Diceratocephalid trilobites from the uppermost Changhia and Kushan formations (Guzhangian, Mialolingian, Cambrian) in North China Platform

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Examination of type material of the type species of *Wongia*, *W. triangulata* and new material from the uppermost Changhia Formation and Kushan Formation, in Shandong and Liaoning, necessitates transfer of the genus from Avoninidae to Diceratocephalidae. Many species, formerly assigned to *Cyclolorenzella* or *Jiulongshania,* are re-assigned to *Wongia*. Because *Agraulos acalle* the type species of *Jiulongshania* is assigned to *Wongia*, *Jiulongshania* is synonymized with *Wongia. Jiulongshania* was previously assigned to Inouyiidae but as a synonym of *Wongia* belongs to the Diceratocephalidae. *Cyclolorenzella* is also revised based on new material. *Cyclolorenzella* is distinguished from *Wongia* in having a relatively larger, subquadrate cranidium, with a shorter frontal area, longer occipital spine, and a transverse semi-ellipticalsemi-elliptical pygidium, without a narrow pygidial border, but with a weak posteromedian embayment. Three new species: *Wongia nanzhaocunensis* Yuan, *Wongia laevigate* Yuan, and *Torifera intermedia* Yuan, Ren & Gao are erected. Ranges of the constituent species of *Wongia*, *Cyclolorenzella*, and *Torifera* between the *Damesella paronai–Ajacicrepida ajax* Zone of the uppermost Changhia Formation to the *Diceratocephalus armatus* Zone of the uppermost Kushan Formation are detailed. This study facilitates the subdivision of pre-established fossil zones and the establishment of biozones based on the First Appearance Datum (FAD) of species, enabling the determination of the sequence of genera and species appearances in the stratigraphic record. It also contributes to the global correlation of the base of the Guzhangian and Paibian Stage in North China Platform.

Key words: Trilobita, Diceratocephalidae, *Wongia*, *Cyclolorenzella*, *Torifera*, Guzhangian, Miaolingian, Cambrian, North China Platform.

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Introduction

Wongia, with *W. triangulata* Sun, 1924, as its type species, was based on poorly preserved cranidia from the Cambrian (Guzhangian, Miaolingian) succession in North China and Korea. However, the supposed proparian course of the facial suture and the long spine thought to be metafixigenal, resulted in assignment to the Avoninidae Lochman, 1936 (Harrington et al. 1959; Lu et al. 1963, 1965; Jell and Adrain 2003; Zhu 2008). Sun's (1924) type material from

the *Blackwelderia* Zone of the Kushan Formation, Lincheng County, Hebei, together with a large quantity of new material from the Kushan Formation and the uppermost Changhia Formation in Shandong, Hebei and eastern Liaoning, show this interpretation to have been in error. *Cyclolorenzella*, with *Lorenzella quadrata* Kobayashi, 1935, as its type species, was also based on a poorly preserved cranidium and also occurs in the Cambrian (Guzhangian, Miaolingian) succession in North China and Korea. Although emended and discussed in detail (Park et al. 2008), the relative rarity of specimens has hampered full understanding of the type species and reliable identification of members of the genus. Following Park et al. (2008), only *Cyclolorenzella quadrata* (Kobayashi, 1935), and *C. convexa* (Resser and Endo in Endo and Resser, 1937) remain in the genus, which is confined to a narrow stratigraphic interval within the *Drepanura* Zone (=*Neodrepanura* Zone) of the Kushan Formation, North China and the Sesong Formation, Korea. Examination of the types of *Wongia triangulata* and new collections from North China (Fig. 1) demonstrates that most of the species formerly assigned to *Cyclolorenzella* or *Jiulongshania* (considered herein as synonymous with *Wongia*) are re-assigned to *Wongia*. *Cyclolorenzella* sp. from the *Lejopyge armata* Zone of the Machari Formation, Yongwol Group, Korea (Hong et al. 2003), and *Cyclolorenzella distincta* Zhang, 1985, from the upper Hulusitai Formation, are assigned to *Cyclolorenzella*. *Torifera* Wolfart, 1974, with *T. triangularis* Wolfart, 1974, as its type species, known from Afghanistan, Himalaya (India), Iran, Oman, Vietnam, South China (northwestern Hunan, eastern Guizhou, western and southeastern Yunnan, southeastern Sichuan, western Guangxi and southern Jiangsu), is recorded in North China for the first time. The main aim of this study is to provide a thorough reassessment of *Wongia*, *Jiulongshania*, *Cyclorenzella*, and *Torifera*.

Institutional abbreviation.—NIGP, Nanjing Institute of Geology and Palaeontology, Nanjing, China; USNM, United States National Museum, Washington, D.C., USA; SG, Shenyang Institute of Geology and Mineral Resources, Chinese Academy of Gelological Sciences, Shenyang, Liaoning, China.

Other abbreviations.—BAS, Baijiashan; exsag., exsagittal; jls, jiulongshan; ju, julinshan; NZC, Nanzhaocun; S1–S3, the first to third pair of lateral glabellar furrows; sag., sagittal; tr., transversal.

Nomenclatural acts.—This published work and the nomenclatural acts it contains, have been registered in Zoobank: urn:lsid:zoobank.org:pub:F3FCCD0A-6952-4504-A4EF-9F0ACBA613B5

Geological setting

The material used in the present paper were mainly collected from: (i) the Jiulongshan section (36°44’52.8’’ N, 117°44’47.4’’ E), Gangcheng District, Jinan City, Shandong; (ii) the Julinshan section (35°06’56.6’’ N, 117°59’36.31’’ E), at Renhezhuang Village, Feixian County, Linyi City, Shandong; (iii) the Nanzhaocun section (36°15’21.9’’ N, 118°24’51.6’’ E), Linqu County, Weifang City, Shandong; and (iv) from the Baijiashan section (39°26’26.1’’ N, 121°40’38.6’’ E), Dalian City, Liaoning (Fig. 1). The Cambrian succession of Shandong includes, in ascending order: the Liguan, Zhushadong, Manto, Changhia, Kushan, and Chaumitien formations (Zhang and Liu 1996), and in eastern Liaoning, the Cambrian succession consists of the Dalinzi, Getun, Jichang (= Changping), Sanqi (= lower Manto), Tangshih (= upper Manto), Taitzu (= Changhia), Kushan, Changshan and Fengshan (= Chaumitien) formations (Duan et al. 2005).

Wongia occurs in the uppermost part of the Changhia Formation and the Kushan Formation (Guzhangian) with the exception of *Wongia acuta* (Duan in Duan et al., 2005), which questionably occurs in the upper Manto Formation (upper Xuzhuagian Stage = ?upper Wuliuan), and *Wongia humilis* (Zhang in Qiu et al., 1983), which questionably occurs in the Changshanian Stage (the Chaumitien Formation, Furongian).

The uppermost Changhia Formation in Jiulongshan section (ca. 3–20 m thick) is mainly composed of light grey, thin- to medium-bedded limestone. The Kushan Formation in both the Jiulongshan and Julinshan sections is predominantly grey to yellowish-brown shale intercalated with grey to dark grey, thin-bedded limestone, and calcareous nodules or calcareous mudstone in the lower part (ca. 10–30 m thick). The middle part of the Kushan Formation (ca. 25–35 m thick) is mainly composed of grey to light grey thin-bedded to medium-bedded limestone and grey thin-bedded intraclastic rudstone, alternating with a few grey shale intervals. The upper part (ca. 30–40 m thick) chiefly consists of thin-bedded to medium-bedded bioclastic wackestones, grey slabby limestone, grey thin-bedded limestone-shale couplets, and occasionally intercalated with grey, thin- to medium-bedded oolitic limestone in the uppermost part.

Systematic palaeontology

The terminology and systematic classification follow that of the revised edition of the Treatise on Invertebrate Palaeontology (Whittington and Kelly 1997).

Class Trilobita Walch, 1771

Order Ptychopariida Swinnerton, 1915

Family Diceratocephalidae Lu, 1954

Genus *Wongia* Sun, 1924

Type species: *Wongia triangulata* Sun, 1924, from the *Wongia triangulata* Zone of the Kushan Formation, Lincheng County, Hebei, China.

Species included: *Wongia acalle* (Walcott, 1905), *Wongia rotundata* (Resser & Endo in Endo and Resser, 1937), *Wongia triangulata* Sun, 1924, *Wongia subcylindrica* (Chu, 1959), *Wongia regularis regularis*

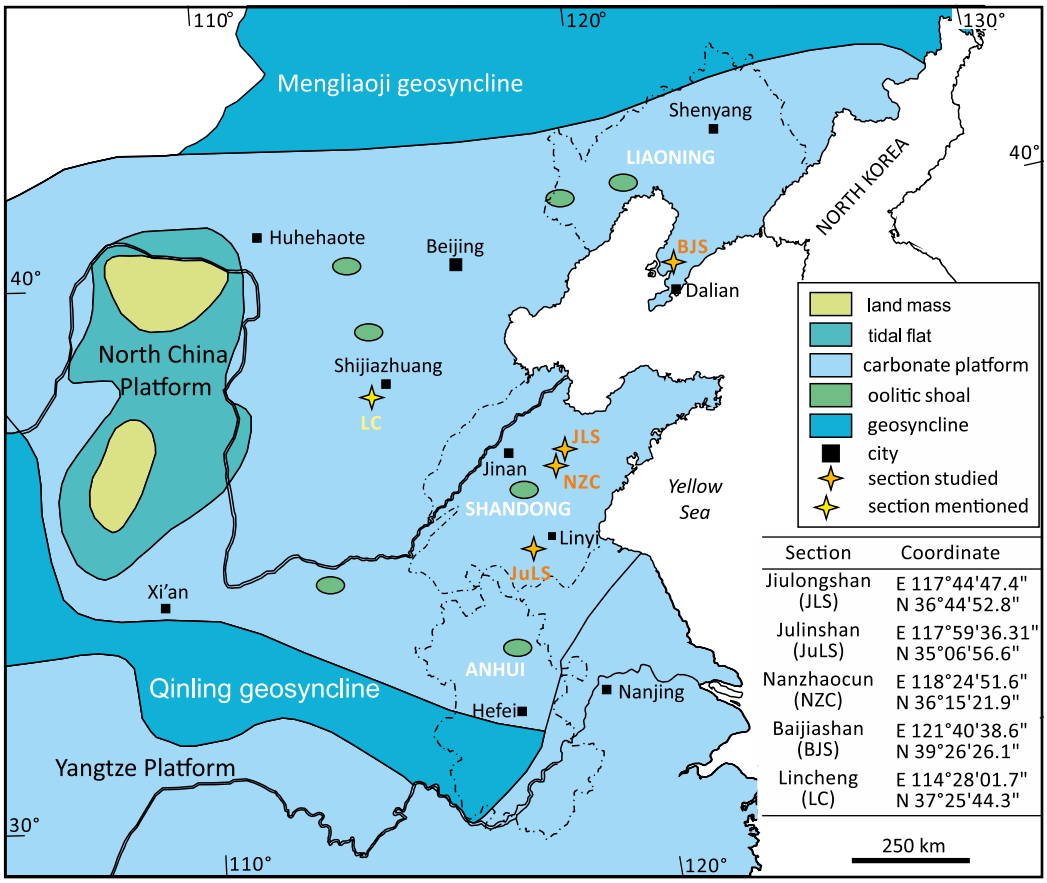

Fig. 1. Palaeogeographic map of the North China Platform in the middle to late Cambrian (Guzhangian–Paibian) with locations of the studied sections (modified after Feng et al. 2002; Wang et al. 2020).

(Walcott, 1906), *Wongia regularis pustulosa* (Chu, 1959), *Wongia acuta* (Duan in Duan et al., 2005), *Wongia humilis* (Zhang in Qiu et al., 1983), *Wongia magezhuangensis* (Zhang & Wang, 1986), *Wongia valida* (Nan & Chang, 1985), *Wongia longa* (Park, Han, Bai & Choi, 2008), *Wongia nanzhaocunensis* Yuan sp. nov., and *Wongia laevigate* Yuan sp. nov.

Emended diagnosis.—Small diceratocephalid; cephalon with or without genal spine; axial furrow broad and deep; cranidium triangular to subtrapzoidal, with gently to strongly convex preglabellar boss defined by a pair of short, divergent furrows on frontal area, anterior margin more strongly bending forward; anterior border very narrow and low, anterior border furrow indistinct; glabella short, conical, subconical or subcylindrical, with 3 pairs of faintly impressed lateral glabellar furrows; occipital ring convex, semi-elliptical; opisthoparian facial suture, posterior branch of facial suture slanting outwards, bending near a small node located at the end of the posterior border furrow, then slightly to strongly slanting inwards, cutting the posterior border; posterior border narrower (tr.) than basal glabellar width, with obtuse intergenal angle, posterior border furrow shallow, slightly bending forwards distally; librigena narrow, sloping outwards; palpebral lobe short to moderately long, 1/3 size of the glabella. Thorax of 8 segments. Pygidium convex, rhombic, anterior margin bent strongly posteriorly at fulcrum, lateral margin long, strongly slanting backwards, acutely rounded laterally, posterior margin very broad, well rounded gently bending backwards; axial furrow very shallow, axis broad and long, tapering backwards, with 3–5 axial rings, axial ring furrows long and shallow, each pleural field as wide as axis, pleural lobe with or without terrace lines, pygidial border narrow and flat; surface finely granulose or smooth.

Remarks.—*Wongia* differs from *Cyclolorenzella* mainly in lacking a long occipital spine, in its subtriangular to subtrapezoidal cranidium with more strongly bending forward anterior margin, shorter (sag.) and slender (tr.) conical to subconical glabella, shorter (sag.) palpebral lobe located at anteriorly, posterior branches of facial sutures slanting outwards, bending near a small node located at the end of the posterior border furrow, then slightly to strongly slantng inwards, and its rhombic pygidium without posteromedian indentation. *Wongia* differs from *Torifera* Wolfart, 1974, chiefly in the latter having distinct anterior border furrow, a low baccula at the posteroproximal corner of the fixigena, broader fixigenae between palpebral lobes, and a shorter (sag.), wider (tr.) elliptical pygidium. In the general configuration of the cranidium and glabella, the type species of *Jiulongshania*, *Agraulos acalle* Walcott, 1905, is quite similar to the type species of *Wongia*, *W. triangulata* but differs from the latter mainly by its shorter genal spine directed at a different angle. *Jiulongshania* belongs in *Wongia*.

Stratigraphic and geographic range.—The uppermost Changhia Formation–uppermost Kushan Formation, *Damesella paronai–Ajacicrepida ajax* Zone to the *Diceratocephalus armatus* Zone, Guzhangian, Miaolignian, Cambrian; North-Northeast China and South Korea.

Wongia triangulata Sun, 1924

Fig. 2.

1924 *Wongia triangulata* Sun 1924: 85, pl. 5: 12a, b.
1956 *Wongia triangularis* Sun; Wang et al. 1956: 142, text–fig. 1.
1957 *Wongia triangulata* Sun; Lu 1957: 273, pl. 143: 17.
1959 *Wongia triangulata* Sun; Harrington et al. 1959: 283, text-fig. 209-3.
1960 *Wongia triangulata* Sun; Kobayashi 1960: 387: text-fig. 9h.
1965 *Wongia triangulata* Sun; Lu et al. 1965: 259, pl. 44: 2, 3.
1989 *Cyclolorenzella longispina* Wittke & Zhu; Zhu and Wittke 1989: 214, pl. 3: 13.
2008 *Cyclolorenzella longispina* Wittke & Zhu in Zhu and Wittke; Yang 2008: 107, pl. 13: 26–28; pl. 14: 1–3, 5–7, 9, 13, 18, 19 [not figs. 4, 8, 10–12, 14–17, 20, 21]; pl. 15: 1–13, 15–20, 22, 23, 25–32, 34, 35 [not figs. 14, 21, 24, 33].
2008 *Jiulongshania longispina* (Wittke & Zhu in Zhu and Wittke); Park et al. 2008: 260, fig. 7O–Q [non fig. 7A–K, L–N].
2013 *Jiulongshania longispina* (Wittke & Zhu in Zhu and Wittke); Park et al. 2013: 998, fig. 5.1–5.17.
2017 *Wongia triangulata* Sun; Ren 2017: 111, pl. 18: 12, 13, [non figs. 14, 15]; non pl. 42: 5.
2017 *Wongia rotundata* (Resser & Endo in Endo and Resser, 1937); Ren 2017: 114, pl. 18: 19, [non figs. 18, 20, 21].
2020 *Jiulongshania longispina* (Wittke & Zhu in Zhu and Wittke); Peng 2020: 458, pl. 203: 2, 6, [non figs. 1, 3–5, 7].
2023 *Wongia triangulata* Sun; Lei 2023: 9, 10, pl. 3: 11, ?12, 13, ?14, ?15.

Holotype: NIGP 628b, cranidium with partly librigena (Sun 1924: pl. 5: 12a; Fig. 2I).

Type locality: Lincheng County, Hebei Province, China.

Type horizon: Kushan Formation (*Blackwelderia* Zone), Guzhangian, Miaolingian, Cambrian.

Material.—Six cranidia and two pygidia (NIGP 205906–205913), all from Kushan Formation (Guangzhangia), Shandong Province, China.

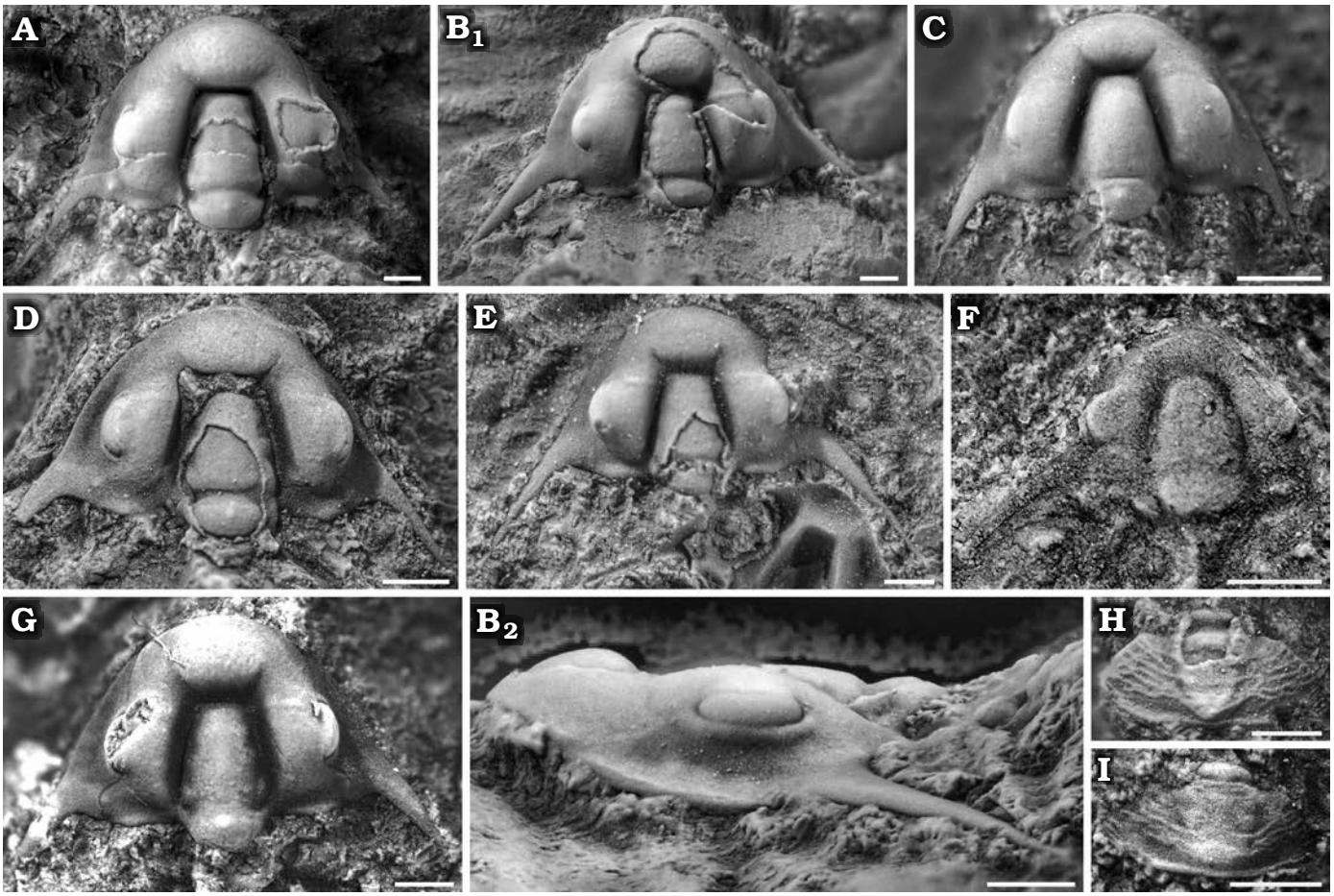

Fig. 2. Diceratocephalid trilobite *Wongia triangulata* Sun, 1924, from Guangzhangian, Miaolingian (Cambrian), the Kushan Formation of China, the *Wongia triangulata* Zone, Jiulongshan section, Shandong Pronvince (A–E; G–I), and *Blackwelderia* Zone (= *Wongia triangulata* Zone), Lincheng County, Hebei Pronvince (F). **A**. NIGP205906 (field no. jls 124), cephalon in dorsal view. **B**. NIGP205907 (field no. jls 126), cephalon in dorsal (B_1) and lateral (B_2) views. **C**. NIGP00205908 (field no. jls124), cephalonin dorsal view. **D**. NIGP00205909 (field no. jls124), cephalonin dorsal view. **E**. NIGP00205910 (field no. jls124), cephalonin dorsal view. **F**. Holotype NIGPG.S.Ch,6286, incomplete cephalonin dorsal view. **G**. NIGP 205911 (field no. jls316-2), cephalonin dorsal view. **H**. NIGP205912 (field no. jls124), pygidiumin dorsal view. **I**. NIGP205913 (field no. jls126), pygidium. Scale bars: A, B, D, E, G, 500 μm; C, F, H, I, 200 μm.

Emended diagnosis.—Cephalon moderately vaulted, with moderately long genal spine directed posterolaterally at about 45° to the saggital line; cranidium triangular, glabella convex, subconical, with 3 pairs of shallow lateral furrows; librigena narrow, strongly sloping outwards; palbebral lobe moderately long, crescentic, located at opposite the anterior portion of the glabella, about 0.4 times as long as glabella. Pygidium short and convex, rhombic, acutely rounded laterally, axial furrow shallow; axis broad and long, distinctly tapering backwards, with 3–4 axial rings and a terminal piece, axial ring furrows very shallow, pleural field as wide as axis; surface smooth, or covered with 10–11 transverse teracelines; pygidial border very narrow and flat.

Description.—Cephalon moderately vaulted, with moderately long genal spine directed posterolaterally at about 45° an angle to the saggital line; axial furrow broad and deep; cranidium inflated, triangular, with distinct convex preglabellar boss defined by a pair of anteriorly divergent furrows on frontal area; glabella subconical, with 3 pairs of shallow lateral furrows; anterior branches of facial sutures parallel or slightly convergent forward, posterior branches divergent outwards, bending near a small node located at the end of the posterior border furrow, then slighty slantng inwards (Fig. 2G); eye ridge horizontal; palpebral lobe moderately long, crescentic, between middle and anterior of glabella, about 0.4 times as long as glabella; posterior border narrower (tr.), about 0.8 times as wide as basal glabellar width, with obtuse intergenal angle, posterior border furrow shallow, slightly bending forwards distally; librigena narrow, strongly sloping outwards; occipital ring semi-elliptical, with a small occipital node anteriorly; occipital furrow shallow. Pygidium rhombic, acutely rounded laterally; axial furrow very shallow; axis convex, broad and long, tapering backwards, with 3–4 axial rings and a terminal piece, axial ring furrows very shallow; pleural field as wide as axis, surface smooth or covered with terrace lines on pleural areas, pleural furrows very weakly impressed; pygidial border very narrow and flat.

Remarks.—In the general configuration of the cephalon and pygidium, especially in having relatively long genal spine, *W. triangulata* is quite similar to *W. subcylindrica* (Chu, 1959). However, it differs from the latter in having a triangular cranidium with distinct convex preglabellar boss and a subconical glabella, and the genal spine being directed posterolaterally at about 45° to the saggital line, whereas the latter possessed a subquadrate cranidium with an indistinct convex preglabellar boss, and the genal spine is directed posterolaterally at about 60–80° to the saggital line.

Stratigraphic and geographic range.—Kushan Formation, *Wongia triangulata* Zone, Guzhangian, Miaolingian, Cambrian; Jiulongshan section, Gangcheng District, Jinan City, Shandong, China.

Wongia acalle (Walcott, 1905)

Fig. 3.

1905 *Agraulos acalle*; Walcott 1905: 43.
1913 *Inouyia*? *acalle* (Walcott); Walcott 1913: 150, pl. 14: 15.
1935 *Lorenzella acalle* (Walcott); Kobayashi 1935: 253.
1937 *Lorenzella*? *ogurai* Resser & Endo; Endo and Resser 1937: 232, pl. 51: 17–19.
1959 *Lorenzella kushanensis*; Chu 1959: 61, 99, pl. 2: 14, 15.
1960 *Cyclolorenzella acalle* (Walcott); Kobayashi 1960: 389.
1960 *Cyclolorenzella ogurai* (Resser & Endo); Kobayashi 1960: 389.
1965 *Cyclolorenzella acalle*; Lu et al. 1965: 251, pl. 42: 16, 17.
1965 *Cyclolorenzella ogurai*; Lu et al. 1965: 255, pl. 43: 16–18.
1965 *Cyclolorenzella kushanensis* (Chu); Lu et al. 1965: 252, pl. 42: 21, 22.
1980 *Cyclolorenzella normalis* Zhou; Zhou and Zheng 1980: 65, pl. 1: 3, 4.
1982 *Cyclolorenzella normalis*; Zhou et al. 1982: 248, pl. 62: 12, 13.
1986 *Cyclolorenzella kushanensis* (Chu); Zhang and Wang 1986: 405, pl. 122: 11, 12.
1985 *Cyclolorenzella denotata*; Nan and Chang 1985: 11, pl. 1: 22–25.
1987 *Cyclolorenzella acalle* (Walcott); Zhang and Jell 1987: 132, pl. 51: 1–4, [non figs. 5–7].
1989 *Cyclolorenzella hebeiensis hebeiensis* Wittke & Zhu; Zhu and Wittke 1989: 214, pl. 5: 6–8.
1989 *Cyclolorenzella hebeiensis tangshanensis* Wittke & Zhu; Zhu and Wittke 1989: 214, pl. 5: 9–12.
1989 *Cyclolorenzella uniforma* Wittke & Zhu; Zhu and Wittke 1989: 214, pl. 3: 11, 12; pl. 5: 13, 14.
1992 *Cyclolorenzella acalle* (Walcott); Zhu 1992: 345, pl. 117: 14.
non 1996 *Cyclolorenzella acalle* (Walcott); Guo et al. 1996: 114, pl. 59: 12–16.
non 2001 *Cyclolorenzella acalle* (Walcott); Luo 2001: 379, pl. 4: 11b, c, 17.
2008 *Cyclolorenzella acalle* (Walcott); Yang 2008: 100, pl. 13: 1–9, 11–14, 16–25, 27, 29, 30; pl. 16: 18–21, 24, 27; text fig. 17.1–17.3).
2008 *Jiulongshania acalle* (Walcott); Park et al. 2008: 256, fig. 5A–C, F–N, P–W, [non fig. 5D, E, O].
part 2008 *Cyclolorenzella magezhangensis*; Zhang & Wang 2008: 1986, fig. 22B, C (right cranidium and librigenae), pl. 13: 10, 15, 26 [not fig. 22A (left cranidium)].
2010 *Jiulongshania acalle* (Walcott); Chough et al. 2010: 266, fig. 15a.
2012 *Jiulongshania acalle* (Walcott); Yuan et al. 2012: 371, pl. 223: 1–15; pl. 224: 10, 12–14; pl. 225: 14, 15.
2017 *Wongia acalle* (Walcott); Ren 2017: 112–114, pl. 18: 9–11, [non fig. 8]; pl. 41: 20; pl. 42: 1–4.
2020 *Jiulongshania acalle* (Walcott); Peng 2020: 456, pl: 8–14.

Holotype: USNM 58023, cranidium (Walcott 1913: pl. 14: 15; Zhang and Jell 1987: pl. 51: 1).

Type locality: Southwest of Yanzhuag Town, Laiwu District, Jinan City, Shandong Province, China.

Type horizon: Kushan Formation Guzhangian (*Damesella paronai–Teinistion typicalis* Zone), Miaolingian, Guzhangian, Cambrian.

Material.—Two cephala, eleven cranidia, two pygidia, and one hypostome (NIGP 205914–205929), all from Kushan Formation (Guangzhangia), Shandong Province, China.

Emended diagnosis.—Cephalon with moderately long genal spine directed posteriorly to posterolaterally at approximately 15–30° to sagittal line; cranidium inflated, triangular, with moderately convex preglabellar boss defined by a pair of short, distinctly divergent furrows on frontal area; glabella conical, 3 pairs of glabellar furrows short and shallow; anterior branches of facial sutures slightly convergent anteriorly, posterior branches slanting outwards,

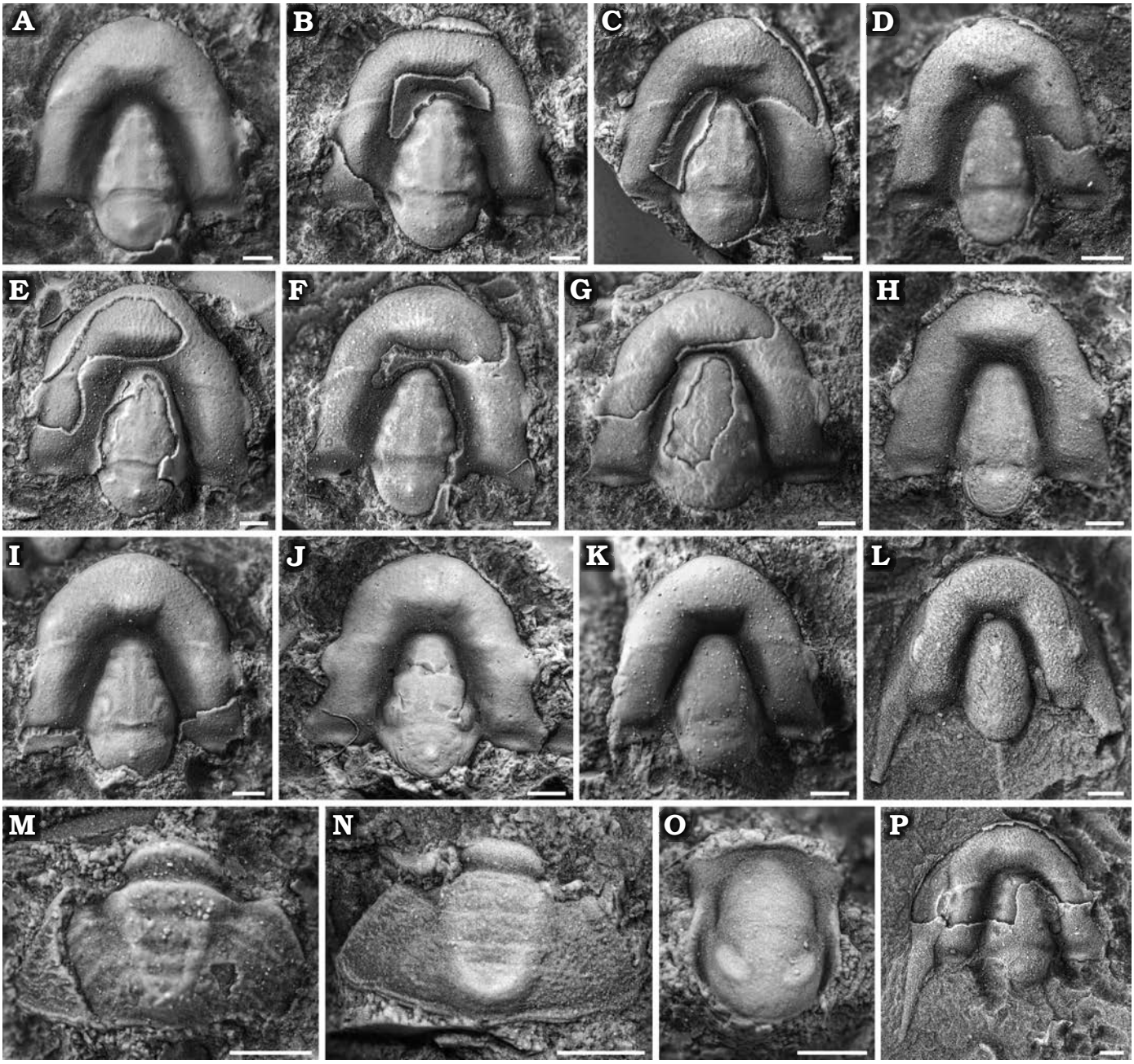

Fig. 3. Diceratocephalid trilobite *Wongia acalle* (Walcott, 1905) from Guangzhangian, Miaolingian (Cambrian), the Kushan Formation of China, the *Damesella paronai–Teinistion typicalis* Zone, Jiulongshan (D, H, J, N, O), Julinshan (A–C, E–G, I, K, M) and Helilu (L, P) sections, Shandong Pronvince. **A**. NIGP205914 (field no. Ju-2-R6-2), cranidium. **B**. NIGP205915 (field no. Ju-2-R6-2), cranidium. **C**. NIGP205916 (field no. Ju-2-RBD), cranidium. **D**. NIGP205923 (field no. jls102), cranidium. **E**. NIGP205917 (field no. Ju-2-R6-2), cranidium. **F**. NIGP205918 (field no. Ju-2-R6-2), cranidium. **G**. NIGP205919 (field no. Ju-2-R7-2), cranidium. **H**. NIGP205924 (field no. jls102), cranidium. **I**. NIGP205920 (field no. Ju-2-R6-2), cranidium. **J**. NIGP205925 (field no. jls102), cranidium. **K**. NIGP205921 (field no. Ju-2-R6-2), cranidium. **L**. NIGP205928 (field no. hl-16), cephalon. **M**. NIGP205922 (field no. Ju-2-R6-2), pygidium. **N**. NIGP205926 (field no. jls102), pygidium. **O**. NIGP205927 (field no. jls102), hypostome. **P**. NIGP205929 (field no. hl-16), cephalon. All in dorsal view. Scale bars: A–N, 500 μm; O, 200 μm; P, 1 mm.

gently bending backwards near proximal end of posterior border furrow (Fig. 3P); posterior border gently convex, about 0.6–0.7 times as wide as glabella at the base, without intergenal angle; palpebral lobe short, crescentic, located between middle and anterior of glabella; pygidium rhombic, acutely rounded laterally; axial furrow very shallow; axis convex, broad and long, tapering backwards, with 3–4 axial rings and a terminal piece.

Description.—Cephalon with moderately long genal spine directed posteriorly to posterolaterally at approximately 15–30° to sagittal line; axial furrow broad and deep; cranidium inflated, triangular, with moderately convex preglabellar boss defined by a pair of short strongly divergent furrows on frontal area; glabella conical to subconical, with 3 pairs of short and shallow lateral furrows; anterior branches of facial sutures slightly convergent forward, posterior branches

slanting outwards, gently bending backwards near proximal end of posterior border furrow (Fig. 3P); palpebral lobe short, crescentic, located between middle and anterior of glabella; eye ridge faint, transverse; posterior border gently convex, about 0.6–0.7 times as wide as glabella at the base, without intergenal angle; librigena narrow, strongly sloping outwards; occipital ring broad (sag.), semi-elliptical, with a small occipital node in the centre, and with a few terrace lines on the posterior part; occipital furrow shallow. Hypostome very small, subovate, and divided into an ovoid central body and a crescentic posterior lobe, with a pair of small suboval maculae behind the very shallow middle furrow. Pygidium rhombic, acutely rounded laterally; axial furrow very shallow; axis convex, broad and long, tapering backwards, with 3–4 axial rings and a terminal piece, axial ring furrows very shallow, but on exfoliated specimens axial ring furrows broad and deep, disconnected with axial furrow; pleural field as wide as axis, surface smooth or with weakly impressed terrace lines on pleural areas. Pleural furrows very weakly impressed; pygidial border very narrow and flat.

Remarks.—This species is characterized by a pair of strongly divergent, short furrows on the frontal area, with a moderately convex preglabellar boss, librigenae with a moderately long genal spine directed posteriorly to posterolaterally at about 15–30° to the sagittal line, conical glabella with short, faint glabellar furrows, and a rhombic pygidium, with a relatively broad longer axis. In the general configuration of the cranidium and glabella, this species is quite similar to the type species, *Wongia triangulata* but differs from the latter mainly by its shorter genal spine directed at a different angle. The cranidium has a less convex preglabellar boss, defined by a pair of shorter strongly divergent furrows on the frontal area; it also shows a conical to subconical glabella, shorter palpebral lobes located between the middle and anterior portion of glabella, and the posterior branches of the facial sutures gently bending backwards near proximal end of posterior border furrow, posterior border gently convex, about 0.6–0.7 times as wide as glabella at the base, without intergenal angle.

Stratigraphic and geographic range.—*Damesella paronai–Teinistion typicalis* Zone of the Kushan Formation, Guzhangian, Miaolignian, Cambrian; Jiulongshan and Julinshan sections, Shandong, China.

Wongia subcylindrica (Chu, 1959)

Fig. 4.

1959 *Lorenzella subcylindriica*; Chu 1959: 60, 98, pl. 2: 11–13.
1960 *Cyclolorenzella subcylindrica* (Chu); Kobayashi 1960: 389.
1965 *Cyclolorenzella subcylindrica* (Chu); Lu et al. 1965: 254, pl. 43: 8, 9.
2008 *Jiulongshania subcylindrica* (Chu), Park et al. 2008: 256.
2008 *Cyclolorenzella longispina* (Wittke & Zhu in Zhu and Wittke); Yang 2008: 107–109, [non pl.13: 26–28], pl. 14: 4, 8, 10, 11, 12, 14–17, 20, 21, [non figs. 1–3, 5–7, 9, 13, 18, 19], pl. 15: 14, 21, 24, 33, [non figs. 1–13, 15–20, 22, 23, 25–32, 34, 35].
2008 *Jiulongshania longispina* (Wittke & Zhu in Zhu and Wittke); Park et al. 2008: 260, fig. 7A–K, L–N, [non fig. 7O–Q].
2012 *Jiulongshania subcylindrica* (Chu); Yuan et al. 2012: 369.
2017 *Wongia triangulata* Sun; Ren 2017: 111–112, pl. 18: 14, 15, [non figs. 12, 13]; pl. 42: 5.
2020 *Jiulongshania longispina* (Wittke & Zhu in Zhu and Wittke); Peng 2020: 458, pl. 203: 1, 3–5, 7, [non figs. 2, 6].

Holotype: NIGP 9456, a pygidium (Chu 1959: pl. 2: 13).

Type locality: Jiulongshan and Julinshan sections, [Yaopu (=Yaobao), Dongsanli, Tienshihfu, Penchi (=Benxi) district of Liaoning], Shandong Province, China.

Type horizon: Kushan Formation (*Blackwelderia* Zone), Guzhangian, Miaolingian, Cambrian

Material.—Five cephala, one cranidium, and three pygidia (NIGP 205930–205938), all from the type locality and horizon.

Emended diagnosis.—Cephalon with long genal spine directed laterally and slightly posteriorly, lies anterior to the genal angle, at approximately 70–80° angle to the sagittal line; cranidium inflated, trapezoidal to subquadrate, with very narrow anterior border, and with a small, weakly convex preglabellar boss, weakly defined by a pair of very short divergent furrows on frontal area, which is strongly sloping outwards; glabella convex, subcylindrical to truncated conical, with 3 pairs of very shallow lateral furrows; librigena steeply sloping outwards; palpebral lobe short, located at a level with middle of glabella. Pygidium short, broad and convex, subfusiform, axis broad and long, tapering backwards, with 5–6 axial rings, axial ring furrows very shallow; pleural field as wide as axis, with or without trasverse terrace lines, pygidial border very narrow and gently convex.

Description.—Cephalon with very long genal spine projecting laterally and slightly posteriorly at about 70–80° to the saggital line; axial furrow broad and deep; cranidium inflated, trapezoidal to subquadrate, with smaller weakly convex preglabellar boss defined by a pair of short, indistinct divergent furrows on frontal area; glabella convex, truncated conical to subcylindrical, with 3 pairs of shallow lateral furrows; anterior branches of facial sutures parallel forward or slightly divergent forward, posterior branches distinctly divergent outwards, bending inwards near a small node located at the end of the posterior border furrow, then cutting the posterior border; posterior border narrow (tr.), about 0.9 times as wide as basal glabellar width,with an obtuse intergenal angle; palbebral lobe moderately long, crescentic, located opposite to anterior potion of glabella; eye ridge faint; librigena narrow, steeply sloping outwards; occipital ring narrow (sag.) and gently convex, semi-elliptical semi-elliptical, with a small occipital node medially; occipital furrow narrow and shallow. Pygidium broad (tr.), subfusiform, acutely rounded laterally; axial furrow very shallow; axis convex, broad and long, tapering backwards, with 4–5 axial rings and a terminal piece, axial ring furrows very shallow; pleural field as wide as axis, surface smooth or covered with terrace lines on pleural areas, pleural furrows very weakly impressed; pygidial border very narrow and gently convex.

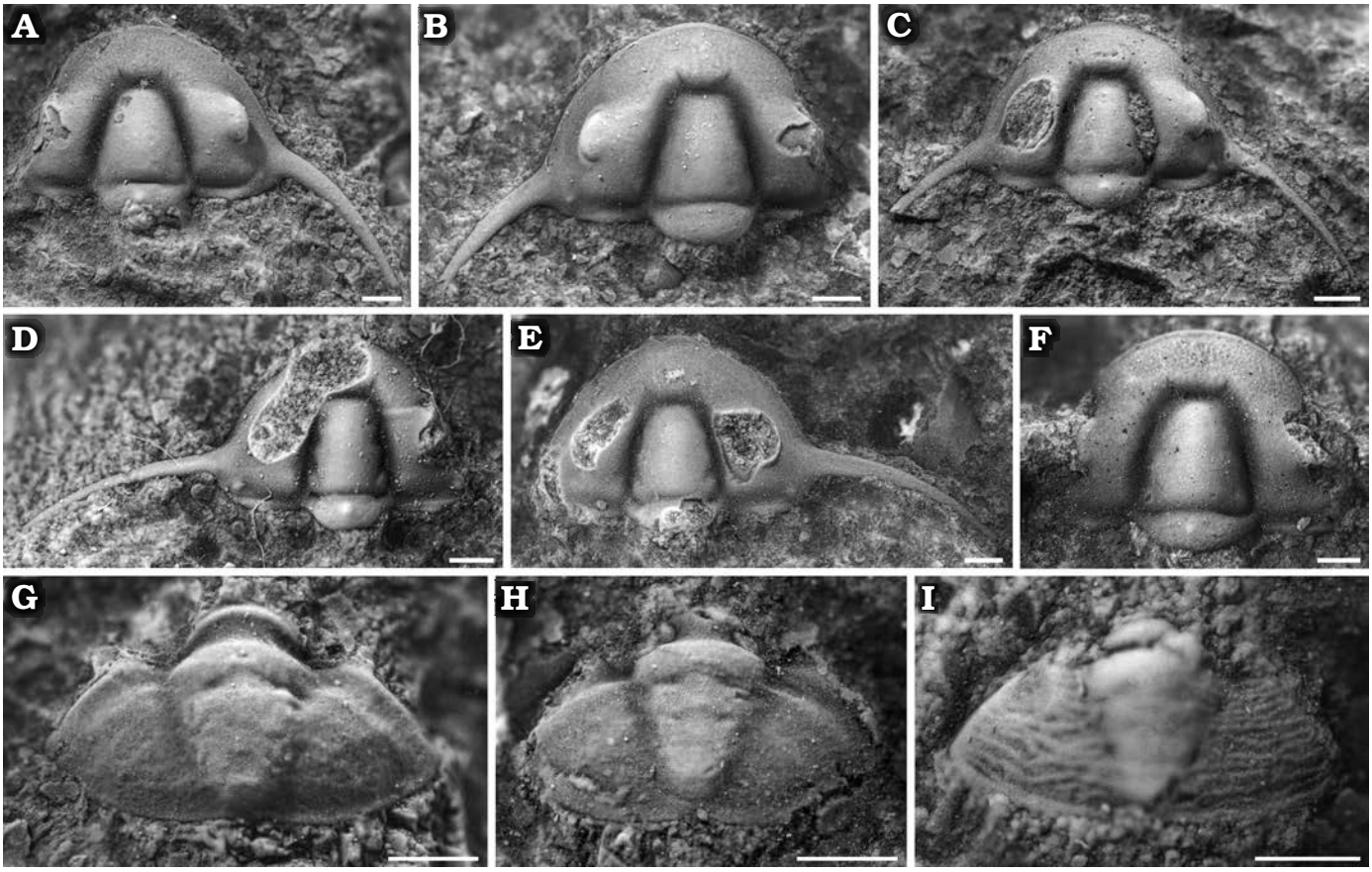

Fig. 4. Diceratocephalid trilobite *Wongia subcylindrica* (Chu, 1959) from Guangzhangian, Miaolingian (Cambrian), the Kushan Formation of China, the *Wongia subcylindrica* Zone, Jiulongshan (D, E, H) and Julinshan (A–C, F, G, I) sections, Shandong Pronvince. **A**. NIGP205930 (field no. ju-4-E11), incomplete cephalon. **B**. NIGP205931 (field no. ju-4-E6), incomplete cephalon. **C**. NIGP205932 (field no. ju-4-E9), cephalon. **D**. NIGP205936 (field no. jls-134), incomplete cephalon. **E**. NIGP2059307 (field no. jls-136), incomplete cephalon. **F**. NIGP205933 (field no. ju-4-E7), cranidium. **G**. NIGP205934 (field no. ju-4-E3), pygidium. **H**. NIGP205938 (field no. jls.136), pygidium. **I**. NIGP205935 (field no. ju-4-E5), pygidium. All in dorsal view. Scale bars: A, C–H, 500 μm; B, 1 mm; I, 200 μm.

Remarks.—In the general configuration of the cranidium and glabella, and especially the cranidium with its indistinct convex preglabellar boss (defined by a pair of short, indistinct divergent furrows on the frontal area), and the course of facial suture, this species is quite similar to *Wongia magezhuangensis* (Zhang & Wang, 1986) from the Changhia Formation at Magezhuang, Hebei, China (Zhang and Wang 1986: 406, pl. 122: 15–18). However, the latter has a narrower preglabellar field (sag.), wider anterior border, narrower fixigenae between the palpebral lobes, broader semicircular occipital ring, and a horizontal, convex eye ridge. This species can also be distinguished from *Wongia triangulata* Sun, 1924, mainly from its very faint convex preglabellar boss, the longer genal spine that projects laterally at about 70–80° to the sagittal line, and the longer, subcylindrical glabella. The strongly curved genal spine of Park's et al. (2008; Fig. 7J) cephalon is comparable to some of the specimens assigned to *W. subcyclindrica* (e.g., Fig. 4A, C). The specimen with distinct lateral glabellar furrows (e.g., Fig. 4D) matches the furrows of some specimens figured by Park et al. 2008 (e.g., Fig. 7E). The weak anterior border (e.g., Fig. 4B) is also comparable to some of Park's et al. (2008) specimens (e.g., Fig. 7M).

Stratigraphic and geographic range.—*Wongia subcylindrica* Zone of the Kushan Formation, Guzhangian, Miaolingian, Cambrian; Jiulongshan and Julinshan sections, Shandong, China.

Wongia rotundata (Resser & Endo in Endo and Resser, 1937)

Fig. 5.

1937 *Lorenzella rotundata* Resser & Endo; Endo and Resser 1937: 232, pl. 46: 4–6; pl. 61: 9, 10 (only cranidia), [non fig. 11].
1957 *Lorenzella parabola*; Lu 1957: 272, pl. 142: 14.
1959 *Lorenzella parabola* Lu; Chu 1959: pl. 1: 35; pl. 2: 1–5.
1959 *Lorenzella yentaiensis*; Chu 1959: 60, 61, pl. 2: 9, 10.
1960 *Cyclolorenzella rotundata* (Resser & Endo); Kobayashi 1960: 389.
1960 *Cyclolorenzella parabola* (Lu); Kobayashi 1960: 389.
1963 *Cyclolorenzella parabola* (Lu); Lu et al. 1963: 91, pl. 11: 11.
1965 *Cyclolorenzella rotundata* (Resser & Endo); Lu et al. 1965: 253, 254, pl. 43: 5 (only cranidium), 7, [non. fig. 6].
1965 *Cyclolorenzella parabola*; Lu et al. 1965: 252, 253, pl. 43: 1–4.
1965 *Cyclolorenzella yentaiensis* (Chu); Lu et al. 1965: 254, pl. 43: 10, 11.
1976 *Cyclolorenzella parabola*; Nan 1976: 336, pl. 196: 9–11.
1983 *Cyclolorenzella parabola*; Qiu et al. 1983: 126, pl. 41: 1.

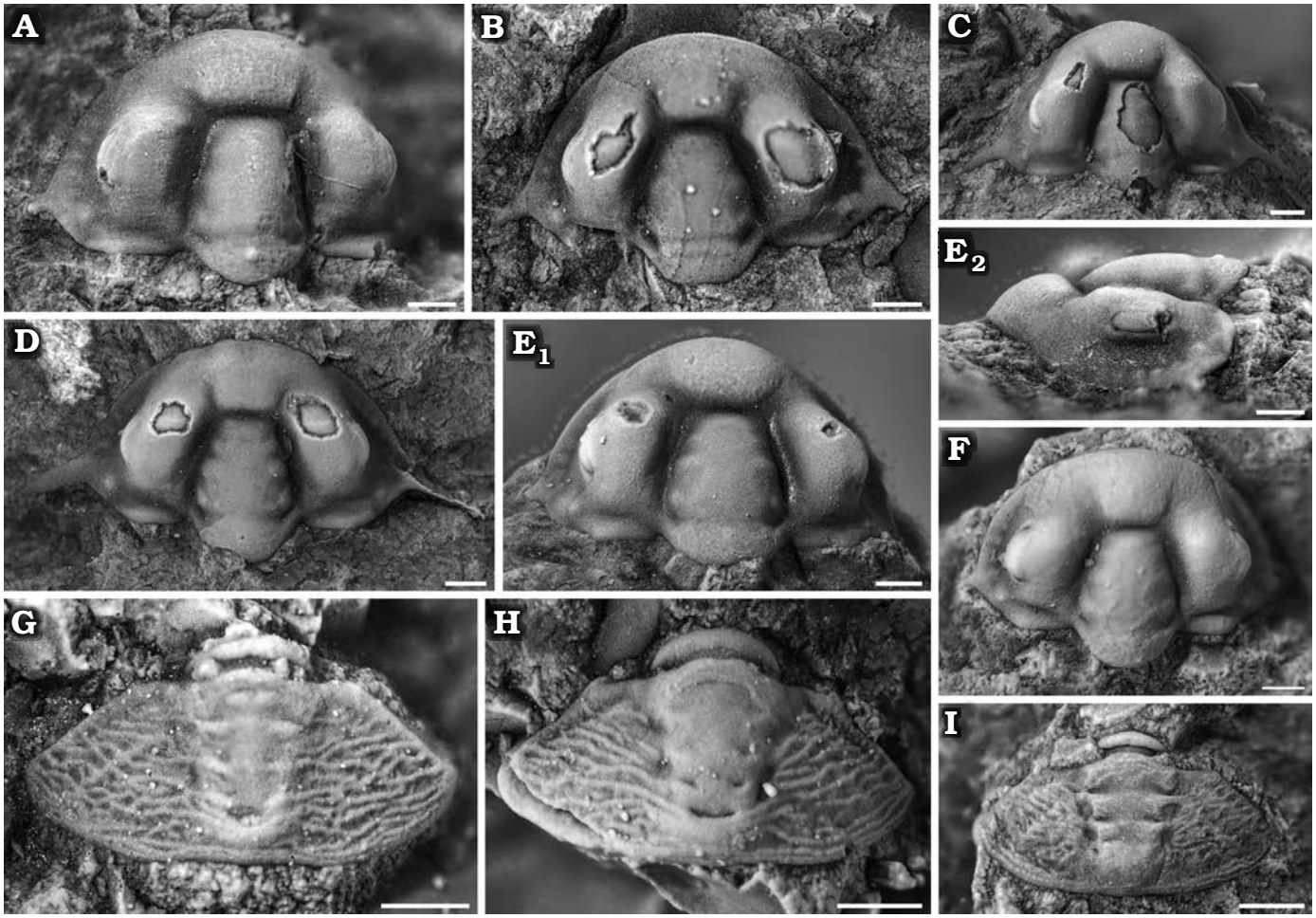

Fig. 5. Diceratocephalid trilobite *Wongia rotundata* (Resser & Endo in Endo and Resser, 1937) from Guangzhangian, Miaolingian (Cambrian), the Kushan Formation of China, the *Wongia rotundata* Zone, Julinshan section, Shandong Pronvince (B–D, G, H) and Baijiashan section, Dalian, Liaoning Pronvince (A, E, F, I). **A**. NIGP205939 (field no. BJS-C21), cephalon in dorsal view. **B**. NIGP205943 (field no. Ju-2-1.6m), cephalon in dorsal view. **C**. NIGP205944 (field no. Ju-2-1.6m), cephalon in dorsal view. **D**. NIGP205945 (field no. Ju-2-1.6m), cephalon in dorsal view. **E**. NIGP205940 (field no. BJS-C25), cephalon in dorsal (E_1) and lateral (E_2) views. **F**. NIGP205941 (field no. BJS-C27), cephalon in dorsal view. **G**. NIGP205946 (field no. Ju-2-1.6m), pygidium in dorsal view. **H**. NIGP205947 (field no. Ju-2-1.6m), pygidium in dorsal view. **I**. NIGP205942 (field no. BJS C37), pygidium in dorsal view. Scale bars: A–C, E–I, 500 μm; D, 1 mm.

1986 *Cyclolorenzella parabola*; Zhang and Wang 1986: 405, pl. 122: 7–9.

1986 *Cyclolorenzella matoshanensis*; Zhang and Wang 1986: 406, pl. 122: 10.

1986 *Cyclolorenzella parabola*; Zhang and Wang 1986: 671, pl. 1: 11–14.

1987 *Cyclolorenzella acalle* (Walcott); Zhang and Jell 1987: 132, 133, pl. 51: 5–7, [non figs. 1–4].

1989 *Cyclolorenzella parabola*; Zhu and Wittke 1989: 213, pl. 5: 1–5.

non 1991 *Cyclolorenzella parabola*; Zhang and Liu 1991: 96, pl. 1: 6–9.

?1993 *Cyclolorenzella parabola*; Zhang and Zhou 1993: 741, pl. 1: 9.

non 1995 *Cyclolorenzella yentaiensis* (Chu); Zhang et al. 1995: 78, pl. 34: 12–14.

1996 *Cyclolorenzella parabola*; Guo et al. 1996: 114, pl. 53: 1–16.

2007. *Cyclolorenzella rotundata*; Kang and Choi 2007: 291: fig. 7m–o.

2008 *Jiulongshania rotundata* (Resser & Endo in Endo and Resser); Park et al. 2008: 258–260, figs. 6A–I.

2012 *Cyclolorenzella rotundata*; Yuan et al. 2012: 369, 370, pl. 224: 11, pl. 225: 1–13, pl. 238: 8–10.

2016 *Jiulongshania rotundata* (Resser & Endo in Endo and Resser, 1937); Yuan et al. 2016: 236, 237, pl. 2: 1, 2.

2017 *Wongia rotundata* (Resser & Endo in Endo and Resser, 1937); Ren 2017: 114, 115, pl. 18: 18, 20, 21, [non fig. 19].

2020 *Jiulongshania rotundata* (Resser & Endo in Endo and Resser, 1937); Peng 2020: 456, pl. 202: 15–20.

Lectotype: USNM 86842b, cranidium (Endo and Resser 1937: pl. 46: 5; Zhang and Jell 1987: pl. 51: 6), selected as the lectotype by Park et al. (2008) from the of the Kushan Formation, at the Shuangmiaozi, 12.5 km east of Liaoyang, Liaoning Province, China.

Type locality: Shuangmiaozi section, 12.5 km east of Liaoyang, Liaoning Province, China.

Type horizon: Kushan Formation (*Blackwelderia* Zone), Guzhangian, Miaolingian, Cambrian.

Material.—Six cephala and three pygidia (NIGP 205939–205947), all from Kushan Formation (Guangzhangia), Shandong Province, China..

Emended diagnosis.—Cephalon moderately vaulted, with short genal spine projecting laterally and slightly posteriorly,

at approximately 70° angle to the sagittal line; cranidium inflated, subtrapezoidal, with broad well-rounded anterior margin, with larger convex elliptical preglabellar boss distinctly defined by a pair of divergent furrows on broader frontal area; glabella wide, convex, truncated conical, with 3 pairs of very shallow lateral furrows; palpebral lobe moderately long, about 0.5 times as long as glabella; anterior branches of facial suture gently convergent forward from palpebral lobes, posterior branches short, slightly slanting outwards, then bending inwards near a small node at the end of posterior border furrow; librigena flat, gently sloping outwards, with 3–5 tubercles on lateral border posteriorly. Pygidium short and convex, fusiform, axis tapering backwards, with 4 axial rings and a terminal piece, surface covered with transverse terrace lines on pleural field, pygidial border very narrow and flat.

Description.—Cephalon moderately vaulted, with very short genal spine projecting laterally and slightly posteriorly at approximately 70° single to the sagittal line; axial furrow broad and deep; cranidium inflated, subtrapezoidal, with broad well-rounded anterior margin, with larger convex elliptical preglabellar boss distinctly defined by a pair of divergent furrows on broader frontal area; glabella wide, convex, truncated conical, with 3 pairs of very shallow lateral furrows; palpebral lobe moderately long, about 0.5 times as long as glabella; anterior branches of facial suture gently convergent forward from palpebral lobes, posterior branches short, slightly slanting outwards, then bending inwards near a small node at the end of posterior border furrow; posterior border gently convex, about 0.8 times as wide as basal glabellar width, with an obtuse intergenal angle; posterior border furrow shallow, slightly bending forward distally; librigena flat, gently sloping outwards, with 3–5 tubercles on lateral border posteriorly; occipital ring semi-elliptical, with a small occipital node anteriorly; occipital furrow very shallow medially, slghtly deeper laterally. Pygidium rhombic, acutely rounded laterally; axial furrow very shallow; axis convex, broad and long, tapering backwards, with 4 axial rings and a terminal piece, axial ring furrows very shallow, disconnected from axial furrow; pleural field as wide as axis, surface covered with strongly impressed transverse terrace lines; pleural furrows very weakly impressed; pygidial border very narrow and gently convex.

Remarks.—The narrow anterior border, and the course of the facial suture make this species most similar to *Wongia regularis regularis* (Walcott, 1906); however, the latter has a wider and more vaulted cranidium, with broader fixigenae; a shorter palpebral lobe located anteriorly; more distinct, nearly horizontal eye ridges; libigenae without a genal spine and without 3–5 tubercles on lateral border posteriorly, and an occipital ring with a larger tubercule or a short occipital spine.

Stratigraphic and geographic range.—*Wongia rotundata* Zone of the Kushan Formation, Guzhangian, Miaolingian, Cambrian; Julinshan section, Shandong; Baijiashan section, Liaoning, China.

Wongia regularis (Walcott, 1906)

Remarks.—*Wongia regularis* and *Wongia pustulosa* (Chu, 1959) share characteristics that include a strongly vaulted cephalon without a genal spine, a very short palpebral lobe located at anteriorly, and a nearly horizontal eye ridge. Consequently, *W. pustulosa* has been suppressed as a synonym of *W. regularis* by both Park et al. (2008) and Peng (2020). Park et al. (2008) assumed that these two species have the same granulose ornament on cranidium. However, the holotype cranidium of *W. regularis* has smooth surface (e.g., Zhang and Jell 1987: pl. 51: 8). Therefore, two subspecies are recognized, with *Wongia regularis pustulosa* differing in having a semicircular cephalon with an obtuse genal angle, a wider (tr.), less convex palpebral lobe, a wider (tr.) pygidium and distinct granules on the surface of the cephalon. This subspecies is a little younger than *Wongia regularis regularis.*

Stratigraphic and geographic range.—*Wongia rotundata* Zone of the Kushan Formation, Guzhangian, Miaolingian, Cambrian; Julinshan section, Shandong; Baijiashan section, Liaoning, China.

Wongia regularis regularis (Walcott, 1906)

Fig. 6.

1906 *Agraulos regularis* Walcott 1906: 578.
1913 *Inouyia*? *regularis* (Walcott); Walcott 1913: 154, pl. 14: 18.
1960 *Latilorenzella regularis* (Walcott); Kobayashi 1960: 390.
1965 *Cyclolorenzella regularis* (Walcott); Lu et al. 1965: p. 253, pl. 42: 25, 26.
1986a *Cyclolorenzella* sp.; Zhang and Liu 1986: 14, pl. 1: 3, 4.
1987 *Cyclolorenzella regularis* (Walcott); Zhang and Jell 1987: 133, pl. 51: 8, 9.
1991 *Cyclolorenzella parabola* (Lu); Zhang and Liu 1991: 96, pl. 1: 6–9.
1995 *Cyclolorenzella yentaiensis* (Chu); Zhang et al. 1995: 78, pl. 34: 12–14.
2008 *Cyclolorenzella regularis* (Walcott); Yang 2008: 103, 104, pl. 17: 2–6, [non figs. 1, 7–25].
non 2008 *Jiulongshania regularis* (Walcott, 1906); Park et al. 2008: 260–263, fig. 9A?, B–H.

Holotype: USNM 58028, cranidium (Walcott 1913: pl. 14: 18; Zhang and Jell 1987: pl. 51: 8).

Type locality: 6.4 km east of Fanglanzhen, Shanxi Province, China.

Type horizon: Kushan Formation (*Blackwelderia* Zone), Guzhangian, Miaolingian, Cambrian.

Material.—Four cephala and three pygidia (NIGP 205948–205954), all from Kushan Formation (Guangzhangia), Shandong Province, China.

Emended diagnosis.—Cephalon strongly vaulted, semi-elliptical, without genal spines, genal angle well rounded; cranidium wide, subquadrate, slightly wider than long, with a gently convex preglabellar boss defined by a pair of short distinct divergent furrows on frontal area, anterior border narrow, strongly sloping outwards; glabella short and convex, truncated conical; occipital ring with a large occipital node or very short occipital spine; fixigenae slightly wider than glabella between palpebral lobes; palpebral lobe short, crescentic, located opposite to anterior glabella, about

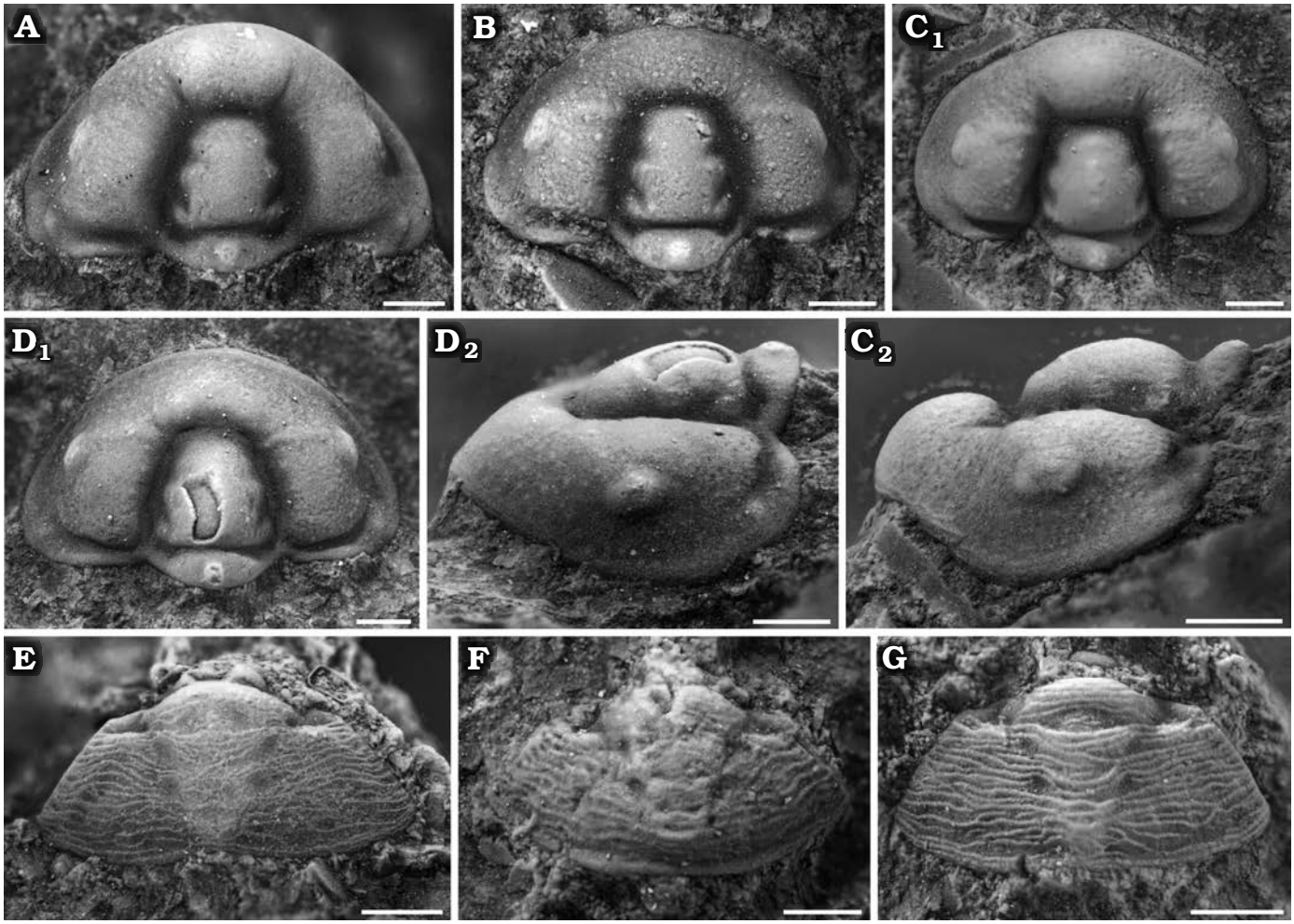

Fig. 6. Diceratocephalid trilobite *Wongia regularis regularis* (Walcott, 1906) from Guangzhangian, Miaolingian (Cambrian), the Kushan Formation of China, the *Wongia regularis* Zone, Julinshan (A–G, I) and Jiulongshan (H) sections, Shandong Pronvince. **A**. NIGP205948 (field no. Ju-4-F6-1), cephalon in dorsal view. **B**. NIGP205949 (field no. Ju-4-F6-1), cephalon in dorsal view. **C**. NIGP205950 (field no. Ju-4-F6-1), cephalon in dorsal (C_1) and lateral (C_2) views. **D**. NIGP205951 (field no. Ju-4-F6-1), cephalon in dorsal (D_1) and lateral (D_2) views. **E**. NIGP205952 (field no. Ju-4-F6-1), pygidium in dorsal view. **F**. NIGP205952 (field no. Ju-4-F6-1), pygidium in dorsal view. **G**. NIGP205953 (field no. Ju-4-F6-1), pygidium in dorsal view. All in dorsal view. Scale bars 500 μm.

0.25–0.3 times as long as glabella; eye ridge slightly curved forwads; anterior branches of facial suture parallel or gently convergent forward from palpebral lobe, posterior branches slanting backwards, bending inwards near a node (metafixigenal node) at the end of the posterior border furrow, then slanting inwards; posterior border gently convex, sharply narrowing and bending forwards distally, 0.8 times as wide as basal glabellar width, with an obtuse intergenal angle; posterior border furrow distinct, shallowing and bending forward distally; surface smooth; relatively short subfusiform to rhombic pygidium acutely rounded laterally, with dense trasverse terrace lines.

Description.—Cephalon strongly vaulted, semi-elliptical in outline, without genal spine, genal angle well rounded; cranidium wide, subquadrate, slightly wider than long, with a gently convex preglabellar boss defined by a pair of short distinct divergent furrows on frontal area; anterior border narrow, strongly sloping outwards, covered with 3–6 terrace lines; glabella short and convex, truncated conical, with 3 pairs of very shallow lateral furrows, of which S1 is incised; palpebral lobe short and convex, crescentic, located at anteriorly, about 0.25–0.3 times as long as glabella; eye ridge slightly curved forwads; occipital ring with a large occipital node or very short occipital spine; cranidium wide and convex, subquadrate, slightly wider than long, with a gently convex preglabellar boss defined by a pair of short divergent furrows on the frontal area, and with a narrow, strongly sloping outwards anterior border covered with 3–6 terrace lines; glabella short and convex, truncated conical, with 3 pairs of very shallow lateral furrows, of which S1 is incised; occipital ring with a large occipital node or very short occipital spine; occipital fuurow wider and deep; fixigenae slightly wider than glabella between palpebral lobes; palpebral lobe short, crescentic, located opposite to anterior glabella, about 0.25–0.3 times as long as glabella; eye ridge slightly curved forwads; anterior branches of facial suture parallel or gently convergent forward from palpebral lobe,

posterior branches slanting backwards, bending inwards near a node (metafixigenal node) at the end of the posterior border furrow, then slanting inwards; posterior border gently convex, sharply narrowing and bending forwards distally, 0.8 times as wide as basal glabellar width, with an obtuse intergenal angle; posterior border furrow distinct, shallowing and bending forward distally; librigena very narrow, sloping outwards. Pygidium short and convex, subfusiform to rhombic, acutely rounded laterally, axis broad and long, tapering backwards, with 3–5 axial rings; pleural field as wide as axis, surface covered with denser transverse terrace lines; pygidial border very narrow and flat.

Stratigraphic and geographic range.—*Wongia regularis* Zone of the Kushan Formation, Guzhangian, Miaolignian, Cambrian; Jiulongshan and Julinshan sections, Shandong, China.

Wongia regularis pustulosa (Chu, 1959)

Fig. 7.

1959 *Lorenzella pustulosa*; Chu 1959: 98, pl. 2: 6–8.
1960 *Cyclolorenzella pustulosa* (Chu); Kobayashi 1960: 389.
1960 *Latilorenzella regularis* (Walcott); Kobayashi 1960: 390.
1965 *Cyclolorenzella pustulosa* (Chu); Lu et al. 1965: 253, pl. 42: 23, 24.
1965 *Cyclolorenzella regularis* (Walcott); Lu et al. 1965: 253, pl. 42: 25, 26.
1986a *Cyclolorenzella* sp.; Zhang and Liu 1986: 14, pl. 1: 3, 4.
1987 *Cyclolorenzella regularis* (Walcott); Zhang and Jell 1987: 133, pl. 51: 8, 9.
1991 *Cyclolorenzella parabola* (Lu); Zhang and Liu 1991: 96, pl. 1: 6–9.
1995 *Cyclolorenzella yentaiensis* (Chu); Zhang et al. 1995: 78, pl. 34: 12–14.
non1996 *Cyclolorenzella regularis* (Walcott); Guo et al. 1996: 115, pl. 59: 17, 18.
2003 *Cyclolorenzella regularis* (Walcott); Hong et al. 2003: 901.
2008 *Cyclolorenzella regularis* (Walcott); Yang 2008: 103, pl. 17: 1, 7–25, [non figs. 2–6].
2008 *Jiulongshania regularis* (Walcott); Park et al. 2008: 260–263, fig. 9A?, B–H.
2009 *Jiulongshania regularis* (Walcott), Park et al. 2009: 121, fig. 3.1–3.10.
2010 *Jiulongshania regularis* (Walcott); Park et al. 2010: 176, fig. 3.6–3.8.
2013 *Jiulongshania regularis* (Walcott); Park et al. 2013: 998, 999, fig. 5.18–5.32.
2017 *Wongia regularis* (Walcott); Ren 2017: 115, 116, pl. 18: 16, 17; pl. 42: 6–13.
2020 *Jiulongshania regularis* (Walcott); Peng 2020: 458, pl. 203: 8–12.

Holotype: NIGP9451, cranidium (Chu, 1959: pl. 2: 8).

Type locality: Tangshiling village, Liaoyang County, Laioning Province, China.

Type horizon: Kushan Formation *Blackwelderia* Zone Guzhangian, Miaolingian, Cambrian.

Material.—Four cephala, one cranidium, and one pygidium (NIGP205955–205960), all from Kushan Formation (Guangzhangia), Shandong Province, China.

Diagnosis.—Cephalon strongly convex, with acutal rounded genal angle; cranidium subtrapezoidal in outline, slightly wider than long, with a gently convex preglabellar swelling boss defined by a pair of more or less short divergent furrows on frontal area; short and convex, truncated conical

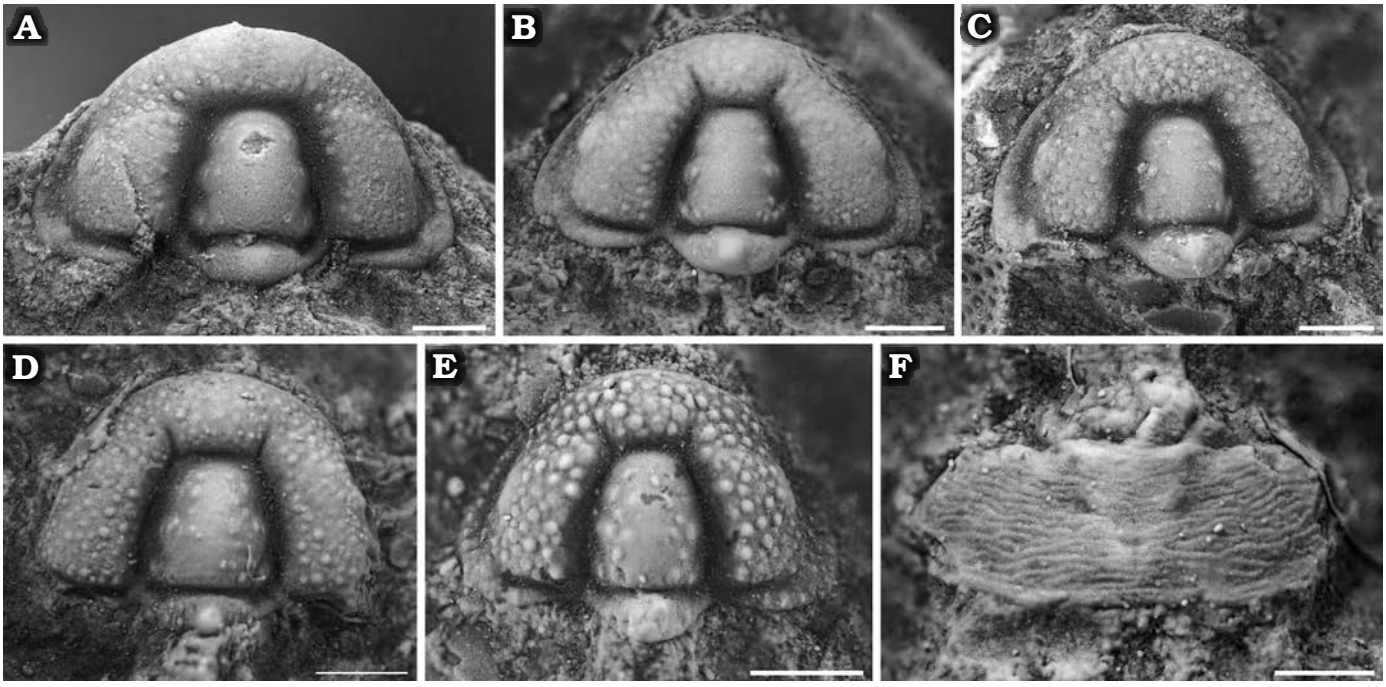

Fig. 7. Diceratocephalid trilobite *Wongia regularis pustulosa* (Chu, 1959) from Guangzhangian, Miaolingian (Cambrian), the Kushan Formation of China, the *Wongia regularis* Zone, Julinshan (A–C, E, F) and Jiulongshan (D) sections, Shandong Pronvince. **A**. NIGP205955 (field no. Ju-3-R19), cephalon. **B**. NIGP205956 (field no. Ju-3-R24), cephalon. **C**. NIGP205957 (field no. Ju-3-R19), cephalon. **D**. NIGP205960 (field no. Jls-140), cephalon. **E**. NIGP205955 (field no. Ju-4-F6-1), cephalon. **F**., NIGP205959 (field no. Ju-3-R19), pygidium. All in dorsal view. Scale bars: A–D, F, 500 μm; E, 200 μm.

glabella; occipital ring with a larger occipital node; surface with tuberculate ornament; wider (tr.) and shorter (sag.) subfusiformis pygidium acutely rounded laterally, with dense trasversal terrace lines.

Description.—Cephalon strongly vaulted, semicircular in outline, librigena very narrow, sloping outwards, absence of genal spines, with acutal rounded genal angle; cranidium wide and vaulted, subtrapezoidal, slightly wider than long, with a moderately convex preglabellar boss defined by a pair of short divergent furrows on frontal area, and with a narrow, strongly outward-sloping anterior border; axial furrow deep and broad; glabella short, truncated conical, with 3 pairs of shallow lateral furrows, of which S1 is incised, S2 and S3 short and faint; occipital ring short (sag.), with a large occipital node; occipital furrow deep, bending forward distally; fixigenae wider, about 1.1–1.2 times as wide as glabella between palpebral lobes; palpebral lobe short, about 0.25–0.3 times as long as glabella, crescentic, located anteriorly; eye ridge low, nearly horizontal; anterior branches of facial sutures short, slightly convergent forwards, posterior branches long, gently divergent outwards, bending near a node located at the end of posterior border furrow, then slanting inwards, posterior border narrow (sag.), gently convex, slightly widening outwards, sharply narrowing and bending forwards diatally, with an obtuse intergenal angle; posterior border furrow deep, bending forward distally; surface with fine dense granules or postulose. Pygidium wider (tr.) and shorter (sag.), subfusiform to rhombic, acutely rounded laterally, axis broad and long, tapering backwards, with 3–5 axial rings; axial furrow very shallow; pleural field as wide as axis, surface covered with denser transverse terrace lines and fine granules; pygidial border very narrow and flat.

Stratigraphic and geographic range.—*Wongia regularis* Zone of the Kushan Formation, Guzhangian, Miaolingian, Cambrian; Jiulongshan and Julinshan sections, Shandong, China.

Wongia valida (Nan & Chang, 1985)

Fig. 8A–I.

1985 *Cyclolorenzella valida*; Nan and Chang 1985: 12, pl. 1: 20, 21.
1996 *Cyclolorenzella acalle* (Walcott); Guo et al. 1996: 114, pl. 59: 12–15, [non. fig. 16].

Holotype: SG030200 (Xn7), cranidium (Nan and Chang 1985: pl. 1: 21).

Type locality: Xishan, Fuzhouwan, Dalian, Liaoning Province, China.

Type horizon: Changhia Formation (*Damesella* Zone), Guzhangian, Miaolingian, Cambrian.

Material.—An incomplete cephalon, seven cranidia, and one pygidium (NIGP 205961–205969), all from Kushan Formation (Guangzhangia), Shandong Province, China.

Emended diagnosis.—Cephalon gently vaulted, long semi-elliptical in outline with short and broad genal spine directed posterolaterally at approximately 45–50° to the sagittal line; cranidium short and broad, subquadrate, with wide well rounded anterior margin; preglabellar field broad (sag.), preglabellar boss indistinct; glabella short, conical, subconical, glabellar length the same as the width as the base; occipital ring wide and long, semi-circular to semi-elliptical, slightly shorter than glabellar length, with a smaller occipital node medially; occipital furrow shallow; fixigenae slightly wider than glabella between palpebral lobes; posterior border (tr.) as wide as glabella at the base. Pygidium rhombic, anterior margin short, transverse, lateral margin long, strongly slanting backwards, acutely rounded laterally; prosopon of fine irregular wrinkles on the surface of preglabellar field and occipital ring.

Description.—Cephalon gently vaulted, broad (tr.), with short genal spine directed laterally and slightly posteriorly, at about 45–50° to the sagittal line; axial furrow deep and broad; cranidium subquadrate, with wide well rounded anterior margin, anterior border and border furrow indistinct, preglabellar field broad (sag.), as long as glabella, gently convex, with indistinct preglabellar boss, without a pair of divergent furrows on frontal area; glabella relatively short, conical, subconical, lateral glabellar furrows obscure or absent; occipital ring wide and long, semicircular to semi-elliptical, slightly shorter than glabellar length; occipital furrow very shallow and narrow; fixigenae slightly wider than glabella between palpebral lobes; palpebral lobe short, about 0.3 times as long as glabella, located at a level in front of middle point of glabella; eye ridge faint, transverse; opisthoparian facial suture, anterior branch of facial sutures parallel or slightly divergent forward from palpebral lobe, posterior branch of facial suture strongly divergent backwards from palpebral lobe, then gently bending outside of posterior border furrow, then slanting inward; posterior border gently convex, as wide as glabella at the base, with an obtuse intergenal angle; posterir border furrow shallow. Pygidium wide (tr.) and short (sag.), rhombic; anterior margin short, transverse; lateral margin long, strongly slanting backwards, acutely rounded laterally; posterior margin very broad; pygidial border very narrow; pygidial axis long, strongly tapering backwards, almost reaching posterior margin, with 4 axial rings, axial ring furrows very shallow; prosopon of fine irregular wrinkles on the surface of preglabellar field and occipital ring.

Remarks.—In general configuration of cranidium, especially with indistinct preglabellar boss on frontal area, this species is quite similar to *Wongia subcylindrica*. However, it differs from the latter mainly in having a shorter conical glabella, much longer (sag.) occipital ring, shallower occipital furrow, wider gently convex librigena with very short and wider genal spine, much shorter (sag.), wider (tr.) pygidium.

Stratigraphic and geographic range.—*Damesella paronai–Ajacicrepida ajax* Zone of the Changhia Formation; Guzhangian, Miaoligian, Cambrian; Julinshan and southern Nanzhaocun section, Shandong, China.

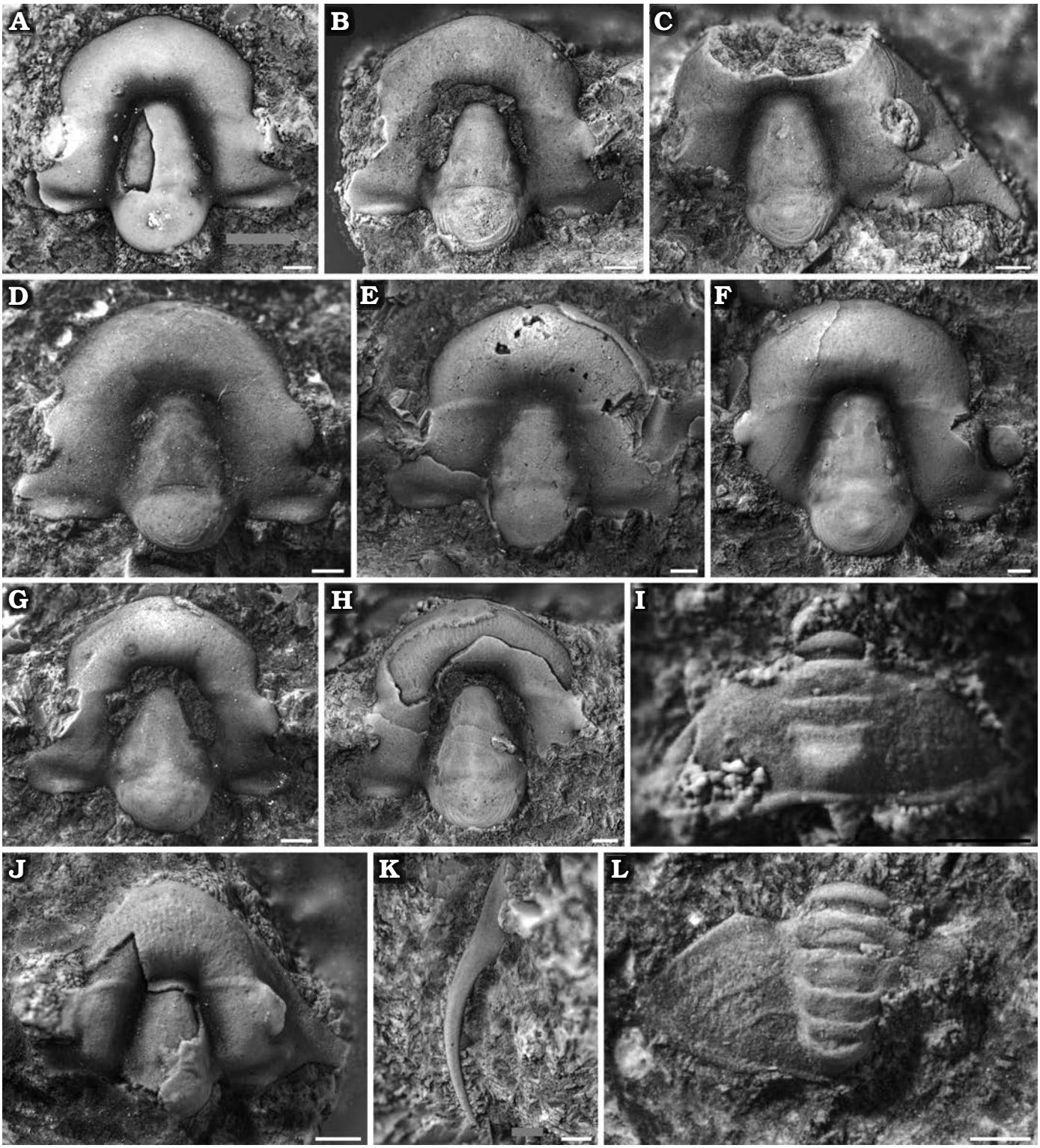

Fig. 8. Diceratocephalid trilobites *Wongia valida* (Nan & Chang, 1985) (A–I) and *Wongia* sp. (J–L) from Guangzhangian, Miaolingian (Cambrian), the Changhia Formation of China, the *Damesella paronai–Ajacicrepida ajax* Zone, southern Nanzhaocun (A, D–G, I, J, L) and Julinshan (B, C, H, K) sections, Shandong Pronvince. **A**. NIGP205961 (field no. NZC-S1-2-1), cranidium. **B**. NIGP205967 (field no. Ju-2-A2-3), cranidium. **C**. NIGP205968 (field no. Ju-2-A2-3), incomplete cephalon. **D**. NIGP205962 (field no. NZC-S1-2-1), cranidium. **E**. NIGP205963 (field no. NZC-S1-2-1), cranidium. **F**. NIGP205964 (field no. NZCS1-2-1), cranidium. **G**. NIGP205965 (field no. NZC-S1-2-1), cranidium. **H**. NIGP205969 (field no. Ju-2-A2-3), cranidium. **I**. NIGP205966 (field no. NZC-S1-2-1), pygidium. **J**. NIGP205970 (field no. NZCS1-2-1), cranidium. **K**. NIGP205972 (field no. Ju-2-A2-3), librigena. **L**. NIGP205971 (field no. NZCS1-2-1), pygidium. All in dorsal view. Scale bars 500 μm.

Wongia sp.

Fig. 8J–L.

Material.—An incomplete cephalon, one librigena, and one pygidium (NIGP 205970–2059972) from *Damesella paronai–Ajacicrepida ajax* Zone, Changhia Fomation, Guzhangian, Miaoligian, Cambrian, Nanzhaocun section, Shandong Province, China.

Description.—Cephalon moderately vaulted, with moderately long genal spine; axial furrow deep; cranidium inflated, triangular; preglabellar field broad (sag.), strongly bending forward, slightly wider than glabellar length; anterior border narrow, sloping outwards; glabella short, truncated conical; posterior border slightly narrower (tr.) than the basal glabellar width, with an obtuse intergenal angle; posterior border furrow shallow; palbebral lobe longer, about 0.5–0.6 times as long as glabellar length, crescentic; eye ridge convex, horizontal; occipital ring semi-elliptical; occipital furrow very shallow; librigena narrow, strongly sloping outwards. Pygidium rhombic, acutely rounded laterally; axial furrow very shallow; axis convex, broad and long, tapering backwards, with 4 axial rings and a terminal piece, axial ring furrows distinct, disconnected with axial furrow; pleural field as wide as axis, surface smooth, pleural furrows very weakly impressed; pygidial border very narrow and flat.

Remarks.—The cephalon of specimens has a relatively long genal spine directed laterally, *Wongia* sp. is quite similar to *W. subcylindrica*; however, it differs from the latter mainly in having a triangular cranidium with longer pregalbellar area, a shorter, more slender glabella, a broader (sag.) occipital ring, a longer palpebral lobe and convex eye ridges. In general configuration of the cranidium, notably the longer frontal area, *Wongia* sp. bears the closest resemblance to *W. longa* (Park, Han, Bai & Choi, 2008) (Park et al. 2008: 263–265, fig. 10A–K), from the lowermost Kushan Formation at Jiulongshan, Shandong; however, it can be distinguished from the latter mainly by its shorter, truncated conical glabella, triangular cranidium with longer frontal area (sag.), and the longer palpebral lobe.

Wongia nanzhaocunensis Yuan sp. nov.

Fig. 9.

Zoobank LSID: urn:lsid:zoobank.org:act:F3FCCD0A-6952-4504-A4EF-9F0ACBA613B5

Etymology: After Nanzhaocun, a village of Linqu County, Shandong, where the new species occurs.

Type material: Holotype: NIGP205979, cephalon (Fig. 9G). Paratypes: two cephala (NIGP 205973, 205974), Fig. 9A, B; 4 cranidia (NIGP 205975–205978), Fig. 9C–F; one pygidium (NIGP 205980) Fig. 9H.

Type locality: Northern Nanzhaocun village, 0.5 km east of Sitou Town, Linqu County, Shandong Province, China.

Type horizon: Changhia Formation (*Damesella paronai–Ajacicrepida ajax* Zone), Miaolingian, Guzhangian, Cambrian.

Material.—Type material only.

Diagnosis.—Cephalon weakly vaulted, semi-elliptical in outline, without genal spine, genal angle well rounded; preglabellar field wider (sag.), nearly as long as glabella, without a preglabellar swelling boss on preglabellar field; glabella short, conical to subconical, strongly tapering forward; occipital ring wide (tr.), semi-elliptical, with a faint occipital node posterally; fixigenae as wide as glabella between palpebral lobes; palpebral lobes short; librigena narrow and flat, with 3–5 tubercles on posterior part of lateral border. Pygidium rhombic, well-rounded laterally, axis broad and long, tapering backwards, with 3–4 axial rings; surface smooth.

Description.—Cephalon weakly vaulted, semi-elliptical, anterior margin strongly bending forward, without genal spine, genal angle well rounded; preglabellar field wide (sag.), nearly as long as glabella, without a preglabellar swelling boss on preglabellar field, with a pair of very short faint furrows that are slightly divergent forwards on preglabellar field; anterior border narrow, slightly sloping outwards; anterior border furrow shallow; glabella short, conical to subconical, strongly tapering forward, with 3 pairs of faint lateral glabellar furrows; palpebral lobes short, about 0.3 times as long as glabellar length, located at a level opposite anterior portion of glabella; occipital ring wide (tr.) and long, semi-elliptical, with a faint occipital node posterally; occipital furrow shallow medially, slightly bending forward laterally; fixigenae as wide as glabella between palpebral lobes; eye ridges nearly transverse; librigena narrow, gently sloping outwards, with 3–5 tubercles on posterior part of lateral border; lateral border narrow, gently convex; opisthoparian facial suture, anterior branch of facial suture running parallel forward or slightly convergent, posterior branch strongly slanting outwards, bending inwards near a small node (metafixigenal node) located at the end of the posterior border furrow, then strongly slantng inwards, cutting the posterior border; posterior border gently convex, slightly broadening outwards, sharply narrowing and bending forwards distally, about 0.8 times as wide as glabella at the base (tr.); posterior border with an obtuse intergenal angle; posterior border furrow shallow, bending forward distally. Pygidium rhombic, well-rounded laterally, axis broad and long, tapering backwards, with 3–4 axial rings, surface smooth.

Remarks.—In general configuration of the cephalon, especially the librigena with 3–5 tubercles on posterior part of lateral border, the new species bears some resembles to *Wongia rotundata* (Resser & Endo in Endo and Resser, 1937), however, it differs from the latter mainly in having less vaulted cephalon with well rounded genal angle, no strongly convex swelling boss on preglabellar field, shorter conical to subconical glabella, wider fixigenae between palpebral lobes, longer and wider occipital ring and narrower (sag.) and wider (tr.) pygidium. In general configuration of cephalon and cranidium, especially the librigenae with its rounded genal angle, the presence of a narrow anterior border, and the course of the facial suture, the new species bears the closest resembles to *Wongia regularis regularis*

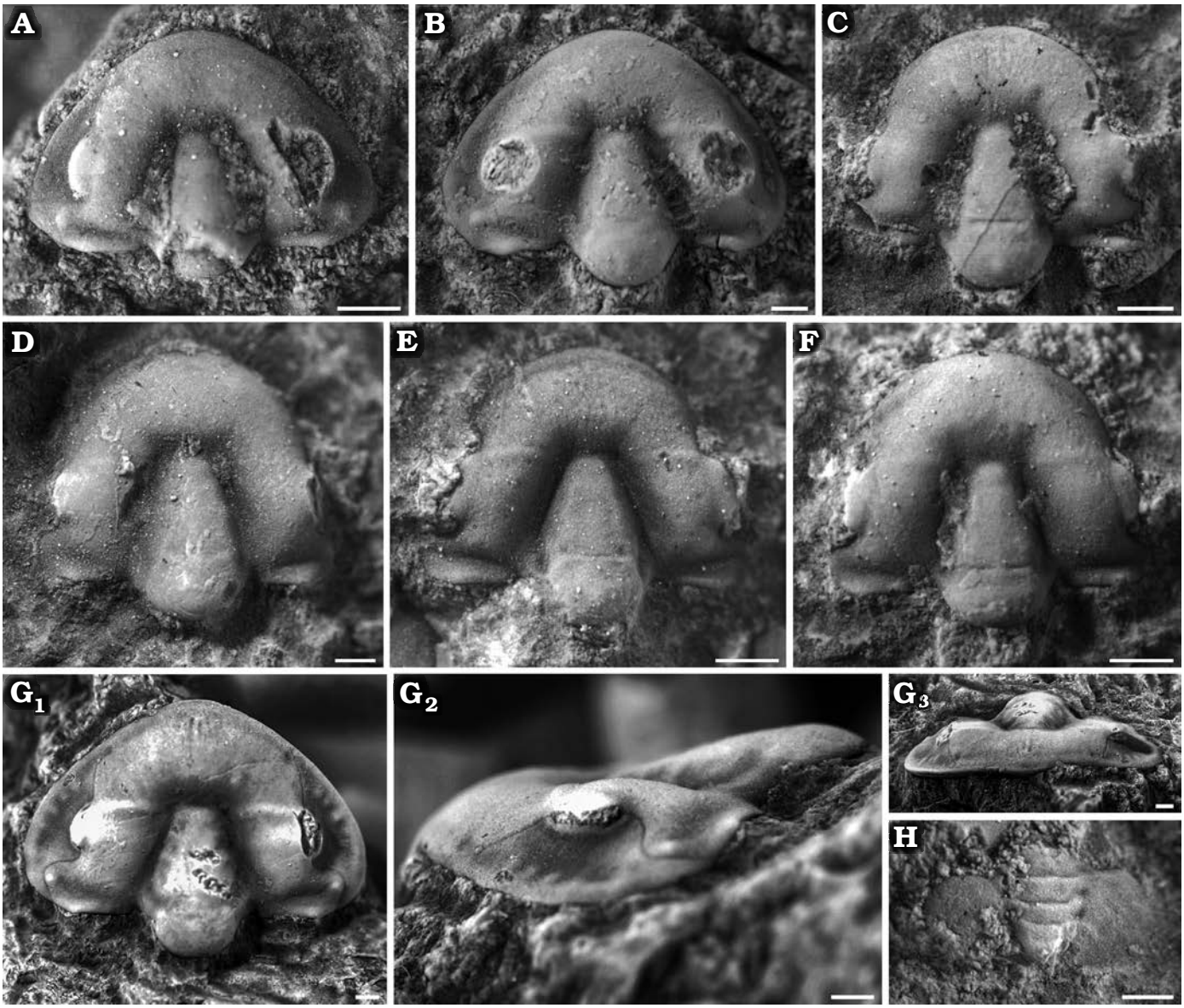

Fig. 9. Diceratocephalid trilobite *Wongia nanzhaocunensis* Yuan sp. nov. from Guangzhangian, Miaolingian (Cambrian), the Changhia Formation of China, the *Damesella paronai–Ajacicrepida ajax* Zone, northern Nanzhaocun section, Shandong Pronvince. **A**. NIGP205973 (field no. NZC-NA2), cephalon in dorsal view. **B**. NIGP205974 (field no. NZC-NA4), cephalon in dorsal view. **C**. NIGP205975 (field no. NZC-NA3), cranidium in dorsal view. **D**. NIGP205976 (field no. NZC-NA3), cranidium in dorsal view. **E**. NIGP205977 (field no. NZC-NA5), cranidium in dorsal view. **F**. NIGP205978 (field no. NZC-NA7), cranidium in dorsal view. **G**. Holotype, NIGP205979 (field no. NZC-NA1), cephalon in dorsal (G_1), lateral (G_2), and anterior (G_3) views. **H**. NIGP205980 (field no. NZC-NA8), pygidium in dorsal view. Scale bars: A, C–F, H, 500 μm; B, G, 1 mm.

(Walcott, 1906), however, it differs from *Wongia regularis regularis* chiefly in having a weakly vaulted cephalon, slender conical to subconical glabella, a broader occipital ring (sag.) without prominent occipital node or spine, no preglabellar swelling boss on the wider preglabellar field, broader fixigenae between the palpebral lobes, and librigena with 3–5 tubercles on the lateral border, and its pygidium covered without denser transverse terrace lines.

Stratigraphic and geographic range.—*Damesella paronai–Ajacicrepida ajax* Zone of the Changhia Formation, Guzhangian, Miaolingian, Cambrian; Northern Nanzhaocun section, Shandong, China.

Wongia laevigata Yuan sp. nov.

Fig. 10.

Zoobank LSID: urn:lsid:zoobank.org:act:A1155397-7127-4677-8E3E-40E15E517D5C

Etymology: From Latin *laevigata*, smooth, glossy; because of the smooth surface on cephalon of the new species.

Type material: Holotype: NIGP 205983, cephalon (Fig. 10C). Paratypes: four cephala (NIGP 205981, 205982, 205984, 205985), Fig. 10A, B, D, E; one pygidium (NIGP 205986), Fig. 10F.

Type locality: Baijiashan section, Dalian City, Liaoning Province, China

Type horizon: Kushan Formation (the lower part of *Wongia rotundata* Zone), Guzhangian, Mialingian, Cambrian.

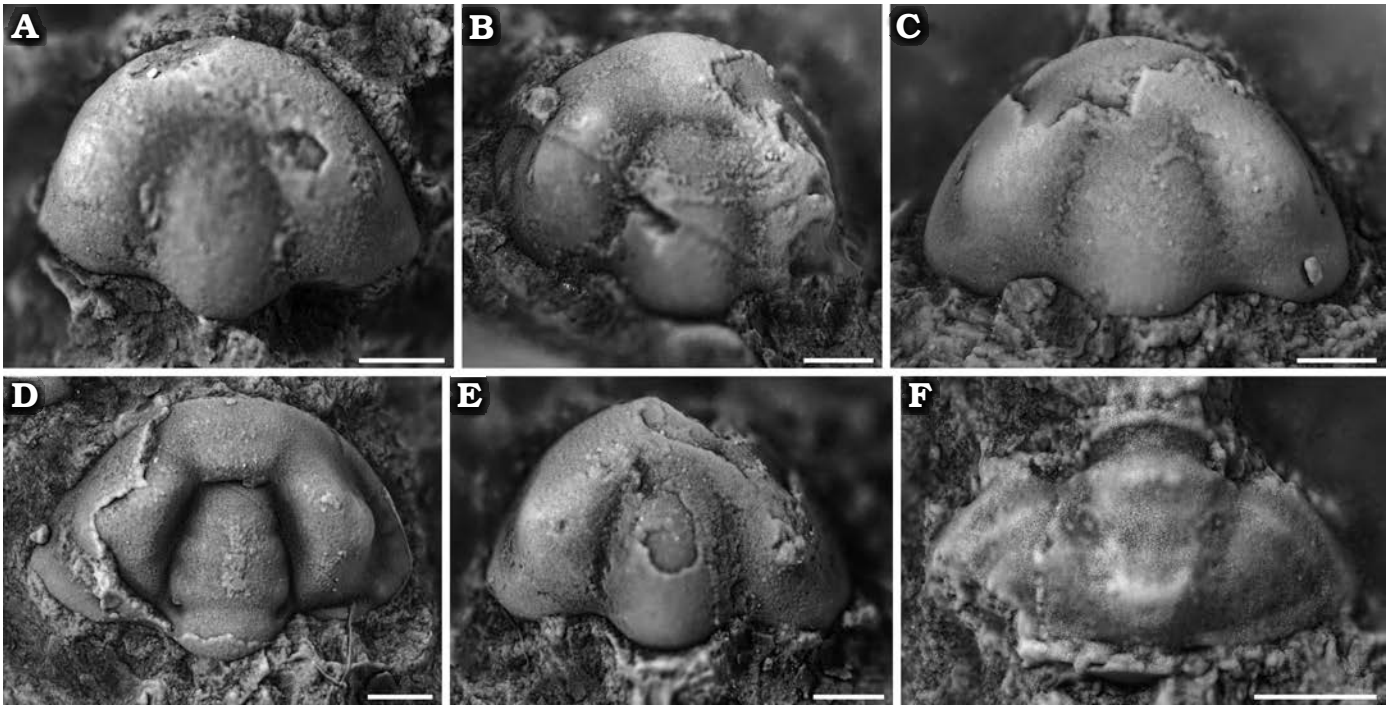

Fig. 10. Diceratocephalid trilobite *Wongia laevigata* Yuan sp. nov. from Guangzhangian, Miaolingian (Cambrian), the Kushan Formation of China, the lower *Wongia rotundata* Zone, Baijiashan section, Liaoning Pronvince. **A**. NIGP205981 (field no. BJS-C39), cephalon. **B**. NIGP205982 (field no. BJS-C38a), cephalon. **C**. Holotype, NIGP205983 (field no. BJS-C38b), cephalon. **D**. NIGP205984 (field no. BJS-C40), cephalon. **E**. NIGP205985 (field no. BJS-C41), cephalon. **F**. NIGP205986 (field no. BJS-C37), pygidium. All in dorsal view. Scale bars: A–E, 500 μm; F, 200 μm.

Material.—Type material only.

Diagnosis.—Cephalon semicircular, moderately vaulted, without genal spines, genal angle obtuse to well-rounded; axial furrow very shallow; preglabellar field relatively short (sag.), nearly 0.35–0.4 times as long as glabella, a lower swelling boss visible on the exfoliated specimen (Fig. 10D); anterior border furrow, lateral border furrow and posterior border furrow indistinct; glabella long and pronounced, subconical to truncated conical, gently tapering forward, lateral glabellar furrows very faint, only on the exfoliated specimen (Fig. 10D) can be observed; occipital ring narrow (sag.) and wide (tr.), without occipital node; occipital furrow very faint; fixigenae slightly narrower (tr.) than glabella between palpebral lobes; palpebral lobes indistinct or moderately long on exfoliated specimen; eye ridge indistinct, surface smooth.

Description.—Cephalon semicircular in outline, moderately vaulted, with obtusely to well-rounded genal angle; genal spines absent; axial furrow very shallow; preglabellar field relatively short (sag.), nearly 0.35–0.4 times as long as glabella, a very gently convex preglabellar boss and a pair of very faint short furrows divergent forward on preglabellar field can be observed only on the exfoliated specimen (Fig. 10D); anterior border narrow; anterior border furrow, lateral border furrow and posterior border furrow indistinct or very narrow and shallow on exfoliated specimen; glabella long and robust, subconical to truncated conical, gently tapering forward, lateral glabellar furrows very faint, only on the exfoliated specimen (Fig. 10D) can be observed; occipital ring narrow (sag.) and wide (tr.), without occipital node; fixigenae slightly narrower (tr.) than glabella between palpebral lobes; palpebral lobes moderately long, about 0.4 times as long as glabellar length, located at a level opposite to anterior portion of glabella on the exfoliated specimen (Fig. 10D); occipital ring wide (tr.) and short (sag.), semi-elliptical, without occipital node; eye ridges obscure; anterior branches of facial suture slightly convergent forward from palpebral lobe, posterior branches divergent backwards, then bending inwards, posterior border gently convex, narrower (tr.) than basal glabellar width, with an obtuse intergenal angle; librigena narrow and flat, gently sloping outwards. Pygidium rhombic, acutely rounded laterally, axis broad and long, tapering backwards, with 4–5 axial rings; axial ring furrows very shallow, pleural ribs gently convex, pleural furrows and interpleural furrows obscure, and surface smooth.

Remarks.—The new species shows some characteristics of the librigena with the rounded genal angle; the new specimens (Fig. 10A–F) bears the closest resemblance to *Wongia regularis regularis* (Walcott, 1906) and *Wongia nanzhaocunensis* Yuan sp. nov. It can be distinguished from *Wongia regularis regularis* (Walcott, 1906) mainly by its less vaulted cephalon with shorter preglabellar field without distinct swelling preglabellar boss, its very shallow axial furrow, anterior border furrow, lateral border furrow, posterior border furrow, occipital furrow, indistinct palpebral lobe and eye ridge, longer and wider glabella without distinct glabellar furrows, the occipital ring lacking an occipital node. It differs also from *W. nanzhaocunensis* Yuan sp. nov. chiefly in having a very shallow axial furrow, longer and

wider truncated conical glabella without glabellar furrows, a narrower preglabellar field, relatively narrower fixigenae between paalpebral lobes (tr.), librigena without 3–5 tubercles on the lateral border, and obscure eye ridges.

Stratigraphic and geographic range.—The lower part of the *Wongia rotundata* Zone, Kushan Formation, Guzhangian, Miaolingian, Cambrian; Baijiashan section, Liaoning, China.

Genus *Cyclolorenzella* Kobayashi, 1960

Type species: *Lorenzella quadrata* Kobayashi, 1935; *Neodrepanura* Zone Guzhangian, Miaolignian, Cambrian; Sesong Formation, Jikdong, Taebaeksan Basin, Korea.

Species included: *Cyclorenzella convexa* (Resser & Endo in Endo and Resser, 1937), *Cyclorenzella distincta* Zhang, 1985, *Cyclorenzella jishanensis* Zhang & Wang, 1986, *Cyclorenzella* sp. reported herein.

Emended diagnosis.—Cranidium subquadrate, slightly wider than long; frontal area moderately long, with a distinct, low convex preglabellar boss outlined by long or short parallel-sided to slightly divergent furrows emerging from antero-lateral corners of glabella; preglabellar area moderately long, preglabellar field and anterior border not differentiated; glabella truncated conical, with 3 pairs of very faint glabellar furrows; occipital ring narrow (sag.), extending backward into a long occipital spine medially; occipital furrow shallow; palpebral lobes short, located opposite glabellar mid-point; eye ridge very faint or obscure. Pygidium semi-elliptical, with a posteromedian indentation; axis long, tapering backwards, with 3–6 axial rings; pleural area with very faint pleural and interpleural furrows; pygidial border very narrow or not differentiated; prosopon of fine granules, or smooth.

Table 1. Correlation Chart between taxa of *Cyclolorenzella* and their replacement names.

Number	Taxa of *Cyclolorenzella*	New assignments
1.	*Cyclolorenzella acalle* (Walcott, 1905)	*Wongia acalle*
2.	*Cyclolorenzella acuta* Duan in Duan et al., 2005	*Wongia acuta*
3.	*Cyclolorenzella armata* (Walcott, 1906)	*Lonchinouyia armata*
4.	*Cyclolorenzella caijiapingensis* Yang, 1978	*Torifera caijiapingensis*
5.	*Cyclolorenzella convexa* (Resser & Endo in Endo and Resser, 1937)	*Cyclolorenzella convexa*
6.	*Cyclolorenzella denotata* Nan & Chang, 1985	*Wongia acalle*
7.	*Cyclolorenzella distincta* Zhang, 1985	*Cyclolorenzella distincta*
8.	*Cyclolorenzella divi* (Walcott, 1905)	*Latilorenzella divi*
9.	*Cyclolorenzella granulata* Lazarenko, 1965	*Sachia granulata* Lazarenko, 1965
10.	*Cyclolorenzella hebeiensis hebeiensis* Wittke & Zhu in Zhu and Wittke, 1989	*Wongia acalle*
11.	*Cyclolorenzella hebeiensis tangshanensis* Wittke & Zhu in Zhu and Wittke, 1989	*Wongia acalle*
12.	*Cyclolorenzella humilis* Zhang in Qiu et al., 1983	*Wongia humilis*
13.	*Cyclolorenzella jishanensis* Zhang & Wang, 1986	*Cyclolorenzella jishanensis*
14.	*Cyclolorenzella kushanensis* (Chu, 1959)	*Wongia acalle*
15.	*Cyclolorenzella latisulcata* Zhang in Qiu et al., 1983	*Torifera latisulcata*
16.	*Cyclolorenzella longispina* Wittke & Zhu in Zhu and Wittke, 1989	*Wongia triangulata*
17.	*Cyclolorenzella magezhuangensis* Zhang & Wang, 1986	*Wongia magezhuangensis*
18.	*Cyclolorenzella matoshanensis* Zhang & Wang, 1986	*Wongia rotundata*
19.	*Cyclolorenzella normalis* Zhou in Zhou & Zheng, 1980	*Wongia acalle*
20.	*Cyclolorenzella ogurai* (Resser & Endo in Endo and Resser, 1937)	*Wongia acalle*
21.	*Cyclolorenzella parabola* (Lu, 1957)	*Wongia rotundata*
22.	*Cyclolorenzella paraconvexa* Yang, 1978	*Torifera*? *paraconvexa*
23.	*Cyclolorenzella pustulosa* (Chu, 1959)	*Wongia regularis pustulosa*
24.	*Cyclolorenzella quadrata* (Kobayashi, 1935)	*Cyclolorenzella quadrata*
25.	*Cyclolorenzella regularis* (Walcott, 1906)	*Wongia regularis regularis*
26.	*Cyclolorenzella rotundata* (Resser & Endo in Endo and Resser, 1937)	*Wongia rotundata*
27.	*Cyclolorenzella spinosa* Ergaliev & Ergaliev, 2008 (nomen nudum)	
28.	*Cyclolorenzella subcylindrica* (Chu, 1959)	*Wongia subcylindrica*
29.	*Cyclolorenzella tonkinensis* (Mansuy, 1915)	*Torifera tonkinensis*
30.	*Cyclolorenzella tuma* Yang in Zhou et al., 1977	*Torifera tuma*
31.	*Cyclolorenzella uniforma* Wittke & Zhu in Zhu and Wittke, 1989	*Wongia acalle*
32.	*Cyclolorenzella valida* Nan & Chang, 1985	*Wongia valida*
33.	*Cyclolorenzella yentaiensis* (Chu, 1959)	*Wongia rotundata*
34.	*Cyclolorenzella* sp. Xiang & Zhang, 1985	*Eurostina* sp.
35.	*Jiulongshania shandongensis* Yuan in Yuan et al., 2012: 372, pl. 224: 1–9	*Torifera latisulcata*
36.	*Jiulongshania longa* Park et al., 2008: 263–265, fig. 10A–K	*Wongia longa*
37.	*Cyclolorenzella* sp. Hong et al., 2003	*Cyclolorenzella* sp
38.	*Cyclolorenzella* sp. Wang & Zhang, 1994: 146, pl. 9: 17	*Torifera latisulcata*

Remarks.—*Cyclolorenzella* Kobayashi, 1960, with type species *Lorenzella quadrata* Kobayashi, 1935, from the *Neodrepanura* Zone (upper Guzhangian, Miaolingian) of the Sesong Formation, Jikdong, Taebaeksan Basin, Korea, has had more than 30 species referred to it from the uppermost Drumian to Guzhangian (Miaolingian; Park et al. 2008) emended the generic concept of *Cyclolorenzella* and retained only *C. quadrata* (Kobayashi, 1935) and *C. convexa* (Resser & Endo in Endo and Resser, 1937) in the genus. They transferred most of the thirty species formerly assigned to *Cyclolorenzella* to *Jiulongshania* (Park et al. 2008). However, *Jiulongshania* is herein a junior subjective synonym of *Wongia* Sun, 1924. In the general configuration of the cranidium, *Cyclolorenzella granulata* (Lazarenko 1965: 15, pl. 1: 3–10; Egorova et al. 1982: 82, pl. 49: 11) from the *Lejopyge laevigata* Zone of the north-central Siberian Platform is quite similar to *Sachia* Rozova, 1964, with *Sachia perexigua* Rozova, 1964, as the type species, and therefore is better assigned to *Sachia* rather than to *Cyclolorenzella*. The revised list of species is provided in Table 1.

Stratigraphic and geographic range.—Guzhangian, Miaolignian, Cambrian; North China and Korea.

Cyclorenzella convexa (Resser & Endo in Endo and Resser, 1937)

Fig. 11A–C.

1937 *Lorenzella* (?) *convexa* Resser & Endo; Endo and Resser 1937: 233, pl. 55: 18, 19; pl. 65: 26, 27.
1959 *Lorenzella* (?) *convexa* Resser & Endo; Endo and Resser; Chu 1959: 61, pl. 2: 16.
1960 *Cyclolorenzella convexa* (Resser & Endo in Endo and Resser); Kobayashi 1960: 389.
1965? *Cyclolorenzella convexa* (Resser & Endo in Endo and Resser); Lu et al. 1965: 254, pl. 43: 12–15.
1987 *Cyclolorenzella convexa* (Resser & Endo in Endo and Resser); Zhang and Jell 1987: 133, pl. 51: 10.
1996 *Cyclolorenzella convexa* (Resser & Endo in Endo and Resser); Guo et al. 1996: 114, pl. 59: 11.
2008 *Cyclolorenzella convexa* (Resser & Endo in Endo and Resser); Park et al. 2008: 253–255, fig. 4A–S.
2008 *Cyclolorenzella convexa* (Resser & Endo in Endo and Resser); Yang 2008: 102–103, text-fig. 18B, [non text-fig. 18A, pl. 15: 36].

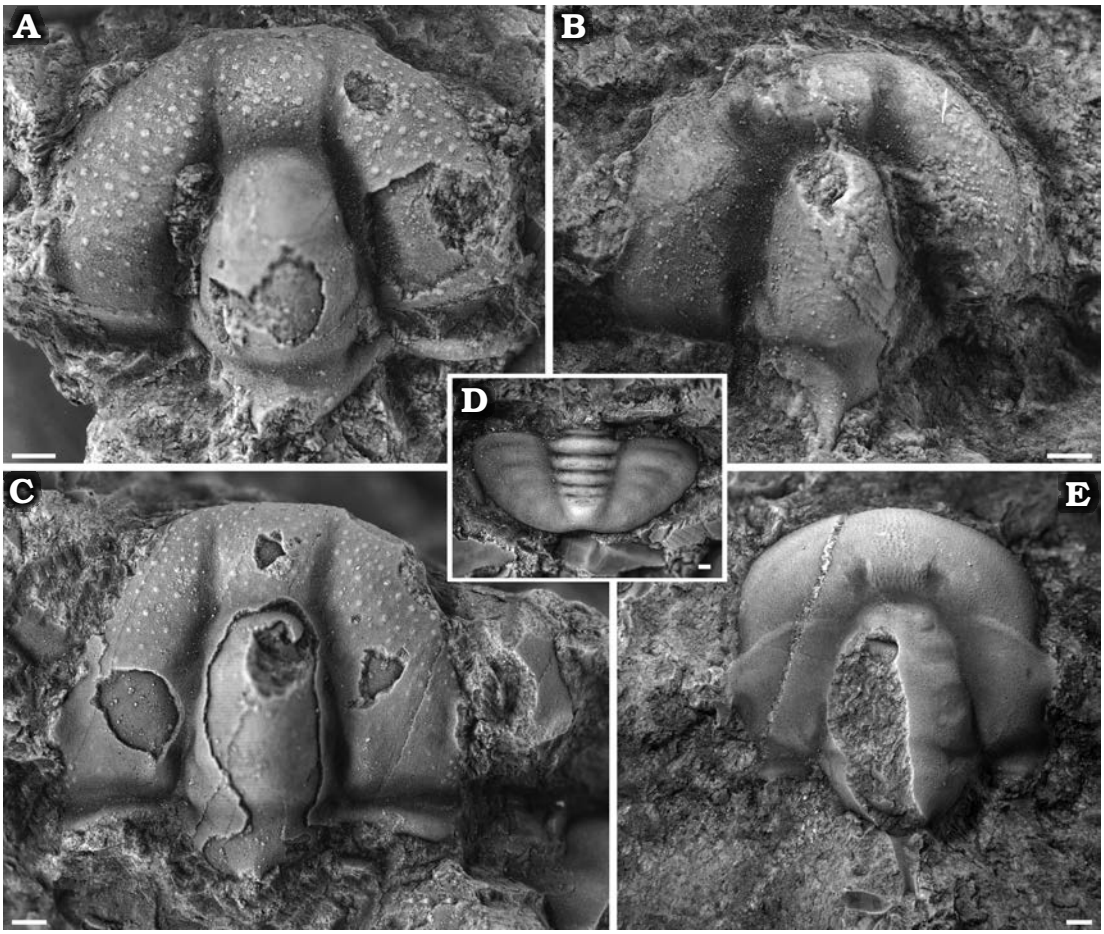

Fig. 11. Diceratocephalid trilobites from Guzhangian, Miaolingian (Cambrian), the Kushan Formation of China. *Cyclolorenzella convexa* (Resser & Endo in Endo and Resser, 1937), the *Diceratocephalus armatus* Zone, Baijiashan section, Liaoning Pronvince (A–C) and *Cyclolorenzella* sp., the *Wongia rotundata* Zone, Julinshan section, Shandong Province (D, E). **A**. NIGP205987 (field no. BJS-A3.3m), cranidium. **B**. NIGP205988 (field no. BJS-A3.3m), cranidium. **C**. NIGP205989 (BJS-A3.3m), cranidium. **D**. Holotype, NIGP205990 (field no. Ju-2-1.6m), pygidium. **E**. NIGP205991 (field no. Ju-2-1.6m), cranidium. All in dorsal view. Scale bars: A–C, 500 μm; D, E, 1 mm.

2010 *Cyclolorenzella convexa*; Park and Choi 2010: 77–79, figs. 4A–O, 5A–K.

2017 *Cyclolorenzella convexa*; Choi and Park 2017: 903, fig. 8: lower row.

2020 *Cyclolorenzella convexa* (Resser & Endo in Endo and Resser, 1937); Peng 2020: 454, pl. 201: 11–14.

2020 *Cyclolorenzella convexa* (Resser & Endo in Endo and Resser, 1937), Wang et al. 2020: 5, fig. 4B.

Holotype: USNM86844, cranidium (Zhang and Jell 1987: pl. 51: 10).

Type locality: Baijiashan section, Dalian, Liaoning Province, China.

Type horizon: Kushan Formation (*Diceratocephalus armatus* Zone), Guzhangian, Miaolingian, Cambrian.

Material.—Three cranidia (NIGP 205987–2059989), all from the type locality and horizon.

Emended diagnosis.—Cranidium subtrapezoidal, frontal area moderately long, with a moderately preglabellar boss that is circular to subquadrate and outlined by long or short parallel-sided or slightly divergent furrows emerging from antero-lateral corners of glabella; glabella truncated conical, with indistinct glabellar furrow S1; occipital ring narrow laterally, extending backward into a long occipital spine medially; occipital furrow shallow; palpebral lobes short, located behind glabellar mid-point; anterior branches of facial sutures slightly convergent forward from palpebral lobe; prosopon of finer and courser granules.

Stratigraphic and geographic range.—*Diceratocephalus armatus* Zone of the Kushan Formation, Guzhangian, Miaolingian, Cambrian; Baijiashan section, Liaoning, China.

Cyclolorenzella sp.

Fig. 11D, E.

Material.—A cranidium and one pygidium (NIGP 205990, 2059991), from *Wongia rotundata* Zone, Kushan Formation, Guzhangian, Miaolingian, Cambrian; Julinshan section, Feixian, Shandong Province, China.

Description.—Cranidium subquadrate, moderately convex, with broadly rounded anterior margin; axial furrow shallow; preglabellar field relatively long (sag.), nearly 0.7–0.8 times as long as glabella, with an indistinct preglabellar boss (slightly convex and circular) demarcated by very short parallel or slightly divergent furrows emerging from antero-lateral corners of glabella; glabella long, prominent, truncated conical to subcylindrical and tapering gently forwards, with 3 pairs of shallow lateral glabellar furrows, of which S1 is bifurcated; palpebral lobes short, about 0.3 times as long as glabella, located opposite the middle portion of glabella; occipital ring broad (sag.), narrow laterally, with a short and slender occipital spine; fixigenae are gently convex, narrow (tr.), about 0.4 times as wide as glabella between palpebral lobes; anterior branch of facial suture slightly divergent from palpebral lobe, posterior branch short, gently slanting backwards. Pygidium semi-elliptical, with a distinct posteromedian indentation; axis long, tapering backwards, with 5–6 axial rings, the axial ring furrows being straight; pleural area with 2–3 pairs of very faint pleural furrows; pygidial border absent; surface smooth.

Remarks.—In the general configuration of the cranidium, *Cyclolorenzella* sp. is quite similar to *Cyclolorenzella distincta* (Zhang 1985: 113, pl. 1: 17, 17a; Yuan et al. 2016: 235, 236, pl. 2: 3–9) and *Cyclolorenzella jishanensis* (Zhang and Wang 1986: 406, pl. 122: 13, 14) from the lower part of the Kushan Formation, Shanxi Province. However, it differs from *Cyclolorenzella distincta* in having a subquadrate cranidium with a broad, well-rounded anterior margin, subcylindrial glabella, shorter palpebral lobe, and a slightly divergent anterior branch of the facial suture. It can also be distinguished from *C. jishanensis* chiefly by its subquadrate cranidium with broad, well-rounded anterior margin, shorter palpebral lobe, and the slightly divergent anterior branch of the facial suture.

Genus *Torifera* Wolfart, 1974

Type species: *Torifera triangularis* Wolfart, 1974; from the *Blackwelderia–Torifera–Crepicephalus* Assemblage Zone, Guzhangian, Miaolignian, Cambrian; Central Afghanistan.

Species included: *Torifera youyangensis* Zhu in Zhang et al., 1980, *Torifera abrupta* Peng, Babcock and Lin, 2004, *Torifera jelli* Peng et al., 2009, *Torifera tonkinensis* (Mansuy, 1915), *Torifera mera* (Romanenko in Goncharova et al., 1972), *Torifera tuma* (Yang in Zhou et al., 1977), *Torifera taoyuanensis* (Peng, 1987), *Torifera*? *paracovexa* (Yang in Yin and Lee, 1978), *Torifera*? *latisulcata* (Zhang in Qiu et al., 1983), *Torifera* sp., *Torifera intermedia* Yuan, Ren & Gao sp. nov.

Emended diagnosis.—Small diceratocephalid trilobites; cephalon with genal spine; axial furrow broad and deep; cranidium convex, subtrapezoidal, with or without gently convex preglabellar boss defined by a pair of short, distinctly divergent furrows on preglabellar field; preglabellar field wide (sag.), convex; anterior border gently convex; anterior border furrow shallow but distinct; glabella convex, conical to truncated conical, with faintly impressed lateral glabellar furrows; fixigenae wider (tr.), vaulted near the palpebral lobe, sloping down towards axial furrow, with a pair of low baccula at posteroproximal corner of fixigenae; eye ridge distinct, transverse; palpebral lobe short to moderately long; gonatoparian facial suture; occipital ring extending backwards, forming triangular, semicircular to semi-elliptical in outline or moderately long occipital spine; occipital furrow shallow and narrow medially, bending forward laterally. Thorax of 8 segments. Pygidium wide (tr.) and narrow (sag.), transverse, semi-elliptical, bluntly rounded laterally; axial furrow very shallow; axis broad and long, reaching posterior border, tapering backwards, with 3–5 axial rings; axial ring furrows broad and shallow; pleural field as wide as axis, pygidial border narrow and flat; prosopon of closely pitted cranidium, or with fine granulation, irregular wrinkles or terrace lines on the surface of cranidium and pygidium.

Remarks.—In the general outline of the cranidium and glabella, and the course of the facial suture, *Torifera* most closely resembles *Wongia* Sun, 1924. However, it differs from the latter mainly in having its occipital ring expanding strongly backwards, a more distinct anterior border and border furrow, bacculae at the posteroproximal corner of fixigenae, broader fixigenae between the palpebral lobes,

and a broader (tr.) and narrower (sag.) elliptical pygidium. *Torifera* has been assigned to the Aulacodigmatidae Öpik, 1967 (Wolfart 1974; Zhang et al. 1980; Wittke 1984), but the Aulacodigmatidae Öpik, 1967, is considered to be synonymous with Diceratocephalidae Lu, 1954 (Zhang and Jell 1987; Jell and Hughes 1997). Subsequently, *Torifera* has been assigned to the Diceratocephalidae (Zhang and Jell 1987; Jell and Hughes 1997; Jell and Adrain 2002; Yuan and Li 2008; Zhu 2008; Luo et al. 2009). The Alsataspididae Turner, 1940, is characterized by its cephalon having a long frontal axial spine, subcircular glabella with a deep anterior median longitudinal glabellar furrow, an absence of palpebral lobes and eye ridges, and a larger pygidium. *Torifera* is therefore quite different from any genera of Alsataspididae, and we do not think that *Torifera* can be placed in Alsataspididae (Peng et al. 2004, 2009; Peng 2008, 2020).

Stratigraphic and geographic range.—Miaolingian, Guzhangian, Cambrian of southern Asia (Afghanistan, India, Iran, Oman, Vietnam), south and southwestern China (western northwestern Hunan, eastern Guizhou, western and southeastern Yunnan, southeastern Sichuan, western Guangxi and southern Jiangsu), and North China (Shandong).

Torifera sp.

Fig. 12A–C.

Material.—Two cranidia and one pygidium (NIGP 205992–205994), from *Damesella paronai–Ajacicrepida ajax* Zone, Changhia Formation, Shandong Province, China.

Description.—Cranidium subtrapezoidal, anterior margin more strongly bending forwards; preglabellar field broad, moderately convex, anterior border furrow distinct, anterior border narrow and convex; glabella short and convex, truncated conical, with faintly impressed lateral glabellar furrow S1; fixigenae gently convex, wider than glabellar width between palpebral lobes, a pair of distinct low bacculae at posteroproximal corner of fixigenae; eye ridge distinct, transverse; occipital ring prominent, extending backwards to form a triangle, slightly shorter than glabellar length; anterior branch of facial suture slightly divergent forward, crossing anterior border furrow and then bending inward. Pygidium wide (tr.), transverse, semi-elliptical, sharply rounded laterally; axial furrows very shallow; axis broad and long, reaching posterior border and gently tapering backwards, with 3–4 axial rings; axial ring furrows broad and shallow, pleural field as wide as axis, pygidial border narrow and flat; prosopon of closely spaced irregular wrinkles on the surface of preglabellar field and occipital ring.

Remarks.—In general configuration of the cranidium and pygidium, and the course of the facial suture, *Torifera* sp. is quite similar to *Torifera triangularis* Wolfart, 1974, from the *Blackwelderia–Torifera–Crepicephalus* Assemblage Zone (upper Cambrian) of Surkh Bum, central Afghanistan (Wolfart 1974: 97–101, text-fig. 11, pl. 12: 1–9; pl. 13: 1–6). However, it differs from the latter mainly in having the cranidium with more strongly bending forward anterior margin, narrower fixigenae between the palpebral lobes, a robust and longer triangular occipital ring, a relatively short glabella, slightly divergent anterior branches of the facial sutures, a more convex anterior border, a wider pygidial border, and closely spaced irregular wrinkles on the surface of the preglabellar field and the occipital ring instead of a pitted surface on the cranidium. It can be also distinguished from *T. latisulcata* (Zhang in Qiu et al., 1983) (Qiu et al. 1983: 126, pl. 41: 3; Yuan et al. 2012: 372, pl. 224: 1–9) mainly by its shorter, truncated conical glabella, longer and more robust triangular occipital ring, the presence of a pair of low bacculae at the posteroproximal corner of the fixigenae, and its wider (tr.) and narrower (sag.) pygidium. The specimens assigned to *Cyclolorenzella magezhuangensis* Zhang and Wang, 1985 (Yang 2008: 109–110, pl. 13: 10, 15) from the uppermost Changhia Formation of Jiulongshan section, Shandong, have been tentatively reassigned to the new species, because of the presence of low bacculae at the posteroproximal corner of the fixigenae and a truncated conical glabella.

Torifera intermedia Yuan, Ren & Gao sp. nov.

Fig. 12D–I.

Zoobank LSID: urn:lsid:zoobank.org:act:F0046226-3808-4E93-A649-3AED2431BB1D

Etymology: From Latin *intermedius*, intermediate; because the new species appears intermediate between species of *Torifera* and *Wongia*.

Type material: Holotype: Incomplete cephalon (NIGP 205995), Fig. 12D. Paratypes: four cranidium (NIGP 205997–206000), Fig. 12H, E, G, F; one pygidium (NIGP 205996), Fig. 12I.

Type locality: Southern Nanzhaocun section, Julinshan and Jiulongshan sections, Shandong Province, China.

Type horizon: Changhia Formation (*Damesella paronai–Ajacicrepida ajax* Zone), Guzhangian, Miaolingian, Cambrian.

Material.—Type material only.

Diagnosis.—Cranidium subquadrate, anterior margin moderately bending forward, with a weakly vaulted boss on preglabellar field; glabella long, truncated conical, with 3 pairs of very faint lateral glabellar furrows; fixigenae with a pair of very low bacculae at posteroproximal corner of fixigenae; occipital ring semi-elliptical, with a distinct occipital node posteriorly; posterior border gently convex, as wide as glabella at the base; posterior border furrow wide and distinct, bending slightly forward laterally; pygidium wide (tr.), transverse, semi-elliptical, bluntly rounded laterally; axis broad and long, moderately convex, reaching posterior border; tapering backwards, with 3–5 axial rings, pygidial border narrow and flat, border furrow shallow; prosopon of indistinct irregular wrinkles on the surface of preglabellar field, librigenae and occipital ring.

Description.—Cranidium subquadrate, anterior margin moderately bending forward; preglabellar field broad, with a weakly vaulted boss on preglabellar field; the anterior border furrow shallow and the anterior border narrow and gently convex; glabella long, truncated conical, with 3 pairs of very faint lateral glabellar furrows; fixigenae as

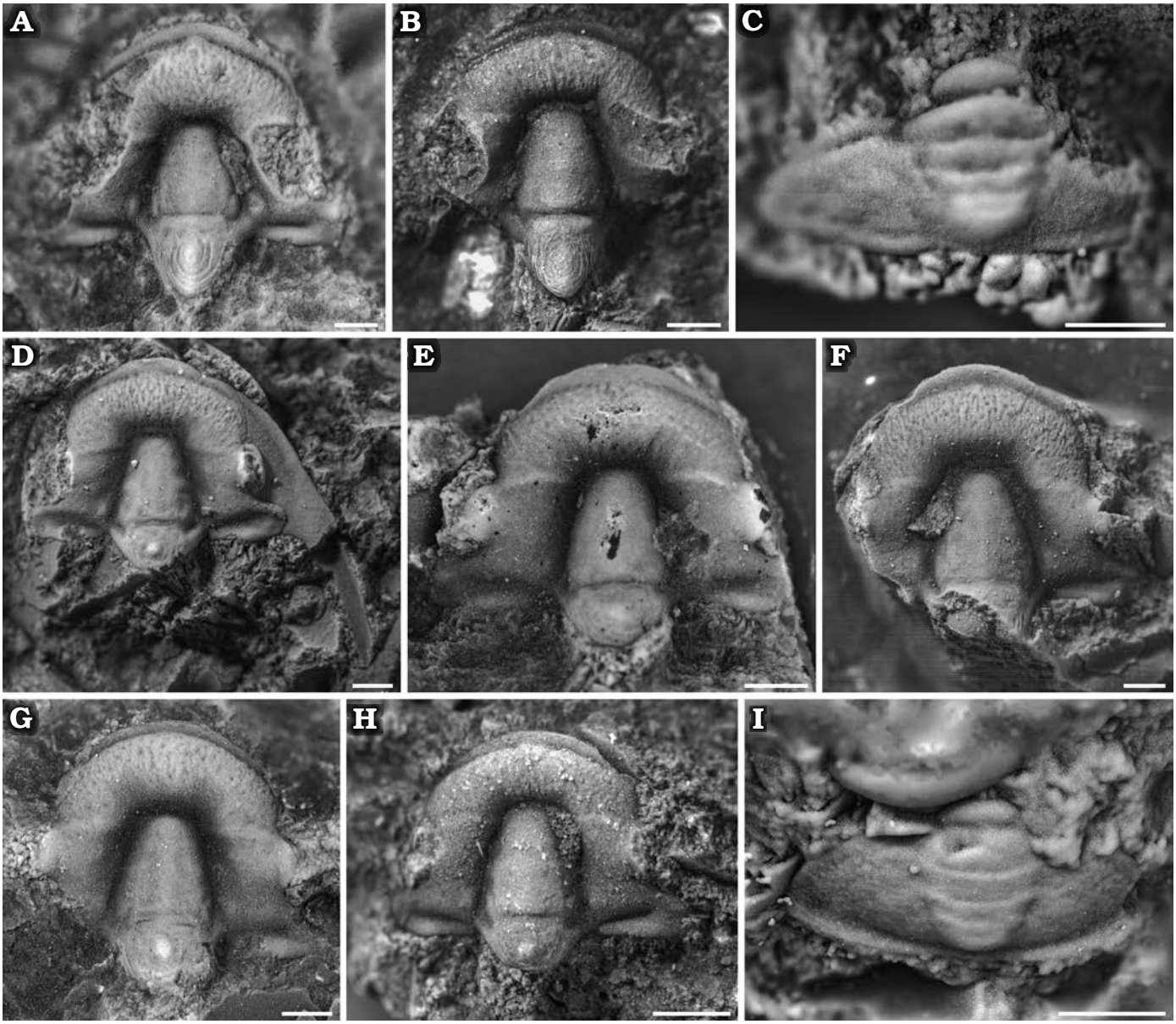

Fig. 12. Diceratocephalid trilobites from Guzhangian, Miaolingian (Cambrian), the Changhia Formation of China. *Torifera* sp., the *Damesella paronai–Ajacicrepida ajax* Zone, Julinshan section, Shandong Pronvince (A–C) and *Torifera intermedia* Yuan, Ren & Gao sp. nov., the *Damesella paronai–Ajacicrepida ajax* Zone, southern Nanzhaocun (D–I), Julinshan (E, G), and Jiulongshan (F) sections, Shandong Province. **A**. Holotype, NIGP205992 (field no. Ju-1-A3-1), cranidium. **B**. NIGP205993 (field no. Ju-1-A3-1), cranidium. **C**. NIGP205994 (field no. Ju-1-A3-1), pygidium. **D**. Holotype, NIGP205995 (field no. NZC-S1-2-1), incomplete cephalon. **E**. NIGP205996 (field no. Ju–1-3-1), cranidium. **F**. NIGP205997 (field no. Jls-91), cranidium. **G**. NIGP205998 (field no. Ju-1-3-1), cranidium. **H**. NIGP205999 (field no. NZC-S1-2-1), cranidium. **I**. NIGP206000 (field no. NZC-S1-2-1), pygidium. All in dorsal view. Scale bars: A–H, 500 μm; I, 200 μm.

wide as glabella between palpebral lobes, with a pair of very low bacculae at posteroproximal corner of fixigenae; occipital ring semi-elliptical, with a distinct occipital node posteriorly; eye ridge distinct, transverse; palpebral lobe short, about 0.4 times glabellar length; anterior branches of facial sutures gently divergent forwards, crossing anterior border furrow and then bending inward; posterior branches of facial sutures strongly divergent outwards, then gently bending inward near the end of posterior border furrow; posterior border gently convex, posterior border furrow wide and distinct, bending slightly forward laterally; librigena moderately wide and flat, with long genal spine; lateral border furrow short and shallow, disappearing opposite midpoint of glabella. Pygidium wide (tr.), transverse, semi-elliptical, and bluntly rounded laterally; axial furrow very shallow, axis broad and long, moderately convex, and reaching posterior border, tapering backwards, with 3–5 axial rings, the axial ring furrows shallow; pleural field as wide as axis, pygidial border narrow and flat, the border furrow shallow; prosopon of indistinct irregular wrinkles on the surface of preglabellar field, librigeenae and occipital ring.

Remarks.—The new species shows some characteristics of *Torifera*, with *Torifera triangularis* as the type species.It has a cranidium with a distinct anterior border and border furrow, fixigenae with low bacculae at the posteroproximal corner, distinct transverse eye ridge, wide (tr.) posterior border, and narrow (sag.) semi-elliptical pygidium. However, it differs from *T. triangularis* in having a semi-elliptical occipital ring and a longer glabella. In the general configuration of the glabella and occipital ring, and the librigena having a long genal spine directed posterolaterally, the new species bears some resemblances to *Wongia*, with *W. triangulata* the type species (Sun 1924: 85, pl. 5: 12a, b). However, it can be distinguished from *Wongia triangulata* chiefly by the presence of a distinct anterior border and border furrow, the fixigenae having low bacculae at the posteroproximal corners, a distinct transverse eye ridge, a wider posterior border (tr.), and a narrower (sag.) semi-elliptical pygidium.

Stratigraphic and geographic range.—Southern Nanzhaocun section, Julinshan and Jiulongshan sections, *Damesella paronai–Ajacicrepida ajax* Zone, Changhia Formation, Guzhangian, Miaolingian, Cambrian; Shandong, China.

Discussion

This study documents the stratigraphic distribution of nine nominal species and subspecies, and one species in open nomenclature of *Wongia*, from the uppermost Changhia Formation to the Kushan Formation in several sections in Shandong and Liaoning. In stratigraphically ascending order, these are *Wongia valida*, *Wongia nanzhaocunensis* Yuan sp. nov., *Wongia* sp., *Wongia acalle*, *Wongia laevigata* Yuan sp. nov., *Wongia rotundata*, *Wongia triangulata*, *Wongia subcylindrica*, *Wongia regularis regularis*, and *Wongiaregularis pustulosa*. The related genera *Cylorenzella* and *Torifera* also occur in these sections, adding to the stratigraphic resolution. *Cyclolorenzella convexa* was recovered from the *Diceratocephalus armatus* Zone of the uppermost Kushan Formation, at the Baijiashan section, Dalian, Liaoning, and *Cyclolorenzella* sp. occurs in the *Wongia rotundata* Zone of the lower part of the Kushan Formation, at the Julinshan section, Feixian County, Shandong. *Torifera* sp. and *T. intermedia* Yuan, Ren & Gao sp. nov. are recorded from the *Damesella paronai–Ajacicrepida ajax* Zone of the uppermost Changhia Formation, at the Julinshan section in Feixian County, and in the southern Nanzhaocun section (Linqu County, Shandong).

The stratigraphic distribution of *Wongia* (as *Jiulongshania*) and *Cyclolorenzella* was most recently revised by Park et al. 2008. Guo et al. (1996) recorded *Wongia acalle* and *W. regularis* (as *Cyclolorenzella*) from the *Damesella–Yabeia* Zone of the uppermost Changhia Formation. However, the general morphology of the cranidium in the specimens assigned to *W. regularis* (Guo et al. 1996: pl. 59: 17–18) seems to resemble *W. nanzhaocunensis* Yuan sp. nov. from the uppermost Changhia Formation, but their preservation is too poor to ascertain whether they are conspecific, or if they represents a new species. The specimens described as *Wongia acalle* (Guo et al. 1996: pl. 59: 12–16) may represent two species, *Wongia valida* (Guo et al. 1996: pl. 59: 12–15) and *Wongia nanzhaocunensis* Yuan sp. nov. (Guo et al. 1996: pl. 59: 16) as mentioned in the text. In previous work, *Cyclolorenzella* has been mentioned as being confined to a narrow stratigraphic interval within the *Neodrepanura* (as *Drepanura*) Zone of the upper Kushan Formation, China, and the Sesong Formation, Korea. New investigation reveals that *Cyclolorenzella* sp. occurs in the *Wongia rotundata* Zone (lower Kushan Formation), and *Cyclolorenzella* sp. occurs in the *Lejopyge armata* Zone, Machari Formation, Yongwol Group, Korea, dated as uppermost Drumian or lowest Guzhangian (Hong et al. 2003). In

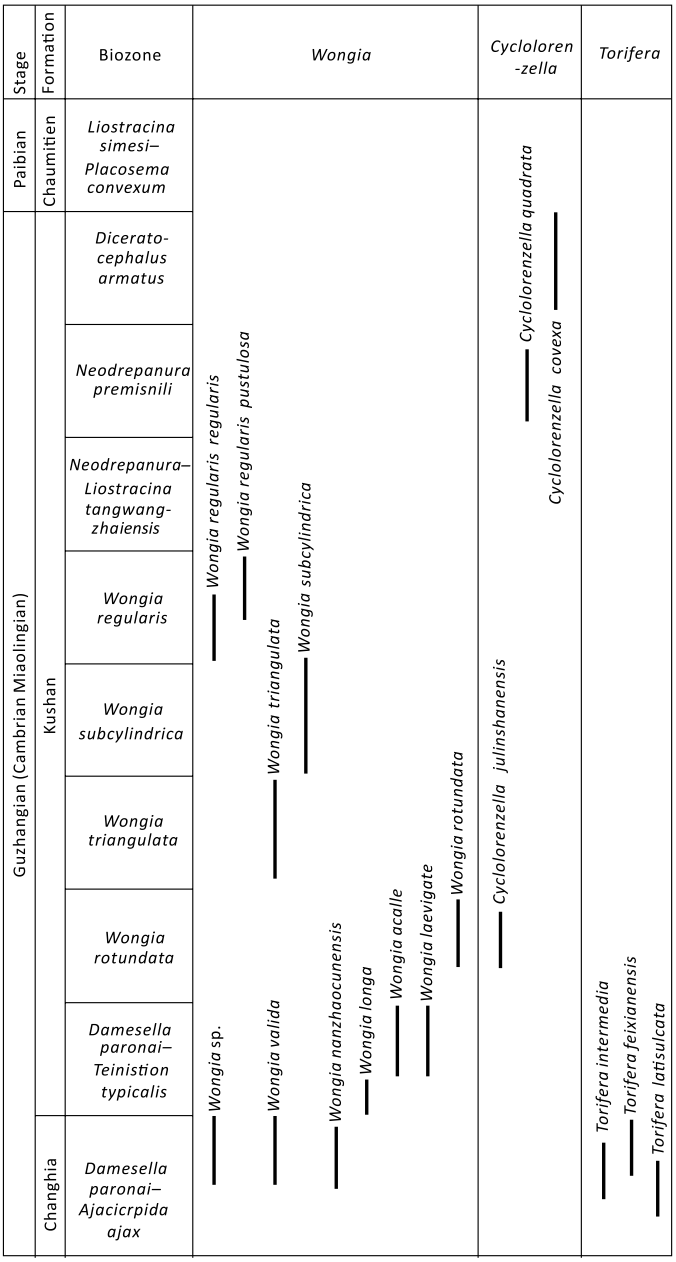

Fig. 13. Stratigraphical distribution of the species of *Wongia*, *Cyclolorenzella*, and *Torifera* on the North China Platform.

summary, *Cyclolorenzella* has a relatively long stratigraphic range from the uppermost Drumian or lowest Guzhangian to the upper Guzhangian. Similarly, *Torifera* has previously been documented as ranging from the *Proagnostus bulbus* Zone through the *Linguagnostus reconditus* Zone to, questionably, the *Glyptagnostus stolidotus* Zone, upper Guzhangian, in southern Asia (Afghanistan, India, Iran, Oman, Vietnam), south and southwestern China (western northwestern Hunan, eastern Guizhou, western and southeastern Yunnan, southeastern Sichuan, western Guangxi and southern Jiangsu) (Peng 2008). *Torifera* sp., *Torifera intermedia* Yuan, Ren & Gao sp. nov. is found here to occur in the *Damesella paronai–Ajacicrepida ajax* Zone of the uppermost Changhia Formation (lowest Guzhangian), which may represent the oldest known record of the genus in the North China Platform. The detailed stratigraphic distributions of these species of *Wongia*, *Cyclolorenzella* and *Torifera* in the North China Platform are shown in the Fig. 13.

This study further subdivided the original genus-level biozones and established species-level biozones based on the FAD (First Appearance of Datum) of species, significantly enhancing the precision of biostratigraphic correlation. As shown in Fig. 13, the traditional *Blackwelderia* biozone (lower part of the Kushan Formation) was subdivided into five precise biozones: *Damesella paronai–Teinistion typicalis*, *Wongia rotundata*, *Wongia triangulata*, *Wongia subcylindrica*, and *Wongia regularis* zones (Ren et al. 2020). A high-resolution biostratigraphic framework was established.

Conclusions

This study revised the taxonomic placement of nineteen species of trilobites *Wongia*, *Cyclolorenzella*, and *Torifera*, along with the establishment of three new species and two indefinate species: *Wongia nanzhaocunensis* Yuan sp. nov., *Wongia laevigate* Yaun sp. nov., *Torifera intermedia* Yuan, Ren & Gao sp. nov., *Cyclolorenzella* sp., and *Torifera* sp., which delineated the first appearance, stratigraphic range, and distribution of the species within the stratigraphic sequence in North China Platform. Simultaneously, establishing the chronological sequence of taxonomic appearances in the strata provides a foundation for studying the systematic evolution of various species. The establishment of a high-resolution biostratigraphic framework holds significant importance for stratigraphic correlation, as it enables precise correlation with both global biozones and the base of the Guzhangian and Paibian stages.

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