, but some of them are fairly long. This feature is observed in certain species of *Bonnia, Corynexochus* and *Bathyuriscus*.[1]

Olenus also has one or two pairs of very tiny spines which originate at the postero-lateral extremities of the articulating segment or of the articulating and first segments.

Ceratopyge canadensis Walcott[2] and *Dolichometopus varro* Walcott[3] are quite different from typical *Ceratopyge* and *Dolichometopus* not only in the cephalon but also in the pygidium. The articulating segment which is produced into lateral spines on both sides is definitely separated from the rest of the pygidium by a clear-cut groove behind the segment. On this account the pygidium of *Housia* appears rather similar to those of *Drepanura* and *Dorypygella*, though its posterior margin is not serrated.

In *Albertella*[4] of the Ptarmigan of western North America the first, or the combination of first and second-anterior, anchylosed segments of the pygidium is extended across the border into a long spine on each side. *Albertella pacifica*[5] from the Kushan beds of Liaotung does not show the root of the spines clearly and in comparison with the Ptarmigan forms the pleural lobes are too narrow. Such a morphological difference and the facts of the areal and time displacements between the American and Asiatic species make me question the claim of their being congeneric. In the pygidium only *Albertella pacifica* more resembles *Protolenus* (?) sp. described by Cobbold[6] than Ptarmigan *Albertella*, but it must be precarious to jump into a conclusion that the two are related, because Cobbold's species was found in the Lower Cambrian *Protolenus* limestone of Comley, Shropshire.

Walcott's *Crepicephalus* covers a wide range of variation and, as was done by him,[7] the pygidia can be separated into a *Crepicephalus iowaensis* group and a *Crepicephalus texanus* group by their outline and aspects of their spines. There is another manner of division based

1) Walcott (1916), Smithson. Misc. Coll. Vol. 64, No. 5.

2) Walcott (1912), Cambro-Ordovician Boundary in British Columbia with Description of Fossils, p. 233, Pl. 35, figs. 13-22.

3) Walcott (1916), Op. cit. p. 374, Pl. 65, figs. 1, 1a-e.

4) E. S. Cobbold (1931), Additional Fossils from the Cambrian Rocks of Comley, Shropshire, (Q. J. G. S. London, Vol. LXXXVII,) p. 475, pl. XL, figs. 17, 17a-b.

5) Walcott (1908), Smithson. Misc, Coll. Vol. 52, No. 2.

6) Walcott (1911), Smithson. Misc. Coll. Vol. 57, No. 4, pp. 76-77, Pl. 14, fig. 6

7) Walcott (1916), Smithson. Misc. Coll. Voll. 64, No. 3, p. 201

upon the properties of spines. In the one type the anchylosed segments are defined clear enough so that their whole length may be traced and the pleural ribs usually come together in the postero-lateral spines. In another type the margin is surrounded by a smooth and flat border where the traces of segmentation are entirely lacking and the spine appears to be a protrusion from the border itself.

In *Prochuangia, Kaolishania, Mansuyia, Proceratopyge, Ceratopyge Hysterolenus* and *Chosenia* the lateral spines orginate charateristically from the pleural ribs next to the articulating segments. The generic distinctions among these pygidia are made upon such features as the outline, strength of the pleural ribs and grooves, presence or absence of the interpleural groove and of the marginal border.

Many dikelocephalids, such as *Dikelocephalus* and *Osceolia*[1] have a pair of spines, but these are produced posteriorly at the angle between the articulating margin which is bent backward and the broadly rounded posterior margin. This aspect is quite different from those found in all of the preceding.

In addition to *Ceratopyge* and *Hysterolenus*, three Lower Ordovician genera *Dikelokephalina*,[2] *Asaphopsis*[3] and *Asaphelina* have a pair of spines on the pygidium. As to these genera, however, a discussion has already been entered into elsewhere in this monograph, so repetition will be avoided here.

Still several more new genera, such as *Kogenium, Koptura, Temnurus, Crepicephalina* and so forth, have a pair of spines on their pygidia and the nature of these will be discussed in the succeeding pages.

Among all of these genera, the spines vary considerably in the position of their origin and in strength. They are sometimes strong spines with round or thick sections (strong type), but sometimes are merely the extension of flat marginal borders and not very different from the simple serration of the postero-lateral margin (weak type). The former kind is for the sake of convenience subdivided into three types according to the position of origin, namely, spines which spring out from the articulating segment (1st type), from the first pleural rib (2nd type), and from the union of several pleural ribs (3rd type). The spines among the genera will be then classified in the following way :—

1) Walcott (1916), Smithson. Misc. Coll. vol. 64, No. 3, p, 201.
2) See Part II, Lower Ordovician Faunas of this monograph, p. 561.
3) See Part I, Middle Ordovician Faunas of this monograph, p. 489.

1) Zacanthoidae (*Albertella*). .... 3rd type.
2) Corynexochidae (*Bonnia*, *Corynexochus*, *Bathyuriscus*.) .... 1st type.
3) Marjumidae (*Marjumia*, *Housia*) .... 1st type.
4) Dorypygellinae (*Dorypygella*, *Drepanura*.) .... 1st type.
5) Kaolishaninae (*Kaolishania*, *Chosenia*.).................. 2nd type.
6) Ceratopygidae (*Proceratopyge*, *Ceratopyge*, *Hysterolenus*.) .... 2nd type.
7) Leiostegidae (*Prochuangia*.) .... 2nd type.
8) Crepicephalidae .... 3rd type, strong and weak.
9) Dikelocephalinae (*Dikelocephalus*) and Osceolinae (*Osceolia*.) .... 1st type but weak.
10) Hungaiinae (*Dikelokephalina*, *Asaphopsis*.) .... weak type.
11) Olenidae (*Olenus*.) .... weak type.

On the point of genesis there are two cases, progressive and regressive. For example the spines in the Olenidae are examples of the former. That is to say, the spines in *Olenus* are a few and tiny, but in later forms as *Peltura* and *Parabolina* they become greatly developed both in their numbers and strength with the climax of variation in *Parabolina spinulosa* (Wallerius).

A retrogressive examples is represented by the Kaolishaninae, which subfamily is derived from the Damesellinae through a diminishing of the number of spines.

As discussed above, the aspects of these spines are considerably different among the families and genera, and as they bear phylogenetical meanings, the nature of the spines serves often as an important criterion in problems of classification and evolution, although it is usually precarious to advance into any analysis simply upon the presence of one pair of spines on the pygidium without further study of the nature of spine itself. [See also *Dorypyge* (p. 145)]

Note on the Ceratopygidae Raymond.

Raymond established this family with a short diagnosis ;—" Opisthoparia with subequal cephalon and pygidium, long nearly smooth glabella and pygidium with long spines at the sides," and grouped *Albertella* Walcott and *Ceratopyge* Corda in it. Walcott added *Crepicephalus* to them and Zittle-Broili appended *Lonchocephalus* Walcott and *Saratogia* Walcott with some question. Owing to the absence of the pygidial spines the last two genera cannot obviously be held in this family.

As discussed at various places, *Crepicephalus* and *Albertella* belong to entirely different evolutional lines from *Ceratopyge*, the second to that of the Zacanthoidae and the first to that of the Crepicephalidae.

As far as I am aware, the following three genera belong to this family with certainty :—

Proceratopyge Wallerius, 1895. (Genotype: *Proceratopyge conifrons* Wallerius.) Upper Cambrian of the Baltic region.

Hysterolenus Moberg, 1898. (Genotype: *Hysterolenus tornquisti* Moberg.) Lower Tremadocian of Sweden.

Ceratopyge Hawle and Corda, 1847. (Genotype: *Olenus forficula* Sars.) Upper Tremadocian of Norway, Sweden and (?)Bavaria.

As noticed later, *Kogenium* from the Middle Cambrian of South Chosen has a typical pygidium of this kind, but no cephalon has been found in the collections which would suggest anything of the Ceratopygidae, whereas the associated cranidium presumably belonging to this genus, is rather suggestive of the Crepicephalidae. In such a situation the generic position is as yet in a precarious state, but for the time being it is provisionally grouped in this family by a simple reason that the genus is based on the pygidium of the Ceratopygidae alliance.

Genus KOGENIUM, new genus.

Remarks:—As discussed above, the character of the pygidial spine certainly bears more than a generic value in taxonomy. In *Kogenium* the first pleural rib is stronger than the others and is produced back into a straight spine. Each pleural rib has an interpleural groove. These diagnostic characters indicate the close resemblance between *Kogenium* and *Hysterolenus.* Both genera agree in the outline, the strength of border and the conical lobe, and in a needle-like posterior projection from the end of the lobe which crosses the border. Some differences between them, however, are recognizable in such points as the number of the axial rings, direction of pleural ribs and the strength of the first rib. On account of the unusual strength of its first lobe *Kogenium* is close to *Ceratopyge.* The cranidium provisionally referred to this genus has nothing in common with these Baltic genera whatever.

In addition to such morphological distinctions the great displacement of the time and area which is found between their occurrences should be kept in mind during a consideration of these genera.

Kogenium is secured from the *Olenoides* zone of Eastern Asia, while the other two genera are members of the Baltic fauna.

Among the Asiatic genera *Kaolishania* has a spine of this type, but its pygidium differs from that of *Kogenium* in the absence of interpleural groove and of the needle-shaped axial ridge across the border.

The associated cranidium is not very far from that of *Kaolishania*; both agree with each other in the outline of glabella, three pairs of strong glabellar furrows, rather anterior eyes and distinct eye-ridge, but *Kogenium* differs from *Kaolishania* primarily by its sharp anterior of the glabella and by its frontal limb. In these respects it is more allied to *Solenoparia* and *Solenopleura*, but *Solenoparia* has a rather smooth glabella and *Solenoparia* possesses two, instead of three, pairs of weak glabellar furrows. In *Solenopleura holometopa* Angelin the glabella does not leave any space for a frontal limb and the fixed cheeks are divided equally on both sides. *Crepicephalus* will be most close to this, if we consider the cranidium only.

The comparisons carried out, segregate *Kogenium* from other similar genera, and the distinctions are clear-cut enough to allow a new genus to be recognized. As to its phylogeny the evidences so far available appear to point to a position in the neighbourhood of *Crepicephalus* and *Kaolishania* and the similarity between the pygidia of *Hysterolenus* and *Kogenium* might be a superficial one. Finally it is noted here that the pygidium will be taken to be of the primary importance for this genus in case it and the associated cephalon are later proved to be parts of different animals.

Genotype:—*Kogenium rotundum*, new species.

Geological and geographical distribution:—Middle Cambrian of Eastern Asia.

PA1145-17-6
PA1146-17-7
PA1147-17-8
PA1148-17-9

Kogenium rotundum, new species.

Plate XVII, figures 6–9.

Description:—Pygidium straight on the anterior margin, forming subrectangles at the extremities of the margin and continuing to the straight longitudinal spines; posterior margin between the spines regularly rounded; axial lobe conical, about one-fifth the breadth of the pygidium, and elevated above the sides; it is divided into about seven rings and a terminal lobe, and tapers regularly, but rather abruptly near the border and then crosses the marginal border in a needle-shape; pleural portion nearly flat, divided into five anchylosed lobes; the articulating one fairly strong and broadly rounded at the lateral angle along the margin; the first one exceedingly strong and the other three diminish in strength in the order from the second to fourth; except for the articulating one all of the ribs directed in the postero-lateral direction and each one is accompanied on its posterior side by a secondary rib which is inserted between the two primaries; marginal border relatively broad and clearly defined by a marginal groove; surface entirely smooth.

Cranidium which belongs most probably to this species is somewhat subtrapezoidal in general outline; glabella conical, surrounded by a deep groove; three pairs of the glabellar furrows strong, convergent toward the axis, but probably disconnected on the axis; free cheek and frontal limb relatively wide and convex; eye medium sized and connected with the glabella by an eye-line; frontal brim rounded and convex; surface smooth.

The cranidium illustrated has suffered lateral secondary compression.

Formation and locality:—*Olenoides* zone of Neietsu.

Kogenium triangulare, new species.

Plate XVII, figures 4-5.

PA1149-17-4

PA1150-17-5.

S

Description:—The pygidium exclusive of the spines subtriangular; axial lobe about as wide as one-fifth the breadth of the pygidium, conical and sharply pointed at the extremity which is located at the middle of the marginal border; about six rings and a terminal lobe counted on the axis; more than four lobes on the pleural portion; articulating rib not so strong; the first cuts across the marginal border, but the others die out at the inner margin of the border; interpleural ribs inserted between the first and second and between the second and third ribs; marginal border concave and broad; surface smooth.

Comparisons:—This species differs from the preceding in the transverse outline of the pygidium, narrower axial lobe, smaller number of the anchylosed segments, and in the absence of the axial line behind the axial lobe proper.

Formation and locality:—Same as the preceding.

Family Crepicephalidae, new family.

Cephalon with genal spines; glabella truncato-conical to semioval; eye at a middle to slightly posterior position; frontal limb and rim distinctly divided. Thorax of twelve segments; axis narrow. Pygidium smaller than, or subequal to, the cephalon, and provided with a pair of lateral spines. Surface smooth or granulate.

Late Lower Cambrian to Lower Ordovician; Eastern Asia, Australia, North America, and Arctic region.

Historical Review:—The general idea of the genus is offered in Walcott's comprehensive revision of 1916 in which he tried to separate out two groups, i. e. *Crepicephalus iowensis* group and *Crepicephalus texanus* group. The genus was distributed over an expanse extending from the circum-Pacific region to eastern North America and ranged from the late Lower to Upper Cambrian. To recognize the various phases of change against such a tremendous background of time and area it is necessary that more genera in the restricted sense are to be established. Taking *Crepicephalus convexus* from China for the genotype, Resser and Endo[1] intend to establish a new genus *Crepicephalina*.

Walcott followed the traditional path in bringing this genus into the family of Ceratopygidae but a comparison among the cephala and thoraces of *Ceratopyge, Albertella* and *Crepicephalus* makes me doubt the validity of this arrangement. *Albertella* has certainly more alliance to *Zacanthoides*. Swinnerton[2] and Poulsen[3] brought *Crepicephalus* into Dikelocephalidae, but this again is rather hard to follow, because the glabellar features are so different from all dikelocephalids, saukids and ptychaspids.

Remarks:—The Lower Cambrian type of *Crepicephalus*, for which I propose here a new name *Palaeocrepicephalus*, reveals a remarkable alliance to the Ptychoparidae in the cephalon and pygidium excepting the lateral spines. The frequent presence of the granulation suggests also a closeness to the *Kochiella* or *Alokistocare* line, but a point of distinction is found in the fact that the concave frontal limb and rim are distinctly separated by a groove between.

Later forms advance from *Palaeocrepicephalus* generally by narrowing the fixed cheek, enlarging the glabella, palpebral lobe and pygidium, and so on. Among the various forms of the Middle and Upper Cambrian time two types of glabellae are to be distinguished,—that is to say, one has a truncato-conical form and the other a conical

1) Resser and Endo, Cambrian and Ozarkian Fossils and Strata of South Manchuria (MS).

2) Swinnerton (1915), Suggestions for a Revised Classification of Trilobites, (Geol. Mag. Dec. VI, Vol. II), p. 541.

3) Poulsen (1927), Cambrian, Ozarkian and Canadian Faunas of Northwest Greenland, p. 336.

form with a round front. In regard to the spines, there are three distinct types,–the first type is a convex, thick lateral spine produced out of a union of pleural ribs; the second, a flat lateral spine extended from the flat border; and the third, short posterior spines separated by a sinuation behind the axis. Basing upon these distinctions, the broad genus of *Crepicephalus* of the various authors will be reanalysed in the following manner :—

1) *Palaeocrepicephalus*, new genus. (Genotype: *Crepicephalus liliana* Walcott.)

Crepicephalidae with a transverse cephalon, truncato-conical glabella provided with dorsal and glabellar furrows; middle eyes of medium size, distinct ocular ridge, and small semicircular pygidium with a pair of large lateral spines divergent from the middle of the lateral margin and with an elevated axis composed of more than five rings. Nerve-like lines are frequently observed on the frontal limb and free cheeks. Surface granulated.

Late Lower Cambrian to Early Middle Cambrian; western North America and Greenland. *C. cecinna* Walcott and *C. celer* belong to this genus.

2) *Crepicephalina* Resser and Endo (MS). (Genotype: *Crepicephalus convexus* Walcott.)

Differs from *Palaeocrepicephalus* by its large glabella rounded in front, little or no frontal limb, narrow fixed cheek, and large eyes, with obscure ocular ridge in the cephalon and by the short robust axis of a few segments, slender spines separated by a posterior sinuation on the pygidium.

Middle Cambrian of South Manchuria and North Chosen.

3) *Mesocrepicephalus*, new genus. (Genotype: *Crepicephalus damia* Walcott.)

This is a direct derivative of *Palaeocrepicephalus* and has combined characters of that genus and *Crepicephalina*. Cephalon is similar to that of *Crepicephalina*, and the pygidium to that of *Palaeocrepicephalus*, but the pygidium is longer and its pleural rib rounded in *Mesocrepicephalus* whereas in *Palaeocrepicephalus* it is broader and its pleural rib usually roof-shaped and changing in its direction about the middle point where a tubercle is located.

This genus contains the genotype from the Middle Cambrian of Shantung and *Crepicephalus etheridgei* Chapman[1] from Victoria.

1) Chapman (1911), New or Little-known Victorian Fossils in the National Museum, [Proc. Roy. Soc, Victoria, 23, (N.S.) Pt. II,] p. 319, Pl. LVIII, fig. 8, 4?; Pl. LIX, fig. 20 21 ?

Finally it is noted that the pygidium of the genotype should be selected for the type of this genus in case the cranidium, free cheek and pygidium are proved to be of different species.

4) *Koptura* Resser and Endo (MS). (Genotype: *Anomocare lisani* Walcott.)

Cephalon of *Alokistocare-Amecephalus* type; pygidium with a conical axis and deep sinuation behind. (Page 288.)

Middle Cambrian of Alberta, Liaotung and South Chosen. *Crepicephalus chares* Walcott belongs here.

5) *Tricrepicephalus*, new genus. (Genotype: *Arionellus* (*Bathyurus*) *texanus* Shumard.)

This cephalon inclines toward the Solenopleuridae more so than toward the Ptychoparidae. The most distinguishing character is found in the three strong pits usually found upon the frontal groove. Thorax of the twelve segments and narrow axis. Pygidium is small and of the *Palaeocrepicephalus* type, but it is narrower and its spines are very much stronger than those of *Palaeocrepicephalus*.

Upper Cambrian of North America. Walcott's *Crepicephalus texanus, C. thoosa, C. tumidus C. conus,* and *C. tripunctatus* are members of this genus.

6) *Crepicephalus* Owen, 1852. (Genotype: *Dikelocephalus ? iowensis* Owen.)

Except for the small eyes, narrow thoracic axis, pygidial spines the carapace is rather of the Asaphiscidae type. Thorax composed of twelve segments. In regard to the pygidium two types are to be distinguished. In *Crepicephalus iowensis* s. str. the pleural ribs and grooves on the pygidium do not extend into the marginal border from which in turn a flat spine is produced.

P. 90 In *Crepicephalus coosensis* s. str. the marginal border is not well defined and these ribs and grooves run into the spines and unite in a bundle. For this second type Resser and Endo are going to establish a new genus *Temnura*, an undescribed species, *Temnura granulosa* (pl. XXIV, fig. 14) being, however, selected for the genotype. *Crepicephalus airaghii* from the Middle Cambrian of South Chosen will be the earliest representative of this genus.

Two points are recalled to attention, viz. that nerve-like striations on the frontal limb may be observed in well preserved specimens of *C. coosensis* and that thoracic pleurae of *C. iowensis* [Walcott (1916), ibid. Pl. 29, fig. 2,] is usually wide and ends in a long falcation which feature suggests *Olenopsis* rather than *Ptychoparia*.

6) *Uncaspis*, new genus. (Genotype: *Crepicephalus unca* Walcott.)

The general form except for the short spines on the pygidium is similar to that of the Asaphiscidae (ex. *Blainia*). The glabella is long, elevated, rounded in front, and marked by the three pairs of furrows; pygidium large and provided with a conical axis pointed backward and relatively wide border from which a pair of posterior spines is produced.

Upper Cambrian of North America; this genus includes *C. unca* Walcott and *C. camiro* Walcott. *Temnura granulosa* Resser and Endo(MS.) from the Wanwanian will be the latest representative of this genus.

Raymond[1] described *Crepicephalus ceratopygoides* from the Lower Ordovician of British Columbia. Its pygidium has a pair of lateral spines, which feature, however, has not been observed in any other *Crepicephalus* s. l.; the general aspects of the pygidium and lateral spines rather appear to me to be more allied to the Kaolishaninae, Leiostegidae, or Ceratopygidae. The associated cranidium, however, has at runcato-conical glabella without glabellar furrows, narrow fixed cheek and large middle eyes, and on these accounts it is quite similar to the usual form of *C. iowensis* [Walcott (1916), Pl. 29, figs. 2a]. From the latter in turn, however, a specific separation at least is required and the name *C. truncatus* is here suggested.

In conclusion, two interpretations of the phylogeny are presented as being probable on the basis of the general similarity of *Palaeocrepicephalus* to *Kochiella*, *Koptura* to *Alokistocare*, *Tricrepicephalus* to the Solenopleuridae, *Crepicephalus* and *Uncaspis* to the Asaphiscidae, and probably *Mesocrepicephalus* and *Crepicephalina* to *Lisania*.

One case is that these crepicephaloid genera were derived polyphyletically from adjacent groups suggested above through an addition of a pair of spines.

Another is that these similar groups were, however, all derivatives from the Ptychoparidae stock and therefore, since *Palaeocrepicephalus* branched off from the Ptychoparidae stock in the late Lower Cambrian, the rest of the Crepicephalidae were derived from that genus.

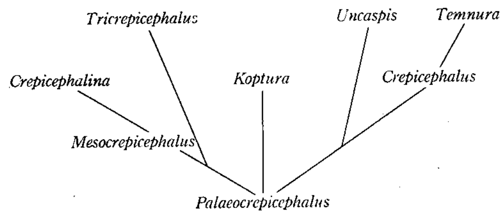
The first explanation readily accounts for short spines as in *Uncaspis*, but it becomes necessary to assume missing links to explain such long spines as in *Tricrepicephalus*. On the contrary *Palaeocrepicephalus*, *Mesocrepicephalus*, *Crepicephalus* and even *Tricrepicephalus* conform a fairly continuous morphological series and the rest of the Crepicephalidae do also. The various resemblances to the other families referred to above might be explained simply as a case of parallelism between

1) Raymond (1925), Bull. Mus. Comp. Zool. Harvard College, vol. LXII, No. 1, p. 53, pl. 2, fig. 15.

the Crepicephalidae lines and Ptychoparidae, Solenopleuridae, and Asaphiscidae lines.

Therefore the second interpretation finally presents a more suitable explanation of the morphological development so far as it has been gathered, and in my opinion it would yield such a " Stammbaum " as is presented here. (See Text-fig. 31.)

The marvelous resemblance between the associated hypostomata of *Crepicephalus iowensis* [Walcott (1916), Pl. 29, fig. 2e,] and *Tricrepicephalus thoosa* [Walcott (1916), Pl. 31, fig. 1e] and the considerable difference from those of the Asaphiscidae might be a good point of evidence for the interpretation by parallelism.



Text-figure 31.

Genus CREPICEPHALINA Resser & Endo, (MS)

Crepicephalina sinuosa, new species.

Plate XXIII, figure 6.

Pygidium long, subtrapezoidal with a broad sinuation on the posterior margin; axial lobe cylindrical, composed of five segments and elevated above the flat pleural portion.

By the cylindrical axis this falls outside of the domain of *Koptura*.

Formation and locality:—Early Middle Cambrian; 2 km. east of Sosan, Sosan area, Heian-hoku-do, North Chosen. (平安北道楚山東方二粁，廣大峯西北山背)

Genus CREPICEPHALUS Owen, 1852.

Crepicephalus airaghii, new species.

Plate XVI, figures 1-2.

Description:—Glabella truncato-conical, defined by a deep dorsal furrow and marked by three pairs of glabellar furrows, which differ in direction from transverse to highly oblique from the first to third pair; occipital furrow strong; frontal limb convex and of moderate length; frontal rim thick, narrowing laterally; the breadth of the fixed cheek across the eyes nearly the same as the length of the frontal limb; postero-lateral limb of the cheek long and triangular; palpebral lobe located at the mid-length of the cranidium; eye-band wide, defined from the fixed cheek by a groove; eye-ridge faint; facial sutures divergent from the eyes on both sides.

Pygidium of *C. iowensis* type; axial lobe conical, and somewhat pointed back; pleural portion gently convex, elevated above the flat border; about five segments counted on the axial and pleural lobes; a pair of lateral spines produced from the mid-points on the lateral margins. Surface smooth.

Comparisons:—This certainly belongs to Walcott's *Crepicephalus iowensis* group, but the truncato-conical glabella; directions of glabellar furrows, medium-sized eye and pointed axial lobe on the pygidium, distinguish this species from the others in that group. In the cranidium the species bears similarity to *Taenicephalus*, but this has three pairs of glabellar furrows changing in their direction from anterior to posterior.

Formation and locality:—*Olenoides* zone of Neietsu.

Crepicephalus subquadratus, new species.

Plate XVI, figure 6. PA1154

Description:—Pygidium subquadrate, narrowing back; the lateral margin produced back into a short spine at the posterior end; axial lobe conical, elevated above the pleurae and divided into about six rings and a terminal lobe; pleural portion gently convex, sloping down toward the flat margin, and divided into seven ribs, each one of which has a median groove; these ribs and grooves are not extended into the flat border; surface smooth.

Comparisons:—By the subquadrate outline, narrow pointed axis and small posterior spine this form entirely escapes from confusion with all other species of *Crepicephalus* in the Orient. This is another representative of the *Crepicephalus iowensis* group.

Formation and locality:—*Olenoides* zone of Neietsu.

Genus KOPTURA Resser and Endo (MS).

Koptura biloba, new species.

Plate XIX, figure 10. PA1156

Description:—Pygidium subcircular; its posterior margin deeply sinuated and consequently the posterior portion is divided into two triangular lobes; axial lobe conical, as long as two-thirds the length of the pygidium, elevated above the gently inclined pleurae, and abruptly narrowed down near the posterior extremity; axial and pleural portions divided into five lobes by narrow grooves; surface smooth.

Comparisons:—*Koptura lisani* (Walcott)[1] is distinguished from this species by the elongate outline of the pygidium and broader axial lobe of that species.

Formation and locality:—*Solenoparia* zone; south of Doten.

Subfamily Elvininae, new subfamily.

Glabella truncato-conical, well defined by a deep dorsal furrow; second and third glabellar furrows strong; eyes middle and not large; frontal limb and rim, convex, divided by a groove; the rim sometimes triangular, pointed at the middle; pygidium small, semi-circular to subtriangular and surrounded by a convex border; axis cylindrical, elevated above the flat pleura.

This subfamily branched off most probably from the Asaphiscidae or some terminal of the Ptychoparidae stock and developed along a line parallel to the Monkaspinae which usually has spinose pygidia.

1) *Maladioides* Kobayashi, 1934. (Genotype: *Maladioides asiaticus* Kobayashi.)

This is an equivalent of *Maladia* in this line. Free cheek are widely separated from each other in front of the glabella. The main difference is in the entire margin of pygidium. Early Upper Cambrian of Liaotung, Shantung and South Chosen.

2) *Elvinia* Walcott, 1924. (Genotype: *Dikelocephalus roemeri* Shumard.)

Differs from *Maladioides* in the longer frontal limb, broader fixed cheek and semi-circular outline of pygidium, instead of triangular as in *Maladioides*. The posterior pair of glabellar furrows are united on the axis. Early Upper Cambrian of New York, Pennsylvania and west of the Mississippi valley.

3) *Moosia* Walcott, 1924. (Genotype: *Moosia grandis* Walcott.)

This is known from the Upper Cambrian of British Columbia. It is my belief from the study on the genotypes, that this and *Elvinia* are congeneric.

4) *Taenicephalus* Ulrich and Resser, 1924. (Genotype: *Conocephalites shumardi* Hall.)

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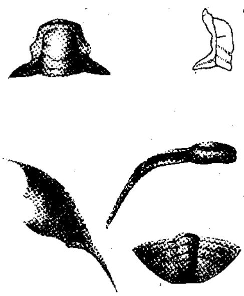
1) Walcott (1913), Cambrian Faunas of China, p. 191, Pl. 18, figs. 4, 4a–e.

This genus has a trace of the first glabellar furrow; relatively anterior eyes, narrow fixed cheek and intermarginal facial suture are the distinguishing characters. Upper Cambrian of the Mississippi valley and the Rocky Mountains. (Text-fig. 32.)

5) *Conaspis* Hall, 1863.(Genotype: *Conocephalites perseus* Hall.)

"*Taenicephalus* differs from *Conaspis* in that the fixed cheeks, palpebral lobes and border surround the glabella, which is cut off square in front, as an elevated ridge. The facial suture is intramarginal to the center, whereas it cuts the margin half way in *Conaspis*. In *Conaspis* the posterior pair of glabellar furrows are united across the glabella. The pygidium assigned to *Taenicephalus* differs from that of *Conaspis* by having a flat rim, and this also occurs along the outer edge of the free cheeks." (Page 321.)



Text-figure 32.
Conocephalites perseus Hall, the genotype of *Conaspis* Hall. [From Hall (1863), Report 16th Univ. of the State of New York, Appendix D, Pl. VII, figs. 18, 20 & 22-23.]

Walcott[1] noted that Lorenz's *Macrotoxus*,[2] 1906, is a synonym of this genus.

Finally it is noted that *Wuhuia* including Walcott's *Conokephalina dryope* and *Conokephalina belus* are tentatively referred here, owing to its close alliance to *Maladioides*.

Genus MALADIOIDES Kobayashi, 1933.

Maladioides coreanicus, new species.

Plate VIII, figures 5-6.

Description:—Glabella conical, rounded in front, convex, elevated above the cheeks, and marked by two pairs of glabellar furrows disconnected on the axis; occipital furrow and ring very strong, bent forward at both extremities; fixed cheeks narrow; palpebral lobes medium sized, close to and opposite the middle of the glabella; frontal limb and rim convex, separated by a strong groove; surface smooth.

Comparisons:—This species is certainly close to *Maladioides asia-*

1) Walcott (1916), Smiths. Misc. Coll. Vol. 57, p. 357.
2) Lorenz (1906), Zeitsch. deutsch. Geol. Gesell. Bd. 58, p. 61.

ticus,[1] but differs from that in the outline of the glabella, forwardly arched anterior margin, and larger eyes.

Formation and locality:—Common in the *Chuangia* zone of Saisho-ri.

Family Marjumidae, new family.

Marjumia Walcott, 1916. (Genotype: *Marjumia typa* Walcott.)

Housia Walcott, 1916. (Genotype: *Dolichometopus* (*Housia*) *varro* Walcott.)

This evolutional line presumably branched off from about the junction of the Ptychoparidae and Asaphiscidae and developed in a course parallel to the Monkaspinae. Except for the pygidial spines *Armonia* is considerably allied to *Marjumia*.

In establishing *Marjumia*, Walcott noticed that *Marjumia typa*, the genotype, appears to be a union of varied characters, possessing namely the cephalon of *Asaphiscus*, thorax of *Ptychoparia* and pygidium of the Olenidae, notably of *Peltura scaraboeoides* and *Parabolina megalops*. Though the affinity of the pygidium is very suggestive, *Marjumia* has nevertheless nothing to do with the Olenidae and moreover, as discussed below, it is a late Middle Cambrian trilobite and is to be traced toward *Housia* of the Upper Cambrian, both having developed in the eastern Pacific realm. The Olenidae on the other hand is considered to be derived from *Liostracus* or some element of the Ptychoparidae and passed its earthly existence in the Upper Cambrian of the Atlantic province.

Walcott's second species, *Marjumia callas* is just between *M. typa* and *Housia canadensis*. The cephalon is typically an Asaphiscidae one, but the pygidium has lost the marginal spines, but a pair of them are produced from the articulating segment.

So far as this unique feature of the spines is concerned, this second species is the same as *Housia*, but the latter is further advanced, or even degenerated, in many other characters. The glabellar outline is obscure, facial suture intramarginal, eyes small and close to the glabella, free cheek without genal spine, thorax composed of ten segments, instead of fourteen segments as in *Marjumia*, its axial lobe much wider and the pygidium except for the spine is that of a typical Asaphiscidae.

1) Kobayashi (1933), Upper Cambrian of the Wuhutsui Basin, etc. p. 146, Pl. XV figs. 9–12.

Family Asaphiscidae Raymond.

Asaphiscus and its allied genera have formerly been grouped together with the *Ogygiopsis* group into the subfamily Ogygiocarinae in the family Asaphidae by Walcott[1] and others. Raymond[2] was first in 1924 to separate *Asaphiscus* group from the Asaphidae. The distinguishing characters are the forward tapering glabella, the eye-line, narrow axial lobe, marginal facial suture and so on. On that occasion he put together *Asaphiscus* Meek, *Blountia* Walcott, *Maryvillia* Walcott, *Blainia* Walcott and *Lloydia* Raymond into the Asaphiscidae with some hesitation for the last two genera.

As *Anomocarella* and groups similar to it are difficult ones to deal with, a monographic work will be required to clarify all the phylogenetical relationships, but as a result of the revisional study discussed in the succeeding chapters I venture to take a step in that direction in such a point that *Asaphiscus* Meek, 1873, *Anomocarella* Walcott, 1905, *Blainia* Walcott, 1916, *Proasaphiscus* Resser and Endo (MS), *Manchuriella* Resser and Endo (MS) and so forth fall into a continuous series, though varying in many characters. The outline of the glabella is as a rule tapering forward, but the rate of tapering varies rather considerably. The frontal margin of the glabella ranges from semi-circular to transverse. Three pairs of glabellar furrows are never strong, and sometimes even practically obscured. The palpebral lobe medium sized, its position middle or posterior on the cephalon, and eye-band and eye-line usually fairly distinct.

Preglabellar area of moderate length, and divided into limb and rim mostly in subequal lengths. The marginal rim is, however, sometimes flattened and sometimes strongly convex. Free cheek in most species has a genal spine, but *Asaphiscus wheeleri* has none. Marginal furrows meet with the occipital one at the inside of the lateral extremity of the cheek, or they unite at a certain point on the genal spine with a sharp angle between.

Pygidium is rather important for the distinction of these genera. In *Proasaphiscus* it is remarkably heteropygous, and is somewhat elliptical. It is semi-elliptical in *Blainia* or semi-circular in *Manchuriella*; posterior margin frequently sinuated and slightly elevated;

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1) Walcott (1916), Smiths. Misc. Coll. Vol. 64, No. 5.

2) Raymond (1924), New Upper Cambrian and Lower Ordovician Trilobites from Vermont, p. 408

marginal border somewhat depressed, poorly defined inside for the most part; pleural rib has a weak interpleural groove and dies out within the border. In *Asaphiscus* the pygidium is semi-circular to sublenticular and has a strong depressed flat border. Except for the articulating segment the segmentation is obsolete. The pygidium of *Anomocarella* is intermediate between *Asaphiscus* and *Blainia*.

As a result of the succeeding discussion the following genera are excepted from this family :—

Generic name	Present family reference
Lloydia Vogdes.	Lloydidae
Lioparia Lorenz.	Anomocarinae
Maryvillia Walcott.	Tsinanidae
Glyphaspis Poulsen.	Anomocarinae
Dolgaia Walcott & Resser	Anomocarinae
Monkaspis, new genus.	Monkaspinae
Solenoparia, new genus.	Solenopleuridae
Koptura Resser and Endo (MS).	Crepicephalidae

The following genera would be retained in this family.

Asaphiscus Meek, 1873.
Anomocarella Walcott, 1905.
Lisania Walcott, 1911.
Blainia Walcott, 1916.
Blountia Walcott, 1916.
Wilbernia Walcott, 1924.
Kaninia Walcott and Resser, 1925.
Orlovia Walcott and Resser, 1925.
Elrathiella Poulsen, 1927.
Manchuriella Resser and Endo (MS).
(?) *Proasaphiscus* Resser and Endo (MS).

As to the discussion on *Lisania* and *Elrathiella* see page 161, and 223 respectively.

Attention is again recalled for the exact comparisons among *Anomocarella, Kaninia* and *Psilaspis* and among *Orlovia, Elrathiella* and *Manchuriella* in the future study.

Resser and Endo's *Psilaspis, Proasaphiscus, Manchuriella, Eymekops* and *Koptura*.

Psilaspis :—A new genus *Psilaspis* is to be set up for an undescribed species, *Psilaspis manchuriensis* by Resser and Endo, (Pl. XXIV, figs. 9–

11), and *Anomocarella temenus* (Walcott) is to be referred thereto. They consider that *Psilaspis* is more like *Asaphiscus* than *Anomocare* and *Anomocarella* in general appearance. Comparing the two forms (*Asaphiscus* and *Psilaspis*) " *Psilaspis* has perhaps a less well defined rim, a striated preglabellar area, weaker palpebral ridges, weaker palpebral grooves and flatter palpebral lobes. In *Asaphiscus* the eye-band is well defined by a furrow, thus marking the eye more conspicuous, which together with a more conical glabella give the *Asaphiscus* head a different aspect. Furthermore, the facial suture is intramarginal for a shorter distance in *Asaphiscus* which apparently also lacks the forward extension of the doublure."

" In the pygidium the general resemblance is maintained, but *Asaphiscus* has a more definite border and at least in some species also more clearly defined pleurae."

The joint authors do not give any information distinguishing *Psilaspis* from *Anomocarella*; however, *Anomocarella temenus* (Walcott) is in good accordance with *Anomocarella chinensis*. Both species have the same type of glabella; their eyes as long as one-third the cranidium; eye-band and eye-ridge distinct; preglabellar field divided into a flat rim and sloping limb of equal length. A rather obvious distinction is found in the absence of the posterior projection of the frontal brim in *Psilaspis*, but this character, as noticed already, varies in strength even among the types of *A. chinensis* and therefore its validity for the generic distinction is very questionable and Walcott's distinctions between *Anomocarella* and *Asaphiscus* quoted on page 295 hold as well between *Psilaspis* and *Anomocarella*. By these reasons *Anomocarella* and *Psilaspis* would be better made to conform a single genus and by the rules of nomenclature *Psilaspis* loses its standing.

Proasaphiscus:—*Anomocare ephori* Walcott and also *Anomocare latelimbatum* Dames with some question are brought into Resser and Endo's new genus *Proasaphiscus*, an undescribed species *Proasaphiscus yabei* (Pl. XXIV, fig. 16) being selected for its genotype. The main distinction of this genus from *Asaphiscus* is in the features of the pygidium which is small and rounded, and has no border; and when the border is somewhat outlined, the pleural furrows run across it to the margin; these furrows are deeper but narrower than those of *Asaphiscus* and transverse near the axis, but sharply curved back near the margin. P. 90.

This genus is very common in the chocolate or green shale of the Middle Cambrian of Manchuria which yields many complete specimens.

The heteropygous character to such a considerable degree naturally requires the generic separation from *Asaphiscus*.

Manchuriella:—Resser and Endo erected a new genus *Manchuriella* for a form of Walcott's *Anomocare minus* (Pl. 19, figs. 1a–b, not figs. 1 & 1c–d) together with a part of *Asaphiscus iddingsi* (Pl. 23, fig. 16, not figs. 1 & 1a.) considering them to be a single species and naming it as *Manchuriella typa*. In its diagnosis the strong convexity of the cephalon and pygidium, weakness of the ocular groove and ridge, and distinct border on the pygidium were stressed by them. The essential characters for this group are, however, the course of the facial suture and position of the palpebral lobes. The eye is located quite posterior, and the anterior branch of the suture is rather straight and more longitudinal, while the posterior branch is quite transverse. The glabella also is relatively large. These qualities distinguish this group from *Anomocare* s. str. as well as *Anomocarella* group clearly.

It is noted here that *Manchuriella* is remarkably allied to *Blainia*; the precise information will be given in a paragraph under *Blainia*.

Lorenz established a new genus *Megalophthalmus* and included *Liostracus megalurus* Dames and *Anomocare minus* Dames; both species are, however, referred by Walcott to *Anomocare*; and Resser and Endo established *Manchuriella* from a certain form of Walcott's *Anomocare minus*. To straight out this confusion a restudy of Dames' and Walcott's types are required. I hope to carry out this tast and my opinion will be written in another paper now in preparation.

Eymekops:—If the palpebral lobe becomes extraordinarily large and close to the glabella, the cranidia naturally assume a shape like that of *Anomocarella hermias*. The latter species has been selected for a new genus *Eymekops* by Resser and Endo. *Haniwa* in the Upper Cambrian represents most probably a direct descendancy from *Eymekops*, the quadrate glabella and transverse glabellar furrows serving for the distinction between the two.

It is noticed that a marvelous similarity is found between *Manchuriella minus* (Dames) [Walcott (1913) Pl. 19, fig. 1,] and *Emmrichella mantoensis* (Walcott). Judging from the facial suture and other respects, *Eymekops* and *Haniwa* might be tied into a common evolutional line from *Emmrichella mantoensis*, or its neighbourhood.

Koptura:—*Koptura* Resser and Endo will be a good genus, as shown by the genotype, *Anomocare lisani*; the cephalon is quite distinct from all species of Walcott's *Anomocare* and *Anomocarella* especially in its long frontal area and small glabella. Its pygidium also stands apart in its slender shape with bilobed posterior wings. In the cephalon only, *A. lisani* is more allied to *Palaeocrepicephalus* and may possibly be a branch of the Crepicephalidae. (See page 276.)

Two new Genera *Solenoparia* and *Monkaspis*.

Anomocare and *Anomocarella* have really been a sort of a dumping ground for a variety of forms. For example, *Anomocarella bergeroni* Walcott from the Upper Cambrian of Shantung is quite distinct from both of these genera, in the outline of the glabella and size and position of the palpebral lobe, but is rather close to certain *Coosia*, such as *Coosia robusta* Walcott from the Upper Cambrian of Tennessee.

Solenoparia:—*Anomocarella tutia*, *Anomocarella subrugosa*, *Anomocarella thraso* and *Anomocarella toxeus* comprise another distinct type, all of them having a somewhat triangular glabella, small middle eyes and very thick convex brim. They exhibit differences of degree in the strength of the eye-ridge, length and convexity of the frontal limb and texture of the carapace, but all of them fall within the gradation between certain type of *Ptychoparia* and *Solenopleura*, such as, *Ptychoparia impar* and *Solenopleura intermedia.* If *P. impar* is compared with *A. tutia* the similarities become apparent at once; and the same is true in making comparisons between *S. intermedia* and *A. toxeus*. *A. subrugosa* has prominent granulations. These four species of *Anomocarella* are, however, still distinguishable from *Ptychoparia* by the outline of glabella and from *Solenopleura* by their longer frontal limb. A new generic name *Solenoparia* is here proposed for this group, and the genotype is to be *Ptychoparia* (*Liostracus*) *toxeus* Walcott. For the erection of this genus a question is raised by the associated pygidium of *Anomocarella thraso*. If that pygidium really belongs to this species, then the species must be separated from *Solenoparia*, because the pygidium is very close to that of the *Anomocarella alvion* type. (See page 259.)

Monkaspis:—Among the remaining species *Anomocare daulis* is rather distinct, being distinguished from all of the others by the serrated margin of its pygidium. On this account it is to be isolated from the others and given a new name, *Monkaspis*.

The two Upper Cambrian genera of North America, *Maladia* and *Tostonia* are very much allied to *Monkaspis* in the large subquadrate glabella, two pairs of fairly clear glabellar furrows, thick marginal brim, medium sized eyes, distinct eye-line and course of the facial suture, and serrated pygidium. These later genera, however, have much larger glabella, narrower fixed cheek and frontal limb and relatively smaller eyes. (See page 300.)

The cranidia of *Monkaspis daulis* and *Koptura lisani* resemble each other very closely in the broad cranidium, the shape and size of glabella, wide fixed cheek and frontal area with narrow brim, and relatively small eyes opposite the middle of the glabella. The eye-ridge is usually clear. These features are quite suggestive of the relation to the *Ptychoparia* stock.

Among the free cheeks that of *Anomocare alcione* is quite distinct from the others and further research may require separating this to a generic rank.

Walcott's BLAINIA, BLOUNTIA, MARYVILLIA, and WILBERNIA.

In 1916 Walcott[1] established the genera *Blountia* and *Maryvillia* from the Upper Cambrian of North America and *Blainia*, a subgenus of *Asaphiscus* found in the Conasauga shale. In 1924, he set up another new genus, *Wilbernia*, from the Upper Cambrian of North America. Their type species are as follows :—

Blainia	*Asaphiscus* (*Blainia*) *gregarius* Walcott.
Blountia.	*Blountia minula* Walcott.
Maryvillia.	*Maryvillia arion* Walcott.
Wilbernia.	*Ptychoparia pero* Walcott.

In regard to the generic characters these genera have already been thoroughly described and discussed by Walcott, so only brief notices in regard to the Asiatic forms are made here.

Blainia :—Detailed comparison between *Blainia gregaria* Walcott and *Anomocare minus* Dames proves how closely both species are allied to each other in the outline of glabella, narrow fixed cheek, size and position of the palpebral lobe, especially in the highly oblique eye-ridge, convexity of the frontal limb and rim, features of free cheeks, course of the facial suture, outline of the pygidium and segmentation, especially in the presence of interpleural groove, and the extension of the pleural ribs and grooves into the depressed border. The difference is recognized

1) Walcott (1916), Smiths. Misc. Coll. Vol. 64, No. 5.

only in the relatively elongate cranidium, round anterior of the glabella, longer pygidium with a more cylindrical axial lobe and some other minor respects in *B. gregaria*. In many respects *B. gregaria* seems to be closer to *A. minus* than to *Asaphiscus wheeleri*. Distinctions which could be of a generic value are the outlines of glabella and pygidium. The glabella is usually rounded in front in *Blainia* while transversely truncated in *Manchuriella*. The pygidium is much longer in *Blainia*, but among the Oriental forms *Manchuriella macar* and *Manchuriella tatian* have much longer pygidia than *M. minus* and they serve as interconnecting links between the genotypes in that respect. If the former criterion will lose its validity, then the genus *Manchuriella* will lose its standing.

Blountia and *Maryvillia* :—Both *Blountia* and *Maryvillia* are distinct from most Middle Cambrian genera in their smaller eyes and they are very close to *Modocia* and *Dunderbergia* of the Upper Cambrian.[1] As pointed out by Walcott, *Maryvillia* will be possibly an intermediate link between *Blountia* and the Asiatic tsinanids. *Maryvillia* is especially close to *Dictya* in the concave curvature of its preglabellar area. Tsinanids have apparently the smooth test, but underneath, the subquadrate outline of the glabella is marked, and even the eye-ridges are impressed, these features in general reminding of *Anomocarella*, *Asaphiscus* or their allied genera.

It is added here that *Blountia* (?) *kini*[2] has been found in the *Tsinania* zone of Sosan area, North Chosen.

Wilbernia :—As to this genus it is noted that such a long and rectangular glabella is found also in *Anomocarella brevifrons* here described; the only difference between *Wilbernia pero* and that species is to be recognized in the narrower fixed cheek and smaller palpebral lobe.

Walcott and Resser's *Kaninia, Orlovia* and *Dolgaia*.

Three genera allied to *Anomocare* and *Anomocarella* have been described by Walcott and Resser from Novaya Zemlya.[3] Their generic names and genotypes are as follows :—

1) Walcott (1924), Cambrian and lower Ozarkian Trilobites, pp. 56, 59.
Walcott (1925) Cambrian and Ozarkian Trilobites, pp. 84, 105.
2) Kobayashi (1933), Japan. Jour. Geol. & Geogr. Vol. XI, p. 104, Pl. XI, fig. 12.
3) Walcott and Resser (1925), Trilobites from the Ozarkian Sandstone of the Island of Novaya Zemlya.

Generic name	Genotype.
Kaninia.[1]	*Kaninia lata* Walcott and Resser.
Orlovia.	*Orlovia arctica* Walcott and Resser.
Dolgaia.	*Dolgaia megalops* Walcott and Resser.

Kaninia :—The authors point out that *Kaninia* differs from *Anomocarella* in its wider fixed cheeks, flattened and not rounded rim, the more posterior position of the eyes, narrower postero-lateral limb and so on, but *Anomocarella temenus* (Walcott) from the Middle Cambrian of Shantung is exceedingly close to *Kaninia lata* except for the more transverse outline of the latter.

Dolgaia :—Another genus *Dolgaia* has a fixed cheek narrower than that of *Kaninia* and on that account it is still closer to such a form as *Anomocarella* or *Psilaspis*, but its eyes and long glabella are quite suggestive of *Eymekops*.

Orlovia :—As to *Orlovia* the authors gave the following diagnosis :— " *Orlovia* has no glabellar furrows, rather wide fixed cheeks, eyes moderately large, situated about the middle of the glabella. The frontal border has a tendency toward the development of a boss. Rim wide and thickened. Occipital furrow present, moderately deep. The facial suture diverges slightly in front of the eyes and is intramarginal for a short distance as seems to be the rule in similar trilobites.

Free cheeks are broad, sub-circular in outline with a thickened, slightly upturned rim and with no genal spines.

Pygidium has a well defined axis with deep axial and pleural furrows and a narrow flattened rim."

It is astonishing to find how every item of the diagnosis fits well with the details of *Anomocare minus* and its allied forms from the Middle Cambrian of China and Manchuria, for the latter of which Resser and Endo are attempting to establish a new genus *Manchuriella*.

As a result of my study upon the types of these genera I have come to believe that very close, if not the congeneric, relationship between the following pairs of genera exists :—

Kaninia, 1925 and *Anomocarella* Walcott.

Dolgaia, 1925 and *Eymekops* Resser and Endo (MS).

Orlovia, 1925 and *Manchuriella* Resser and Endo (MS).

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1) According to Resser's information *Kaninia* Walcott and Resser came from a locality name "Kanin" on the island of Novaya Zemlya and, therefore it must be remembered that this name is entirely different in origin from Michelin's *Caninia* in the Zaphrentidae, *canis* meaning a dog and *caninus*, "relating to a dog".

Subfamily Asaphiscidae, new subfamily.

Genus ASAPHISCUS Meek, 1873.

Asaphiscus monkei, new species.

Plate VIII, figures 1–4.

Description:—Glabella short, conical, rounded in front, well defined by a dorsal furrow; neck ring and furrow distinct, but glabellar furrows practically obscure; frontal limb slightly convex, twice as long as the frontal rim; frontal margin round; eye lobe semi-circular, close to the glabella; anterior and posterior branches of the facial sutures diverging from the eyes; postero-lateral limb of the fixed cheek triangular.

Nothing is known of the free cheek and thoracic segments.

Pygidium convex with a conical axis elevated above the pleurae ending just at the inner margin of the border and divided into more than five axial rings; pleural portions convex, gently sloping down toward the margin; border of medium breadth; articulating segment strong; behind it five weak segments are to be counted, faintly divided by narrow furrows. Surface smooth.

As the fixed cheek is narrow and the palpebral lobe relatively small, this species is referred to this genus rather than to *Anomocarella*.

Formation and locality:—*Prochuangia* zone; Saisho-ri.

Asaphiscus (?) sp. undt.

Plate XX, figures 6–7.

In its elevated axial lobe, gently warping pleurae with a strong articulating lobe, and depressed marginal border this pygidium is certainly allied to *Asaphiscus*, but its definite reference to that genus is made inadvisable at present by its transverse outline, obscure segmentation and marginal furrow. If the obliteration become advanced one step further from such a form as *Asaphiscus calenus*,[1] the derived pygidium would be like this one.

Several pygidia from China, such as *Anomocare alcinoe*[2] and *Anomocare flava*,[3] are very much similar to this, but none are precisely identifiable with this species.

Formation and locality:—*Solenoparia* zone of Doten.

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1) Walcott (1916), Smiths. Misc. Coll. Vol. 64, No. 5, p. 384, Pl. 60, figs. 1, 1a–c.
2) Walcott (1913), Cambrian Faunas of China, p. 187, Pl. 18, figs. 6, 6a–b.
3) Walcott (1913), Op. cit. p. 190, Pl. 18, figs. 8, 8a–c.

Genus ANOMOCARELLA Walcott, 1905.

1905. *Anomocarella* Walcott, Proc. U. S. Nat. Mus. 29, p. 54.
1911. *Anomocarella* Walcott, Smiths. Misc. Coll. 57, p. 91.
1913. *Anomocarella* Walcott, Research in China, 3, p. 195.
1924. *Anomocarella* Zittel-Broili, Grundzüge d. Pal. 1, p. 648.

Genotype:—*Anomocarella chinensis* Walcott.

Remarks:—The genus *Anomocarella*, based upon *Anomocarella chinensis*, was first introduced by Walcott in 1905.

It " differs from *Anomocare* in the absence of glabellar furrows and in the presence of a relatively narrow, flattened frontal rim. The sides of the glabella are parallel, palpebral lobes of medium size and ocular ridge more or less clearly defined. The associated pygidium has a narrow conical axis, marked by several transverse furrows which extend out on the pleural lobes and more faintly on the sloping rim."[1].

On that occasion he described three species of *Anomocarella* in addition to a doubtful form. In 1913 when he carried out a further revision of the Chinese materials many species of *Anomocare* and *Ptychoparia* became transferred to this genus and consequently the number of species attained a total of twenty-one.

Two of Schmidt's species from Siberia and one Whitfield's species from North America were also shifted to *Anomocarella* at that time, namely:—

Liostracus maydelli Schmidt, 1886, i. e. *Anomocarella maydelli*, Walcott, 1913.

Anomocare pawlowskii Schmidt, 1886, i. e. *Anomocarella pawlowskii*, Walcott, 1913.

Crepicephalus onusta Whitfield, 1878, i. e. *Anomocarella onusta*, Walcott, 1916.

One species *Anomocarella smithi* was described in 1911 from North America by him.

Two genera allied to *Anomocare* and *Anomocarella* are Walcott's *Coosia* and Meek's *Asaphiscus*. Walcott mentions that " the cephalon (of *Coosia*) is not unlike that of *Anomocare* and *Anomocarella*. It differs from the former in having small palpebral lobes and a broad, slightly convex frontal border, and from the latter in the character of its frontal border. The thoracic segments of *Coosia* are unlike those of both of the two genera mentioned in having short, slightly marked pleural furrows.

1) Ch. D. Walcott (1905), Proc. U. S. Nat. Mus. 29, p. 54.

The pygidium of *Anomocarella* is quite unlike that of *Coosia*; but the pygidium of *Anomocare* has the broad, flattened margin seen in *Coosia superba*.'"[1]

According to Walcott, *Asaphiscus* is distinguished from *Anomocare* and *Anomocarella* in the following respects:—

"The cranidium of *Asaphiscus* differs from that of *Anomocare* in its shorter, smaller eyes and elongate glabella with well defined furrows and in form of frontal limb and border. The pygidium of the genotype *Asaphiscus wheeleri* differs from that of the genotype *Anomocare laeve* Angelin in having a much longer axial lobe and narrower border, but these characters may be variable in species referred to either genus."

"*Anomocarella* differs from *Asaphiscus* in its shorter, smaller eyes, a shorter and broader glabella in proportion to its width at the base, and in its smaller pygidium which has a narrow border."[2]

Walcott's *Anomocare* and *Anomocarella* are very broad genera and both of them contain long series of variation. Recently Resser and Endo through their study on the Cambrian faunas of Manchuria eliminated several forms as distinct, separate genera and defined *Anomocarella* in a very restricted sense.

According to Resser and Endo "perhaps the most *distinctive generic feature* (of *Anomocarella*) is the curvature of the inner margin of the rim which is bounded by two concave curves that leave a projection inward toward the center of the glabella thereby forming a ridge that often separates the preglabellar area into two lateral portions."[3]

If we examine the specimens from such a standpoint, nearly all of Walcott's *Anomocarella* must be dismembered from *Anomocarella* of the restricted sense. The posterior projection of the brim, however, differs very greatly in strength even among the Walcott's types of *Anomocarella chinensis*, i. e., it is fairly distinct on the cranidia illustrated in figure 4 and 3c on plate 20 (Walcott, 1913), but is absolutely lacking on the cranidium in figure 3b.

Therefore, though the projection may be a rather significant character, yet it is doubtful, whether it is of such value that a new definition of *Anomocarella* can be based upon it in the main.

Here *Anomocarella* is understood to contain such forms which have rather smooth, long, cylindrical to tereto-conical glabella, medium sized

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1) Ch. D. Walcott (1911), Smithson. Misc. Col. Vol. 57, No. 4, p. 96.

2) Ch. D. Walcott (1916), Smithson. Misc. Col. Vol. 64, No. 5, p. 382.

3) Resser and Endo, Cambrian and Ozarkian Fossils and Strata of South Manchuria (MS).

eyes located at the mid-length of the glabella and connected with the glabella by ocular ridges of moderate strength and gently concave or concavo-convex preglabellar fields which are equally and rather clearly divided into limbs and rims. The posterior margin of the brim is sometimes incurved and projected backwards along the axis. Their pygidia are moderately convex with slender conical axes and the pleurae gently merge into the flat or concave, rather wide border.

Anomocarella here emended corresponds to Resser and Endo's *Anomocarella* together with their *Psilaspis*. The latter type approaches *Asaphiscus*, yet it is certainly more allied to *Anomocarella* than *Asaphiscus*, as was discussed in the preceding chapter. (See page 286.)

Anomocarella resseri, new species.

Plate XIX, figures 16–17.

Description:—Glabella cylindrical, truncated in front; no distinct glabellar furrows; occipital furrow moderately strong; a small median tubercle found near the posterior margin of the neck; frontal limb and rim nearly of equal length and the former convex, the latter concave; frontal margin of the rim round, while its posterior margin consists of two curvatures which meet each other upon the axis in an acute angle; palpebral lobe large, accompanies an eye-band which originates at a short distance from the glabella; surface rough with punctae. Free cheek has a concave marginal border which is extended into the genal spine; marginal and occipital grooves swing back and become confluent on the spine.

The holotype measures 6 mm. in length in which the glabella and occipital ring occupy 3.6 mm. and 0.8 mm. The glabella is 2.8 mm. wide; the distance between the eyes is 5.4 mm.

Comparisons:—The cylindrical and smooth glabella and the sub-equal division of the frontal area, the characteristic curvature of the inner margin of the frontal limb all suggest *Anomocarella* s. str. The palpebral lobes are relatively large for this genus, in which respect this species approaches *Eymekops*.

Main specific differences of this species from *Anomocarella chinensis* lie in the elongate outline of cranidium as well as of glabella and in the transverse frontal margin of the glabella.

Formation and locality:—*Solenoparia* zone of Doten.

PA1166-17-10
PA1167-17-11
PA1168-17-12
PA1169-17-13

Anomocarella brevifrons, new species.

Plate XVII, figures 10–13.

Description:—Cephalon semicircular; cranidium somewhat quadrangular, glabella nearly twice as long as wide, parallel sided, slightly narrowing, forward, and truncated in front by a broadly round margin; dorsal and occipital furrows strong, but the glabellar furrows all narrow and weak: free cheek broad; palpebral lobe as long as one-third the length of the cranidium and located a little posterior to the mid-length; eye-band strong and defined by an ocular groove; ocular ridge fairly distinct; frontal limb narrower than frontal rim, the latter moderately convex. Free cheek wide; border rather wide; genal spine tiny. Facial suture cut the margin in front of the eye, its posterior branch transverse and turns back abruptly near the lateral end.

Pygidium probably belonging to this species is semicircular in outline; axial lobe conical, elevated and narrows near the inner margin of the border; pleural lobe flat, a little elevated above the border; segmentation not distinct on the test.

Surface smooth.

Comparisons:—Except for the size of the eye this species is extremely close to *Dikelocephalus* (?) *interpres* Reed[1] from Spiti, but its eye is twice as big as that of the Spiti species. Another similar species is *Ptychoparia* (*Conocephalites*) *memor* Reed[2] from Spiti which again agrees exactly with this species except for the shorter glabella and longer frontal limb of the Spiti forms.

Among the Chinese faunas *Anomocare megalurus* (Dames)[3] is somewhat similar to this species, but the outline of the glabella and the vertical profile of the frontal limb and rim distinguish it.

Formation and locality:—*Olenoides* zone of Neietsu.

PA1170-17-14
PA1171-17-18
PA1172-17-19

Anomocarella cf. *temenus* (Walcott).

Plate XVII, figures 14, 18–19.

1905. cf. *Anomocare temenus* Walcott, Proc. U. S. Nat. Mus. Vol. XXIX, p. 53.
1906. cf. *Anomocare ovatum* Lorenz, Zeitschr. Deutsch. Geol. Gesell. Vol. LVIII, p. 77, Pl. 4, fig. 12.
1913. cf. *Anomocare temenus* Walcott, Research in China, III, p. 206. Pl. XX, figs. 7, 7a–b.

1) Reed (1910), Cambrian Faunas of Spiti, p. 38, Pl. V, figs. 9–13.
2) Reed (1910), Op. cit. p. 31, Pl. IV, figs. 4–5.
3) Dames (1883), in Richthofen's China, Vol. IV, p. 20, Pl. I, figs. 7, 8, 10.

In comparing with the holotype the glabella of my Korean fossil is a little shorter and slowly tapering forward. The associated pygidium is rather strongly compressed laterally, but this difference may very well be due to secondary deformation.

It is noted here that the trilobites from the Huolienchai shale at the western cliff of Huo-lien-chai, South Manchuria were once assigned to *Anomocarella temenus*,[1] but they should be grouped in *Proasaphiscus* as defined in this paper.

Formation and locality:—*Olenoides* zone of Neietsu.

PA1173-14-13
PA1174-20-1
PA1175-20-2
PA1176-20-3
PA1177-20-4

Genus MANCHURIELLA Resser and Endo (MS)

Manchuriella convexa, new species.

Plate XIV, figure 13; Plate XX, figures 1–4.

Description:—Glabella truncato-conical, elevated above the frontal limb and cheek, distinctly keeled on the axis: three pairs of glabellar furrows strong under the test among which the first and second pairs are transverse and the third pair oblique and define triangular lobes on both sides of the base of the glabella; occipital furrow very strong; neck ring narrows abruptly near both extremities; median tubercle on the neck small, located close to the posterior margin of the neck; palpebral lobe semi-circular, rather posterior and relatively small; eye-band wide, marked by a deep groove inside; eye-ridge across the fixed cheek; preglabellar area expanded forward; frontal limb narrow, inclined forward; frontal brim a little wider than the limb and convex, elevated above the limb.

Free cheek moderately wide, surrounded by a wide border; inside of the border there is found a deep marginal groove which makes a sharp angle with the occipital furrow; genal spine short, along the middle of which a shallow groove is running.

Body of hypostoma oblong, considerably convex, and accompanied by a short oblique ridge on each side of the posterior margin and a deep groove between; border narrow, ridged and auriculated on both sides of the anterior margin.

Pygidium semi-circular, sinuated at the posterior end; axial lobe semi-spindle-shaped and extends to the posterior end; pleural portion gently convex, and surrounded by a depressed border of moderate breadth; axis and pleura divided into five sets of lobes in

1) Kobayashi (1931), Japan. Jour. Geol. Geogr. Vol. VIII, p. 178, Pl. XX, figs. 14–15

addition to a narrow articulating segment; each pleural lobe crosses the border and is subdivided into two lobelets by a groove near the margin. Surface smooth.

Comparisons:—In comparison with *Manchuriella typa* Resser and Endo and *Manchuriella mina* (Dames) this cranidium has a considerably convex glabella, strong occipital and marginal furrows, thick and elevated marginal rim, relatively narrow and flat frontal limb, and small palpebral lobe with a thick eye-band and groove; the pygidium has an axial lobe remarkably elevated above the less convex pleura, and a well defined flat border crossed by pleural grooves.

Formation and locality:—*Solenoparia* zone of Doten.

Manchuriella cf. *convexa* Kobayashi.

Plate XVII, figure 20.

Detached pygidium of this type is found very commonly in this beds. It is semicircular in outline, distinctly trilobated, and segmented into about six or seven lobes; axial lobe narrows abruptly near the well defined depressed border and it crosses the border in a narrow ridge.

This resembles very closely the pygidium of *Manchuriella convexa*, but differs in its strongly depressed marginal border and in the absent interpleural groove.

Formation and locality:—*Olenoides* beds of Neietsu.

Manchuriella cf. *tatian* (Walcott)

Plate XIX, figure 18.

1905. cf. *Anomocare tatian* Walcott, Proc. U. S. Nat. Mus. Vol. XXIX, p. 53.

1913. cf. *Anomocarella tatian* Walcott, Cambrian Faunas of China, p. 206, Pl. 21, figs. 1. 1a–b.

1931. cf. *Anomocarella tatian* Kobayashi, Japan. Jour. Geol. Geogr. Vol. VIII, p. 179, Pl. XX, figs. 1a–b.

A pygidium subtriangular, surrounded by a depressed border which broadens posteriorly; axial lobe conical; articulating segment very strong; surface of the test smooth, but transverse furrows are well impressed under the test.

The specimen is secondarily deformed by a lateral compression. Despite the smooth test it is very much allied to *Manchuriella macar* Walcott. On the obliteration of the segmentation and convex anterior margin it agrees more closely, however, with *Manchuriella tatian* (Walcott).

Formation and locality:—*Solenoparia* zone of Doten.

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Manchuriella (*Blainia* ?) *minaformis*, new species.

Plate XIV, figure 16; Plate XX, figure 5.

Description:—Glabella semi-elliptical, slightly widening to the posterior and keeled along the axis; three pairs of the glabellar furrows observable in the crossed light: occipital lobe short, its posterior margin convex backward and pointed at the middle: palpebral lobe rather large, located on both sides of the second and third glabellar lobes; eye-band thick; eye-line across the fixed cheek; preglabellar area expanded forward, and divided into subequal limb and rim; surface smooth.

Comparisons:—*Anomocare minus* Dames[1] resembles this species except in its longer glabella with a round front. Some forms of Mansuy's *Anomocare minus* such as that illustrated in figure 5b on plate VI[2] are very close to this. The rounded front of the glabella on the other hand seems suggestive of *Blainia*.

Formation and locality:—*Solenoparia* zone of Doten.

Subfamily Monkaspinae, new subfamily.

Cephalon surrounded by a distinct convex rim; glabella convex, elevated and provided with two pairs of glabellar furrows; occipital ring strong without spine; eyes about at the middle and medium sized; fixed cheek narrow; anterior facial sutures widely divergent; free cheeks broadly separated in front of the glabella. Pygidium semi-circular with a serrated margin; axis convex, elevated above the pleura.

I presume that this branch was developed from the Asaphiscidae stock.

1) *Monkaspis*, new genus. (Genotype: *Anomocare daulis* Walcott.)

Cephalon medium sized; frontal limb long and concave; eyes large and relatively posterior; pygidium with numerous fine serration, more than eight of which are to be counted in the genotype. Middle Cambrian of Shantung. (See page 289.)

2) *Kolpura* Resser and Endo, (MS). (Genotype: *Pterocephalus* (?) *liches* Walcott.)

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1) Dames (1883), in Richthofen's China, Vol. IV, p. 15, Pl. I, fig. 24.

2) Mansuy (1919), Faunes Cambr. de l' Extrême-Orient Méridional, p. 36, Pl. VI, fig. 56.

Differs from *Monkaspis* by its pygidium which is small and little segmented, about five segments or so in the genotype; marginal serration irregular with a rather deep sinuation behind the axis.

Nothing is known of the cranidium of this genus. A cranidium associated with the genotype in the same specimen is an *Eymekops* and if this will be proved actually to belong to the tail, this generic name will be omitted and at the same time this genus will be excluded from this subfamily owing to the characters of the cephalon. Middle Cambrian of Manchuria.

3) *Mansuyia* Sun, 1924. (Genotype: *Ceratopyge orientalis* Grabau.)

Glabella square; eye at the mid-length of the cranidium and attached close to the glabella; frontal limb narrow.

Pygidium originally referred to this genus by Sun is very probably that of *Kaolishania*. Upper Cambrian of Chihli and Chosen. (Page 178.)

4) *Maladia* Walcott, 1924. (Genotype: *Maladia americana* Walcott.)

Differs from *Mansuyia* simply by the outline of the glabella which gradually narrows forward in this genus. Free cheek without spine; pygidium in itself is quite similar to that of *Blackwelderia* on such a respect that the pleural groove ends at a distance from the margin and the pleural rib runs across the margin into a short spine of equal length. Upper Cambrian of Idaho.

5) *Iostonia* Walcott, 1924. (Genotype: *Dikelocephalus iole* Walcott.)

Small trilobite similar to *Mansuyia*, but has a much larger glabella with two pairs of distinct furrow; similar to *Maladia* but the glabella is more square, and its pygidium has no demarcation or thickening of the border, and therefore the pleural ribs and furrows run across uninterrupted through their whole length.

This genus resembles *Parabolina* and *Parabolinella* in general aspects, but is easily distinguished by its two pairs of glabellar furrows, instead of three as in the second and third genera, forwardly expanded preglabellar area and fused pleura on the longer pygidium.

As noticed by Walcott, in the pygidium only, this is somewhat similar to *Apatocephalus*. Raymond[1] referred it to *Richardsonella*, but the associated pygidium is quite distinct, and even in the cranidium itself it is distinct by the small eyes, glabellar furrows which there are only two, instead of three, and none of them running across the glabella. *Dikelocephalus belli* Billings and a pygidium referred to *Dikelocephalus* (Billings (1865), fig. 384,) might be of this genus.

Upper Cambrian of Nevada, Vermont and (?) Quebec.

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1) Raymond (1924), Proc. Boston Soc. Nat. Hist. Vol. 37, No. 4, p. 441.

Genus MANSUYIA Sun, 1924.

1924. *Mansuyia* Sun, Cambrian Faunas of North China, p. 50.

Remarks:—Based upon *Mansuyia orientalis* from the *Kaolishania* zone of Shantung Sun established this genus noting that "it is characterized by its short oblong glabella, narrow fixed cheeks, and absence of the palpebral ridge. The pygidium has two inward-curving slender lateral spines which spring out from the second segment of the pleural lobe of the pygidium." Not only in the pygidium but also in the cranidium this genus is not unlike *Ceratopyge*. Both genera have thick brims, subquadrate glabellae, and palpebral lobes close to the glabellae, but *Mansuyia* is easily distinguished from *Ceratopyge* by its short and parallel-sided glabella, two pairs of glabellar furrows and absence of median tubercle as well as eye-ridges. If we consider the cephalon only, *Mansuyia* is closer to *Maladia*, *Tostonia* and *Moxonia* of North America, but both *Maladia* and *Tostonia* have serrations on the pygidial margin.

Mansuyia maladiformis, new species.

Plate IV, figures 1–2.

Description:—Cephalon transversely semi-circular and moderately convex. Cranidium with a quadrate glabella which is well defined not only by a shallow dorsal furrow, but also by the elevation of the glabella itself; neck furrow strong, transverse, turning obliquely forward a little at its both extremities; neck ring unknown; two pairs of glabellar furrows oblique backwards from side to axis, and fainted out in the middle; frontal limb long, convexo-concave from inside to outside; frontal brim thick; inner margin sharply defined; fixed cheek very narrow; eyes located opposite the middle of the glabella exclusive of the neck and actually in contact with the dorsal furrow.

Free cheek bordered by a strong marginal groove and brim, the latter of which is produced into a short spine; central portion of the cheek nearly flat. Anterior branches of the facial sutures diverging from the eyes and abruptly incurved after joining with the marginal brim; their posterior branches divergent from the eyes.

Comparisons:—No pygidium has been found in association with the cephalon, but it certainly belongs to the genus *Mansuyia*, so far as the cranidium is concerned. In comparing with *Mansuyia orientalis* (Sun)[1]

1) Sun (1924), Cambrian Faunas of N. China, p. 50, Pl. III, fig. 7a–j.

this species is seen differing by its longer preglabellar field, more angulated glabellar outline and eyes in contact with the glabella.

In regard to elevated glabella with adjacent eyes and two sets of oblique glabellar furrows this species approaches *Maladia americana* Walcott,[1] but it is distinguished from the American species in the following points ;—

1) This glabella does not taper forward.
2) This preglabellar area is longer than that of *M. americana.*
3) This free cheek has a short genal spine.

Formation and locality :—*Eoorthis* zone ; Doten.

Notes on the Smooth Cambrian Trilobites.

In my previous paper[2] four groups of smooth trilobites in the Upper Cambrian were brought into comparison. They were the *Illaenurus, Tsinania, Plethometopus* and *Kingstonia* groups. Upon reading the historical review presented on that occasion, it will be understood how the phylogeny of the smooth trilobites has been a subject of much dispute by various authors. This problem is of course a very difficult one, because these trilobites lost many criteria valuable for classification as the smoothing out of their surface relief progressed.

The first general interpretation which became established in the earlier days was that the smooth trilobites were all related to one another.

From such a viewpoint *Illaenurus* was compared with *Symphysurus* by Brögger and with *Illaenus* by Walcott. Even Raymond grouped *Illaenurus* in the *Illaenidae,* a view which is yet maintained by Ulrich and Resser.

Another fundamental idea which arose later denied the close relationship among the various groups of smooth trilobites, and declared that each group denotes a terminus of an evolutional series springing from a different source. This idea was first suggested and powerfully insisted upon by Raymond. He claimed that *Illaenurus* should be separated from *Symphysurus* by the difference in the breadth of thoracic axis and by the relative length of the pygidium.

Walcott and Raymond increased the number of smooth trilobite groups. The former author brought forth the *Tsinania* and *Kingstonia* groups and the latter, the *Plethopeltis* group. Then Raymond claimed

1) Walcott (1925), Smiths. Misc. Col. Vol. 57, No. 3, p. 105, Pl. 16, figs. 23–28.
2) Kobayashi(1933), Upper Cambrian of the Wuhutsui Basin, etc. p. 131.

that the Illaenurinae marks the end of the Dikelocephalidae line and the *Plethopeltis* group, the terminus of the Ellipsocephalidae.

In the beginning I myself endeavoured to trace the phylogeny of the smooth trilobites under the assumption that they were all relatives of one another, but I found at length that I could not explain all of the facts in this way.

For the study of the smooth trilobites the first thing to be done is the restoration of the general form which existed before the smoothing out process had advanced very far. For this purpose the outline and convexity are more important and ought to be more carefully examined. The breadth of the glabella and axial lobe may be checked from a pair of pits along the articulating margins of the cephalon and pygidium, even when the axial furrows are entirely gone. If the facts of the size and position of the eyes and course of the facial suture are combined with those of the axial pits the breadth of the fixed cheek may then be deduced. The marginal convexity of the cephalon and pygidium sometimes enables us to ascertain the original presence of the border. The associated pygidia are often less smoothed out than the cephala. *Giordanella, Camaraspis* and *Kingaspis* are examples of this.

Further evidence may be secured by examining the casts of the carapace on which the dorsal and glabellar furrows are frequently still retained.

From these careful observations we can in most cases get a tolerably good idea about the essential configuration of the smooth forms.

As a result of such studies I found that a considerable variation exists among the smooth trilobites. *Illaenurus* is quite distinct from the others by its long glabella, narrow fixed cheek, posterior eyes, narrow rim, and broad axis of the thorax and transverse outline of pygidium. The genus merges into the typical forms of the Leiostegidae through *Cholopilus, Platycolpus* and *Koldinia.* (See page 192.)

Raymond has already pointed out that smooth *Plethopeltis* or *Plethometopus* of Ulrich passes into *Plethopeltis* s. str. Really there is a continuous series from *Plethopeltis* to *Leiocoryphe* through *Plethometopus* and *Stenopilus,* and, as is revealed by the fact that the genotype of *Plethopeltis* was originally referred to *Agraulos,* the group also bears many characters of the Ellipsocephalidae.

The *Kingstonia* group comprising *Kingstonia, Bynumia, Ucebia,* and probably *Triarthrella* is not essentially different from the *Plethopeltis* group except for the position of the eye which is usually located a little more anterior in the former than in the latter. *Camaraspis* again differs from these two groups primarily in the position of the eye, size of glabella and depressed border of pygidium. The last feature is more like that of *Kingaspis* which is considered to have been introduced from *Ellipsocephalus*, because the cephala of these two are of the same type, differing in degree of surface relief. (See pages 196, 203).

The long pygidium of the Tsinanidae is very significant. As written in the description of *Dictya depressa*, fortunately I found a good impression of the cephalic carapace which has preserved on it the outline of the glabella. From these evidences I have come to the belief that the general forms of the cephalon and pygidium are of the typical Asaphiscidae type.

Walcott already has suggested that *Maryvillia* and its allied forms are similar to *Tsinania*. The only difference which cannot be overlooked is the outline of the glabella which in the *Maryvillia* group is square like that of the *Anomocarella* type and not tapering as that of the *Asaphiscus* group. In the cephalon by itself even *Blainia paula* [Walcott (1916), ibid. Pl. 62, fig. 2,] approaches *Dictya* in the degree of smoothing.

Giordanella meneghinii (Bornemann) (Pl. XXIV, figs. 21–22) has been formerly referred variously to *Asaphus*, *Illaenus*, *Plathypeltis* and *Psilocephalus*, but as far as the cephalon is concerned, it is astonishingly similar to *Tsinania*. However, if the associated pygidium really belongs to this species, it is then quite different from *Tsinania*; but the pygidium of *Giordanella* is again not very far from the *Anomocarella* type.

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The glabella of *Giordanella* is quadrate in some specimens, but is rather expanded near the anterior end in the others. This might be the reason why it has been referred to the Asaphidae. This feature at the same time reminds me of the glabellar outline of *Anomocare* (?) *campelli*. Wide differences are found in the more transverse outline of the cephalon and pygidium and relatively narrow and small glabella of *Kingaspis campelli*. With some question still attached, *Giordanella* is here grouped in the Tsinanidae.

Family Tsinanidae Kobayashi.

Tsinania Walcott, 1916. (Genotype: *Illaenurus canens* Walcott.)
Dictya Kobayashi, 1933. (Genotype: *Illaenurus dictys* Walcott.)
Dictyella Kobayashi, 1933. (Genotype: *Dictyella wuhuensis* Kobayashi.)
Giordanella Bornemann, 1891. (Genotype: *Illaenus meneghinii* Bornemann).
Maryvillia Walcott, 1916. (Genotype: *Maryvillia arion* Walcott.)

Genus TSINANIA Walcott, 1914.

Tsinania canens (Walcott).

Plate V, figure 20; Plate VI, figures 13–14.

1905. *Illaenurus canens* Walcott, Proc. U. S. Nat. Mus. Vol. XXIX, p. 96.
1913. *Illaenurus canens* Walcott, Cambrian Faunas of China, p. 222, Pl. 23, fig. 3, & 3 b-c.
1914. *Tsinania canens* Walcott, Smithsonian Misc. Col. Vol. 64, No. 1, p. 43.
1916. *Tsinania canens* Walcott, Smithsonian Misc. Col. Vol. 64, No. 5, p. 405.
1931. *Tsinania canens* Kobayashi, Japan. Jour. Geol. & Geogr. Vol. VIII, p. 186, Pl. XX, figs. 7–9.
1933. *Tsinania canens* Kobayashi, Upper Cambr. of the Wuhutsui Basin, etc. p. 136, Pl. XVI, figs. 4–6.

Cranidium is rather regularly convex, subquadrate in its anterior half; eyes located at the mid-length of the cranidium; pygidium semi-parabolic, gently convex; axis undefined from the pleurae, narrow, multisegmented; posterior and lateral margins abruptly bent down. These features of the Korean specimens permit their identification to this species without any hesitancy.

Formation and locality:—Common in the *Dictya* zone of Kasetsu-ji and Shokudo. This is an important indicator of the *Tsinania canens* zone of North Chosen, South Manchuria and North China.

Genus DICTYA Kobayashi, 1933.

Dictya trigonalis Kobayashi.

Plate VI, figures 9–12.

1933. *Dictya trigonalis* Kobayashi, Upper Cambrian of Wuhutsui Basin, etc. p. 139, Pl. XIV, figs. 10–11, 13–15.

The cranidium and pygidium of this species are very common in South Chosen. The cranidia are well characterized by their subtriangular outline, shallow concavity behind the anterior margin, and comparatively large posterior eyes. The associated pygidium is a little shorter and more rounded than the Manchurian form, but has a narrow and multisegmented axis and distinct marginal border as do the Manchurian specimens.

Formation and locality:—*Dictya* zone of Doten and Kasetsu-ji; in the Wuhutsui basin, Liaotung this species is procured from the *Dictyella* zone which lies just above the *Tsinania* zone.

Dictya depressa, new species.

Plate VI, figures 16–19.

Description:—Cranidium somewhat triangular in general form; glabella as broad as one-third the breadth of the cranidium which is only marked by the pits on the articulating margin; under the test the glabella is rather well outlined in an oblong configulation; frontal limb and rim distinctly differentiated; the rim almost flat and depressed in step-form below the limb; fixed cheek of moderate breadth; eye a little posterior to the mid-length of the cranidium; eye-ridge moderately distinct. Facial sutures isoteli-form anterior to the eyes and simply diagonal posterior to the eyes.

Pygidium transversely semicircular; axial lobe narrow, slowly tapering back and terminating at an elevating end; pleural portions moderately convex, separated from the axis by a groove; marginal border flat and depressed.

A specimen of pygidium from Kasetsu-ji is associated with a free cheek which has a clearly defined flat border.

Comparisons:—This species is certainly related to *Dictya dictys* and *Dictya trigonalis*, but it is easily distinguished from these two species in its eye-ridge and unusually depressed marginal border on the cephalon and pygidium.

In regard to these features this species is notably allied to *Kingaspis campelli* (King)[1] from the Dead Sea, but the associated pygidia of both species are quite different from each other, namely, King's species has a transverse outline and broad axial lobe. Other similar forms are *Giordanella meneghinii* Bornemann[2] and *Camaraspis convexus* (Whitfield.)[3] The former species, however, is quite distinct in its pygidium; and in both of them the frontal limb and rim are not very well differentiated.

Formation and locality:—*Dictya* zone of Doten; Kasetsu-ji, probably in the same zone.

Dictys longicauda, new species.

Plate VI, figure 15.

Comparisons:—A single pygidium in hand is 15 mm. long, elongately triangular. In the outline it resembles *Tsinania longa*,[4] but differs

1) W. B. R. King, (1923), Cambrian Fossils from the Dead Sea, (Geol. Mag. Vol. LX), pp. 511–514, figs. 3 & 4 a b.

2) Joh. Georg. Bornemann, (1891), Die Versteinerungen des Cambrische Schichtensystems der Insel Sardinien, II, p. 476.

3) R. P. Whitfield, (1882), Geology of Wisconsin, Vol. IV p. 190, Pl. I, fig. 17.

4) T. Kobayashi (1933), Upper Cambrian of Wuhutsui Basin, etc. p 137, Pl. XIV, figs. 20–21.

from it in the presence of a distinct marginal border. *Dictya brevicephala* to which this is most closely allied, differs in the outline, and strength of axial lobe. In this species the articulating segment is separated from the rest by a deep groove and the axial lobe is faintly segmented by grooves about ten in number, and traversed by a narrow median longitudinal line.

Formation and locality:—*Dictya* zone of Doten.

Family Dikelocephalidae Miller.

Since this family name was proposed by Miller, it has been discussed at various times by Beecher, Brögger, Walcott, Raymond, Clark, Ulrich and Resser and others. As the historical review and the related discussions of the Asiatic genera have already been presented in my previous paper,[1] I shall merely add some points as to the subfamily assemblages.

According to Raymond the Dikelocephalidae comprises four subfamilies, -Dikelocephalinae, Richardsonellinae Hungaiinae and Illaenurinae.

Ulrich and Resser are of the opinion that Raymond's Ptychaspidae is bridged from the Saukinae through an undescribed genus, *Saukaspis*, and thereby it should be brought into the Dikelocephalidae as a subfamily. Further, the Illaenurinae and Hungaiinae are on the other hand to be excluded from the Dikelocephalidae. The former is related to the Illaenidae and the latter sep up into a distinct family which comprises *Pterocephalia*, *Elkia* and *Burnetia* in addition to *Hungaia*.

As already touched upon at several places, the Illaenurinae will be best understood as an element of the Leiostegidae. (See page 192.) The objections to bringing it into the Dikelocephalidae and Illaenidae have already been discussed thoroughly. Ulrich and Resser's Hungaiidae is also difficult to accept, because *Pterocephalia* appears to be an off-shoot from the *Amecephalus-Amecephalina* development on one hand (see page 230), and *Burnetia* and *Elkia* reveal most possibility of being referable to the Dokimocephalinae here proposed on the other. (See page 269.)

In my belief *Dikelokephalina* is the genus which has closest alliance to *Hungaia*. The two have the same kind of facial suture, palpebral lobes of similar size and position, and large flat border on the cephalon

1) Kobayashi (1933), Upper Cambrian of the Wuhutsui Basin, etc. (Japan. Jour. Geol. & Geogr. Vol. XI,) p. 113.

and pygidium. Their preglabellar areas are usually ornamented by lines or ridges somewhat divergent from the anterior of the glabella. Their glabellae are marked by two pairs of furrows, though the base of the glabella is much narrower in *Dikelokephalina* than in *Hungaia*, in consequence of which the glabella of the former is truncato-conical and a moderate space of the fixed cheek between the glabella and eye is present; distinct oblique eye-ridges are connected from the eye to the anterior of the glabella and a pair of semicircular depressions are also located on both sides of the glabellar base. In the latter genus on the other hand the glabella is roundly triangular and furrows mark a pair of semicircular areas upon the lateral ends of the glabellar base but not outside of the glabella.

The pygidium of *Hungaia* has a narrow cylindrical axis with a pointed posterior end, but relatively short. Pleural ribs and furrows are bent back gently in the same way as those of *Dikelokephalina*, but *Hungaia* has several pairs of marginal spines. The same comparison would be found between *Hungaia* and *Asaphopsis*, because *Dikelokephalina* and *Asaphopsis* are very close genera except for the position of the marginal spines on the pygidium.

Richardsonella is in my opinion fairly close to *Loganellus* Devine. Both have the same kind of cephalon and pygidium; primary differences are found in the length of the glabella and size and position of the palpebral lobes. The third glabellar furrows run across the glabella in the genotype of *Richardsonella*, but this is not the usual case, and in such a species as *Richardsonella oweni*, glabellar furrows are of the same type as that of *Loganellus*. Even *Euloma* is not very far from both of these except in the breadth of the fixed cheek which is much wider in it. These three have the characteristic Ptychoparian type of nerve-like lines and wide subtriangular pygidium. These features combined are never found in any of the families of the Dikelocephalidae. It is therefore quite doubtful, whether Richardsonellinae should be traced toward the common stock of dikelocephalids, or combined with *Loganellus* and *Euloma* into a group which might have come directly from the ptychoparid-stock.

Some question is still entertained as to whether the Ptychaspidae is a distinct family or subfamily of the Dikelocephalidae, because the typical forms of ptychaspids have much smaller and anterior eyes and wide subtriangular or semi-elliptical pygidia. Through the drooping of the frontal border, the outline of the cranidium is quite unique and the free cheek is as a consequence narrow and convex, but such a ptychaspid was obviously derived from a certain form like *Quadraticephalus* and *Changia* through specialization. The position and size of the eyes vary considerably among the species of *Quadraticephalus* and *Changia*. Ulrich and Resser noted that Ptychaspinae is located next to Saukinae. Various observations might be more favourable toward the combining of the Ptychaspidae and Dikelocephalidae even more closely than did Raymond.

In accordance with the above points the subfamily relations may be outlined as follows :—

Subfamily Dikelocephalinae Beecher.

1) *Dikelocephalus* Owen, 1852. (Genotype : *Dikelocephalus minnesotensis* Owen.)
2) *Briscoia* Walcott, 1925. (Genotype : *Briscoia sinclairensis* Walcott.)
3) *Coreanocephalus*, new genus. (Genotype : *Coreanocephalus kogenensis*, new species).
4) *Parabriscoia*, new genus. (Genotype : *Parabriscoia elegans*, new species.)

Subfamily Osceolinae Ulrich and Resser.

1) *Osceolia* Walcott, 1914. (Genotype : *Dikelocephalus osceola* Hall.)
2) *Walcottaspis* Ulrich and Resser, 1930. (Genotype : *Dikelocephalus vanhornei* Walcott.)

Subfamily Saukinae Ulrich and Resser.

1) *Saukia* Walcott, 1914. (Genotype : *Saukia acuta* Ulrich and Resser.)
2) *Calvinella* Walcott, 1914. (Genotype : *Dikelocephalus spiniger* Hall.)
3) *Anderssonia* Sun, 1924. (Genotype : *Ptychaspis* (*Anderssonia*) *tani* Sun.)
4) *Tellerina* Ulrich and Resser, 1933. (Genotype : *Dikelocephalus crassimarginatus* Whitfield.)
5) *Prosaukia* Ulrich and Resser, 1933. (Genotype : *Dikelocephalus misa* Hall.)
6) *Saukiella* Ulrich and Resser, 1933. (Genotype : *Saukiella typicalis* Ulrich and Resser.)

Subfamily Ptychaspinae Raymond.

1) *Ptychaspis* Hall, 1862. (Genotype: *Ptychaspis granulosa* Hall.)
2) *Keithia* Raymond, 1924. (Genotype: *Keithia schucherti* Raymond.)
3) *Changia* Sun, 1924. (Genotype: *Changia chinensis* Sun.)
4) *Quadraticephalus* Sun, 1924. (Genotype: *Quadraticephalus walcotti* Sun.)
5) *Bayfieldia* Clark, 1924. (Genotype: *Bayfieldia tumifrons* Clark).
6) *Euptychaspis* Ulrich, 1930. (Genotype: *Euptychaspis typicalis* Ulrich.)
7) *Asioptychaspis* Kobayashi, 1933. (Genotype: *Ptychaspis ceto* Walcott.)
8) *Shirakiella*, new genus. (Genotype: *Shirakiella elongata*, new species.)

Subfamily Hungaiinae Raymond.

1) *Dikelokephalina* Brögger, 1897. (Genotype: *Centropleura* (?) *dicraeura* Angelin.)
2) *Hungaia* Walcott, 1914. (Genotype: *Dikelocephalus magnificus* Billings.)
3) *Asaphopsis* Mansuy, 1920. (Genotype: *Asaphopsis jacobi* Mansuy.)

? Subfamily Richardsonellinae Raymond.

1) *Euloma* Angelin, 1854. (Genotype: *Euloma laeve* Angelin.)
2) *Loganellus* Devine, 1863. (Genotype: *Loganellus quebecensis* Devine.)
3) *Richardsonella* Raymond, 1924. (Genotype: *Dikelocephalus megalops* Billings.)

Subfamily Dikelocephalinae Beecher.

A new genus *Coreanocephalus* is established here for an Oriental dikelocephalid; the genotype is *Coreanocephalus kogenensis*. This form shows many characters suggestive of the Dikelocephalinae-alliance, such as a wide, flat, marginal border, two distinct glabellar furrows, and posterior eye lobes located close to the glabella and accompanied by a clear cut eye-band. The precise comparison, however, reveals some important distinctions. The eyes are relatively anterior in consequence of which the posterior branch of the facial suture is more or less diagonal.

The anterior branch of the suture is marginal, instead of intramarginal as in *Dikelocephalus* and *Briscoia*. In *C. kogenensis* the marginal border is concave, at least on the free cheeks, but it is rather convex in *C. cylindricus*. The convexity or concavity of the border to such an extent, however, is not very important. Yet to group this genus in the Dikelocephalinae would require some modifications of the subfamily diagnosis, but the general resemblance to the members of this subfamily encourages me to put it therein, although it might be better to separate it from the other two into a distinct section.

Among the Alaskan material of dikelocephalids I found two distinct groups, the one typified by *Briscoia* s. str, and the other differing by the serration on the pygidial margin of its members. Such a distinction may be judged to be of either a generic or subgeneric value. But in the case of other dikelocephalids the main qualifying character is the spine; between *Dikelocephalus* and *Briscoia*, the presence or absence of the marginal spines; between *Dikelokephalina* and *Asaphopsis*, the position of the spines. Therefore I am led to believe that many authors have reached an agreement with one another to place great weight on these spines for this group. To accord with their views in regard to this point the serrated type of *Briscoia* has been separated from *Briscoia* s. str. and called by a new name, *Parabriscoia*.[1]

Genus COREANOCEPHALUS, new genus.

Remarks:—This genus is established here, based upon the cephalon which is undoubtedly related to the dikelocephalids such as *Dikelocephalus* Owen, *Walcottaspis* Ulrich and Resser and others in the major characters. This genus is, however, distinct from the others in its narrow, truncato-conical glabella, comparatively anterior position of eyes and triangular postero-lateral limb of the cranidium. The glabellar furrows are obscure as in *Walcottaspis*, but the V-shaped, continuous course of two furrows neverthless observable. Further observations on this genus will be found in the description of the genotype species

Genotype:—*Coreanocephalus kogenensis*, new species.

Geological and geopraphical distribution:—Late Upper Cambrian; South Chosen.

1) T. Kobayashi (in print), The *Briscoia* Faunas of the Late Upper Cambrian etc. (Japan. Jour. Geol. Geogr. vol. XII.)

Coreanocephalus kogenensis, new species. P PA1195-4-15

Plate IV, figures 15a, 16. H PA1196-4-16

Description:—Cephalon flat and semi-circular with large genal spines. Cranidium narrow in its frontal half; glabella rather well defined by a dorsal furrow, gradually narrowing forward and roundly truncated in front; glabellar furrows obscure; but traces of two furrows uniting in a V-shape and running as one in the middle may be seen; occipital furrow marking off a narrow transverse occipital lobe; preglabellar field large; fixed cheeks narrow between the eyes; the posterior limbs of the cheeks subtriangular; palpebral lobe large with a wide eye-band and located at the mid-length of the cranidium. Free cheek flat and broad, bordered by a wide and slightly concave marginal border. Facial sutures describing a semi-circular course in front of the eyes and running diagonally behind them.

The holotype cranidium gives the following dimensions:—

Length of cranidium.	16.5 mm.
Basal breadth of cranidium.	2.5 mm.
Breadth of cranidium between the eyes.	13.5 mm.
Breadth of cranidium in the preglabellar area.	12 mm.
Length of glabella.	12 mm.
Basal breadth of glabella.	9.5 mm.
Frontal breadth of glabella.	6.5 mm.
Length of occipital ring.	2 mm.

Formation and locality:—*Dictya* zone; Doten.

Coreanocephalus cylindricus, new species.

Plate V, figures 21-22. PA1197-5-21 PA1198-5-22

In the general form this cephalon is quite similar to that of *Coreanocephalus kogenensis*, but differs in the convex subcylindrical glabella which is elevated and bordered by wide axial furrows and a broad convex marginal border.

The palpebral lobe is smaller and elevated.

An associated pygidium is semicircular in outline; axis subcylindrical, divided into four rings and a terminal lobe; pleural portion sloping gradually, divided into a strong articulating segment and about five ribs and furrows of moderate strength ; border of medium breadth inclined and flat. Surface smooth.

Formation and locality:—*Dictya* zone of Makkol. This species is associated with many large pygidia of *Tsinania canens*.

Coreanocephalus (?) *tenuisulcata*, new species.

Plate IV, figures 6–8.

Description:—Cephalon semi-circular and moderately convex; glabella convex, cylindrical, rounded in front; dorsal and occipital furrows rather distinct, but the glabellar furrows almost faded out; only the third glabellar and occipital furrows observable, the former are slightly oblique, faint out in the middle; eye medium sized, semi-circular, with broad eye-band located close to the middle of glabella; frontal border convex, inclined forward; postero-lateral limb of the fixed cheek unknown.

Associated free cheek moderately convex, bordered by a shallow marginal groove and broad brim, latter of which is produced into a genal spine in the postero-lateral direction. Facial sutures semi-circular in front of the eyes and cutting the frontal margin nearly in front of the eye; their posterior branches diagonal.

Comparisons:—This species is well characterized by the moderately convex cephalon, weak glabellar furrows and medium sized eye. In comparing with *Coreanocephalus kogenensis*, this cephalon is seen differing in its greater unevenness, nearly parallel-sided glabella.

Formation and locality:—*Eoorthis* zone of Doten.

Subfamily Saukinae Ulrich & Resser.

Genus PROSAUKIA Ulrich and Resser, 1933.

Prosaukia (?) sp.

Plate IV, figure 18.

Pygidium is imperfect but stands apart in having a large and more transverse outline than that of *Calvinella*. Axial lobe stout, short, cylindrical, tapering rather rapidly near the posterior end and ending in a small needle-shaped ridge across the border. Pleural portion is moderately convex and merging into a concave margin; four pleural lobes are counted, each of which being subdivided again into subequal halves by a secondary groove.

The transverse outline, stout cylindrical axis and pleural segmentation which extends to near the margin suggest that this pygidium belongs to *Saukia* or *Prosaukia* rather than to *Saukiella* or *Calvinella*.

Formation and locality:—*Dictya* zone of Saisho-ri.

Genus SAUKIA Walcott, 1914.

Saukia sp.

Plate VI, figure 20.

This is a typical pygidium of *Saukia*. PA1121

It is a small one 4.6 mm. long and 7 mm. wide; axial lobe large, conical, divided into three subequal rings and a semi-circular terminal lobe; a narrow longitudinal ridge crosses the margin from the terminal lobe; pleural portions gently sloping from axis to margin and divided into four lobes, each of which is subdivided into two parts by an interpleural groove; marginal border wide and somewhat concave; surface smooth.

Formation and locality:—*Dictya* zone; Doten.

Genus CALVINELLA Walcott, 1914. PA1203-4-11

Calvinella walcotti (Mansuy) PA1204-5-14 PA1205-5-15

Plate IV, figure 11; Plate V, figures 14–16. PA1206-5-16

1915. *Ptychaspis walcotti* Mansuy, Faunes Cambr. Haut-Tonkin, p. 22, pl. II, figs. 16a-b, etc.
1916. *Ptychaspis walcotti*, Mansuy, Faunes de l'Extrême Orient Méridional, pp. 33–34, Pl. V, figs. 10–11.
1924. *Ptychaspis walcotti* Sun, Contr. to Cambrian Faunas of North China, p. 68, Pl. V, fig. 2.
1931. *Ptychaspis walcotti* Kobayashi, Cambro-Ordovician of South Manchuria, p. 183, Pl. XXII, figs. 18–19.
1933. *Calvinella walcotti* Kobayashi, Faunal Study of the Wanwanian Series, p. 254, (listed).
1933. *Calvinella walcotti* Kobayashi, Upper Cambrian of the Wuhustui Basin, p. 129.

The elongately oblong glabella, narrow fixed cheek, frontal groove obliquely crossing the frontal brim, long occipital spine and granulated surface are the important characters of the cranidium. The associated free cheek is strongly convex, bordered by a strong marginal brim and groove; the brim produced postero-laterally into a genal spine; surface covered by granules.

Ulrich and Resser[1] established *Calvinella walcotti* for the Trempealeau formation of Wisconsin, but this specific name is preoccupied, and hence *Calvinella americana* is proposed for their species.

Formation and locality:—*Dictya* zone of Doten, South Chosen. This species is widely distributed in the *Calvinella walcotti* zone of Tonkin, Shakuotun limestone on the western border of Manchuria, and Wanwankou dolomite of the Niuhsintai basin, Manchuria.

PA1207

Calvinella sp.

Plate V, figure 11.

A detached pygidium subcircular in outline; axis conical, elevated, sharply pointed near the posterior end, and consisting of five subequal rings and a triangular terminal lobe; pleural portion divided into five ribs which die out on the wide, undefined, concave border; each pleural rib accompanied by a narrow riblet on the posterior side; surface smooth.

Pygidia of *Saukiella* and *Calvinella* are quite similar, but in most pygidia of *Saukiella* each pleural rib is divided into subequal halves by an interpleural groove, while in *Calvinella* the posterior riblet is much narrower than the anterior main rib. Therefore this pygidium is here provisionally referred to the latter genus.

Formation and locality:—*Dictya* zone of Doten.

PA1208

Calvinella (?) sp.

Plate IV, figure 17.

This pygidium has a long axis, fused pleurae and little marginal border through which it is quite distinct from the preceding. The final generic reference must await further material.

Formation and locality:—*Kaolishania* zone of Doten.

Genus TELLERINA Ulrich and Resser, 1933.

PA1209-4-5
PA1210-4-12
PA1211-4-13
PA1212-4-14

Tellerina coreanica, new species.

Plate IV, figures 5, 12–14.

Description:—Cephalon convex, semi-circular, bordered by a strong marginal brim and groove; glabella oblong, defined by a strong dorsal furrow; frontal furrow crosses the frontal brim obliquely at both ex-

1) Ulrich and Resser (1933), Cambrian of Upper Mississippi Valley, p 235, Pl. 40, figs. 1–14.

tremities; the brim drooping remarkably; first and second pairs of glabellar furrows short and oblique; the third and occipital furrows across the glabella and bent gently backward; fixed cheek exclusive of the postero-lateral limb very narrow; eyes elevated, close to the glabella and located at its mid-length; central portion of free cheek broad and convex; facial suture subparallel, anterior to the eyes and diagonal posterior to them.

Pygidium hemispheric with a conical, narrow axis which consists of about ten rings and produced back into a sharp ridge across the margin; pleural lobe marked by primary and secondary grooves; marginal border concave and of moderate breadth. Surface smooth.

Comparisons:—This species is allied to *Tellerina callisto* (Walcott)[1] and *Tellerina chinhsiensis* (Sun),[2] but *T. callisto* has a narrower glabella, broader fixed cheek and more broadly rounded margin of the free cheek, while *T. chinhsiensis* has weaker dorsal, glabellar and marginal furrows, more rounded frontal lobe of glabella and narrower free cheek.

Formation and locality:—*Eoorthis* zone; Doten.

Tellerina (?) *obsoleta*, new species.

V H P PA1213-4-9 PA1214-4-10

Plate IV, figures 9-10.

Imperfect specimens of a cranidium and a free cheek are in hand. Glabella convex, subquadrate; occipital furrow distinct, marking off a narrow neck ring; glabellar furrow obsolete; the third glabellar furrows moderately distinct and sinuated backwards; eye small, semicircular, close to and opposite the third glabellar furrows; postero-lateral limb of the fixed cheek transversely elongated. Free cheek has a strong marginal border which is produced back into a long genal spine; central portion of the cheek convex, surrounded by the marginal and occipital furrows.

The distinguishing characters of this species are its smooth and convex glabella, tiny posterior eye close to the glabella, transverse postero-lateral limb and strong marginal border.

Formation and locality:—*Eoorthis* zone; Doten.

Subfamily Ptychaspinae Raymond.

Genus BAYFIELDIA Clark, 1924.

1924. *Bayfieldia* Clark, Paleont. of the Beekmantown Series, p. 31.

1) Walcott (1913), Cambrian Faunas of China, p. 153, Pl. 16, fig. 14, 14a.
2) Sun (1924), Cambrian Faunas of N. China, p. 64, Pl. IV, 8a-f.

Genotype:—*Bayfieldia tumifrons* Clark.

Remarkes:—Clark established *Bayfieldia* on the basis of his new species *Bayfieldia tumifrons* and put it into the Dikelocephalidae; but he added an opinion that "this genus is most nearly related to *Lloydia* Vogdes." The holotype is an incomplete cranidium showing only the glabella and preglabellar area, but that it is more distant from *Lloydia* than from the dikelocephalids, is quite clear, because it has no convex rim on the anterior margin. The glabella is strongly convex, gently tapering forward; no glabellar furrows except the deep occipital one; anterior branches of the facial sutures parallel and turn rectangularly toward the straight frontal margin. As far as the type specimen is concerned, it is closer to some Upper Cambrian trilobites of the Upper Mississippi Valley such as *Conaspis eryon* and *Shirakiella anatinus*.

Genus ASIOPTYCHASPIS Kobayashi, 1933.

Asioptychaspis cf. *subglobosa* (Grabau).

Plate V, figure 13.

1923. cf. *Ptychaspis subglobosa* (Grabau), in Sun, Bull. Geol. Soc. China, Vol. II, (listed).

1924. cf. *Ptychaspis subglobosa* Sun, Cambrian Faunas of North China, p. 72, Pl. V, figs. 3a–d.

1931. cf. *Ptychaspis subglobosa* Kobayashi, Japan. Jour. Geol. Geogr. Vol. VIII, p. 139.

1933. cf. *Asioptychaspis subglobosa* Kobayashi, Upper Cambrian of the Wuhutsui Basin, etc. p. 118, Pl. XII, figs. 1–7.

An imperfect cranidium is in hand; the glabella subcylindrical, slightly expanding forward; dorsal and glabellar furrows strong; postero-lateral limb of the fixed cheek elongated, triangular; surface marked by irregular lines which cross from antero-lateral to postero-axial side on the fixed cheek.

As the frontal portion of the glabella is not preserved, no one can tell if it is an *Asioptychaspis* or *Quadraticephalus*, but so far as the observations which can be made are concerned, every item of the Korean specimen agrees exactly with the diagnosis of the former genus.

Formation and locality:—*Dictya* zone of Saisho-ri. This species is widely distributed in the *Tsinania* zone of Shantung, China and Manchuria.

Genus CHANGIA Sun, 1924.

Changia chosensis, new species.

Plate V, figures 1-2.

PA1216-5-1
PA1217-5-2

Description:—Glabella subpyriform, somewhat contracted at a point one-third from the front of the glabella and well defined by a dorsal furrow; three pairs of glabellar furrows oblique backward from side to axis and disconnected; occipital furrow and ring strong, convex backwards; frontal border broad, flat and inclined forward; palpebral lobes close to and opposite the middle of the glabella and elevated; postero-lateral limb short and transverse; surface with irregular lines, but smooth under the test.

The holotype cranidium (pl. V, fig. 1) measures 4.8 mm. in length and about 6.8 mm. in breadth; the distance between the eyes 4 mm.; the glabella 4 mm. long and 2.3 mm. broad.

Comparisons:—In the pyriform glabella, inclined frontal border and other aspects this cranidium appears quite similar to that of *Quadraticephalus pyrus* Kobayashi, but by the posterior and large eyes this species is easily separated from that. From *Changia chinensis* Sun this differs by its disconnected, oblique glabellar furrows, transverse postero-lateral limb of the fixed cheek, long eye and surface striation.

Formation and locality:—*Dictya* zone; Doten.

Genus QUADRATICEPHALUS Sun, 1924.

Quadraticephalus teres Resser and Endo.

Plate V, figures 3-7.

PA1218-5-3
PA1219-5-4
PA1220-5-5
PA1221-5-6
PA1222-5-7

1933. *Quadraticephalus teres* Kobayashi, Upper Cambrian of the Wuhustui Basin, etc. p. 124, Pl. XII, fig. 14.

Description:—Cephalon moderately convex, semi-circular, with genal spines. Cranidium subquadrate anterior to the eyes, and trapezoidal posterior to them; glabella oblong, about twice as long as wide and well defined by a dorsal furrow; glabellar furrows weak; the neck furrow strong; palpebral lobes located close to the glabella and at a point one-third the distance across from front to base; postero-lateral limb of the fixed cheek triangular, slightly broader than the occipital ring. Free cheek convex with a narrow border which in turn is produced back into a long spine.

Pygidium semi-circular; axis short, conical, elevated above the gently convex pleurae and abruptly pointed at the extremity; axis and pleurae divided faintly into about three segments; each pleural rib subdivided into two halves by an interpleural groove; marginal border not well defined.

Whole surface of the cephalon and pygidium roughed by irregular lines; under the test, however, entirely smooth.

This species is well characterized by the rough surface, unfurrowed and cylindrical glabella and transverse outline of pygidium with a poorly defined border.

Formation and locality:—Rather common in the *Dictya* zone of Doten. This species occurs also in the *Dictyella* zone of Paichia-shan, Wuhutsui basin, and in the late Upper Cambrian limestone near Hsi-chang-shu-tung, 6 miles northwest of Liaoyang, Manchuria.

PA1223-6-1
PA1224-6-2
PA1225-6-3
PA1226-6-4,5
PA1227-6-6
PA1228-6-7

Quadraticephalus manchuricus Kobayashi.

Plate VI, figures 1–7.

1933. *Quadraticephalus manchuricus* Kobayashi, Upper Cambrian of the Wuhutsui Basin, p. 121, Pl. XII, figs. 2–7.

In the truncato-conical and elevated glabella, small anterior eyes, broad frontal border, convex cheek without demarcation of the border, stout genal spine, transverse pygidium with an elevated conical axial lobe the South Korean specimens are safely to be assigned to this species.

Formation and locality:—Common in the *Dictya* zone of Kasetsu-ji. This species occurs also in the *Tsinania canens* zone of the Wuhutsui basin, Liaotung.

PA1229

Quadraticephalus quadratus, new species.

Plate VI, figure 8.

Similar to *Quadraticephalus manchuricus* in the general form of the cranidium, oblong glabella, small anterior eye and punctated surface, but differs from it by the short, quadrate glabella, forward bent occipital furrow and narrower frontal border.

The holotype cranidium is 7 mm. long; its glabella 5.6 mm. long and 3.6 mm. broad, parallel sided; first glabellar furrow practically faded out and the second and third broadly rounded backward, while the occipital furrows bend forward; neck ring rather prominently elevated at the middle; palpebral lobe close to and opposite the second glabellar furrow and obliquely elevated above the flat cheek; frontal border narrow, somewhat rounded, and inclined; postero-lateral limb of the fixed cheek flat, large, triangular; surface finely punctated.

Formation and locality:—*Dictya* zone of Kasetsu-ji.

Quadraticephalus elongatus, new species.

Plate [illegible], figures 8–9.

This species is well characterized by the unusually long, cylindrical glabella, obscure glabellar furrows, narrow fixed cheeks in the cranidium, and broad outline of the pygidium with lateral extremities produced into a wing-shape and the short stout axis divided into three or four distinct rings and flat pleural portions.

The holotype cranidium is 3 mm. long.

This small trilobite somewhat resembles *Quadraticephalus calchas* (Walcott) in its long cylindrical glabella, but is distinguished from it by the larger frontal border, weaker glabellar furrows and larger eyes of this species.

Formation and locality:—*Dictya* zone of Kasetsu-ji and Doten.

Genus SHIRAKIELLA, new genus.

Generic diagnosis:—Cephalon semi-circular with tiny genal spine. Cranidium somewhat trapezoidal in general form; glabella truncato-conical, elevated above the flat cheeks; no glabellar furrows; occipital furrow distinct; preglabellar field more or less convex, transversely subquadrate, without any demarcation of marginal border; palpebral lobe medium sized, located at about the mid-length of the cranidium and close to the glabella. Free cheek rather broad; marginal border faintly defined by a groove near the genal angle. Facial sutures subparallel in front of the eyes and transversely diagonal behind them.

Thorax and pygidium unknown.

Genotype:—*Shirakiella elongata*, new species.

Remarks:—In 1863 Hall[1] grouped six species of *Conocephalites* from the Upper Cambrian of Wisconsin, viz. *C. perseus*, *C. shumardi*, *C. nasutus*, *C. oweni*, *C. eryon* and *C. anatinus* into his proposed *Conaspis*. In 1913, Walcott[2] published a note on *Conaspis* and he added *Ptychoparia patersoni* (Hall), *Arionellus bipunctatus* Shumard (?) from Wisconsin and *Ptychoparia llanoensis* Walcott from Texas to that genus.

1) James Hall (1863), 16th Annual Rep. New York Cabinet of Natural History, p. 152.

2) Walcott (1914), Smithsonian Misc. Coll. 57, p. 357.

Conaspis and *Shirakiella* are very closely allied in their major characters, such as the subconical glabella, eye-lobes of medium size, rather strong postero-lateral limb, narrow fixed cheeks and their facial sutures which extend forward from the eye-lobes so as to form a narrow frontal limb; but in *Conaspis* s. str. as shown in the genotype *C. perseus*, the frontal brim is usually well defined even on the cranidium and the glabellar furrows are much stronger than those of *Shirakiella*. Among the species referred to *Conaspis*, *C. anatinus* quite possibly comes into the present genus.

The genus *Haniwa*[1] Kobayashi somewhat resembles *Shirakiella*, but the former is easily distinguished from the latter by the oblong outline of glabella, large eyes and the forward divergence of facial sutures in front of the eyes.

Coosia tokunagai[2] from South Manchuria fits more closely into *Shirakiella* than into *Coosia* and *Haniwa*, because it differs from *Coosia* in its preglabellar field lacking a brim and from *Haniwa* in its small eyes. In my previous work I understood the red shale of Chiushukou, Niuhsintai basin containing *C. tokunagai* as being Middle Cambrian, but the implications arising out of the new generic reference of this species make me suspect, that the red shale is actually much higher than I first believed.

Geological and geographical distribution:—The Upper Cambrian of Eastern Asia and possibly Wisconsin, North America.

Shirakiella elongata, new species.

Plate VII, figures 7-13.

Description:—Cephalon semi-circular, somewhat sinuated on the frontal sides; glabella long, slightly elevated, truncato-conical, well defined by a dorsal furrow and entirely smooth except for an occipital furrow; fixed cheek narrow; eyes anterior to the mid-length of the cranidium; preglabellar field wide and a little convex; free cheek of moderate breadth; marginal border rather clearly defined on lateral sides; genal spine small, inside of which the articulating margin is slightly sinuated; surface smooth.

The holotype cranidium (pl. VII, fig. 10) is 5.6 mm. long; its glabella inclusive of the neck ring 4 mm. long and 3 mm. wide; and the distance between the eyes 5 mm.

1) Kobayashi (1933), Upper Cambrian of the Wuhutsui Basin, p. 147.
2) Kobayashi (1931), Japan. Jour. Geol. Geogr. Vol. VIII, p. 180, Pl. XX, figs. 4-6.

A paratype cranidium shows the frontal portion tolerably well on which a narrow marginal brim is still retained and the facial sutures are shown bent inward and meeting each other at the front. Therefore in such a form the intimate relation of *Shirakiella* to *Conaspis* is undeniable.

Formation and locality:—*Kaolishania* zone; Doten and Saisho-ri.

Shirakiella laticonvexa, new species.

Plate VII, figures 15-18.

1931. *Coosia tokunagai* Kobayashi, (partim), Japan. Jour. Geol. Geogr. Vol. VIII, Pl. XX, fig. 5.

Description:—Cephalon rather flat except for the glabella; cranidium as long as two-thirds the breadth; glabella convex, elevated, as long as wide, short, truncato-conical; neck-ring as long as one-third the length of the glabella; no glabellar furrow except for the strong occipital furrow; eyes on both sides of the anterior portion of the glabella; preglabellar field transversely quadrate and slightly convex; postero-lateral limb of the fixed cheek transversely triangular.

Free cheek broad, flat; marginal border rather broad, faintly defined by a groove; a ridge crossing from the inside of the border laterally to the middle point of the margin of the free cheek; a tiny spine produced from a point anterior to the genal angle. Surface entirely smooth.

The holotype cranidium (pl. VII, fig. 16) is 5.5 mm. long and 5 mm. broad between the eyes; its glabella 4 mm. in length and 3.5 mm. in breadth. The occipital ring is about 1 mm. long at the middle and narrows down towards the both extremities.

Comparisons:—In the general characters of the cranidium this species is closely related to *Shirakiella elongata*, but it is clearly distinct in the form of the glabella. In this species the glabella is much shorter and marked off by parallel courses of the dorsal furrows on the lateral sides.

Free cheek is very wide. The second specimen of *Coosia tokunagai* is quite similar to this species and differs from the holotype of *C. tokunagai* in the short and rounded glabella outline.

Formation and locality:—*Kaolishania* zone; Doten.

Subfamily Hungaiinae Raymond.

Genus Hungaia Walcott, 1914.

Genotype:—*Dikelocephalus magnificus* Billing.

Remarks:—The genus was named by Walcott, but the generic characters were first discussed by Raymond who added a new species *Hungaia minuta*. In the *Briscoia* fauna of Alaska I found *Hungaia* (?) *pacifica*.

Geological and geographical distribution:—Upper Cambrian Highgate of Vermont, Levis conglomerate of Quebec, and (?) *Briscoia* zone of Alaska.

Subfamily Richardsonellinae Raymond.

Genus RICHARDSONELLA Raymond, 1924.

Genotype:—*Dikelocephalus megalops* Billings.

Besides the genotype, the author of the genus also included therein *Dikelocephalus tribulis* Walcott, *Dikelocephalus oweni* Billings, *Richardsonella germana* Raymond, *Dikelocephalus cristata* Billings and *Dikelocephalus iole* Walcott. The last species, however, was selected as the genotype for a new genus *Tostonia* by Walcott in the same year.

Geological and geographical distribution:—Upper Cambrian of eastern North America; precisely, the Hoyt limestone of New York, Highgate formation of Vermont and Levis conglomerate of Quebec. It is also found in the *Parabriscoia* zone of Eureka District, Nevada. [Kobayashi, *Briscoia* Fauna of Late Upper Cambrian, etc. (Japan. Jour. Geol. Geogr. Vol. XII.)]

Genus LOGANELLUS Devine, 1863.

Genotype:—*Olenus* (?) *logani* Devine, (i. e. *Loganellus quebecensis* Devine.)

Remarks:—This genus was compared with *Conocoryphe*, and with *Ptychoparia*; Clark put it in the family Olenidae adding a new species *Loganellus billingsi*. Clark's species is fairly close to *Solenopleura* in the aspects of the glabella, course of facial suture and frontal margin. Surface of the test is rough, and large but not numerous granules are observed in the anterior portion of the glabella.

Geological and geographical distribution:—Levis conglomerate (Upper Cambrian ?) of Quebec.

Hypostoma, gen. et sp. undt.

Plate XXII, figure 7.

Formation and locality:—This hypostoma is found on a slab with *Shantungia spinifera* and *Pseudagnostus douvilléi* only which is collected from the Kushan beds of Tschanghsingtao, Liaotung, Manchuria. (U. S. Nat. Mus. Catal. No. 86917).

Free cheek, gen. et sp. undt.

Plate XII, figure 1.

Formation and locality:—This large peculiar free cheek was found in the *Drepanura* zone of Shokudo, which in itself is new for the Kushan fauna in Eastern Asia.

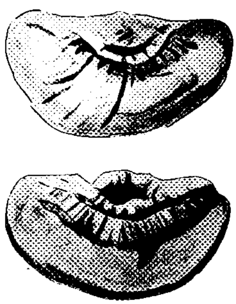
Incerta Sedis.

Genus MYONA, new genus.

Myona flabelliformis, new species.

Plate XIV, figures 20-21; Text-figure 33.

Description:—Carapace semi-circular and bilaterally symmetrical; the dorsal margin straight, a little below which lies the maximum breadth of the carapace.



Text-figure 33.
Myona flabelliformis new species.

Internally, two strong concentric grooves are found near the dorsal half which are subcircular in the middle, but sweep lateraly toward both extremities; a number of radial grooves diverging from the middle point of the dorsal margin; these grooves especially strong between and outside of the concentric grooves, but fade out toward the ventral margin.

All the specimens in hand are internal casts; nothing is known about the external feature of the carapace. The carapace is about 3 mm. long and 4 mm. broad on an average.

Comparisons:—This peculier fossil resembles certain atremate brachiopods rather than any other brachiopod or pelecypod, because it agrees with them not only in the bilateral symmetry, but also in the radial markings like the vascular sinus of *Kutorgina cingulata* Billings, or *Schuchertina cambria* Walcott. The essential difference from all of brachiopods and pelecypods is, however, to be found in the exactly equivalved nature of this fossil.

In comparisons with Notostoracans and Ostracods, the interior structure serves for the distinction from them. The feature of vascular trunks somewhat resembles that of *Burgessia bella* Walcott,[1] but the posterior margin of its carapace has no sinuation as seen in *Burgessia*.

Septadella recently established by Stubblefield[2] is most similar to this form especially in the bilateral symmetry and vertical ridges, but the two differ from each other in the outline of the carapace and in the vertical ridges which diverge from the rounded margin to the more straight one in *Septadella* while these run in reverse direction and are crossed by another elevation at the mid-length in *Myona*.

Among this collection no specimen shows anything which would tell whether both valves are anchylosed and folded on the dorsal side, or whether they are separate valves which are hinged. But, as seen from figures 20–21, on plate XIV, both valves are exactly the same internally and each valve is symmetrical on both sides. These equivalved and bilaterally symmetrical characters are the most distinguishing ones through which this form escapes from confusion with similar fossils mentioned above.

As far as I am aware, there is no genus or family of animal which can include this form. The placing of this fossil in the *Arthropoda* is simply a suggestion.

Formation and locality:—*Drepanura* zone of Saisho-ri.

Postscript.

1) On page 457, Part I.

Th. Lorenz[3] described *Polydesmia canaliculata* from the Ordovician of Shantung. His description is as follows:—

"Spitzes Gehäuse mit fester Spindel. Auffallend spitzer Suturwinkel. Die Umgänge zeigen starke Anschwellungen, die über die nachfolgenden überhangen, ohne sie zu berühern. An der Naht befindet sich eine starke Einschnürung, die durch die bauchige Auslage des Umganges erzeugt wird. Über die Mündung ist nichts zu sagen, da sie nicht erhalten ist.

Die Schneckennatur dieser Versteinerung ist unzweifelhaft.

1) Walcott (1912), Middle Cambrian Brachiopoda, Malacostraca, Trilobita and Merostomata, (Smiths. Misc. Coll. Vol. 57, No. 6,) p. 177, Pl. 27, figs. 1–3; Pl. 30, figs. 3–4.

2) C. J. Stubblefield & Stanley Smith (1933), On the Occurrence of Tremadoc shale in the Tortworth Inlier (Gloucestershire), (Q. J. G. S. London, Vol. LXXXIX,) p. 371.

3) Th. Lorenz (1906), Beiträge zur Geologie u. Paläontolgie von Ostasien, usw. II, Palaeontol. Teil, (Zeitsch. deutsch. geol. Gesell. Bd. 58), p. 103, Text-fig.

Schwieriger ist die Zuteilung zu einer bestehenden Gattung. Da ich etwas ähnliches in der paläontologichen Literatur nicht habe ausfinding machen können, so habe ich mich entschlossen, obige Gattung aufzustellen."

In looking incidentally his illustration upside-down, I was struck by an impression that *Polydesmia* appears so much alike a siphuncle of a certain actinoceroid. If so, this siphuncle is well charcterized by the high inclination of the divarticula and relatively wide curvature of the septal neck. The latter character brings this form to the neighbourhood of the Actinoceratidae and the former specifies that it is closer to *Maruyamaceras* than to any other actinoceroids. The main question is in the mode of the siphuncular deposit. If any one can ascertain this generic identity through the restudy on the Lorenz's type, then *Maruyamaceras* Kobayashi, 1931 should lose its standing owing to the synonymy with *Polydesmia* Lorenz, 1906.

2) On page 492, Part I.

In 1928 Cowper Reed expressed an opinion in his paper. "Notes on the Family Encrinuridae," (Geol. Mag. Vol. LXV,) that "*Encrinurella* seems worthy of generic rather than subgeneric rank and may be associated with the Encrinuridae rather than with the Cheiruridae in spite of its pygidium," and he has also the opinion that *Pliomera martellii* would be congeneric with *Pliomera insangensis*, the genotype of *Encrinurella.*

3) On page 525, Part II.

Dr. T. H. Withers gives a comment in his letter, the 31st Dec. 1934 that Stems of Cystoids (p. 525, pl. I, figs. 7–8,) and Cystoid (?) stem (p. 525, pl. I, figs. 3–6,) seem to him "to represent perfectly good examples of the genus *Lepidocoleus*, (Machaeridia)."

4) On page 544, Part II.

i) *Apatokephalus magificus* (Billings) was recognized as the genotype of *Hungaia* Walcott. [Raymond (1924), New Upper Cambrian and Lower Ordovician Trilobites from Vermont, (Proc. Boston Nat. Hist. Vol. 37, No. 4, p. 44.]

ii) Wiman added a new species, *Apatocephalus pecten* from the *Shumardia* shale of Lanna in Nerike. (Arkiv. for Zool. Bd. 2, No 11, p. 6, pl. 1, figs. 7–12.)

iii) Walcott referred the pygidia of *Dikelocephalus multicinctus* Hall and Whitfield and *Dikelocephalus flabellifer* Hall and Whitfield of Nevada to *Apatokephalus* (Walcott, Smiths. Misc. Coll. Vol. 57, No. 12, pp. 350 &

352,); Brögger and Walcott assigned *Dikelocephalus dubius* Linnarsson to *Apatokephalus*. Reed transferred *Tramoria punctata* Reed to *Apatokephalus*. (Geol. Mag. IV, 1900, Vol. VII, p. 46.)

5) Part III.

After completed this manuscript, I received a copy of Cambrian and Ordovician Fossils from Kashmir (Palaeont. Indica, New Ser. Vol. XXI, No. 2, 1934,) from Dr. F. R. Cowper Reed, in which he established a new genus *Hundwarella*, its genotype being *Hundwarella personata* Reed.

6) On p. 271, Part III.

M. Schwarzbach[1] found recently a pygidium of *Protolenus* and expressed an opinion that the taxonomic position of the genus should be brought to the neighbourhood of *Redlichia* from the Ellipsocephalidae where it was used to be located. Accordingly, some such genera as *Micmacca* Matthew, *Mohicana* Cobbold, *Blayacina* Cobbold, and *Palaeolenus* Mansuy might be turn out of the Ellipsocephalidae, since they are so intimately related to *Protolenus*.

Published November 30th, 1935

1) M. Schwarzbach (1934), Über die systematische Stellung der Trilobitengattung *Protolenus* G. F. Matth. (Centralbl. f. Min. Abt. B. pp. 233-239.)

Index to Families, Genera and Species

[Note: —See foot-note if number of page is cited in brackets]

Plate I.

Upper Cambrian Brachiopods of South Chosen.

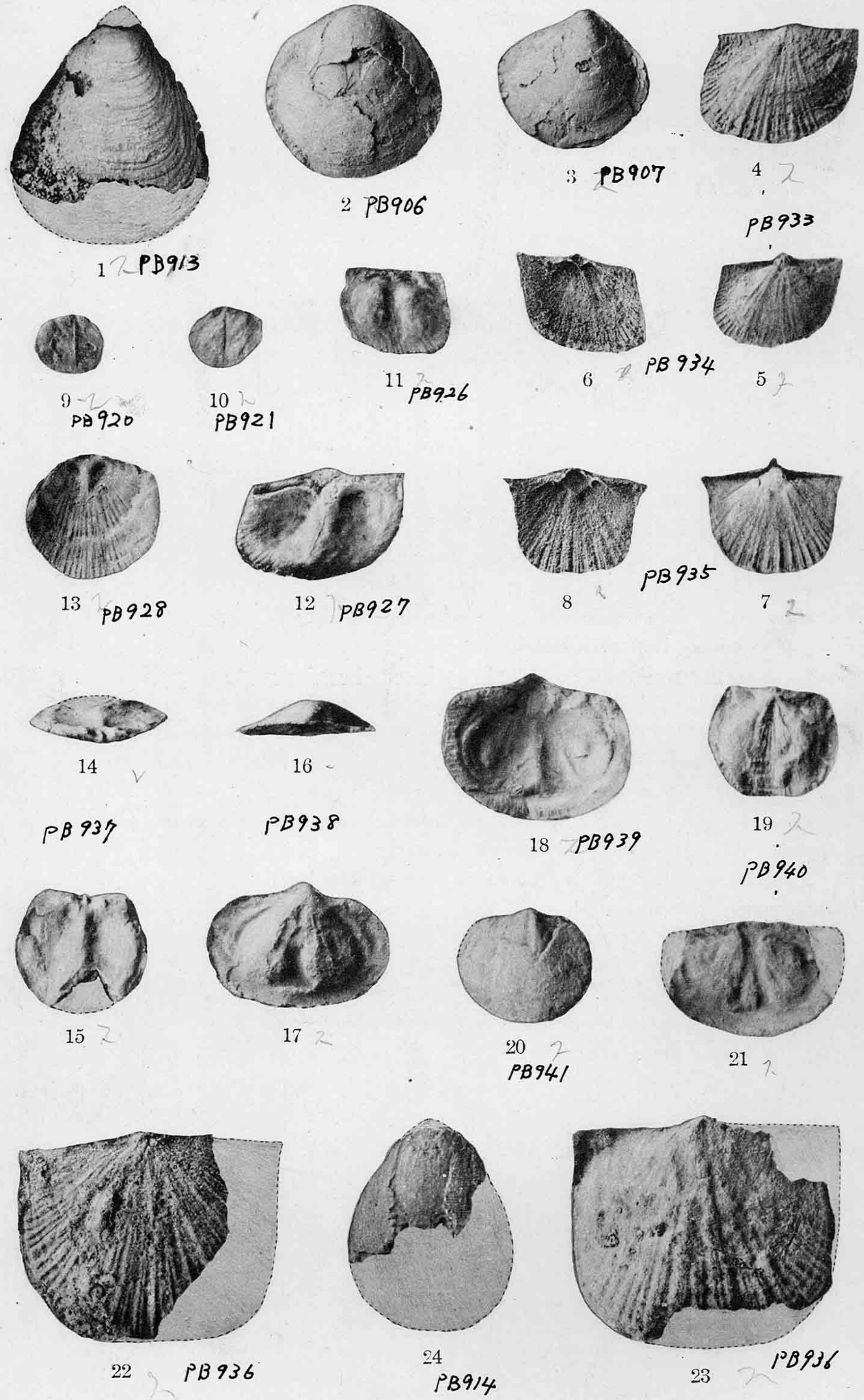


Photo. by H. Kobayashi.

T. Kobayashi:

Cambrian Brachiopods of South Chosen.

Obolus (*Westonia*) cf. *blackwelderi* Walcott . . . . p. 62

Figure 1. Ventral valve.

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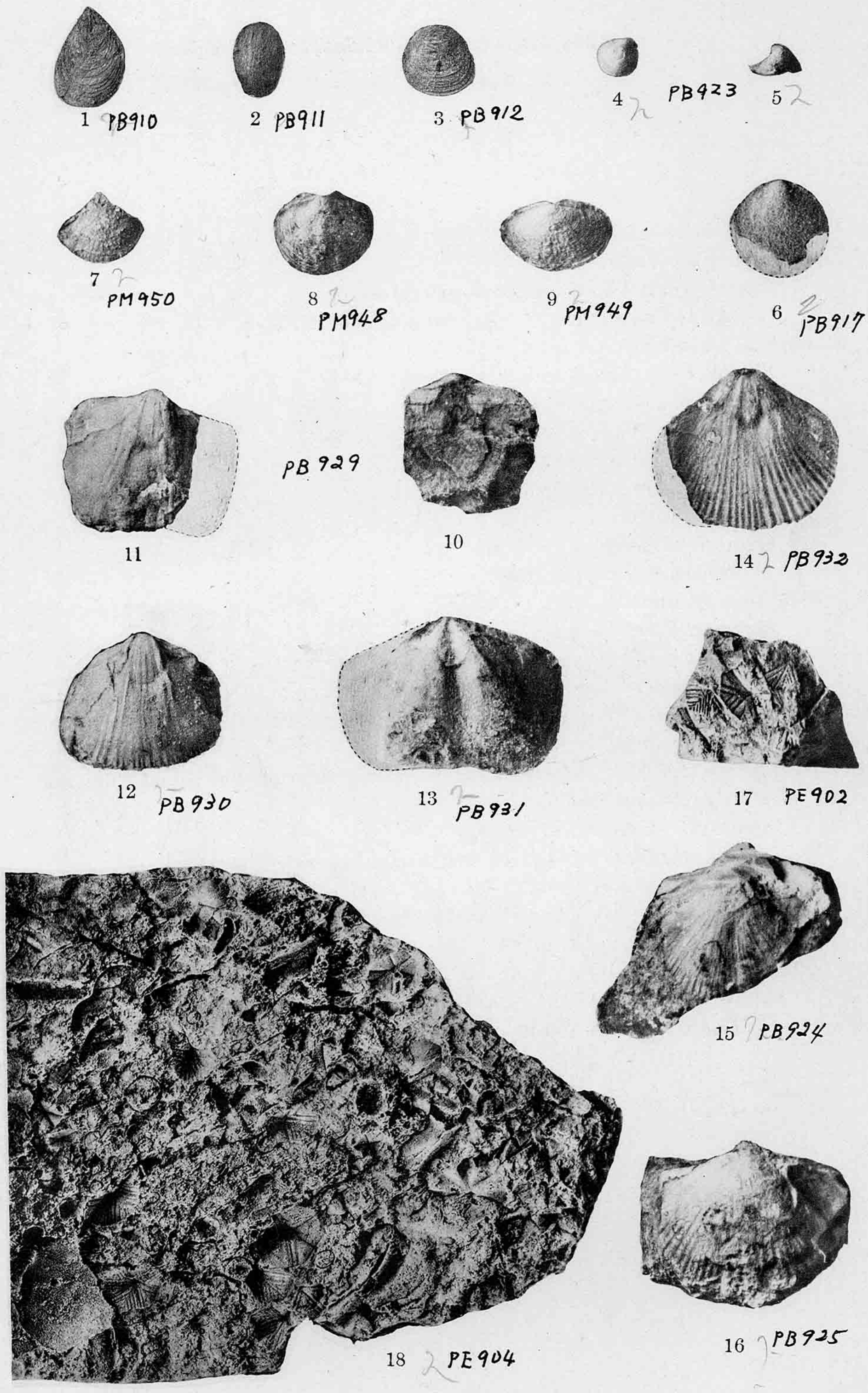

Photo. by H. Kobayashi.

T. KOBAYASHI:

Cambrian Fossils of South Chosen.

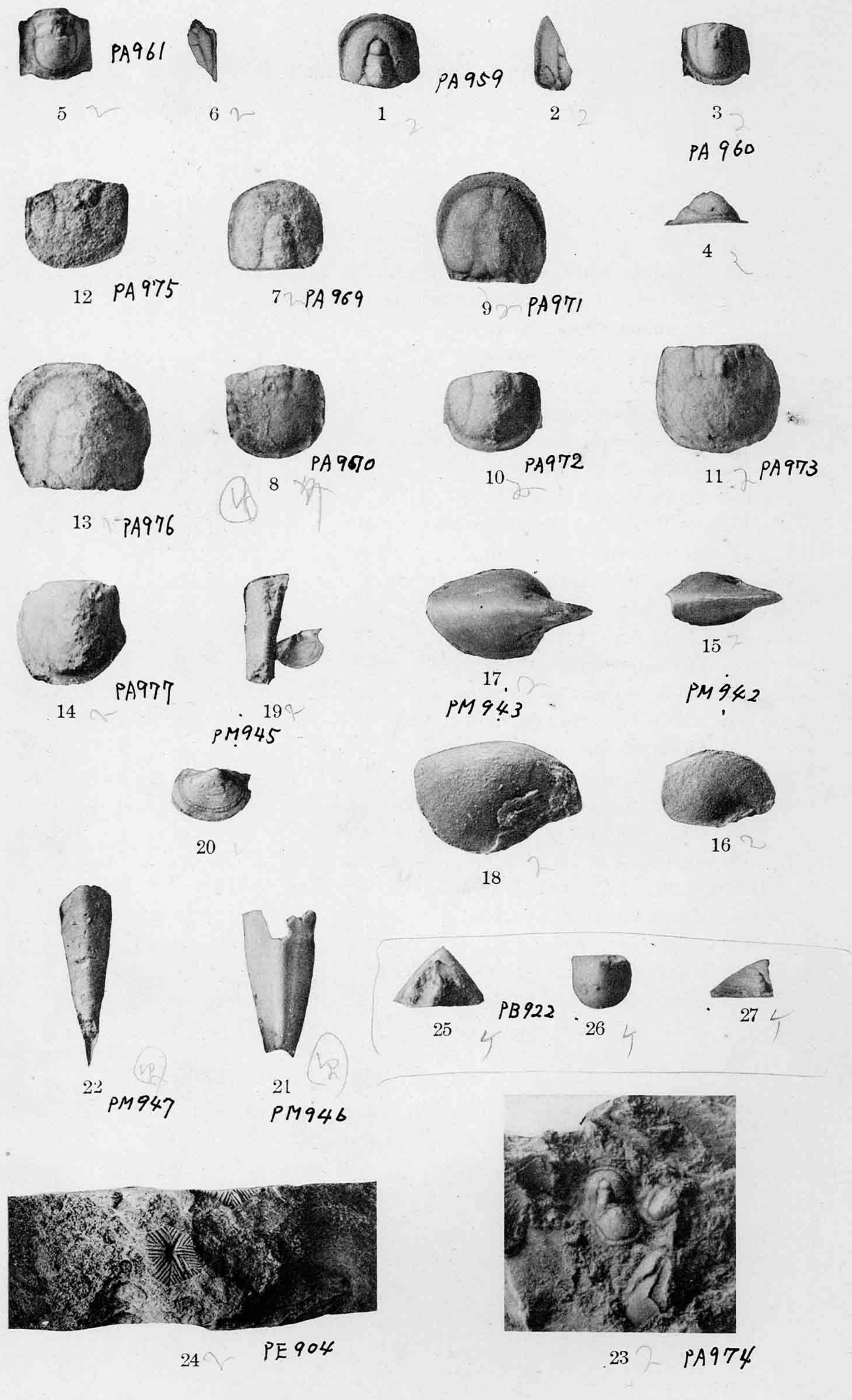

Photo. by H. Kobayashi.

T. Kobayashi:

Cambrian Fossils of South Chosen.

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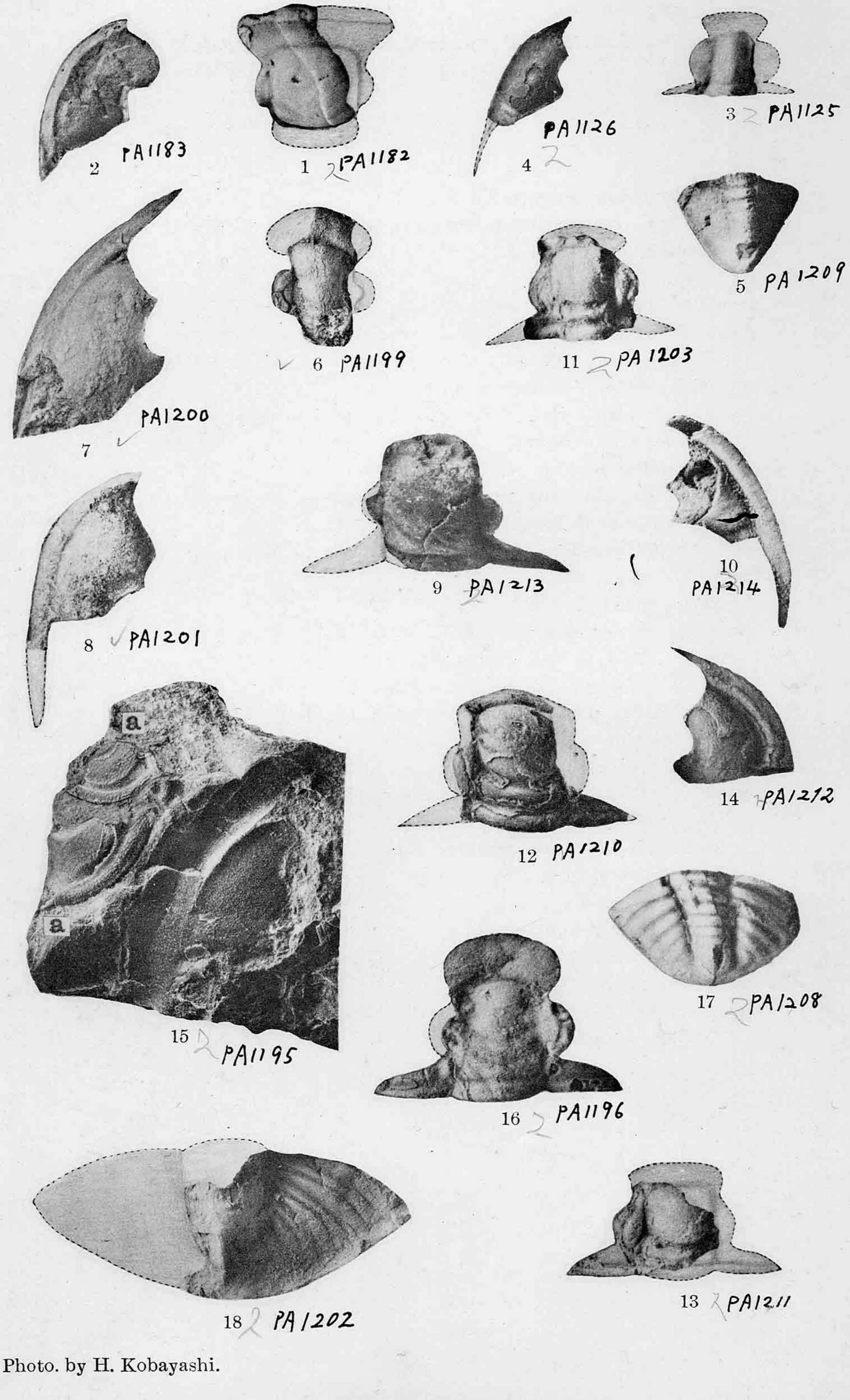

Photo. by H. Kobayashi.

T. KOBAYASHI:

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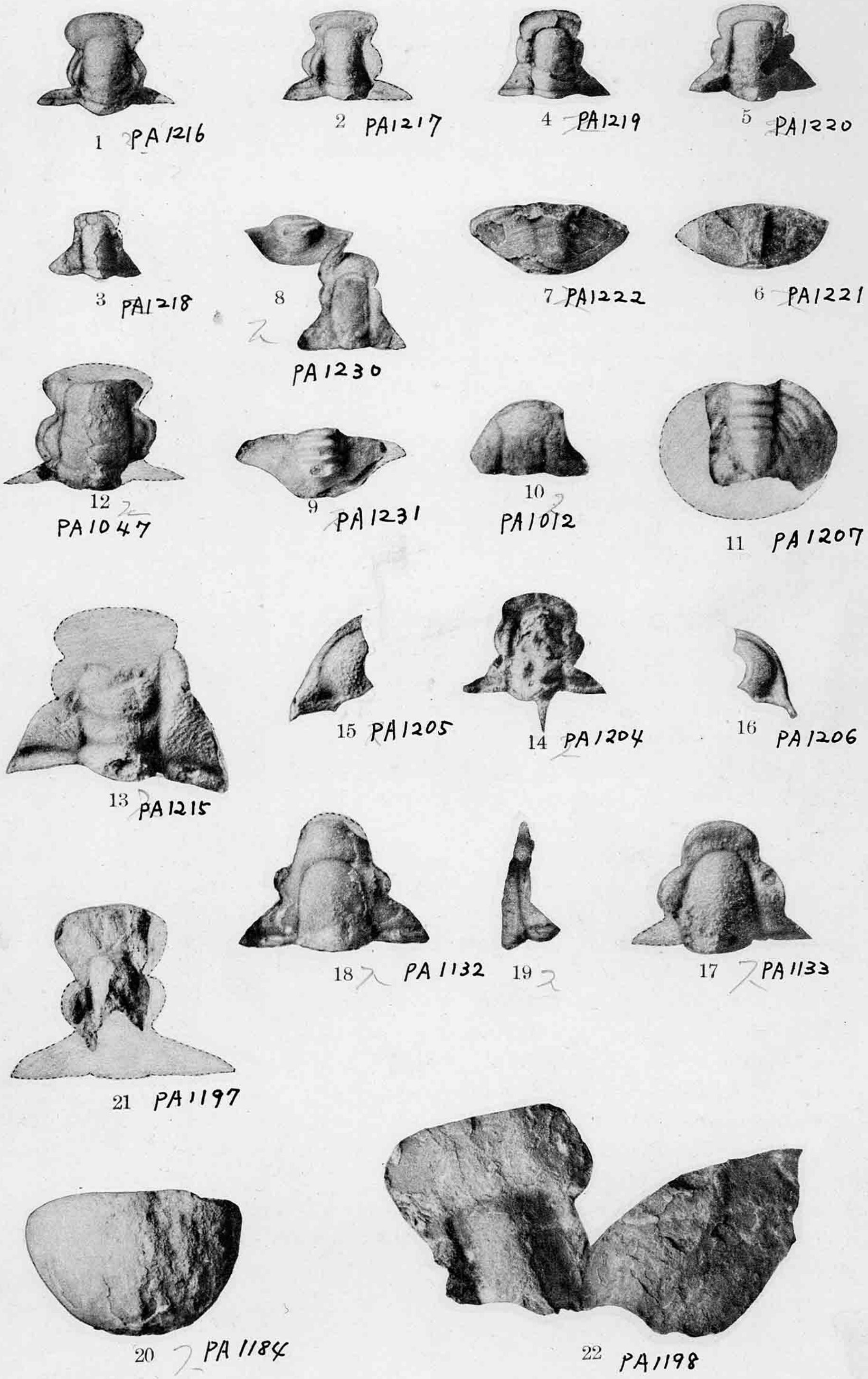

Photo. by H. Kobayashi.

T. Kobayashi:

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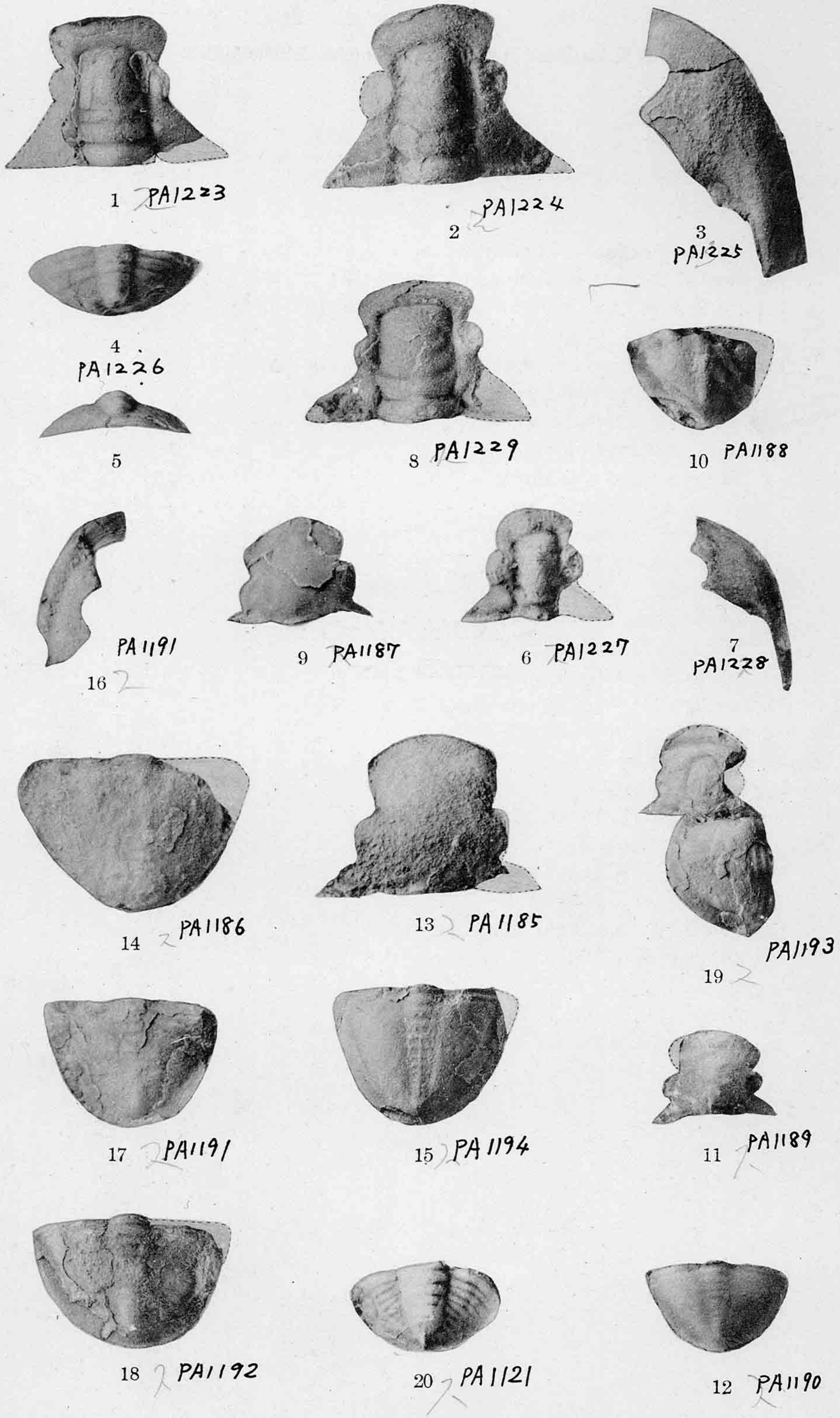

Photo. by H. Kobayashi.

T. Kobayashi:

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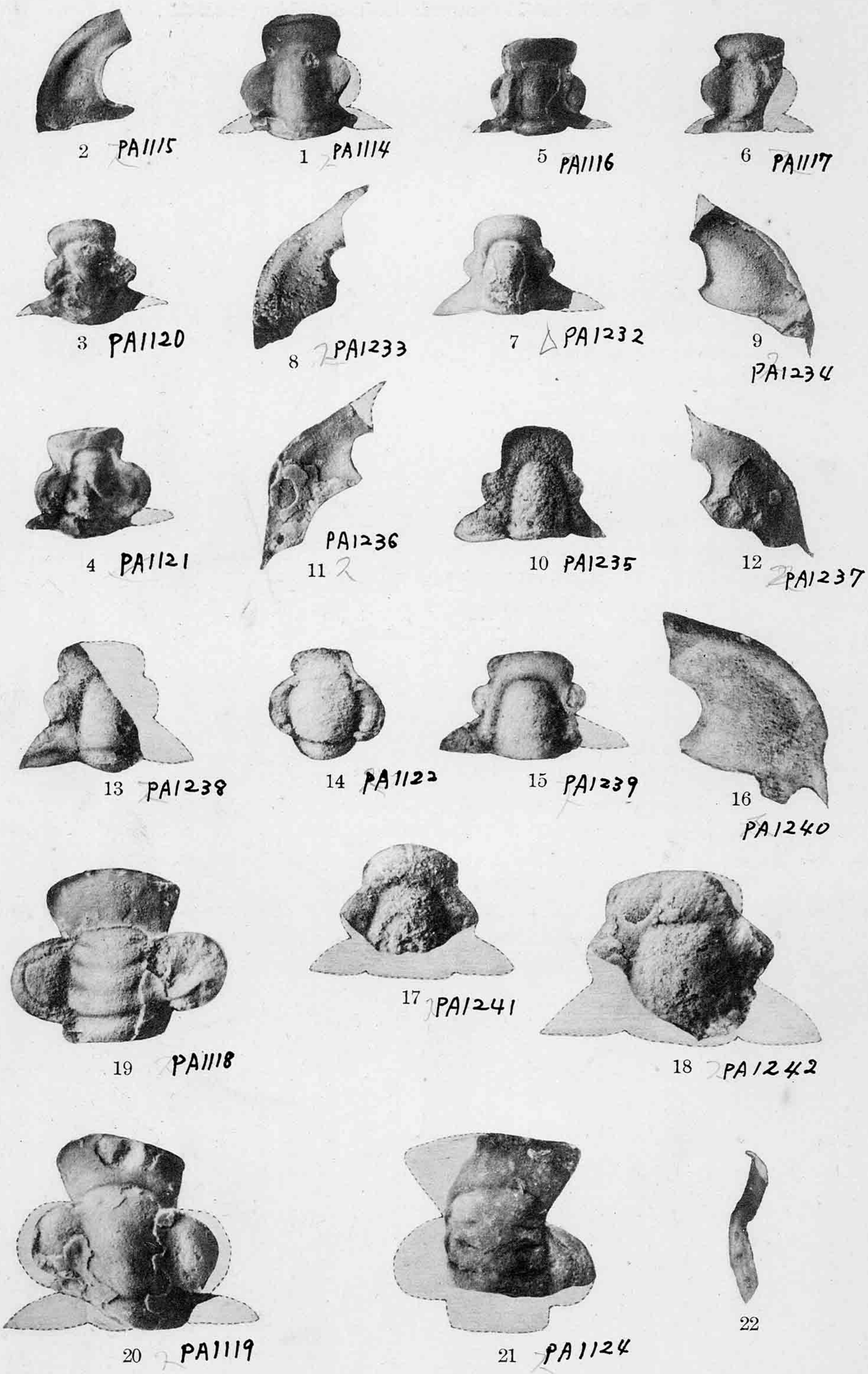

Photo. by H. Kobayashi.

T. Kobayashi:

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Jour. Fac. Sci., Imp. Univ. Tokyo, Sec. II, Vol. IV, Pt. 2, Pl. VIII.

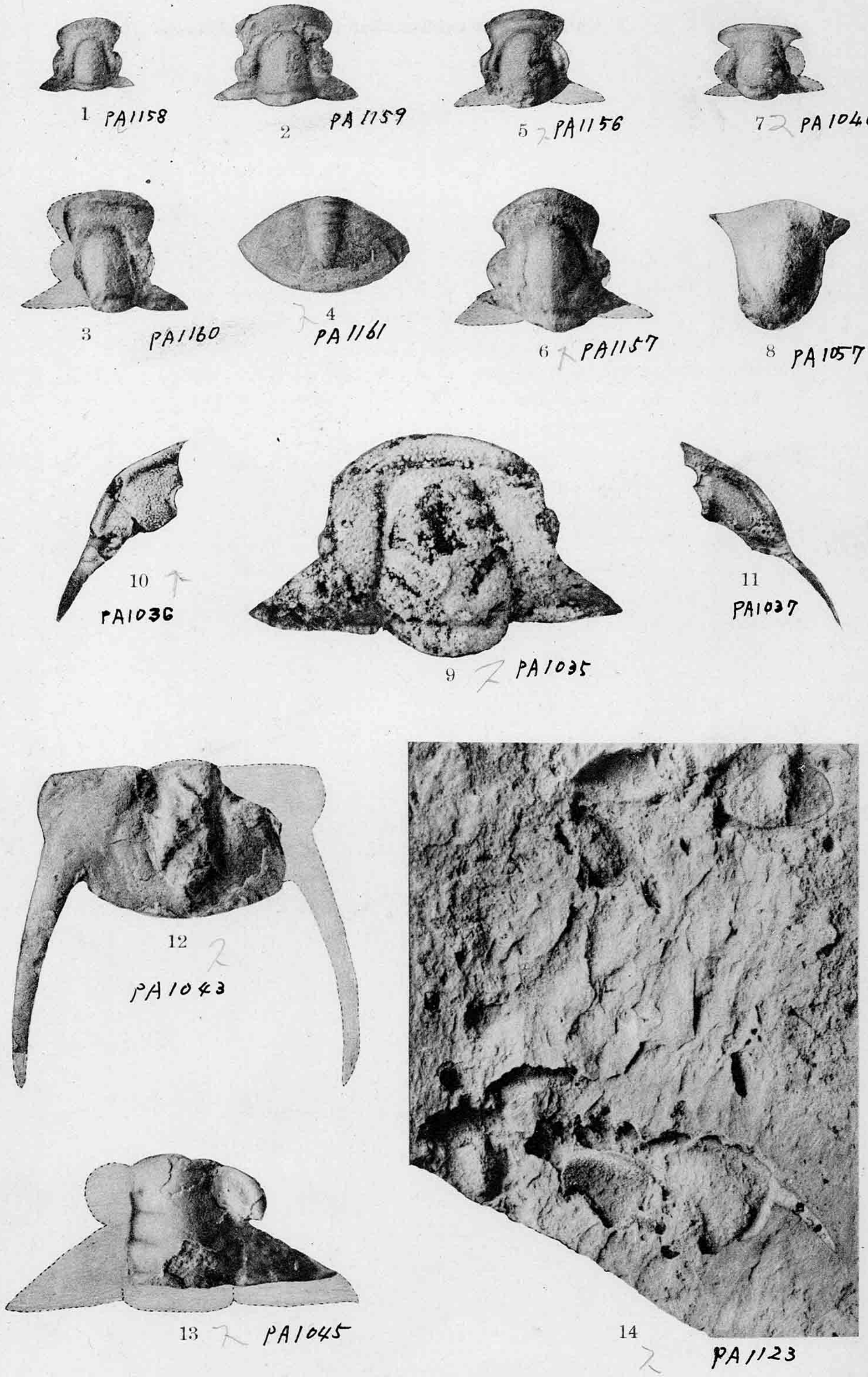

Photo. by H. Kobayashi.

T. Kobayashi:

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Kaolishania obsolata Kobayashi, ... p. 177
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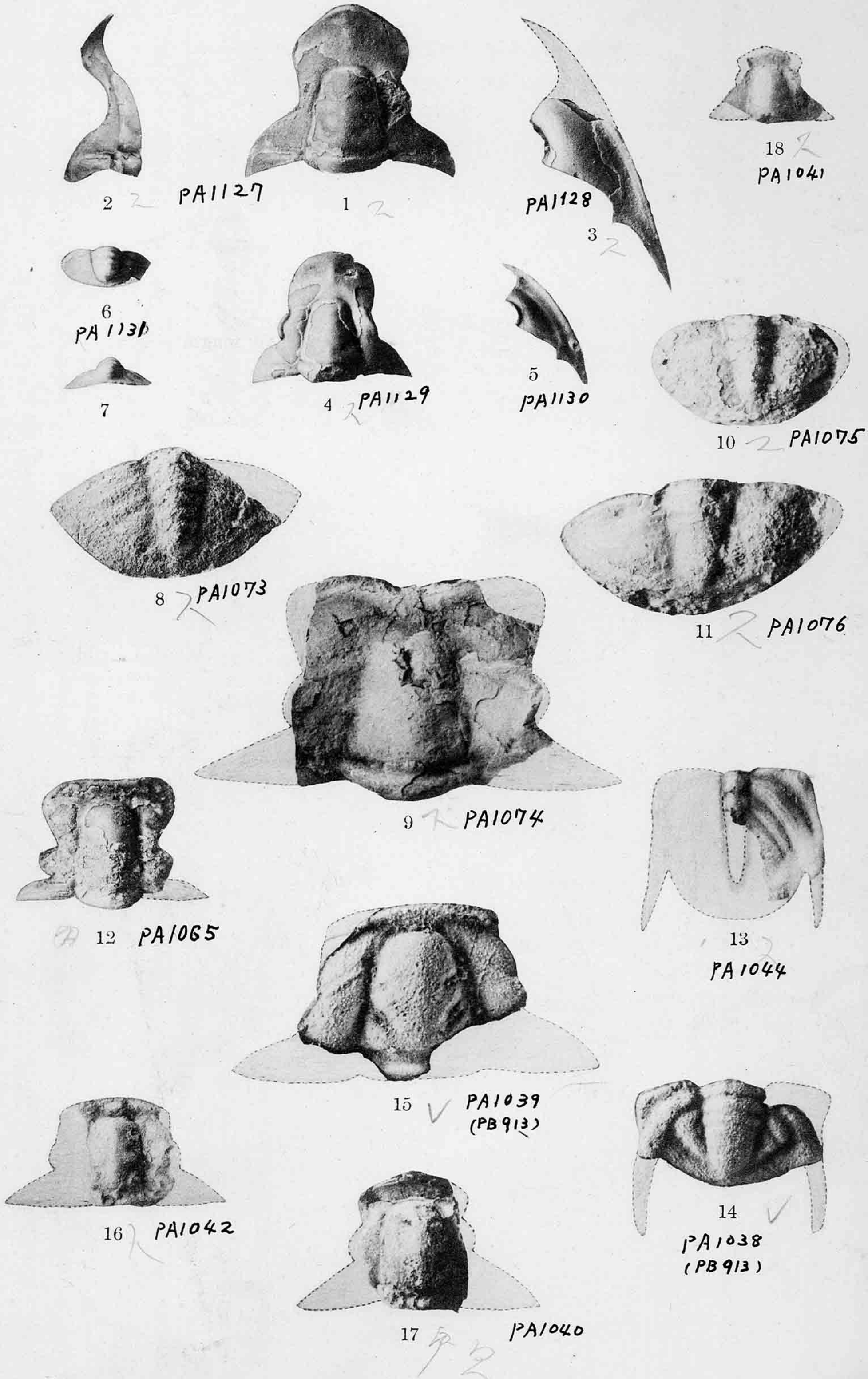

Photo. by H. Kobayashi.

T. Kobayashi:

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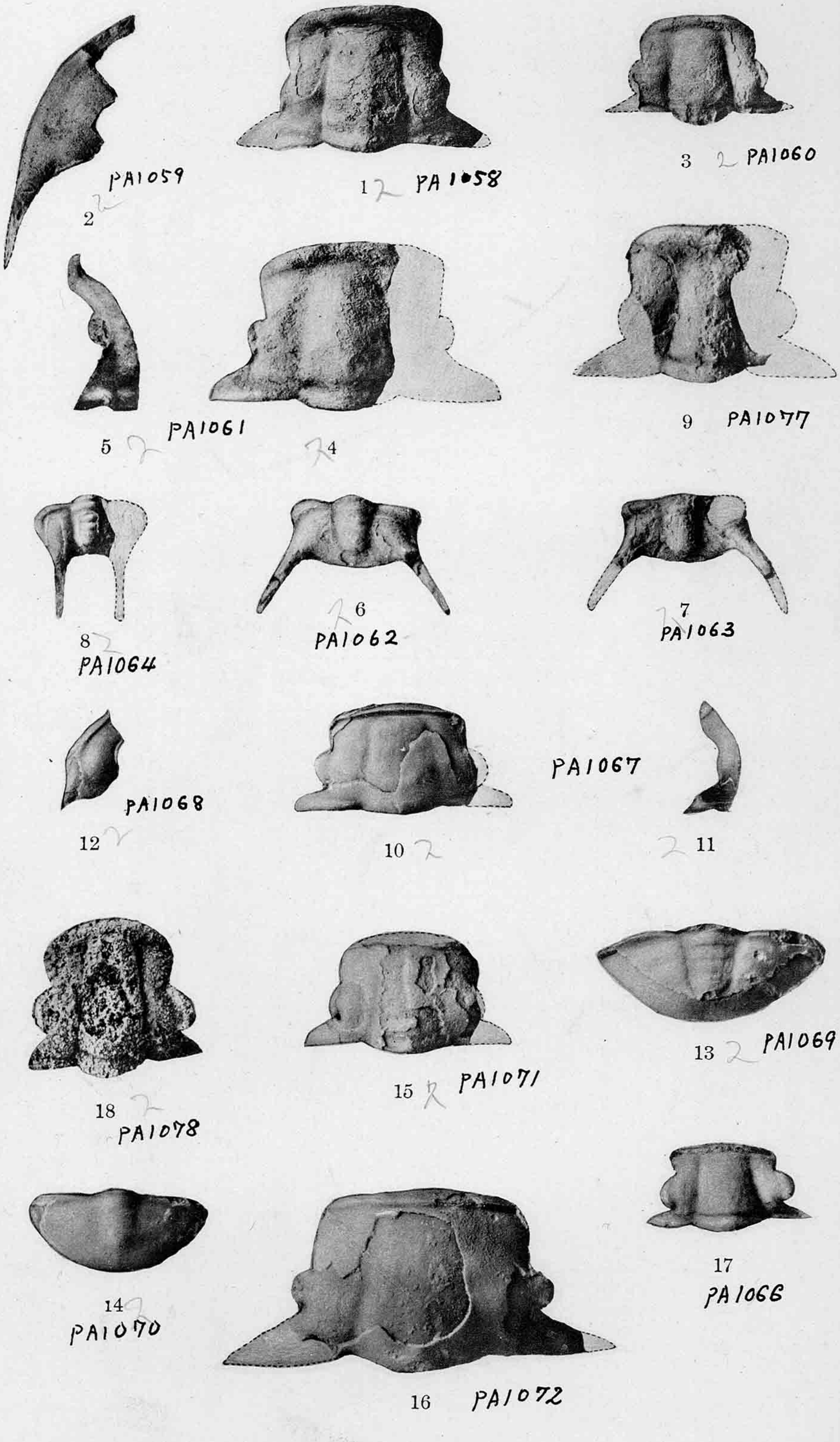

Photo. by H. Kobayashi.

T. KOBAYASHI:

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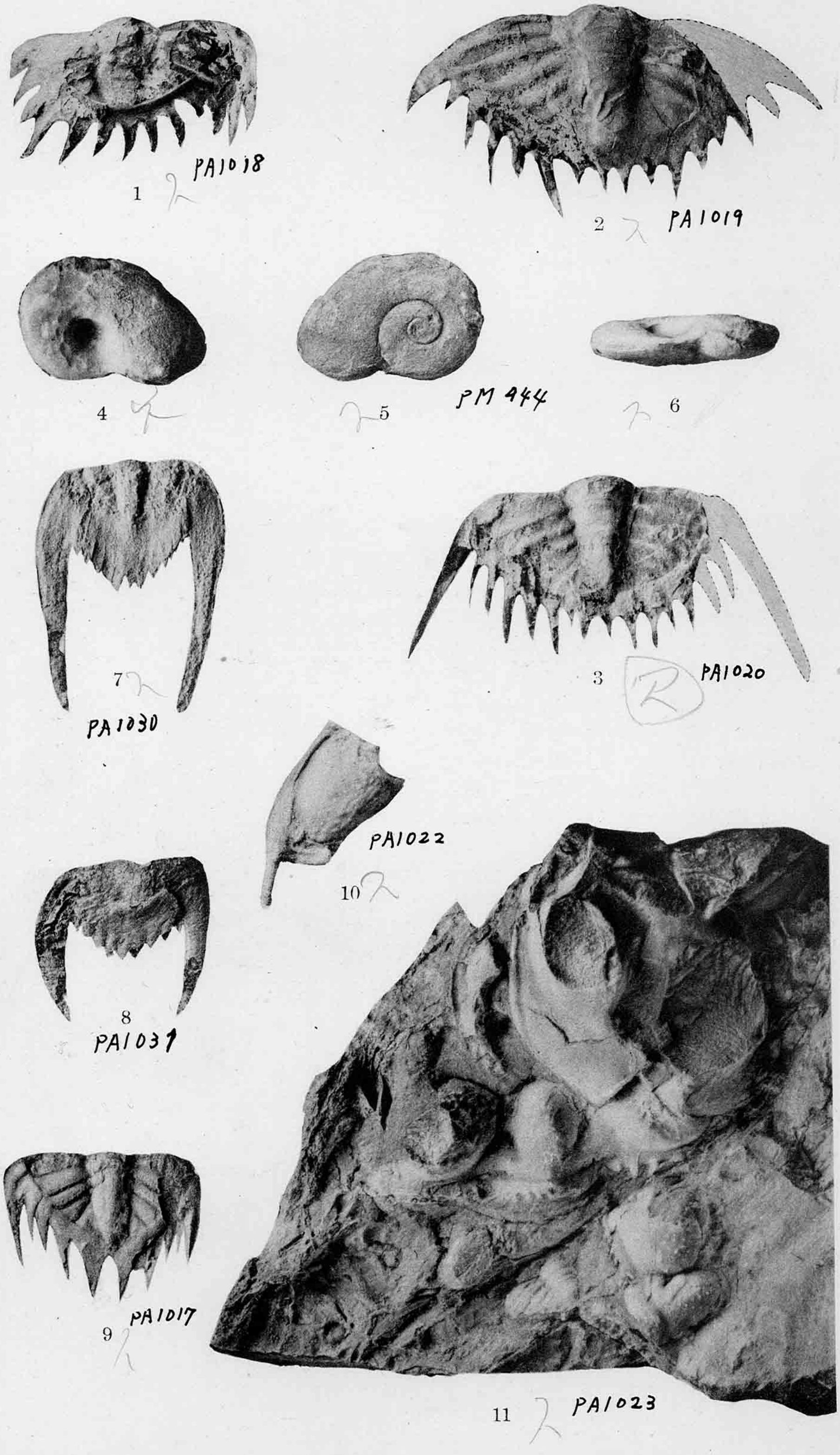

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T. Kobayashi:

Late Middle Cambrian Gastropods and Trilobites of South Chosen.

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Blackwelderia sinensis (Bergeron). . . . . p. 171

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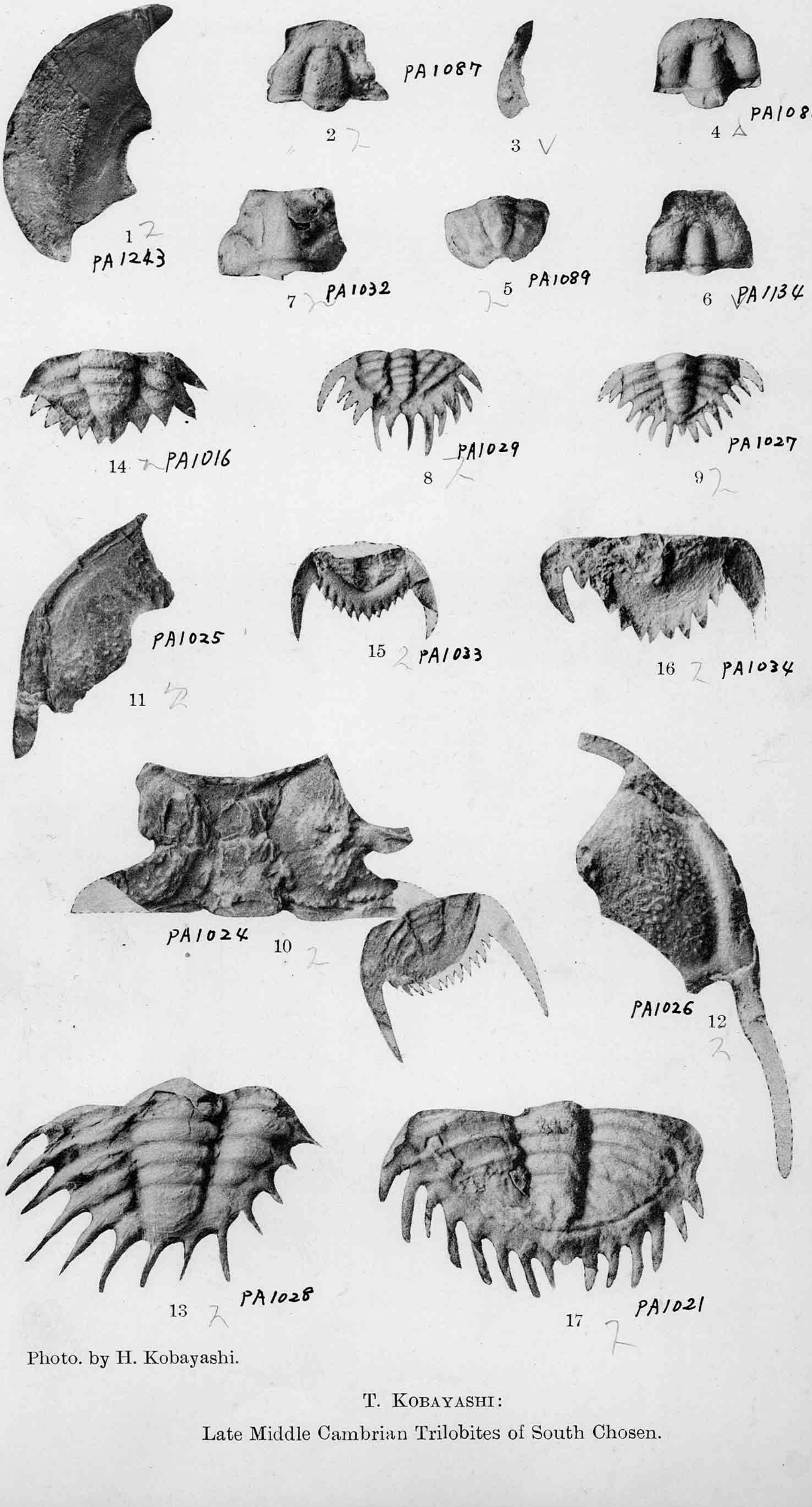

Photo. by H. Kobayashi.

T. Kobayashi:

Late Middle Cambrian Trilobites of South Chosen.

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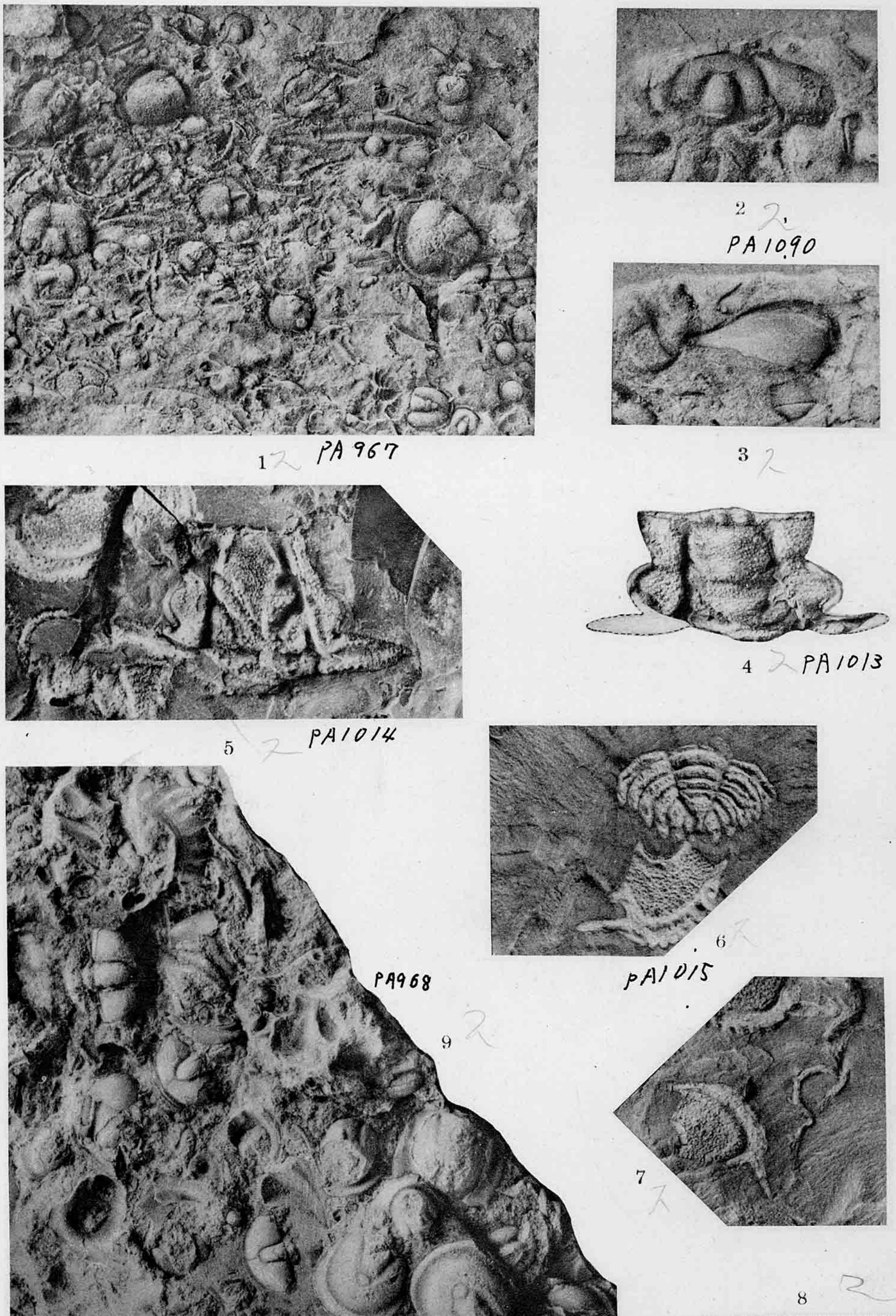

Photo. by H. Kobayashi.

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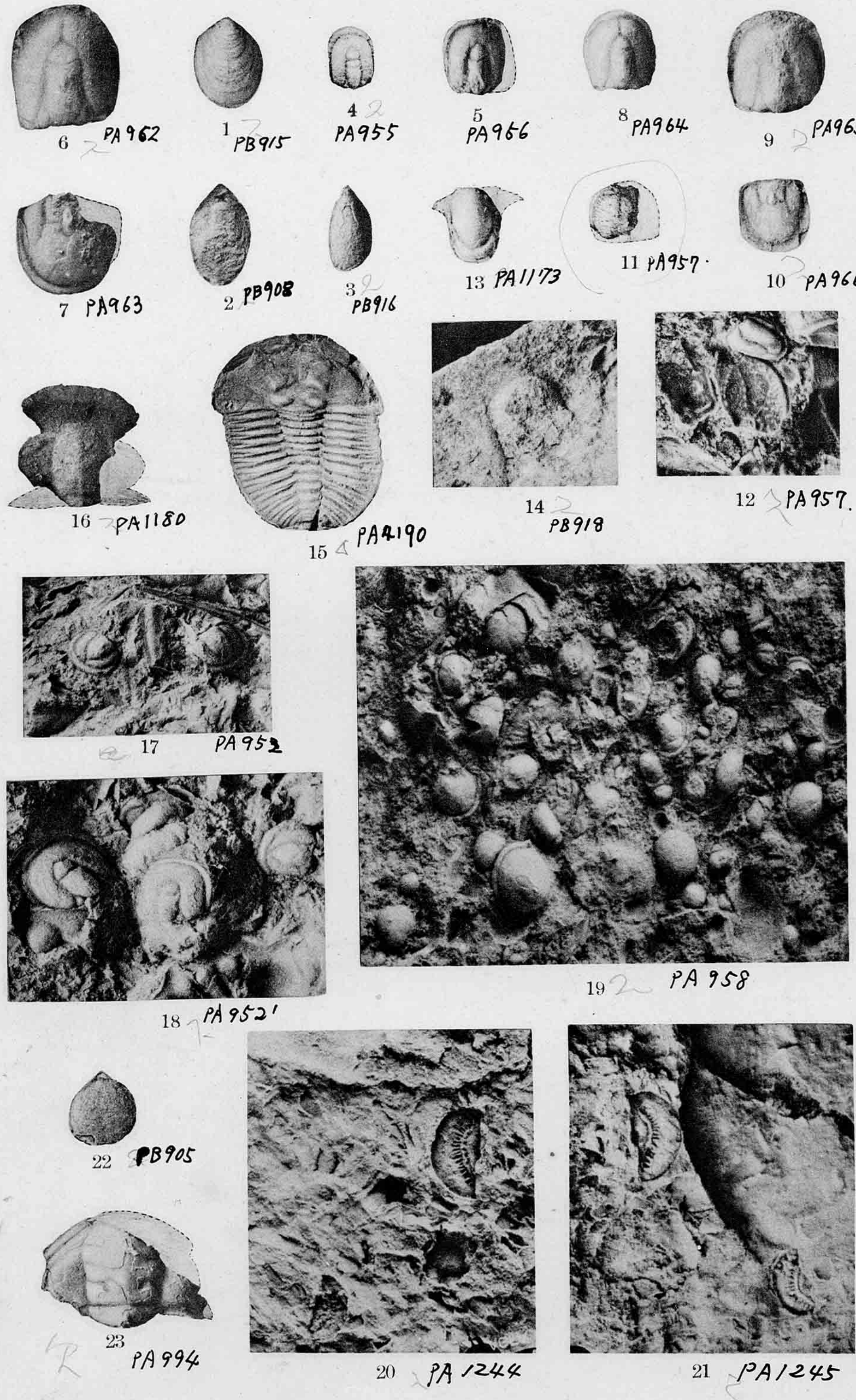

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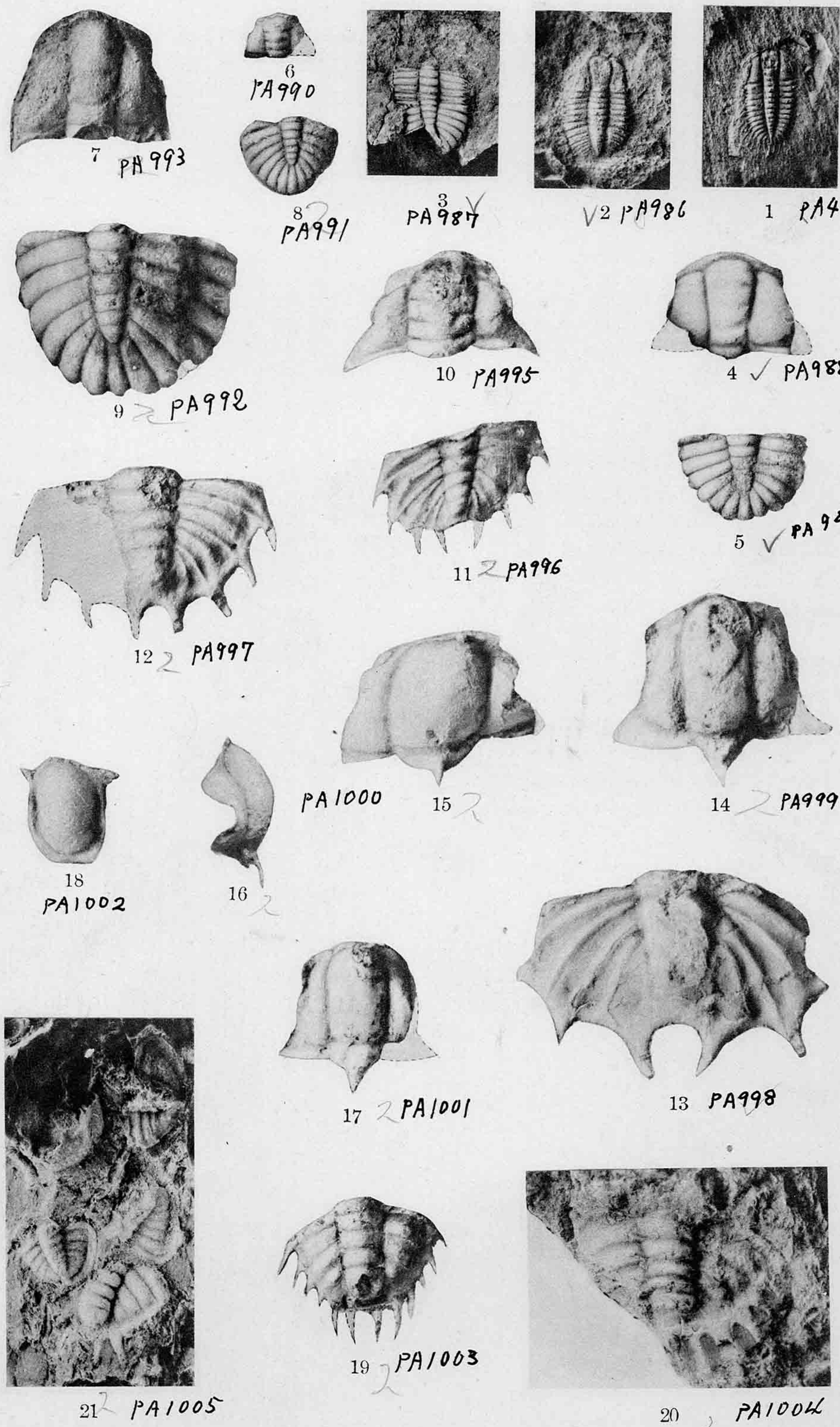
All collected from the *Olenoides* zone of Neietsu, South Chosen.

Jour. Fac. Sci., Imp. Univ Tokyo, Sec. II, Vol. IV, Pt. 2, Pl. XV.



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T. Kobayashi:

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All collected from the *Olenoides* zone of Neietsu, South Chosen.

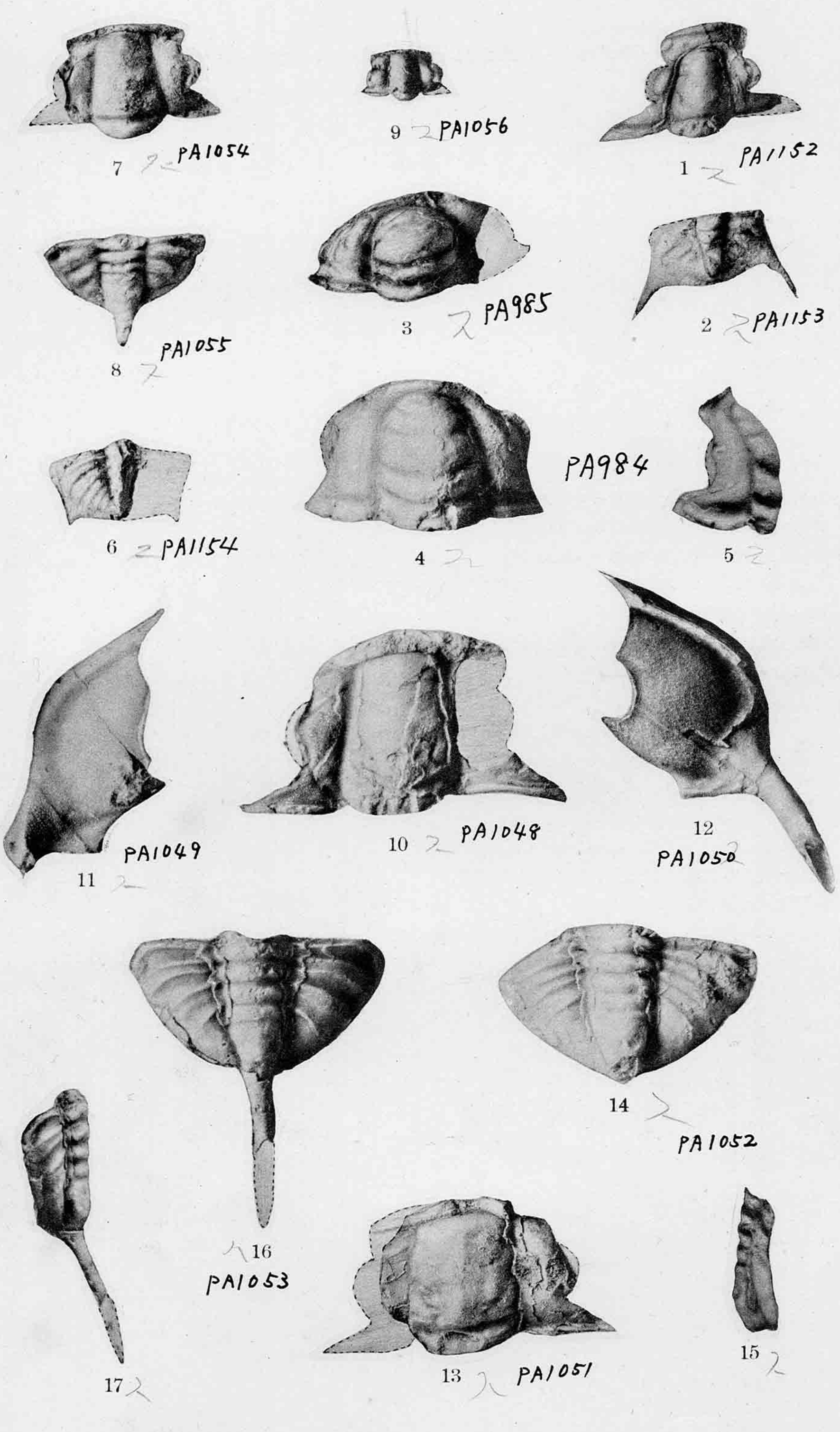

Photo. by H. Kobayashi.

T. Kobayashi:

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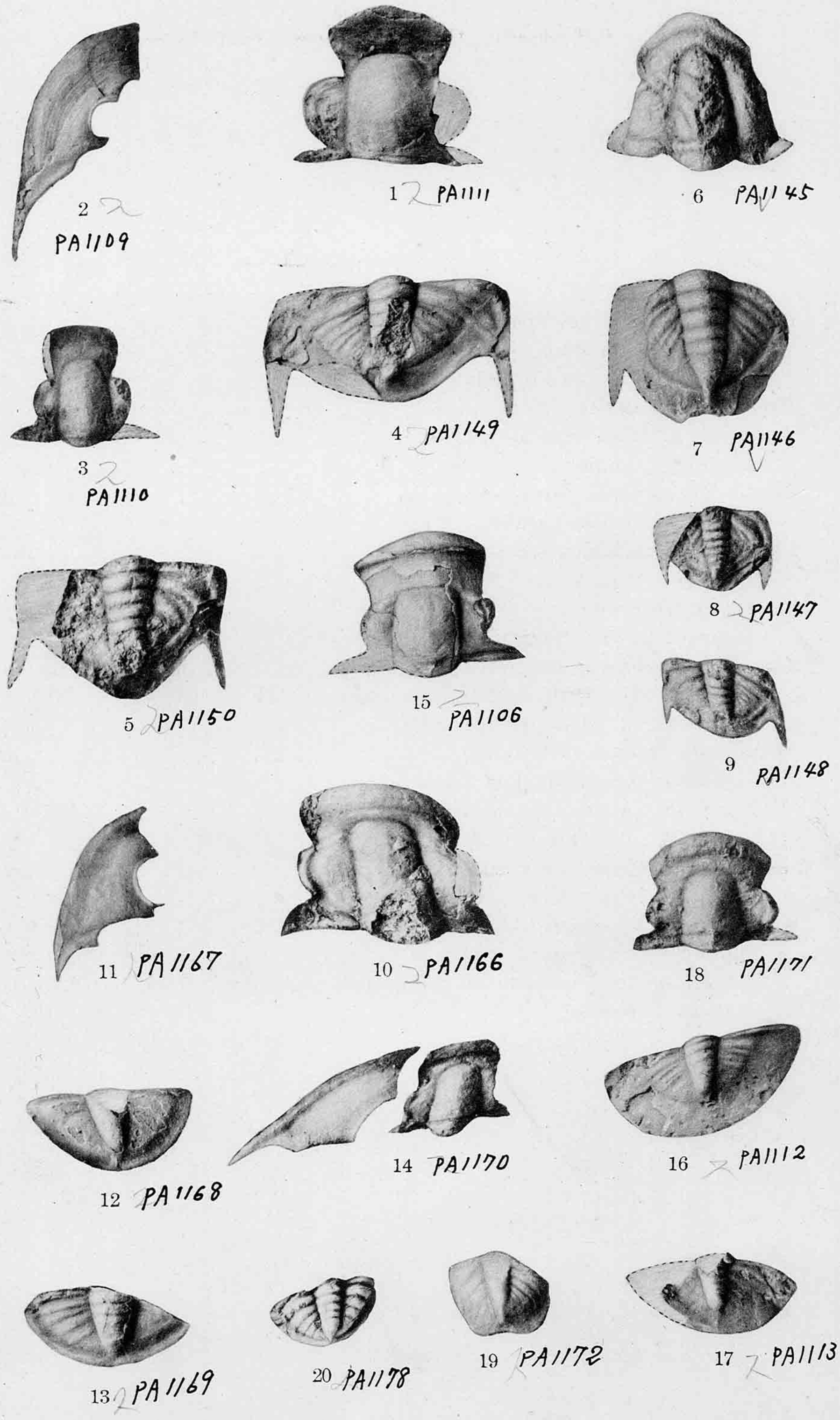
All species illustrated on this plate were collected from the *Olenoides* zone of Neietsu.



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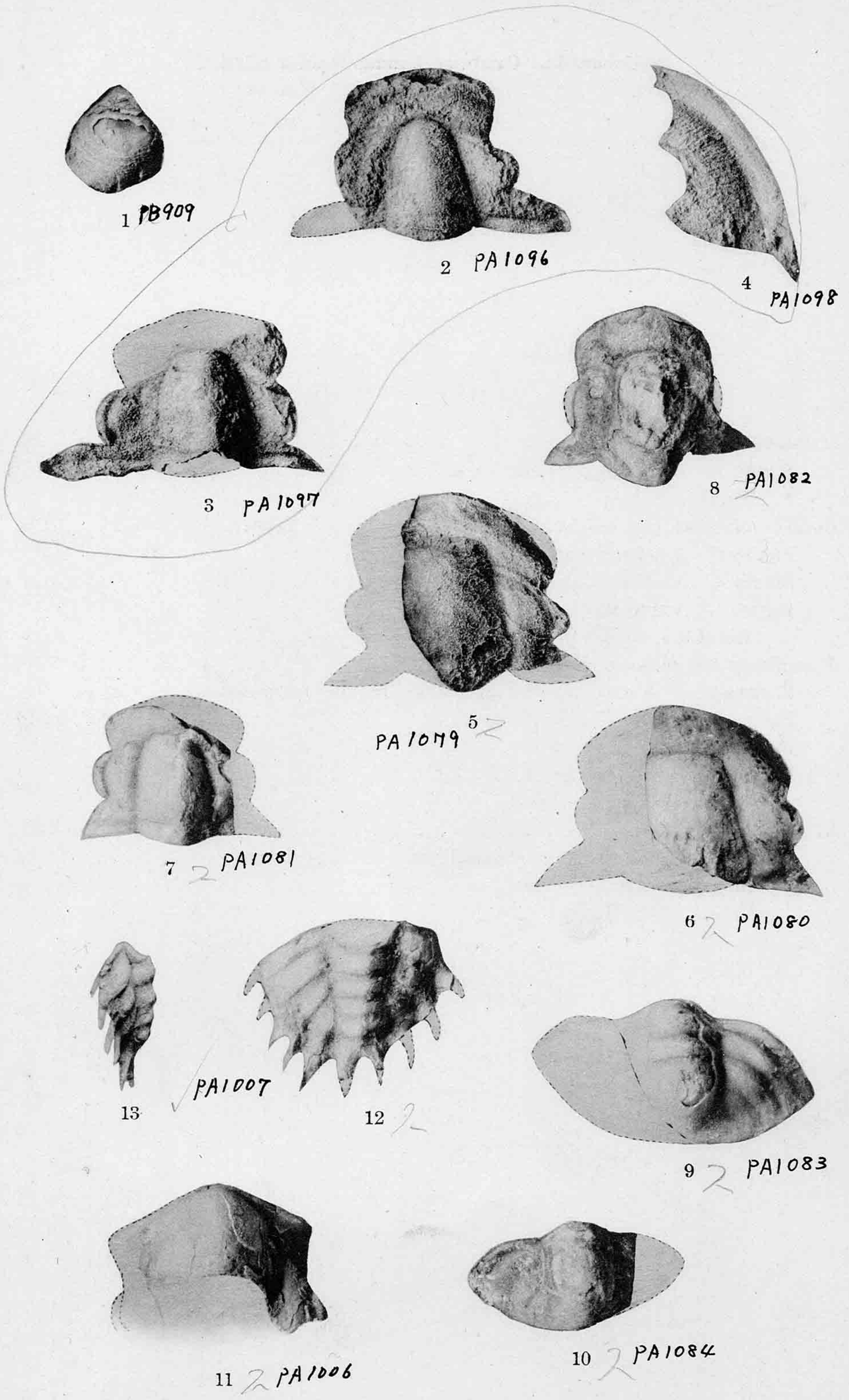
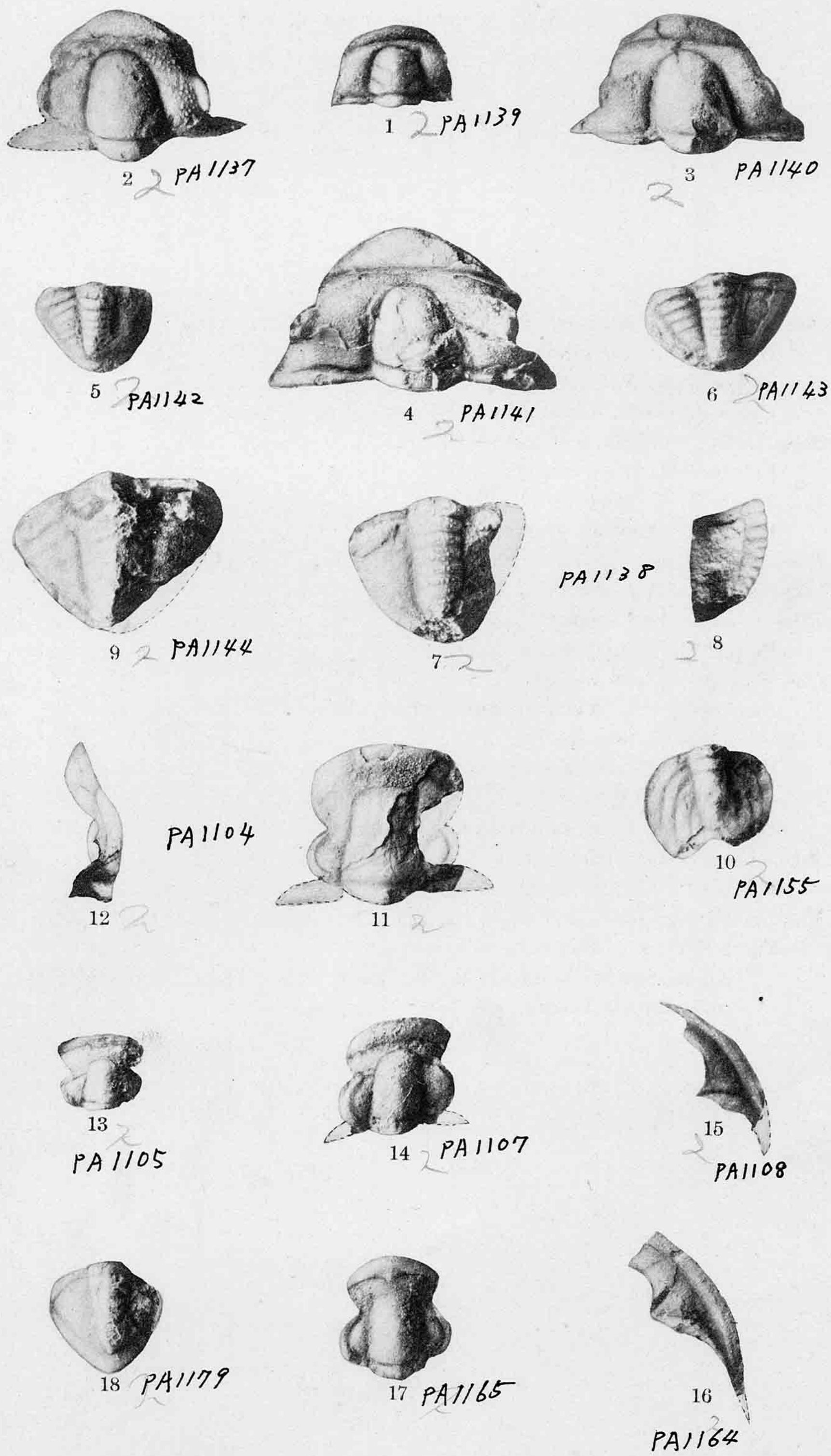


Photo. by H. Kobayashi.

T. Kobayashi:

Cambrian Fossils of South Chosen.

All specimens illustrated on this plate were collected from the *Solenoparia* zone of Doten.



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Salterella zone of Doten.

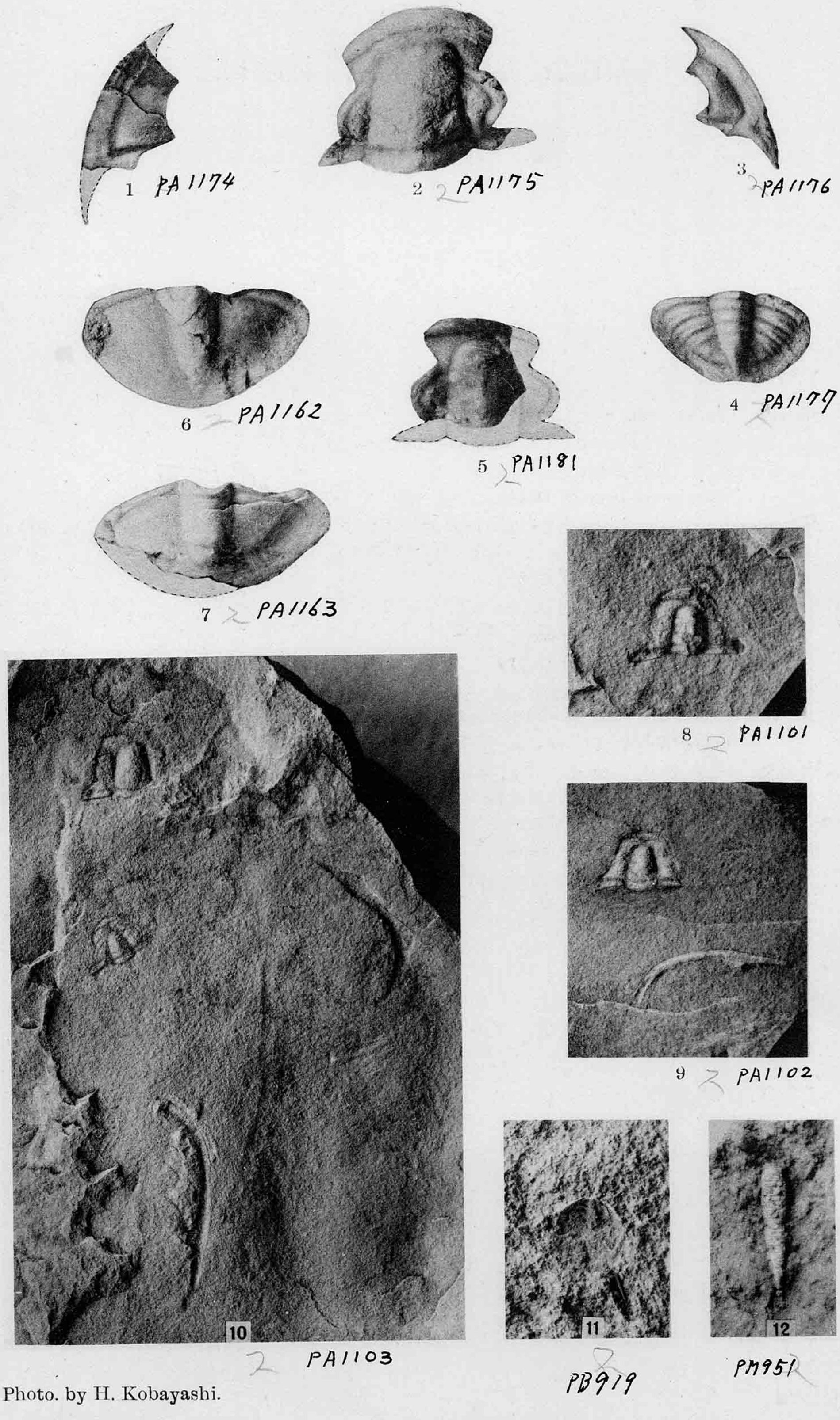

Photo. by H. Kobayashi.

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Figure 4. Paratype showing a spine on the sixth thoracic segment; ×2.

Locality same as the preceding.

Figure 5. Another paratype showing a spine on the eleventh thoracic segment; ×3.

Redlichia shale, southeastern slope of Genkokuri in the Sosan area, North Chosen. (平安北道楚山郡元谷里東南山背)

Redlichia manchuriensis Resser and Endo (MS). . . . . p. 120

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Redlichia shale at Sanshihlipu, Manchuria.

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Redlichia shale at Masanri near Kenjiho, North Chosen.

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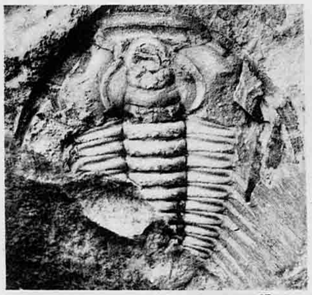
Redlichia shale at Sanshihlipu, Manchuria.



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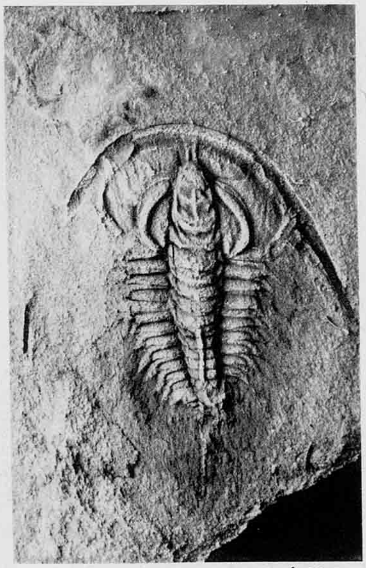

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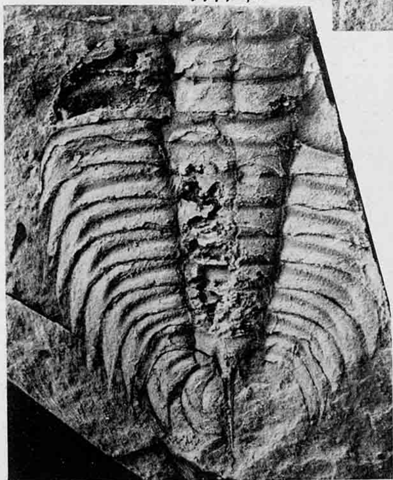
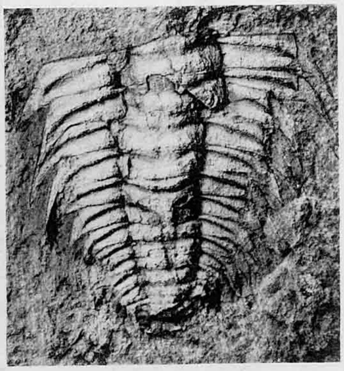


8 PA 4186

1 PA953

2 PA954



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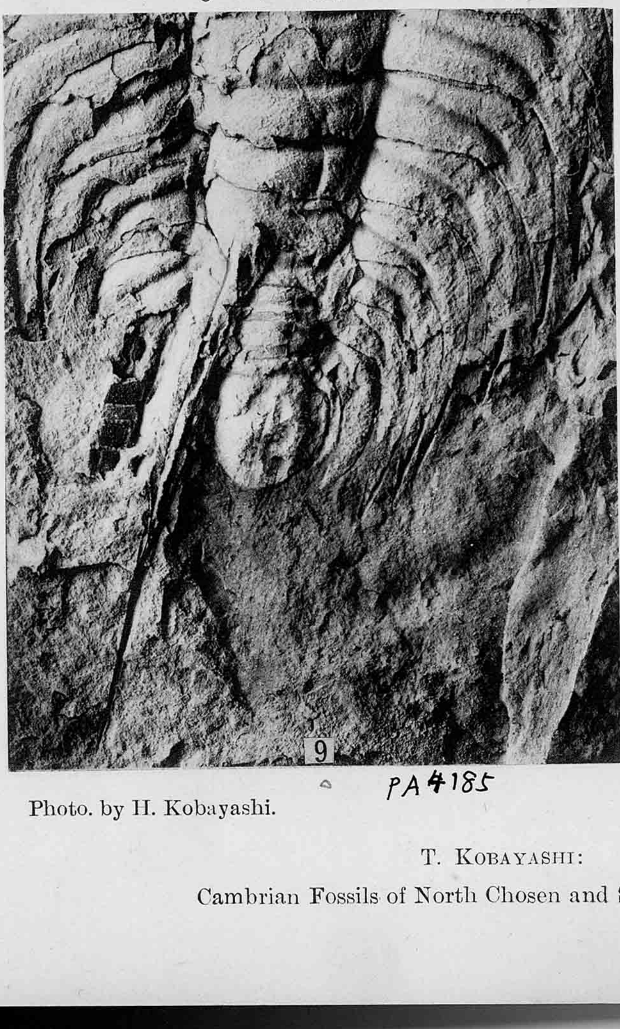

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5 PA981

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Cambrian Fossils of North Chosen and South Manchuria.

Cheiruroides orientalis (Resser and Endo). . . . . p. 163

Figures 1–2. Two cranidia; ×6.

Redlichia shale of Misaki, Misakiyama, Manchuria.

Dinesus ida Etheridge. . . . . p. 134

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Middle Cambrian of Templeton River, Queensland; collected by Wm. E. Schville and kept in Museum of Comparative Zoology, Harvard University, (No. 1853).

Pseudolisania breviloba (Walcott). . . . . pp. 94, 162

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Upper Cambrian Maryville limestone, 1.5 miles south of Greeneville County, Tennessee.

Kootenia asiatica, new species. . . . . p. 158

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Hypostoma, gen. et sp. undt. . . . . p. 324

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Upper Cambrian St. Lawrence Formation near Mazomanie, Dave Co. Wisconsin.

Dorypyge manchuriensis Resser and Endo (MS). . . . . p. 160

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Middle Cambrian; 4 km. N. E. N. of Kojo, Sosan Area, Heian-hokudo, North Chosen. (平安北道楚山郡古場北東北四粁月岳洞)

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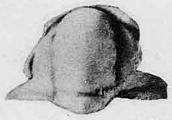
Early Middle Cambrian shale; southern slope of Rakkatsuho, Sosan area, North Chosen. (洛葛峰南坂)

Amphoton deois (Walcott). . . . . p. 138

Figure 12. Cranidia and cheeks of this species in association with some pygidia of *Dorypyge manchuriensis* Dames; ×2.

Locality same as the preceding slab.

1 PA4192



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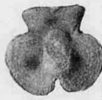

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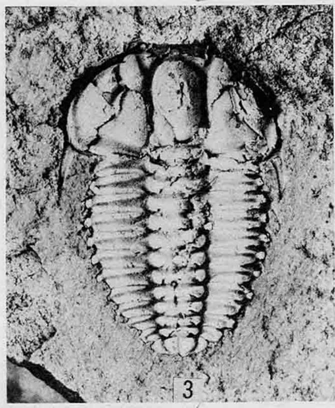

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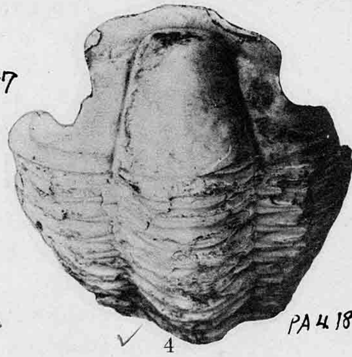

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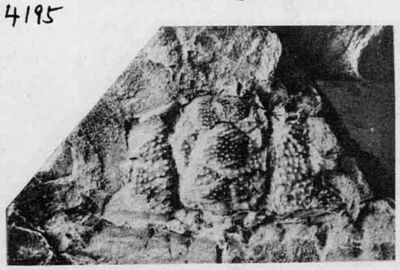

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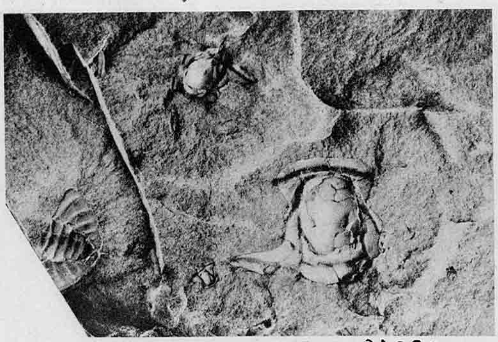
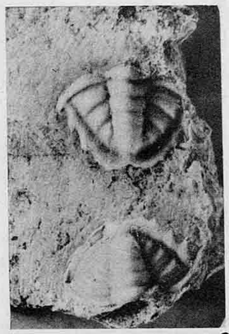


11 PA982



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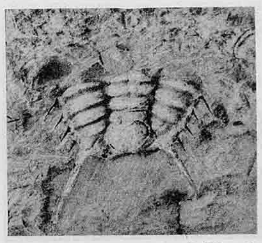
12 PA983.



10 PA1011

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T. Kobayashi:
Cambrian Fossils.

Elrathia chuwaensis, new species. . . . . p. 227

Figure 1. Holotype; ×3.

Early Middle Cambrian; west of Chuwa, Heian-nan-do, North Chosen.

Elrathia kikkawai, new species. . . . . p. 227

Figure 2. Holotype; $\times 1\frac{1}{2}$.

Early Middle Cambrian of Sho-ryu-san, Heian-nan-do, North Chosen. (小龍山南谷)

Ptychoparia (?) *coreanica*, new species. p. 226

Figures 3–4. Paratype cranidium and holotype carapace; $\times 1\frac{1}{2}$.

Early Middle Cambrian of Ritsuri, Chuwa area, Heian-nan-do, North Chosen. (栗里隱松泉洞)

Probowmania ligea (Walcott). . . . . p. 250

Figure 5. Holotype, (U. S. Nat. Mus. Catal. 56953); ×3.

Lower Cambrian; Changhia, Shantung. (C_{31})

Crepicephalina sinuosa, new species. p. 280

Figure 6. Holotype; $\times 2\frac{1}{2}$.

Early Middle Cambrian; 2 km. east of Sosan, Sosan area, Heian-hokudo, North Chosen. (平安北道楚山東方二粁廣大峰西北山背)

Camaraspis cf. *convexus* (Whitfield.) . . . . p. 203

Figures 7–8. A cranidium ($\times 1\frac{1}{2}$) and pygidium (×1).

Franconia of Upper Cambrian; Roch-a-cri, Wisconsin.

Kingaspis campelli (King). . . . . p. 196

Figures 9–10. A cranidium and pygidium; $\times 1\frac{1}{2}$.

Upper Cambrian (?) of Wadi Zerka, Maain, Dead Sea, Palestine.

Ellipsocephaloides. cf. *curtus* (Whitfield.) . . . . p. 196

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Franconia formation of Upper Cambrian; Thompson's Valley, west of Mondovi, Wisconsin.

Figure 12. Cephalon, free cheek and pygidium; $\times 1\frac{1}{2}$.

Franconia formation of Upper Cambrian; Road cut $2\frac{1}{2}$ miles south of Durano, Wisconsin.

Conocoryphe lantenoisi Mansuy. . . . . p. 218

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Megagraulos coreanicus, new species. p. 207

Figure 15. Cranidium, free cheek and incomplete thoracic segments; $\times 1\frac{1}{2}$; early Middle Cambrian shale of Nankaso, Sosan Area, North Chosen. (南下倉)

Changshania bronus (Walcott). . . . . p. 225

Figure 16. Cranidia, free cheeks and a pygidium; $\times 1\frac{1}{2}$; Middle Cambrian (?); SW. of Yen-chuang, Shantung, (C_6).

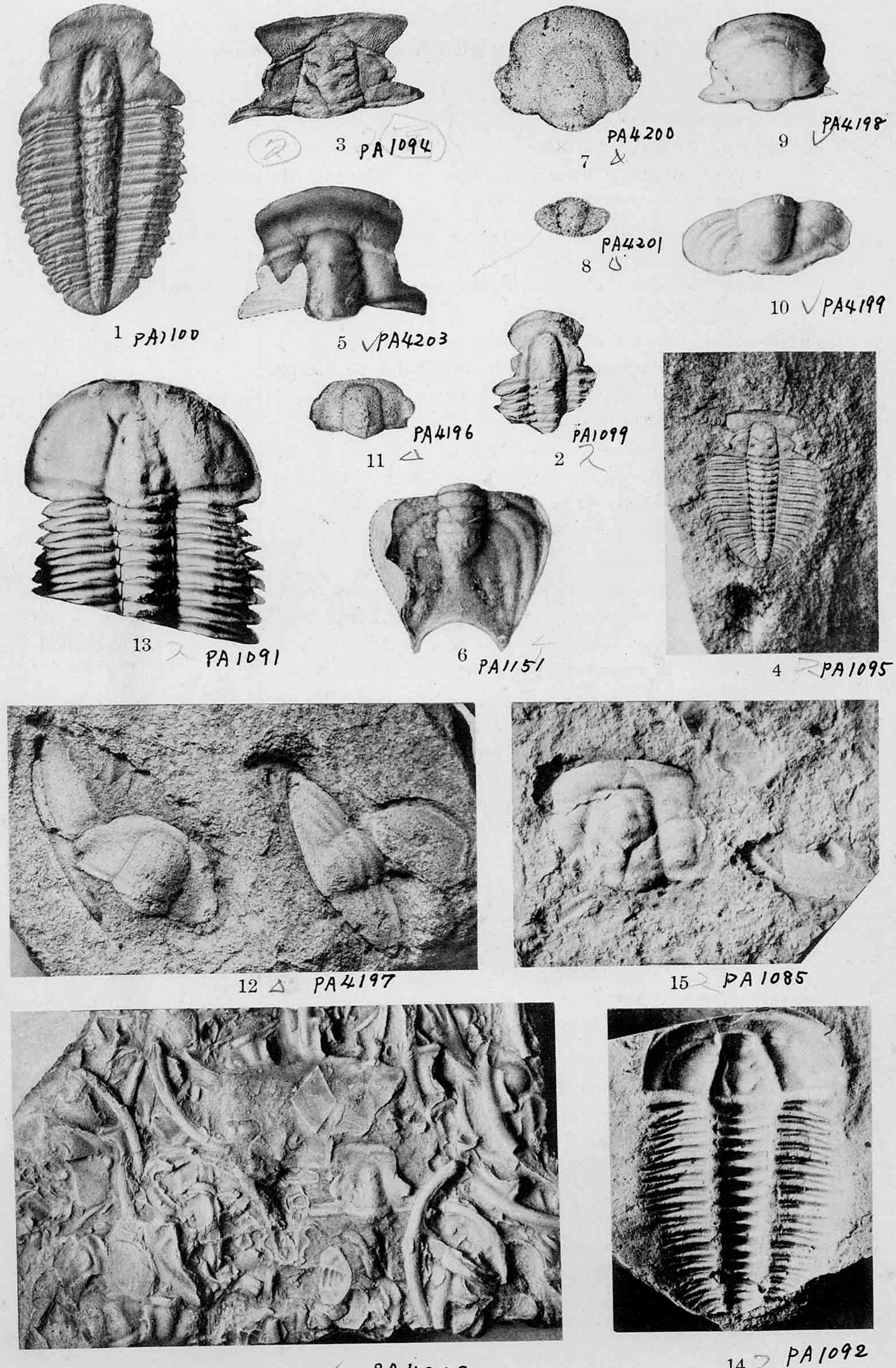

Photo. by H. Kobayashi.

T. Kobayashi:

Cambrian Fossils.

Inouyella peiensis Resser and Endo (MS). p. 89
Figure 1. The genotype of *Inouyella*; ×2.
Middle Cambrian (Taitzu); 3.8 miles south of Liaoyang.

Taitzuia insueta Resser and Endo (MS). p. 90
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Middle Cambrian (Taitzu); Tangshihling, Manchuria.

Aojia spinosa Resser and Endo (MS). . . . . p. 89
Figures 3–4. The genotype cranidium and pygidium; ×3.
Middle Cambrian (Taitzu); Tangshihling, Manchuria.

Peishania convexa Resser and Endo(MS). p. 90
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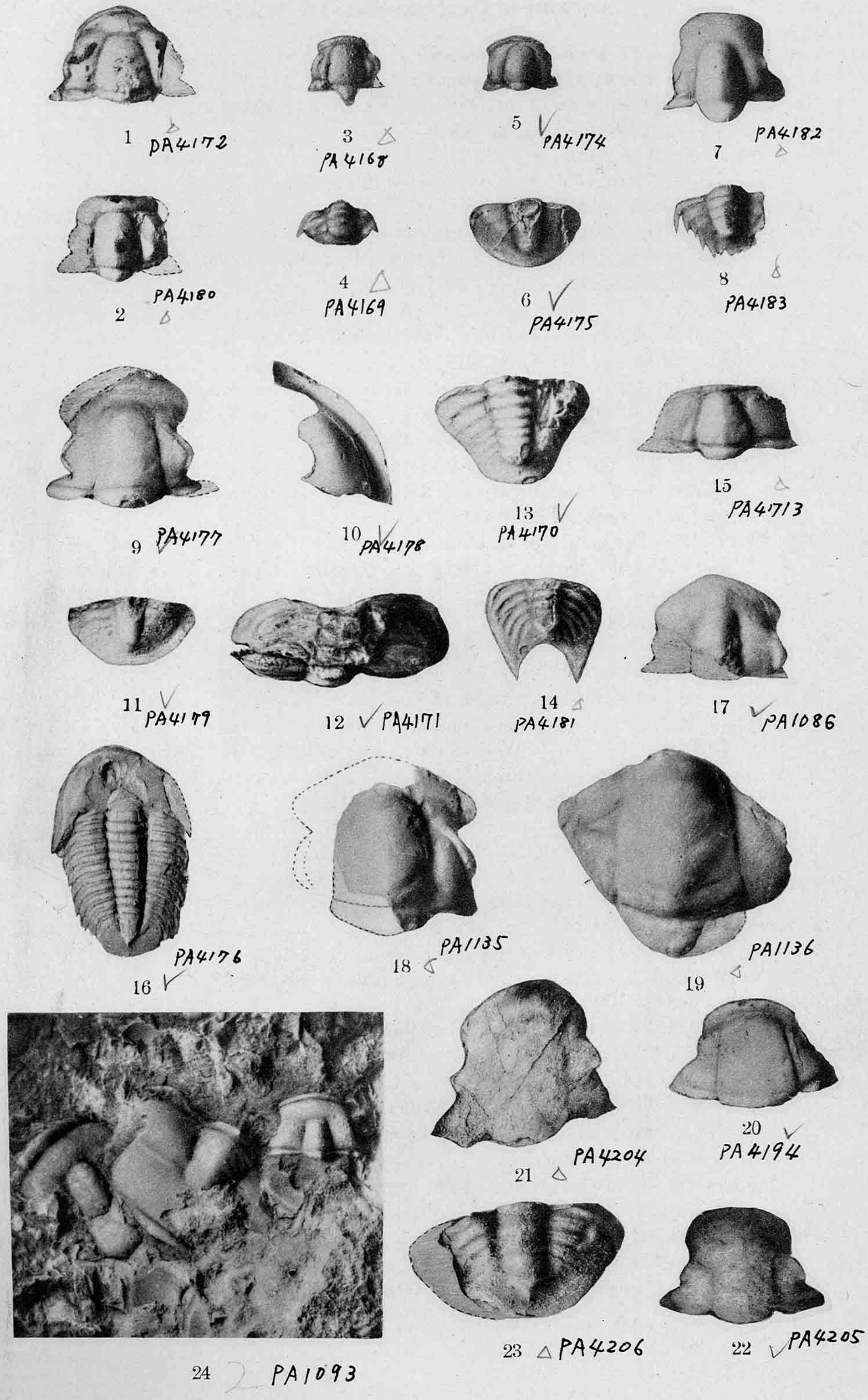

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