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Ostracods (Crustacea) as shelf to basin indicators: evidence from Late Devonian Yangdi and Nandong sections in Guangxi, South China

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Abstract. Forty-eight ostracod species belonging to 28 genera from the Late Devonian of Guangxi in South China are described and figured. The ostracod assemblage from the Nandong section can be attributed to the *rehnana–linguiformis* conodont zones. The ecological assemblages of ostracods from the Yangdi section correspond to a smooth-podocopid association accompanied by some pelagic entomozoids. This mixed assemblage is indicative of an environment of carbonate platform to slope during an ongoing regression. The ostracod faunas from the Nandong section are on the contrary composed of both pelagic and benthic ostracods and pelagic forms dominate in number of specimens suggesting a basin environment.

1 Introduction

Ostracods are one of the most widespread and diverse group of crustaceans since the Early Ordovician (Horne et al., 2002; Siveter, 2008). Devonian is a prosperous period for ostracods, particularly in marine environments from very shallow coastal seas to deep abyssal plains. With their great distribution, they play an important role in stratigraphic subdivisions and consequently for correlations (e.g. Lethiers, 1978, 1981; Casier, 1987, 2003, 2004, 2008). In addition, ostracods offer special insights into palaeoenvironmental and palaeogeographical reconstructions for their sensitivity to the ambient environments (i.e. salinity, bathymetry, temperature, hydrodynamics, oxygenation and nutrients, etc.) (Lethiers, 1981; Casier, 1985; Casier and Olempska, 2008; Olempska and Belka, 2010; Casier et al., 2011; Racheboeuf et al., 2012; Maillet et al., 2013; Song and Gong, 2015a, b, 2017; Song et al., 2017).

Systematic biostratigraphy and palaeoecology of the Early and Middle Devonian ostracods in South China have been

well studied (e.g. Wang, 1979, 1986, 1987, 1988; Zhang, 1986, 1995; Wang et al., 1992; Wang and Liu, 1994). An entomozoacean zonation was established by Wang (1987, 2009) and a sinoleperditine biostratigraphical sequence for the Devonian was summarized by Wang and Peng (2005). However, there are only a few studies on the Late Devonian ostracods from South China (Casier et al., 1997; Wang and Ma, 2007). This paper aims to provide a systematic description of some Late Devonian ostracods from the Yangdi and Nandong sections (Guangxi, South China) and discuss their biostratigraphical and palaeoecological values.

2 Geological setting and section descriptions

During the Late Palaeozoic, the South China Block has a 90° anticlockwise position comparative to today. The palaeogeographic frame of South China consisted of the Yangtze–Cathaysia continent and the southern South China Sea. The South China Block was subject of two transgressions from the southwest to the northeast during the Devonian. From the

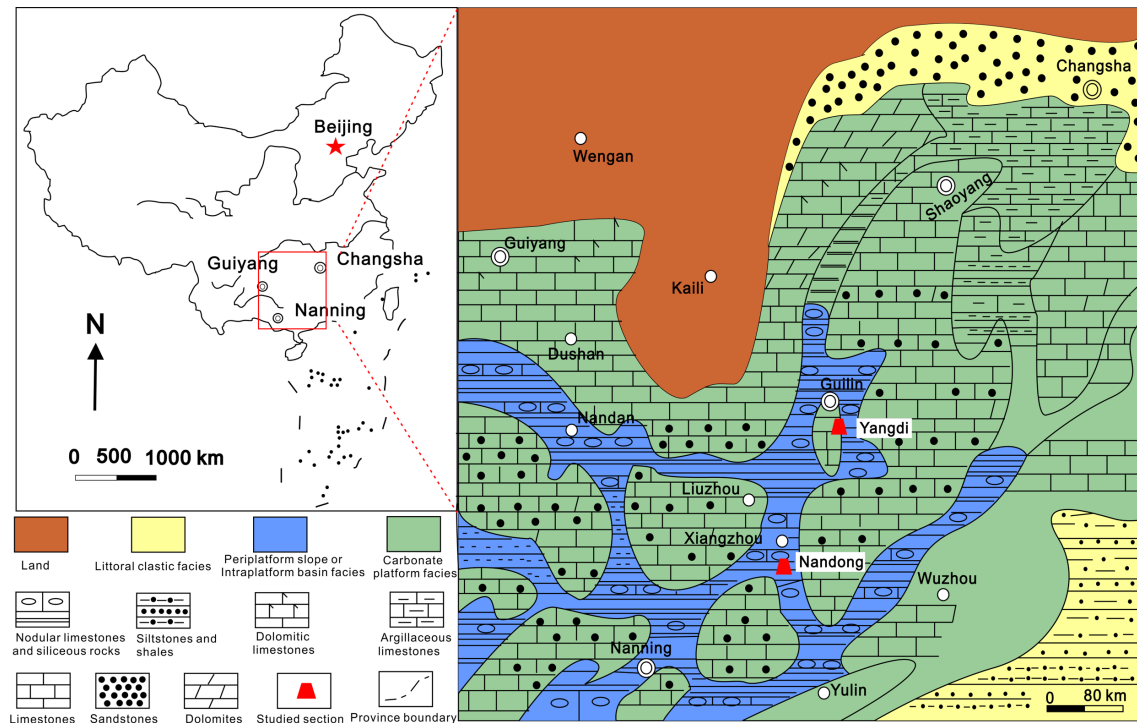


Figure 1. Late Devonian lithofacies and palaeogeography of South China (modified after Huang and Gong, 2016; Ma et al., 2016) with the locations of the studied sections.

late Emsian to the Famennian, the basement of the epicontinental sea of South China Block was cut by varied intersected rifts, developing into a complex palaeogeography of shallow-water platforms separated by deep-water basins (Dong, 1982; Ma and Bai, 2002) (Fig. 1). This special palaeogeographic pattern controlled the distribution of bio- and lithofacies (Ji, 1989; Hou et al., 1988). The basin or slope facies are distributed in a rift belt to the northeast and northwest and cross-cut the carbonate platform facies. Benthic organisms (such as brachiopods, ostracods and corals) dominated in the shallow carbonate platform facies, while pelagic organisms (e.g. conodonts, ammonoids and some allegedly pelagic ostracods) preponderated in the deep basin facies (Ma, 2004).

The Yangdi section ($24^{\circ}58.2' \text{ N}$, $110^{\circ}22.8' \text{ E}$) is located along the road from Baoan to Yangdi, about 35 km southeast of Guilin city, Guangxi. It is a well-outcropped section with continuous deposition of the Late Devonian, which has been studied in detail for biostratigraphy, lithostratigraphy, chemostratigraphy and cyclostratigraphy (Ji, 1989; Gong et al., 1997, 2001, 2005; Wang, 1990; Ma and Bai, 2002; Chen et al., 2013). A reliable and high-resolution conodont biostratigraphy has been established in this section by Huang and Gong (2016). The Yangdi section displays a continuous sedimentation from the Frasnian to the Famennian with, from the bottom to the top, the Fuhe, Lazhutai, Xiangtian, and Wuzhishan formations (Ji, 1989; Ma and Bai, 2002). The lower and middle Frasnian is represented by two strati-

graphic units, i.e. the Fuhe Formation and the Lazhutai Formation (see detailed descriptions in Ji, 1989; Ma and Bai, 2002). The Xiangtian Formation (28 m thick), which is dated to the late Frasnian, can be divided into three parts. The lower part is composed of grey to dark-grey thin-bedded wackestones intercalated with banded cherts (Beds 0–11); the middle part is about 2 m thick and characterized by dark-grey thick-bedded brecciated limestones (Bed 12); the upper part consists of grey argillaceous limestones intercalated with nodular limestones and dark-grey thin-bedded calcareous turbidites (Beds 13–41). The Wuzhishan Formation is mainly characterized by light-grey thick-bedded nodular limestones (Fig. 2).

The Nandong section is well exposed along a river close to Nandong Village, in Wuxuan County, Guangxi ($23^{\circ}46'42.98'' \text{ N}$, $109^{\circ}41'57.63'' \text{ E}$). This section has been studied previously for lithostratigraphy, biostratigraphy and geochemistry (Bai et al., 1994; Gong and Li, 2001; Huang, 2015). The Nandong section exhibits a continuous deposition from the Liujiang Formation to the Wuzhishan Formation (Fig. 3). The Liujiang Formation is made of grey thin-bedded siliceous rocks intercalated with argillaceous limestones. The lower part of the Wuzhishan Formation is characterized by grey nodular limestones, and the upper part is composed of dark-grey thin-bedded siliceous rocks.

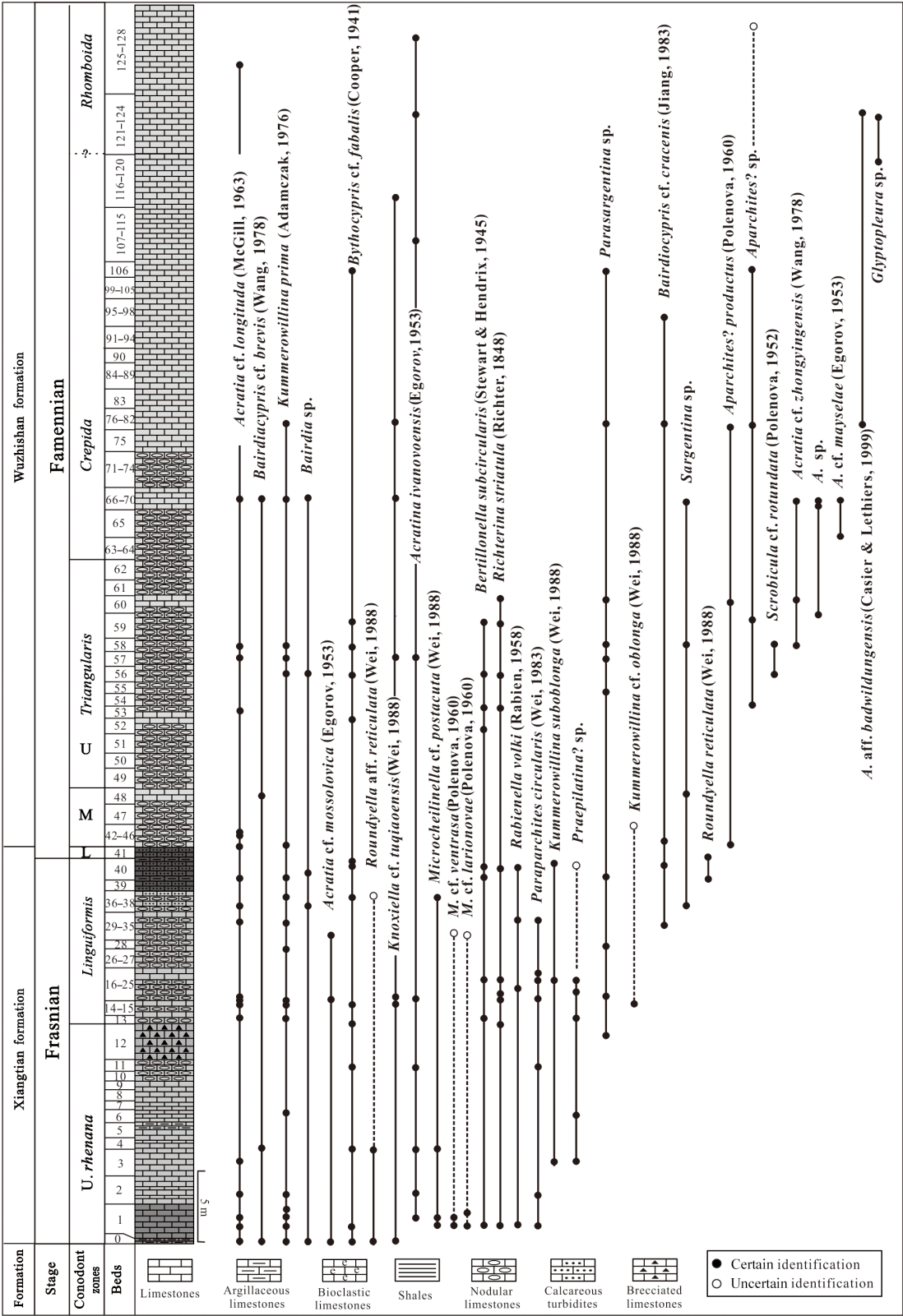


Figure 2. Distribution of ostracods in the Late Devonian in the Yangdi section, South China (log and conodont zones from Huang and Gong, 2016).

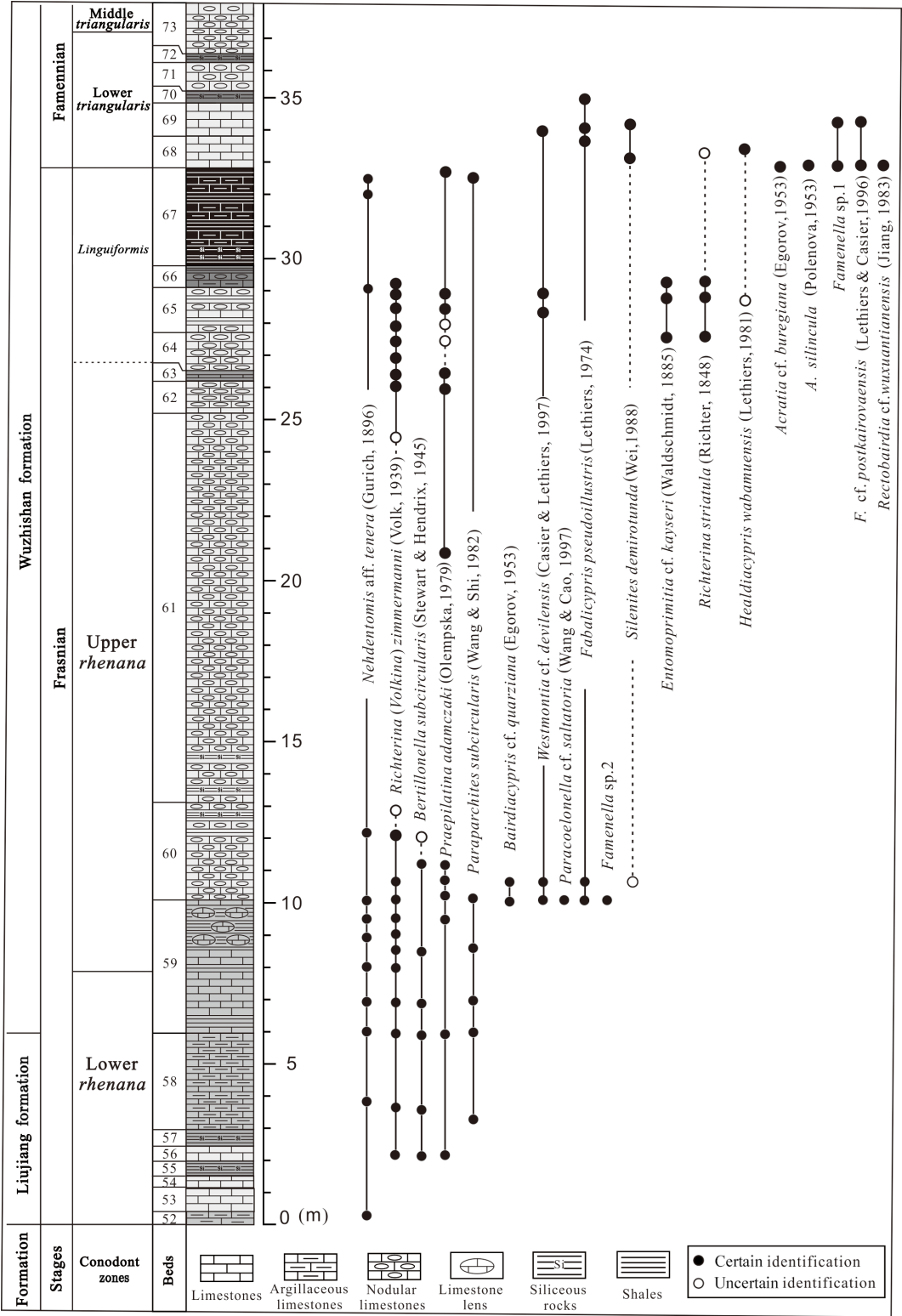


Figure 3. Distribution of ostracods in the Late Devonian in the Nandong section, South China (log and conodont zones from Huang, 2015).

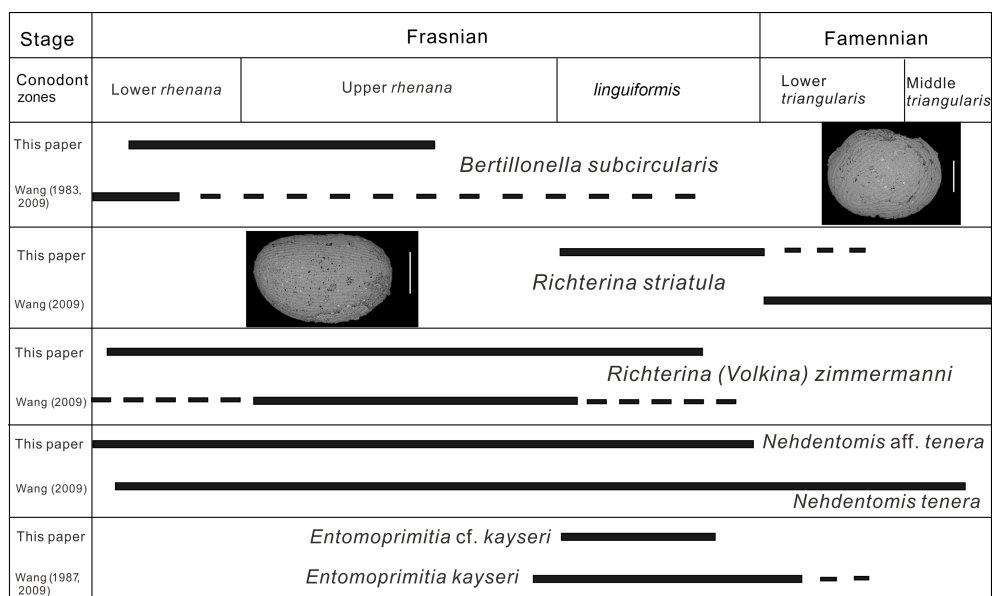


Figure 4. Comparison of the distribution of entomozocean ostracod found in the Nandong section (conodont zones from Huang, 2015; scale bars represent 200 µm).

3 Material and methods

Three periods of fieldwork, from 2012 to 2015, have been carried out in South China to sample the Yangdi and Nandong sections. In total, 131 and 81 samples were collected respectively from the two studied sections (Yangdi and Nandong). The so-called “hot-acetolysis” method was used to extract ostracods from limestones (Lethiers and Crasquin-Soleau, 1988; Crasquin-Soleau et al., 2005). For siliceous rocks, the ostracods were extracted after dilute hydrofluoric acid (HF) (2 to 5 %) processing, the same method used to extract radiolarians from cherts (Pessagno Jr. and Newport, 1972). About 1000 and 1500 specimens were thus obtained from the Yangdi (including single valves and carapaces) and Nandong (mostly single valves) sections, respectively. In total, 48 species belonging to 28 genera were recognized: 31 species belonging to 19 genera in the Yangdi section and 19 species belonging to 15 genera in the Nandong section (Figs. 2, 3). All specimens figured in this paper are deposited in the palaeontological collections of the Museum of the China University of Geosciences (Wuhan, People’s Republic of China) numbered from YD15001 to YD15034 (Yangdi section) and ND15001 to ND15022 (Nandong section).

4 Entomozocean from the Nandong section

Although the pelagic entomozocean ostracod faunas show high abundance in the Nandong section, they cannot be ascribed to the entomozocean zonation summarized by Wang (2009) for South China. Indeed, the diversity is low (five species belonging to four genera). *Bertillonella subcir-*

cularis Stewart & Hendrix, 1945 (Plate 3, fig. 16) is one of the characteristic species of the *suberecta*–*subcircularis* entomozocean Zone in South China (Wang, 1984). According to the newly established conodont zonation (Huang, 2015) in the Nandong section, *suberecta*–*subcircularis* Zone may be equivalent to the lower *rhenana* Zone and middle part of upper *rhenana* Zone (Fig. 4). *Richterina striatula* (Richter, 1848) (Plate 4, figs. 1, 2) was widespread in the Famennian of Europe, North Africa, and South China (Kummerow, 1939; Rabien, 1954; Olempska, 1979, 2002; Casier, 1985, 1986; Wang, 1984, 2009). However, the first appearance of this species seems to be earlier in the Nandong section than that in previous reports and should be in the late Frasnian *linguiformis* Zone (Fig. 4). *Richterina (Volkina) zimmermanni* (Volk, 1939) (Plate 4, figs. 3, 4) was reported from the Frasnian of Europe, North Africa, and South China (Rabien, 1954; Olempska, 2002; Casier, 1982; Wang, 1983, 1984, 2009). *Nehdentomis* aff. *tenera* (Gürich, 1896) (Plate 4, fig. 6) is similar to *Nehdentomis tenera* (Gürich, 1896), which was discovered in the Frasnian–Famennian transitional deposits from South China (Wang, 2009). In particular, these two species range in *rhenana*–*linguiformis* zones based on the results of conodonts in the Nandong section (Fig. 4). *Entomoprimitia* cf. *kayseri* (Waldschmidt, 1885) (Plate 3, fig. 15) is close to *Entomoprimitia kayseri* (Waldschmidt, 1885), which is one of the most characteristic species in the Frasnian–Famennian in Europe and South China (e.g. Waldschmidt, 1885; Walliser et al., 1989; Casier and Lethiers, 1998; Olempska, 2002; Wang, 1987, 2009). *Entomoprimitia* cf. *kayseri* just appeared in the late Frasnian *linguiformis* Zone in the Nandong section (Fig. 4).

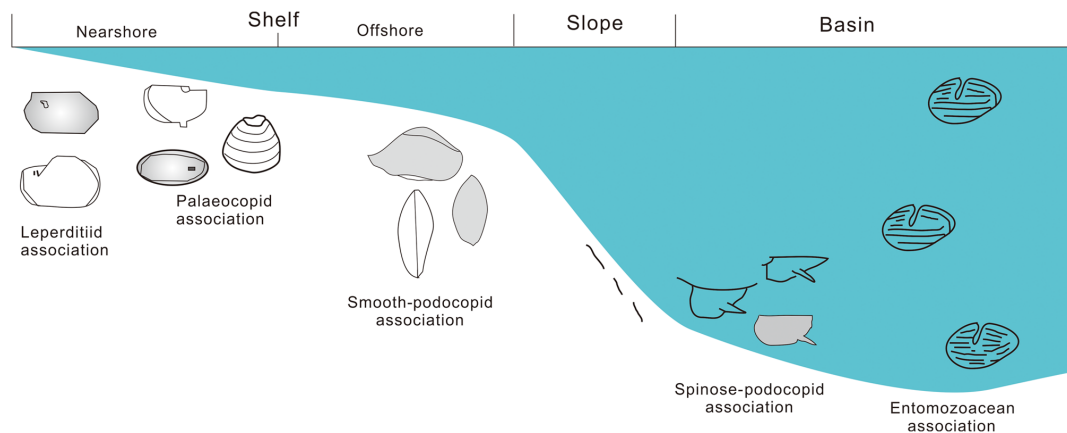


Figure 5. The ecological position of Late Palaeozoic ostracod associations from South China (Wang, 1988).

5 Palaeoenvironmental analysis

Five ostracod associations were recognized in the Palaeozoic strata of the South China by Wang (1988) i.e. the leperditiid, palaeocopid, smooth-podocopid, spinose-podocopid, and entomozoacean associations, which represent the palaeoenvironments from the nearshore to deep basins (Fig. 5). Following Wang (1988), the smooth-podocopid association was generally characterized by a rich bairdiacean fauna with smooth carapaces and is indicative of offshore environments. The entomozoacean association characterized by entomozoid and/or cyprinoid ostracods is indicative of deep-water basin environments.

The ostracod faunas from the Yangdi section are dominated by podocopids (about 63 % of total number of species) and palaeocopids (about 22 % of species). Myodocopids and platycopids are rare, just 9 and 6 % of species, respectively. Therefore, the ostracod assemblage belongs to the smooth-podocopid association (Fig. 5), which consists of Bairdioidea (e.g. *Bairdia* McCoy, 1844; *Acratia* Delo, 1930; *Bairdiacypris* Bradfield, 1935; *Fabalicypis* Cooper, 1946; and *Bythocypris* Brady, 1880), Bairdiocypridoidea (such as *Bairdiocypris* Kegel, 1932 and *Praepilatina* Polenova, 1970) and Healdioidea (i.e. *Kummerowillina* Adamczak, 1978). Previous studies have indicated that entomozoaceans (pelagic “fingerprint” ostracods) prefer living in low-energy deeper waters (Bandel and Becker, 1975; Casier et al., 1995; Becker and Bless, 1987; Wang, 1988; Lethiers and Casier, 1995; Olempska, 2002; Casier, 2004, 2008). Generally, the entomozoacean association (equivalent to the Myodocopid Mega-Assemblage of Casier, 2004, 2008) reflects an environment of deep-water basin (Wang, 1988). However, some studies from South China showed that the water depth could be shallower when there is a mixed assemblage of benthic and pelagic ostracods (Wang, 1984, 1987, 1988). The smooth-podocopid association was accompanied by some

entomozoids (three species belonging to three genera) in the Yangdi section. Among these are *Bertilionella subcircularis* Stewart & Hendrix, 1945 and *Richterina striatula* (Richter, 1848) up to Bed 60; this implies environments from a carbonate platform to a slope. Further up, environments becomes shallower as attested by the disappearance of entomozoids and by a carbonate platform environment. It may be a response to the regression that was reported in the early Famennian in South China (Zong et al., 2015). Geochemistry, sedimentology, and other faunal evidence (e.g. conodonts) suggest a slope environment in the Yangdi section (Ji, 1989; Ma and Bai, 2002; Chen et al., 2013; Huang and Gong, 2016). However, none of the spinose podocopids (indicative of deep- and cold-water environments; Blumenstengel, 1965, 1979; Kozur, 1972; Bandel and Becker, 1975; Lethiers and Crasquin, 1987; Wang, 1988; Casier, 2004; some authors also considered spinose-podocopid ostracod assemblages as indicative for low-energy environments, which might not be particularly deep or cold; Becker, 2000; Groos-Uffenorde et al., 2000) were found together with the smooth-podocopid association in the Yangdi section. This means a deposition in a shallower environment than that of the slope. So we deduce that the Xiangtian and Wuzhishan formations in the Yangdi section were deposited on an external carbonate platform–slope setting during a regression.

The ostracod faunas from the Nandong section are dominated by podocopids (65 % of total number of species) and myodocopids (25 % of total number of species). Palaeocopids and platycopids are rare, with each having just 5 % of the total number of species. The ostracod assemblage is represented by smooth podocopids (i.e. Bairdioidea and Bairdiocypridoidea), which is similar to the ostracod faunas in the Yangdi section. However, thin-shelled entomozoaceans show a significant preponderance (more than 65 % of total number of specimens) in the Nandong section. Moreover, most ostracods species are represented by relatively small

carapaces (< 1 mm), thin valves, and simple hinge structures, which may be a result of specialization in a low-energy and anoxic deep-water environment (Wang, 1988). Therefore, the bathymetry was deeper during the deposition of the Liujiang and Wuzhishan formations in the Nandong section than during the contemporaneous deposition in the Yangdi section. The ecological assemblages of ostracods in the Nandong section indicated a basin environment (Fig. 5).

6 Systematic palaeontology

The taxonomic classifications of Becker (2002) and Liebau (2005) are used in the paper. Abbreviations: CA, cardinal angles; ACA, anterior cardinal angle; PCA, posterior cardinal angle; AB, anterior border; PB, posterior border; DB, dorsal border; ADB, anterodorsal border; PDB, posterodorsal border; VB, ventral border; AVB, anteroventral border; PVB, posteroventral border; *L*, maximum length; *H*, maximum height; *W*, maximum width.

Family Aparchitidae Jones, 1901

Genus *Aparchites* Jones, 1889

Aparchites? productus Polenova, 1960

(Plate 1, fig. 1)

1960 *Aparchites productus* Polenova: 8–9, pl. 1, fig. 2.

Material: Two carapaces and two valves.

Description: Equivalve carapace. DB straight and long; CA obtuse. AB rounded with a large radius of curvature and a maximum convexity located between first third of *H* and mid-*H*; VB regularly curved; PB with a relative small radius of curvature and a maximum convexity located below mid-*H*. Surface smooth.

Dimensions: *L* = 0.76–0.80 mm, *H* = 0.61–0.65 mm, *W* = 0.47–0.51 mm.

Occurrence: Late Devonian, Guangxi (Xiangtian and Wuzhishan formations of Yangdi section), South China.

Remarks: In lateral outline, the specimens resemble *Aparchites productus* Polenova, 1960 from the Middle Devonian of the Russian Platform (Polenova, 1960). The specimens figured by Polenova (1960, Plate 1, figs. 2a, b), as well as our specimens, do not possess the adventral structure characteristic of the genus. Therefore, our species is assigned to *Aparchites* with doubt.

Aparchites? sp.

(Plate 1, fig. 2)

Material: Two carapaces and two valves.

Description: DB straight to slightly curved; AB and PB rounded; VB regularly concave; left valve slightly overlaps the right along the free margins. Surface smooth.

Dimensions: *L* = 0.36–0.42 mm, *H* = 0.30–0.37 mm, *W* = 0.24–0.27 mm.

Occurrence: Late Devonian, Guangxi (Wuzhishan Formation of Yangdi section), South China.

Remarks: In outline, the specimens resemble *Aparchites circularis* Wei, 1983 from Early Devonian of Sichuan, South China (Wei et al., 1983), but poor preservation makes further identification impossible.

Family Uncertain

Genus *Parasargentina* Zheng, 1982

Parasargentina sp.

(Plate 1, fig. 3)

Material: Two carapaces and four valves.

Description: Round ovoid carapace, DB straight to slightly arched; AB and PB rounded; VB regularly concave; left valve slightly overlaps the right along the free margins. Surface smooth.

Dimensions: *L* = 0.51–0.56 mm, *H* = 0.36–0.40 mm, *W* = 0.24–0.27 mm.

Occurrence: Late Devonian, Guangxi (Xiangtian and Wuzhishan formations of Yangdi section), South China.

Remarks: In lateral outline, the specimens could be attributed to the genus *Parasargentina* Zheng, 1982, for their nearly straight dorsal margin and rounded AB, but poor preservation forbids further assignment.

Family Scrobiculidae Posner, 1951

Genus *Scrobicula* Posner, 1951

Scrobicula cf. *rotundata* Polenova, 1952

(Plate 1, fig. 4)

Material: Three carapaces and two valves.

Description: DB slightly curved; AB rounded with a large radius of curvature and a maximum convexity located a little below mid-*H*; VB nearly straight on left valve and regularly convex on right one; PB with a relative small radius of curvature and a maximum convexity located at mid-*H*. Left valve overlaps slightly the right one with a maximum at

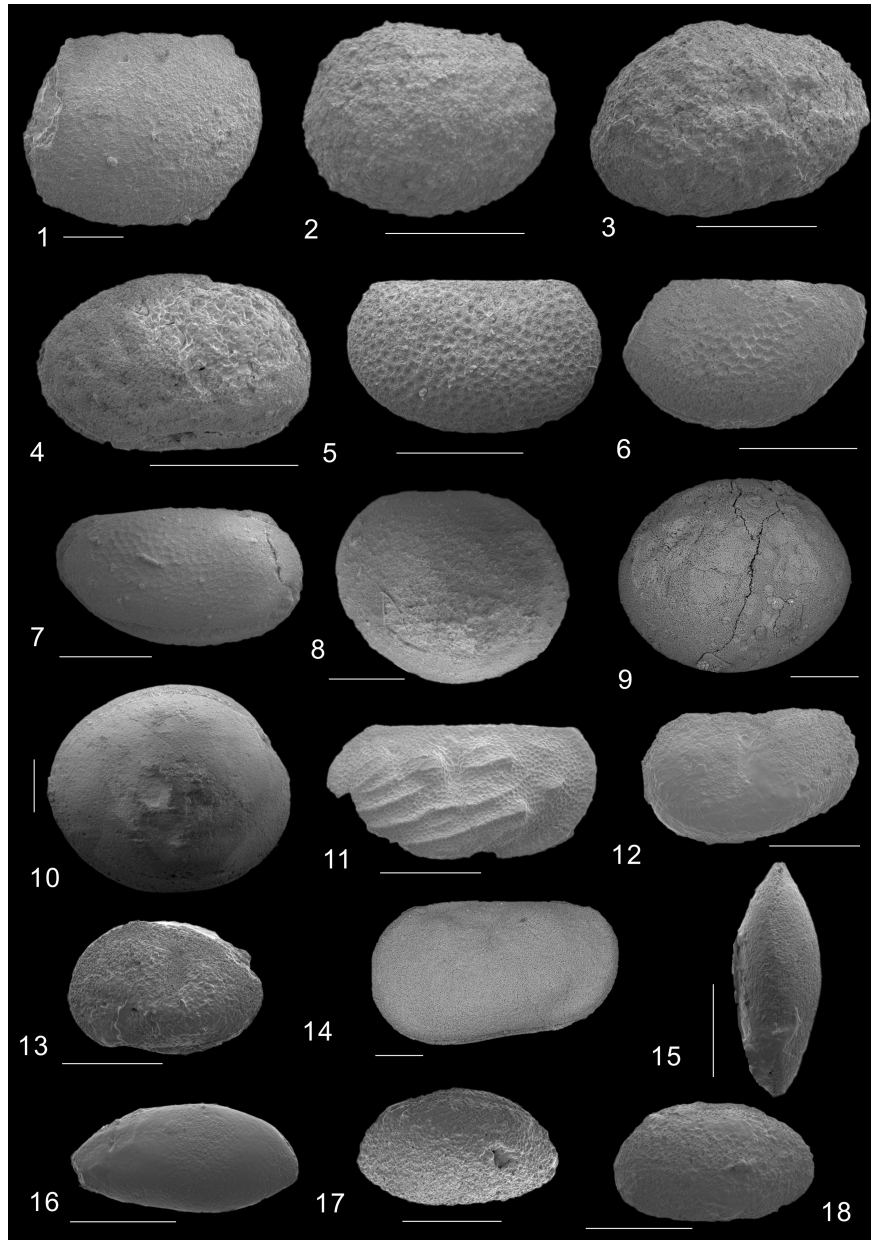


Plate 1. (1) *Aparchites? productus* Polenova, 1960. Right lateral view of complete carapace, YD15001, Frasnian–Famennian, Yangdi section (Bed 60). (2) *Aparchites?* sp. Left lateral view of complete carapace, YD15002, Famennian, Yangdi section (Bed 79). (3) *Parasargentina* sp. Right lateral view of complete carapace, YD15003, Frasnian–Famennian, Yangdi section (Bed 79). (4) *Scrobicula* cf. *rotundata* Polenova, 1952. Right lateral view of complete carapace, YD15004, Famennian, Yangdi section (Bed 58). (5) *Roundyella reticulata* Wei, 1988. Right lateral view of complete carapace, YD15005, Frasnian, Yangdi section (Bed 39). (6, 7) *Roundyella* aff. *reticulata* Wei, 1988. (6) Left lateral view of complete carapace, YD15006. (7) Right lateral view of complete carapace, YD15007; Frasnian, Yangdi section (Bed 40). (8) *Paraparchites circularis* (Wei, 1983). Right valve, YD15008, Frasnian, Yangdi section (Bed 1). (9, 10) *Paraparchites subcircularis* (Wang and Shi, 1982). (9) Right lateral view of complete carapace, ND15001. (10) Right lateral view of complete carapace, ND15002; Frasnian, Nandong section (Bed 60). (11) *Glyptopleura* sp. Right valve, YD15009, Famennian, Yangdi section (Bed 116). (12) *Knoxiella* cf. *tuqiaoensis* Wei, 1988. Left lateral view of complete carapace, YD15010, Frasnian–Famennian, Yangdi section (Bed 68). (13) *Sargentina* sp. Left lateral view of complete carapace, YD15011, Frasnian–Famennian, Yangdi section (Bed 58). (14) *Westmontia* cf. *devilensis* Casier & Lethiers, 1997. Left lateral view of complete carapace, ND15003, Frasnian–Famennian, Nandong section (Bed 60). (15, 16) *Acratia* cf. *longituda* (McGill, 1963). (15) Dorsal view of complete carapace, YD15012. (16) Right lateral view of complete carapace, YD15013; Frasnian–Famennian, Yangdi section (Bed 41). (17, 18) *Acratina ivanovoensis* Egorov, 1953. (17) Right lateral view of complete carapace, YD15014. (18) Right lateral view of complete carapace, YD15015; Frasnian–Famennian, Yangdi section (Bed 123). Scale bars represent 200 μm.

VB. Surface reticulated.

Dimensions: $L = 0.32\text{--}0.40$ mm, $H = 0.19\text{--}0.26$ mm, $W = 0.20\text{--}0.26$ mm.

Occurrence: Late Devonian, Guangxi (Wuzhishan Formation of Yangdi section), South China.

Remarks: In lateral outline, the specimens are close to *Scrobicula rotundata* Polenova, 1952 from the Middle Devonian of the Russian Platform (Polenova, 1952), but differs by the smaller radius of curvature of the PB.

Genus *Roundyella* Bradfield, 1935

Roundyella reticulata Wei, 1988

(Plate 1, fig. 5)

1988 *Roundyella reticulata* Wei: 284, pl. 95, fig. 14.

Material: Five carapaces and six valves.

Description: Small equivale carapace with subrectangular outline in lateral view. DB straight and long; ACA obtuse and bigger than PCA. AB rounded with a large radius of curvature and a maximum convexity located a little below mid- H ; VB regularly curved; PB with a relative small radius of curvature and a maximum convexity located at mid- H . Surface finely reticulated.

Dimensions: $L = 0.40\text{--}0.42$ mm, $H = 0.22\text{--}0.24$ mm, $W = 0.15\text{--}0.16$ mm.

Occurrence: Middle Devonian of Longmen Mts., Sichuan, South China, and Late Devonian of Yangdi section, Guangxi, South China.

Roundyella aff. *reticulata* Wei, 1988

(Plate 1, figs. 6, 7)

Material: Four carapaces and six valves.

Description: Small equivale carapace with subrectangular outline in lateral view. DB straight and long; ACA obtuse and bigger than PCA. AB rounded with a large radius of curvature and a maximum convexity located below mid- H ; VB regularly curved; PB with a relative small radius of curvature and a maximum convexity located at lower third of H . Surface finely reticulated.

Dimensions: $L = 0.42\text{--}0.45$ mm, $H = 0.24\text{--}0.26$ mm, $W = 0.16\text{--}0.18$ mm.

Occurrence: Late Devonian, Guangxi (Wuzhishan Formation of Yangdi section), South China.

Remarks: In lateral outline, the specimens resemble *Roundyella reticulata* Wei, 1988 from the Middle Devonian of Sichuan, South China (Wei, 1988), but differ by the small radius of curvature of the PB.

Family Paraparchitidae Scott, 1959

Genus *Paraparchites* Ulrich & Bassler, 1906

Paraparchites circularis (Wei, 1983)

(Plate 1, fig. 8)

1983 *Aparchites circularis* Wei; Wei et al.: 46, pl. 11, figs. 7–9.

1988 *Antiparaparchites circularis* (Wei); Wei: pl. 102, figs. 2–3.

Material: Three valves.

Description: Subrounded carapace. DB slightly curved; both AB and PB rounded with a large radius of curvature and a maximum convexity located at mid- H ; VB regularly curved. Surface smooth.

Dimensions: $L = 0.41\text{--}0.55$ mm, $H = 0.42\text{--}0.53$ mm.

Occurrence: Late Devonian, Guangxi (Xiangtian and Wuzhishan formations of Yangdi section), South China.

Remarks: The present specimens are assigned to *Paraparchites circularis* (Wei et al., 1983) from the Early Devonian of Sichuan, South China. Wei (1988) changed the generic attribution, certainly due to the lack of adventral structure and referred the species to *Antiparaparchites* Coryell & Rogatz, 1932. This genus is considered as a junior synonym of *Paraparchites* since the revision of Paraparchitoidea by Sohn (1971, 1972).

Paraparchites subcircularis (Wang & Shi, 1982)

(Plate 1, figs. 9, 10)

1982 *Antiparaparchites subcircularis* Wang & Shi: 103, pl. 3, figs. 11–13.

1988 *Antiparaparchites subcircularis* Wang & Shi; Wei: pl. 102, fig. 6.

Material: Six carapaces and two valves.

Description: Carapace rounded. DB regularly convex; both AB and PB rounded with a large radius of curvature and a maximum convexity located at mid- H ; VB regularly curved. Left valve overlaps the right one with maxima at DB and AB, surface smooth.

Dimensions: $L = 0.75\text{--}0.81$ mm, $H = 0.74\text{--}0.80$ mm, $W = 0.35\text{--}0.41$ mm.

Occurrence: Middle Devonian of Guangxi, South China; Late Devonian of Guangxi (Liujiang and Wuzhishan formations of Nandong section), South China.

Remarks: *Antiparaparchites* Coryell & Rogatz, 1932 is considered as a junior synonym of *Paraparchites* since the revision of Paraparchitoidea by Sohn (1971, 1972).

Family Glyptopleuridae Girty, 1910

Genus *Glyptopleura* Girty, 1910

Glyptopleura sp.

(Plate 1, fig. 11)

Material: Three valves.

Description: DB straight and long; CA obtuse and ACA larger than PCA. Both AB and PB rounded with large radius of curvature and maximum convexity located at mid-*H*; VB regularly curved. Valve ornamented by longitudinal narrow ridges. Surface finely reticulate.

Dimensions: $L = 0.68\text{--}0.72$ mm, $H = 0.32\text{--}0.36$ mm.

Occurrence: Late Devonian, Guangxi (Wuzhishan Formation of Yangdi section), South China.

Remarks: In lateral outline, the specimens resemble *Glyptopleura venosa* (Ulrich, 1891) from the Late Devonian to the Early Carboniferous of the Illinois, USA (Ulrich, 1891), but broken valves forbid further assignment.

Family Geisinidae Sohn, 1961

Genus *Knoxiella* Egorov, 1950

Knoxiella cf. *tuqiaoensis* Wei, 1988

(Plate 1, fig. 12)

Material: Four carapaces.

Description: DB long and straight; CA obtuse; AB with a relatively large radius of curvature, and with a maximum curvature located at mid-*H*; VB regularly rounded with a maximum curvature located at posterior part of VB; PB rounded with a large radius of curvature and a maximum located at mid-*H*. A short and deep subcentral sulcus almost reaches the dorsal border.

Dimensions: $L = 0.43\text{--}0.50$ mm, $H = 0.30\text{--}0.35$ mm, $W = 0.29\text{--}0.32$.

Occurrence: Late Devonian, Guangxi (Xiangtian and Wuzhishan formations of Yangdi section), South China.

Remarks: The specimens resemble *Knoxiella tuqiaoensis* Wei, 1988 from the Middle Devonian of Longmen Mts., Sichuan, South China (Wei, 1988) in outline, but poor preservation of the surface ornamentation forbids further assignment.

Genus *Sargentina* Coryell & Johnson, 1939

Sargentina sp.

(Plate 1, fig. 13)

Material: Two carapaces and three valves.

Description: DB regularly convex; AB with relatively large radius of curvature with maximum located at mid-*H*; PB with small radius of curvature with maximum located a little below mid-*H*; VB slightly concave. Overlap of right valve on left one with a maximum at VB. A short subcentral sulcus located a little below DB. Surface smooth.

Dimensions: $L = 0.41\text{--}0.48$ mm, $H = 0.28\text{--}0.35$ mm, $W = 0.26\text{--}0.32$ mm.

Occurrence: Middle Devonian of Yunnan, South China; Late Devonian of Guangxi (Xiangtian and Wuzhishan formations of Yangdi section), South China.

Remarks: In outline, the specimens are close to *Sargentina arcuata* (Egorov, 1950) sensu Wei et al., 1983 from the Early Devonian of Sichuan, South China (Wei et al., 1983). But *S. arcuata* is more elongate and has a larger radius of curvature at PB. Our specimens may belong to a new species. The poor preservation could not allow a precise determination.

Family Uncertain

Genus *Westmontia* Loranger, 1963

Westmontia cf. *devilensis* Casier & Lethiers, 1997

(Plate 1, fig. 14)

Material: Two carapaces and two valves.

Description: DB long and straight; CA obtuse; AB flattened with a relatively large radius of curvature and with a maximum located a little below mid-*H*; PB flattened with a large radius of curvature with maximum located at mid-*H*; VB straight to slightly curve. *S*₂ developed and nearly reach to DB. Right valve slightly overlaps the left one with a maximum at VB.

Dimensions: $L = 0.85\text{--}1.05$ mm, $H = 0.48\text{--}0.65$ mm, $W = 0.28\text{--}0.36$ mm.

Occurrence: Late Devonian, Guangxi (Wuzhishan Formation of Nandong section), South China.

Remarks: The specimens resemble *Westmontia devilensis* Casier & Lethiers, 1997 from the Frasnian–Famennian (Late Devonian) of Nevada, USA (Casier and Lethiers, 1997), in outline, but differ by more obtuse CA.

Family Acraatiidae Gründel, 1962

Genus *Acratia* Delo, 1930

Acratia cf. *longituda* (McGill, 1963)

(Plate 1, figs. 15, 16)

Material: Seven carapaces.

Description: DB slightly convex; AB with a relatively large radius of curvature and with a maximum located a little below mid-*H*; PB with a small radius of curvature and with a maximum located at mid-*H*; VB regularly curved with a maximum convexity located at between first third of *L* and mid-*L*. Overlap of left valve on right one. Surface smooth.

Dimensions: $L = 0.42\text{--}0.51$ mm, $H = 0.21\text{--}0.25$ mm, $W = 0.10\text{--}0.12$ mm.

Occurrence: Late Devonian, Guangxi (Xiangtian and Wuzhishan formations of Yangdi section), South China.

Remarks: In outline, our specimens are closed to *Acratia longituda* (McGill, 1963) from the Middle and Late Devonian of Alberta, Canada (McGill, 1963), and Chaohu, Anhui, China (Chen and Bao, 1990). But *Acratia longituda* (McGill, 1963) is more elongate.

Acratia cf. *mossolovica* Egorov, 1953

(Plate 2, fig. 1)

Material: Three carapaces.

Description: DB nearly straight; AB and PB with a relatively small radius of curvature and with a maximum located at mid-*H*; VB slightly curved to straight. Overlap of left valve on right one with a maximum at DB. Surface smooth.

Dimensions: $L = 0.92\text{--}1.01$ mm, $H = 0.38\text{--}0.45$ mm, $W = 0.40\text{--}0.47$ mm.

Occurrence: Late Devonian, Guangxi (Xiangtian Formation of Yangdi section), South China.

Remarks: In outline, our specimens resemble *Acratia mossolovica* Egorov, 1953 from the Late Devonian of the Russian Platform (Egorov, 1953). But *A. mossolovica* is more elongate and has a larger radius of curvature at AB and PB. Our specimens may belong to a new species.

Acratia cf. *mayselae* Egorov, 1953

(Plate 2, fig. 2)

Material: Three carapaces.

Description: Carapace diamond-shaped in lateral outline; DB regularly arched; ADB and PDB arched; AB and PB with small radius of curvature and with maxima located at mid-*H*; VB regularly concave. Left valve slightly overlaps the right with a maximum at VB. Surface smooth.

Dimensions: $L = 0.58\text{--}0.68$ mm, $H = 0.38\text{--}0.45$ mm, $W = 0.34\text{--}0.41$ mm.

Occurrence: Late Devonian, Guangxi (Wuzhishan Formation of Yangdi section), South China.

Remarks: In lateral outline, these specimens resemble *Acratia mayselae* Egorov, 1953 from the Late Devonian of the Russian Platform (Egorov, 1953). They differ by a more tapered AB.

Acratia cf. *zhongyingensis* Wang, 1978

(Plate 2, fig. 3)

Material: Two carapaces and three valves.

Description: DB regularly convex; AB with a large radius of curvature and with a maximum located between first third of *H* and mid-*H*; PB with a relative small radius of curvature and with a maximum located at lower third of *H*; VB nearly straight. Left valve slightly overlaps the right one along the free margins with a maximum at DB and VB. Surface smooth.

Dimensions: $L = 0.41\text{--}0.50$ mm, $H = 0.21\text{--}0.28$ mm, $W = 0.17\text{--}0.24$ mm.

Occurrence: Late Devonian, Guangxi (Wuzhishan Formation of Yangdi section), South China.

Remarks: In lateral outline, the specimens resemble *Acratia zhongyingensis* Wang, 1978 from the Late Permian of Guizhou, China (Wang, 1978). It differs by being more elongate.

Acratia cf. *buregiana* Egorov, 1953

(Plate 2, fig. 4)

Material: Five carapaces.

Description: DB slightly convex; AB with a relatively small radius of curvature and with a maximum located at lower third of *H*; PB with a large radius of curvature and with a maximum located at mid-*H*; VB slightly concave. Overlap of left valve on right one with a maximum at DB. Surface smooth.

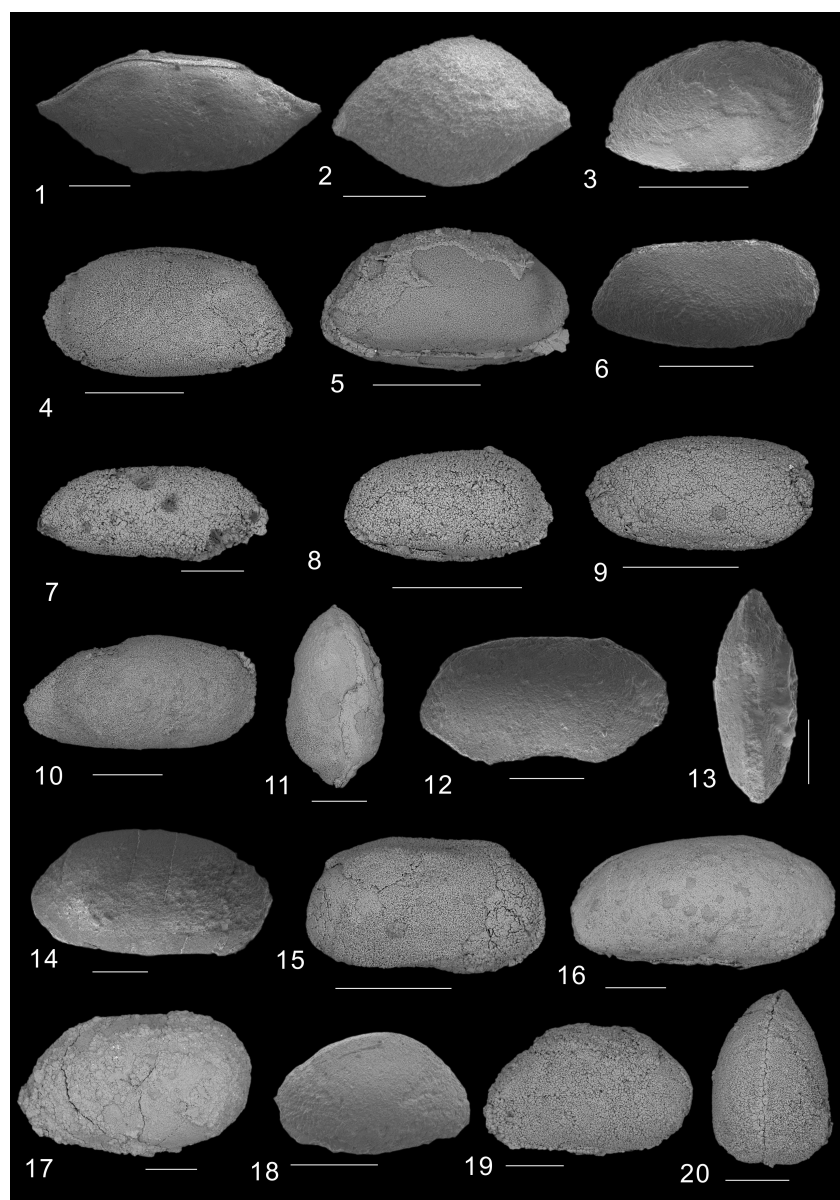


Plate 2. (1) *Acratia* cf. *mossolovica* Egorov, 1953. Right lateral view of complete carapace, YD15016, Frasnian, Yangdi section (Bed 0). (2) *Acratia* cf. *mayselae* Egorov, 1953. Right lateral view of complete carapace, YD15017, Famennian, Yangdi section (Bed 68). (3) *Acratia* cf. *zhongyingensis* Wang, 1978. Right lateral view of complete carapace, YD15018, Famennian, Yangdi section (Bed 58). (4) *Acratia* cf. *burgiana* Egorov, 1953. Right lateral view of complete carapace, ND15004, Famennian, Nandong section (Bed 68). (5) *Acratia* cf. *silincula* Polenova, 1953. Right lateral view of complete carapace, ND15005, Famennian, Nandong section (Bed 68). (6) *Acratia* aff. *badwildungensis* Casier & Lethiers, 1999. Right lateral view of complete carapace, YD15019, Famennian, Yangdi section (Bed 79). (7) *Acratia* sp. Right lateral view of complete carapace, YD15020, Famennian, Yangdi section (Bed 68). (8) *Famenella* cf. *postkairovaensis* Lethiers & Casier, 1996. Right lateral view of complete carapace, ND15006, Famennian, Nandong section (Bed 68). (9) *Famenella* sp. 1. Right lateral view of complete carapace, ND15007, Famennian, Nandong section (Bed 68). (10, 11) *Famenella* sp. 2. Right lateral view and dorsal view of complete carapace, respectively, ND15008, Frasnian, Nandong section (Bed 59). (12, 13) *Bairdia* sp. Right lateral view and dorsal view of complete carapace, respectively, YD15021, Frasnian–Famennian, Yangdi section (Bed 0). (14) *Bairdiacypris* cf. *brevis* (Wang, 1978) sensu Wei et al., 1983. Right lateral view of complete carapace, YD15022, Frasnian–Famennian, Yangdi section (Bed 0). (15) *Bairdiacypris* cf. *quarziana* (Egorov, 1953) sensu Casier & Lethiers, 1998. Right lateral view of complete carapace, ND15009, Frasnian, Nandong section (Bed 60). (16) *Fabaliacypris pseudoillustris* Lethiers, 1974. Right lateral view of complete carapace, ND15010, Frasnian–Famennian, Nandong section (Bed 60). (17) *Rectobairdia* cf. *wuxuantianensis* Jiang in Wei et al., 1983. Right lateral view of complete carapace, ND15011, Famennian, Nandong section (Bed 68). (18) *Bythocypris* cf. *fabalis* Cooper, 1941. Right lateral view of complete carapace, YD15023, Frasnian–Famennian, Yangdi section (Bed 3). (19, 20) *Healdiacypris wabamuensis* Lethiers, 1981. (19) Right lateral view of complete carapace, ND15012. (20) Dorsal view of complete carapace, ND15013; Famennian, Nandong section (Bed 68). Scale bars represent 200 μ m.

Dimensions: $L = 0.58\text{--}0.65$ mm, $H = 0.32\text{--}0.38$ mm, $W = 0.20\text{--}0.24$ mm.

Occurrence: Late Devonian, Guangxi (Wuzhishan Formation of Nandong section), South China.

Remarks: The specimens are close to *Acratia buregiana* Egorov, 1953 from the Late Devonian of the Russian Platform (Egorov, 1953) in outline, but they differ by a sharper ADB and a rounder AB.

Acratia cf. *silincula* Polenova, 1953

(Plate 2, fig. 5)

Material: Four carapaces.

Description: DB slightly curve; AB with relatively a large radius of curvature and with a maximum located at mid- H ; PB with a small radius of curvature and with a maximum located at lower third of H ; VB nearly straight. Slight overlap of left valve on right one; maximum at VB. Surface smooth.

Dimensions: $L = 0.48\text{--}0.60$ mm, $H = 0.28\text{--}0.38$ mm, $W = 0.25\text{--}0.35$ mm.

Occurrence: Late Devonian, Guangxi (Wuzhishan Formation of Nandong section), South China.

Remarks: The specimens resemble *Acratia silincula* Polenova, 1953 from Frasnian-Famennian (Late Devonian) of the Russian Platform (Polenova, 1953) in outline, but differ by a flattened AB.

Acratia aff. *badwildungensis* Casier & Lethiers, 1999

(Plate 2, fig. 6)

Material: Five carapaces.

Description: DB straight; AB with relatively a large radius of curvature and with a maximum located at mid- H ; PB with a small radius of curvature and with a maximum located at lower third of H ; VB regularly curved. Left valve slightly overlaps the right one with a maximum at DB. Surface smooth.

Dimensions: $L = 0.48\text{--}0.60$ mm, $H = 0.21\text{--}0.31$ mm, $W = 0.19\text{--}0.28$ mm.

Occurrence: Late Devonian, Guangxi (Wuzhishan Formation of Yangdi section), South China.

Remarks: In lateral outline, the specimens strongly resemble *Acratia badwildungensis* Casier & Lethiers, 1999 from Frasnian-Famennian (Late Devonian) of the Schmidt

quarry, Germany (Casier et al., 1999). They differ by a more elongate carapace and an AB with a larger radius of curvature.

Acratia sp.

(Plate 2, fig. 7)

Material: Three carapaces and two valves.

Description: DB straight, almost equal and parallel to VB; AB and PB tapering. The left valve slightly overlaps the right one. Surface smooth.

Dimensions: $L = 0.52\text{--}0.67$ mm, $H = 0.23\text{--}0.33$ mm, $W = 0.20\text{--}0.25$ mm.

Occurrence: Late Devonian of western Junggar, NW China, and Guangxi (Wuzhishan Formation of Yangdi section), South China.

Remarks: In outline, the specimens resemble *Acratia tanaica* Egorov, 1953 from the Late Devonian of the Russian Platform (Egorov, 1953), but broken valves forbid further assignation.

Genus *Acratina* Egorov, 1953

Acratina ivanovoensis Egorov, 1953

(Plate 1, figs. 17, 18)

1953 *Acratina ivanovoensis* Egorov: 45, pl. 20, fig. 5a–c.

2017 *Acratina ivanovoensis* Egorov; Song et al.: 266, fig. 8B.

Material: Four carapaces and three valves.

Description: DB nearly straight, ADB and PDB straight; AB with a small radius of curvature and with a maximum located below mid- H ; PB with a relative large radius of curvature and with a maximum located at lower third of H ; VB nearly straight. Left valve slightly overlaps the right one along the free margins with maxima at DB and VB. Surface smooth.

Dimensions: $L = 0.41\text{--}0.50$ mm, $H = 0.21\text{--}0.28$ mm, $W = 0.17\text{--}0.24$ mm.

Occurrence: Frasnian-Famennian (Late Devonian) of the Russian Platform, western Junggar, NW China, and Yangdi section, Guangxi, South China.

Genus *Famenella* Polenova, 1953

Famenella cf. *postkairovaensis* Lethiers & Casier, 1996

(Plate 2, fig. 8)

Material: Three carapaces and two valves.

Description: DB straight to slightly convex; AB with a relatively large radius of curvature and with a maximum located below mid-*H*; PB with a small radius of curvature and with a maximum located at mid-*H*; VB straight to slightly curved. Left valve overlaps the right one with a maximum at VB. Surface smooth.

Dimensions: $L = 0.32\text{--}0.40\text{ mm}$, $H = 0.18\text{--}0.23\text{ mm}$, $W = 0.14\text{--}0.20\text{ mm}$.

Occurrence: Late Devonian, Guangxi (Wuzhishan Formation of Nandong section), South China.

Remarks: In outline, the specimens resemble *Famenella postkairovaensis* Lethiers & Casier, 1996 from the Late Devonian of Coumiac (France) (Lethiers and Casier, 1996), but differ by bigger radius of curvature of PB and AB.

Famenella sp. 1

(Plate 2, fig. 9)

Material: Four carapaces and two valves.

Description: DB slightly convex; AB with a relatively large radius of curvature and with a maximum located at mid-*H*; PB with a small radius of curvature and with a maximum located at mid-*H*; VB straight to slightly curved. Left valve overlaps the right one with a maximum at VB. Surface smooth.

Dimensions: $L = 0.38\text{--}0.45\text{ mm}$, $H = 0.20\text{--}0.24\text{ mm}$, $W = 0.17\text{--}0.21\text{ mm}$.

Occurrence: Late Devonian, Guangxi (Wuzhishan Formation of Nandong section), South China.

Remarks: These specimens are assigned to the genus *Famenella* Polenova, 1953 based on their outline, but poor preservation makes impossible further assignation.

Famenella sp. 2

(Plate 2, figs. 10, 11)

Material: Two carapaces and one valve.

Description: DB slightly convex; AB with a large radius of curvature and with a maximum located at mid-*H*; VB nearly straight; PB with a relative small radius of curvature and with a maximum located at the lower third of *H*; left valve slightly overlaps the right one. Surface smooth.

Dimensions: $L = 0.71\text{--}0.78\text{ mm}$, $H = 0.35\text{--}0.41\text{ mm}$, $W = 0.40\text{--}0.45\text{ mm}$.

Occurrence: Late Devonian, Guangxi (Wuzhishan Formation of Nandong section), South China.

Remarks: These specimens are assigned to the genus *Famenella* Polenova, 1953, for their outline. But this one has a smaller radius of curvature of PB by comparison with other species belonging to the genus. It may be a new species; however, to date, the material is insufficient to establish a new species.

Family Bairdiidae Sars, 1887

Genus *Bairdia* McCoy, 1844

Bairdia sp.

(Plate 2, figs. 12, 13)

Material: Two carapaces.

Description: DB regularly slightly curved; AB and PB rounded and almost equal; VB slightly concave; AVB and PVB nearly straight. Left valve overlaps the right with a maximum at PB. Surface smooth.

Dimensions: $L = 0.61\text{--}0.65\text{ mm}$, $H = 0.32\text{--}0.35\text{ mm}$, $W = 0.25\text{--}0.28\text{ mm}$.

Occurrence: Late Devonian, Guangxi (Xiangtian and Wuzhishan formations of Yangdi section), South China.

Remarks: In outline, the specimens are close to *Bairdia dushanensis* Shi, 1964, from the Middle and Late Devonian of Guizhou, South China (Shi, 1964). The difference is the larger radius of curvature of PB in our specimens and the maximum located higher. They may belong to a new species.

Genus *Bairdiacypris* Bradfield, 1935

Bairdiacypris cf. *brevis* (Wang, 1978) sensu Wei et al., 1983

(Plate 2, fig. 14)

Material: Four carapaces.

Description: DB slightly convex; AB with a relatively large radius of curvature and with a maximum located at mid-*H*; PB with a small radius of curvature and with a maximum located at below mid-*H*; VB straight to slightly curved. Left valve slightly overlaps the right one. Surface smooth.

Dimensions: $L = 0.80\text{--}0.90\text{ mm}$, $H = 0.41\text{--}0.49\text{ mm}$, $W = 0.28\text{--}0.34\text{ mm}$.

Occurrence: Late Devonian, Guangxi (Xiangtian and Wuzhishan formations of Yangdi section), South China.

Remarks: In lateral outline, the specimens resemble *Bairdiacypris brevis* (Wang, 1978) sensu Wei et al., 1983 from the Late Permian of Guizhou, South China (Wei et al., 1983), but they differ by less overlap at VB.

Bairdiacypris cf. *quarziana* (Egorov, 1953) sensu Casier & Lethiers, 1998

(Plate 2, fig. 15)

Material: Two carapaces and three valves.

Description: DB straight; AB with a relatively large radius of curvature and with a maximum located below mid-*H*; PB with a small radius of curvature with a maximum located at the lower third of *H*; VB slightly convex. Left valve overlaps the right one with a maximum at DB and AB. Surface smooth.

Dimensions: $L = 0.41\text{--}0.50$ mm, $H = 0.26\text{--}0.33$ mm, $W = 0.22\text{--}0.28$ mm.

Occurrence: Late Devonian, Guangxi (Wuzhishan Formation of Nandong section), South China.

Remarks: The specimens resemble *Bairdiacypris quarziana* (Egorov, 1953) sensu Casier & Lethiers, 1998, from the Late Devonian of Nevada, USA (Casier and Lethiers, 1998), in outline, but differs by a smaller radius of curvature on AB.

Genus *Fabalicypis* Cooper, 1946

Fabalicypis pseudoillustris Lethiers, 1974

(Plate 2, fig. 16)

1974 *Fabalicypis pseudoillustris* Lethiers: 1616, pl. 1, figs. 3, 4.

Material: Four carapaces three valves.

Description: DB slightly curved; AB and PB rounded and nearly equal; VB straight to slightly convex. Left valve overlaps the right one, with a maximum at VB. Surface smooth.

Dimensions: $L = 0.85\text{--}0.90$ mm, $H = 0.43\text{--}0.48$ mm, $W = 0.32\text{--}0.35$ mm.

Occurrence: Late Devonian–Early Carboniferous of the Dinant Basin, Belgium, and Late Devonian of Guangxi (Wuzhishan Formation of Nandong section), South China.

Genus *Rectobairdia* Sohn, 1960

Rectobairdia cf. *wuxuantianensis* Jiang, 1983

(Plate 2, fig. 17)

Material: Two carapaces and three valves.

Description: DB nearly straight; AB with a large radius of curvature and with a maximum located at mid-*H*; PB with a relative small radius of curvature and with a maximum located at the lower third of *H*; VB slightly curved. Left valve slightly overlaps the right one with maximum at VB. Surface smooth.

Dimensions: $L = 0.71\text{--}0.89$ mm, $H = 0.41\text{--}0.52$ mm, $W = 0.37\text{--}0.44$ mm.

Occurrence: Late Devonian, Guangxi (Wuzhishan Formation of Nandong section), South China.

Remarks: The outline of our specimens is similar to *Rectobairdia wuxuantianensis* Jiang, 1983 from the Middle Devonian of South China (Wei et al., 1983), but our specimens differ by larger carapaces and a smaller overlap on DB.

Family Bythocyprididae Maddocks, 1969

Genus *Bythocypris* Brady, 1880

Bythocypris cf. *fabalis* Cooper, 1941

(Plate 2, fig. 18)

Material: Two carapaces and three valves.

Description: DB regularly arched and ADB and PDB almost equally inclined; AB with a small radius of curvature and with a maximum located at lower third of *H*; PB with a relatively larger radius of curvature and with a maximum located at mid-*H*; VB slightly convex. Left valve overlaps right one with a maximum at VB. Surface smooth.

Dimensions: $L = 0.30\text{--}0.41$ mm, $H = 0.19\text{--}0.27$ mm, $W = 0.16\text{--}0.24$ mm.

Occurrence: Late Devonian of Guangxi (Xiangtian and Wuzhishan formations of Yangdi section), South China.

Remarks: In outline the specimens resemble *Bythocypris fabalis* Cooper, 1941, from the Early Carboniferous of Illinois, USA (Cooper, 1941), but differ by a smaller radius of curvature at PB.

Family Bairdiocyprididae Shaver, 1961

Genus *Healdiacypris* Bradfield, 1935

Healdiacypris wabamuensis Lethiers, 1981

(Plate 2, figs. 19, 20)

1981 *Healdiacypris wabamuensis* Lethiers: 66, pl. 12, figs. 116–119.

Material: Eight carapaces and three valves.

Description: DB regularly convex; AB with a relatively large radius of curvature and with a maximum located at mid-*H*; PB with a small radius of curvature and with a maximum located at lower third of *H*; VB nearly straight. Left valve overlaps the right one with maxima at DB and AB. Surface smooth.

Dimensions: $L = 0.53\text{--}0.70\text{ mm}$, $H = 0.30\text{--}0.44\text{ mm}$, $W = 0.30\text{--}0.40\text{ mm}$.

Occurrence: Late Devonian, western Canada, and Guangxi (Wuzhishan Formation of Nandong section), South China.

Genus *Bairdiocypris* Kegel, 1932

Bairdiocypris cf. *cracenis* Jiang, 1983

(Plate 3, fig. 1)

Material: Three carapaces and two valves.

Description: DB regularly convex; AB with a relatively large radius of curvature and with a maximum located a little below mid-*H*; PB with a small radius of curvature and with a maximum located at lower third of *H*; VB nearly straight. Left valve strongly overlaps the right one with maxima at DB and ADB. Surface smooth.

Dimensions: $L = 0.92\text{--}1.10\text{ mm}$, $H = 0.57\text{--}0.61\text{ mm}$, $W = 0.40\text{--}0.45\text{ mm}$.

Occurrence: Late Devonian, Guangxi (Xiangtian and Wuzhishan formations of Yangdi section), South China.

Remarks: The specimens strongly resemble *Bairdiocypris cracenis* Jiang, 1983 from the Middle Devonian of Yunnan, South China (Wei et al., 1983) in outline. However, the broken carapaces forbid further attribution.

Genus *Praepilatina* Polenova, 1970

Praepilatina adamczaki Olempska, 1979

(Plate 3, fig. 2)

1979 *Praepilatina adamczaki* Olempska: 115, pl. 22, fig. 5.

1997 *Praepilatina adamczaki* Olempska; Olempska: 313, fig. 10G, H.

2017 *Praepilatina adamczaki* Olempska; Song et al.: 268, fig. 8J.

Material: Four carapaces and two valves.

Description: DB strongly convex, ADB and PDB almost symmetrically inclined; AB and PB widely rounded; VB straight to slightly concave. Left valve overlaps right one all around carapace with maxima at VB and AB. Surface smooth.

Dimensions: $L = 0.46\text{--}0.58\text{ mm}$, $H = 0.32\text{--}0.43\text{ mm}$, $W = 0.21\text{--}0.33\text{ mm}$.

Occurrence: Late Devonian of Holy Cross Mts., Poland, western Junggar, Xinjiang, NW China, and Guangxi (Liujiang and Wuzhishan formations of Nandong section), South China.

Praepilatina? sp.

(Plate 3, fig. 3)

Material: Three valves.

Description: Carapace rounded in lateral outline. DB strongly curved; PB slight rounder than AB; VB regularly curved. Left valve slightly overlaps the right one along the free margins with maximum at VB. Surface smooth.

Dimensions: $L = 0.50\text{--}0.60\text{ mm}$, $H = 0.46\text{--}0.55\text{ mm}$.

Occurrence: Late Devonian, Guangxi (Xiangtian and Wuzhishan formations of Yangdi section), South China.

Remarks: Based on the rounded outline our specimens may be assigned to the genus *Praepilatina* Polenova, 1970. The specimens in outline resemble *Praepilatina subcirculata* Wang & Ma, 2007 from the Late Devonian in Xikuangshan, Hunan, China (Wang and Ma, 2007), but they differ by a more curved PVB. Our specimens perhaps belong to a new species, but at present the material is insufficient to establish it.

Genus *Silenites* Coryell & Booth, 1933

Silenites demirota Wei, 1988

(Plate 3, fig. 13)

1988 *Silenites demirota* Wei: 301, pl. 109, figs. 11–13.

Material: Three carapaces and two valves.

Description: Carapace arched. DB regularly curved; both AB and PB rounded with a small radius of curvature and a maximum convexity located at lower third of *H*. VB straight. Slight overlap of left valve on right one with a maximum at DB. Surface smooth.

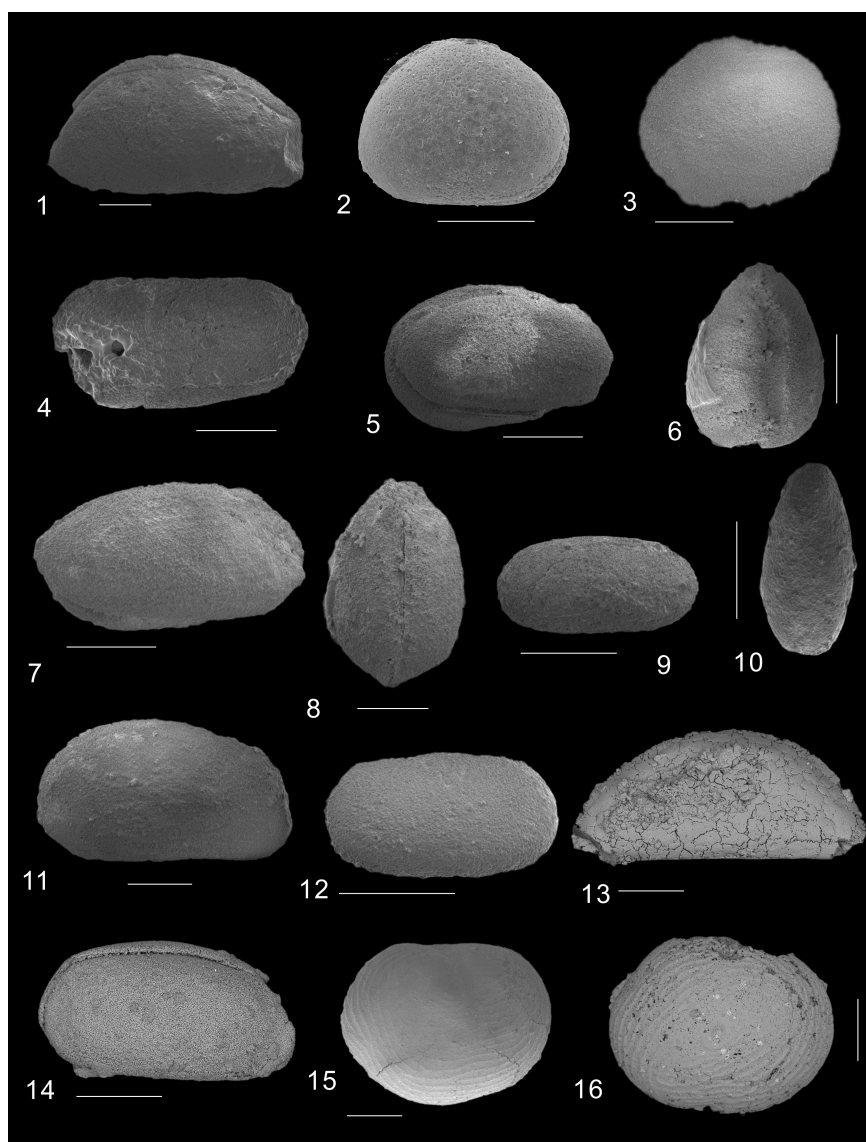


Plate 3. (1) *Bairdiocypris* cf. *cracenis* Jiang, 1983. Right lateral view of complete carapace, YD15024, Frasnian–Famennian, Yangdi section (Bed 98). (2) *Praepilatina adamczaki* Olempska, 1979. Right lateral view of complete carapace, ND15014, Frasnian–Famennian, Nandong section (Bed 68). (3) *Praepilatina?* sp. Right valve, YD15025, Frasnian, Yangdi section (Bed 21). (4) *Microcheilinella* cf. *postacuta* Wei, 1988. Right lateral view of complete carapace, YD15026, Frasnian, Yangdi section (Bed 1). (5, 6) *Microcheilinella* cf. *ventrasa* Polenova, 1960. Right lateral view and dorsal view of complete carapace, respectively, YD15027, Frasnian, Yangdi section (Bed 1). (7, 8) *Microcheilinella* cf. *larionovae* Polenova, 1960. Right lateral view and dorsal view of complete carapace, respectively, YD15028, Frasnian, Yangdi section (Bed 1). (9, 10) *Kummerowillina prima* (Adamczak, 1976). (9) Right lateral view of complete carapace, YD15029; (10) Dorsal view of complete carapace, YD15030; Frasnian–Famennian, Yangdi section (Bed 68). (11) *Kummerowillina* cf. *oblonga* (Wei, 1988). Right lateral view of complete carapace, YD15031, Frasnian, Yangdi section (Bed 15). (12) *Kummerowillina suboblonga* (Wei, 1988). Right lateral view of complete carapace, YD15032, Frasnian, Yangdi section (Bed 15). (13) *Silenites demirotunda* Wei, 1988. Right lateral view of complete carapace, ND15015, Frasnian–Famennian, Nandong section (Bed 68). (14) *Paracoelonella* cf. *saltatoria* Wang & Cao, 1997. Left lateral view of complete carapace, ND15016, Frasnian, Nandong section (Bed 60). (15) *Entomoprimitia* cf. *kayseri* (Waldschmidt, 1885). Right lateral view of complete carapace, ND15022, Frasnian, Nandong section (Bed 66). (16) *Bertillonella subcircularis* Stewart & Hendrix, 1945. Right lateral view of complete carapace, ND15017, Frasnian–Famennian, Yangdi section (Bed 54); Frasnian, Nandong section (Bed 59). Scale bars represent 200 μm.

Dimensions: $L = 0.71\text{--}0.80$ mm, $H = 0.33\text{--}0.41$ mm, $W = 0.25\text{--}0.32$ mm.

Occurrence: Late Devonian of Sichuan and Guangxi (Wuzhishan Formation of Nandong section), South China.

Family Microcheilinellidae Gramm, 1975

Genus *Microcheilinella* Geis, 1933

Microcheilinella cf. *postacuta* Wei, 1988

(Plate 3, fig. 4)

Material: Three carapaces.

Description: DB straight; VB slightly curved on left valve and straight on right one; both AB and PB rounded, the former smaller. Strong overlap of left valve on right one all around the carapace with maxima at PVB and PB. Surface smooth.

Dimensions: $L = 0.63\text{--}0.70$ mm, $H = 0.21\text{--}0.25$ mm, $W = 0.24\text{--}0.28$ mm.

Occurrence: Late Devonian, Guangxi (Xiangtian Formation of Yangdi section), South China.

Remarks: In lateral outline, the specimens strongly resemble *Microcheilinella postacuta* Wei, 1988, from the Early Devonian of Sichuan, South China (Wei, 1988). It differs by its stronger overlap at PVB.

Microcheilinella cf. *ventrasa* Polenova, 1960

(Plate 3, figs. 5, 6)

Material: Two carapaces and five valves.

Description: DB regularly arched; AB with a small radius of curvature and with a maximum located below mid- H ; PB with a relative large radius of curvature and with a maximum located at mid- H ; VB regularly curved on left valve and nearly straight on right one. Left valve strongly overlaps the right one, with a minimum at AB. Surface smooth.

Dimensions: $L = 0.67\text{--}0.72$ mm, $H = 0.45\text{--}0.48$ mm, $W = 0.48\text{--}0.51$ mm.

Occurrence: Late Devonian, Guangxi (Xiangtian Formation of Yangdi section), South China.

Remarks: The specimens resemble *Microcheilinella ventrasa* Polenova, 1960, from the Middle Devonian of the Russian Platform (Polenova, 1960) in outline. It differs by its more elongate lateral outline and smaller overlap at AVB.

Microcheilinella cf. *larionovae* Polenova, 1960

(Plate 3, figs. 7, 8)

Material: Two carapaces and two valves.

Description: DB slightly arched; both AB and PB rounded and quite equivalent; VB slightly curved. Left valve overlaps the right one with maxima at VB and PVB. Surface smooth.

Dimensions: $L = 0.60\text{--}0.65$ mm, $H = 0.34\text{--}0.38$ mm, $W = 0.40\text{--}0.43$ mm.

Occurrence: Late Devonian, Guangxi (Xiangtian Formation of Yangdi section), South China.

Remarks: The specimens resemble in outline *Microcheilinella larionovae* Polenova, 1960 from the Middle Devonian of the Russian Platform (Polenova, 1960). It differs by absence of pit ornamentation on the valves.

Family Healdiidae Harlton, 1933

Genus *Kummerowillina* Adamczak, 1978

Kummerowillina prima (Adamczak, 1976)

(Plate 3, figs. 9, 10)

1976 *Kummerowia prima* Adamczak: 394, pl. 30, figs. 197–199.

1978 *Kummerowillina prima* Adamczak: 515.

1988 *Kummerowia prima* Adamczak; Wei: pl. 109, fig. 5.

Material: Five carapaces.

Description: Small and almost quadrangular carapace. Both DB and VB nearly straight; both AB and PB rounded and quite equivalent. Overlap of left valve on right valve all around the carapace with a maximum at VB. Surface smooth.

Dimensions: $L = 0.34\text{--}0.40$ mm, $H = 0.16\text{--}0.20$ mm, $W = 0.08\text{--}0.12$ mm.

Occurrence: Middle Devonian of Poland, Early Devonian of Sichuan, South China and Late Devonian of Guangxi (Xiangtian and Wuzhishan formations of Yangdi section), South China.

Remarks: The genus of *Kummerowia* Adamczak, 1976 is in reality a junior synonym of *Kummerowia* Samoilova & Smirnova, 1960. It has been replaced by *Kummerowillina* (Adamczak, 1978).

Kummerowillina cf. *oblonga* (Wei, 1988)

(Plate 3, fig. 11)

Material: Two carapaces and three valves.

Description: DB regularly arched; AB with a small radius of curvature and with a maximum of curvature located at lower third of H ; PB with a relative large radius of curvature and with a maximum located at mid- H ; VB nearly straight to slightly convex. Left valve overlaps the right one with maxima at VB and PVB. Surface smooth.

Dimensions: $L = 0.75\text{--}0.82$ mm, $H = 0.37\text{--}0.43$ mm, $W = 0.25\text{--}0.30$ mm.

Occurrence: Late Devonian, Guangxi (Xiangtian Formation of Yangdi section), South China.

Remarks: The specimens resemble *Kummerowia oblonga* Wei, 1988 from the Middle Devonian of Longmen Mts., South China (Wei, 1988) in outline. It differs by its straighter VB and a smaller overlap on PB.

Kummerowina suboblonga (Wei, 1988)

(Plate 3, fig. 12)

1988 *Kummerowia suboblonga* Wei: 300, pl. 109, fig. 10.

2017 *Kummerowia suboblonga* Wei; Song et al.: 272, fig. 9L–M

Material: Four carapaces and two valves.

Description: Small and almost quadrangular carapace. Both DB and VB straight and nearly parallel; AB and PB almost equivalent and regularly rounded. Left valve slightly overlaps the right one along the free margins. Surface smooth.

Dimensions: $L = 0.40\text{--}0.45$ mm, $H = 0.20\text{--}0.24$ mm, $W = 0.20\text{--}0.25$ mm.

Occurrence: Early Devonian of Sichuan, South China; Late Devonian of western Junggar, NW China, and Guangxi (Xiangtian Formation of Yangdi section), South China.

Family Uncertain

Genus *Paracoelonella* Wang, 1983

Paracoelonella cf. *saltatoria* Wang & Cao, 1997

(Plate 3, fig. 14)

Material: Two carapaces and two valves

Description: DB regularly convex; AB with a relatively large radius of curvature and with a maximum located at mid- H ; PB with a small radius of curvature and with a maximum located at lower third of H ; VB nearly straight. The right valve strongly overlaps the left one with a minimum at PB. Some small nodules distribute irregularly on the

surface.

Dimensions: $L = 0.60\text{--}0.68$ mm, $H = 0.28\text{--}0.33$ mm, $W = 0.24\text{--}0.27$ mm.

Occurrence: Late Devonian, Guangxi (Wuzhishan Formation of Nandong section), South China.

Remarks: The specimens close to *Paracoelonella saltatoria* Wang & Cao, 1997 from the Early Devonian of Yunnan, South China (Wang and Cao, 1997) in outline. However, in our specimens the ADB is sharper and the VB is straighter.

Family Entomozoidae Přibyl, 1951

Genus *Entomoprimitia* Kummerow, 1939

Entomoprimitia cf. *kayseri* (Waldschmidt, 1885)

(Plate 3, fig. 15)

Material: One carapaces and four valves.

Description: Carapace subelliptic. DB straight; AB and PB rounded and nearly equal; VB regularly convex. Surface with 10 concentric ribs, and four to five longitudinal ribs in the middle part of the carapace; a small node is present at the end of sulcal depression. The sulcus is shallow and short.

Dimensions: $L = 1.00\text{--}1.20$ mm, $H = 0.96\text{--}1.08$ mm, $W = 0.35$ mm.

Occurrence: Late Devonian, Guangxi (Wuzhishan formations of Nandong section), South China.

Remarks: The specimens resemble *Entomoprimitia kayseri* (Waldschmidt, 1885) from the Late Devonian of Germany (Waldschmidt, 1885) in outline. It differs by the absence of swelling and node before the sulcal depression.

Genus *Bertillonella* Stewart & Hendrix, 1945

Bertillonella subcircularis Stewart & Hendrix, 1945

(Plate 3, fig. 16)

1945 *Bertillonella subcircularis* Stewart & Hendrix: 100, pl. 11, figs. 1, 2.

1981 *Bertillonella subcircularis* Stewart & Hendrix 1945; Duffield & Warshauer: 81, pl. 3, figs. 11, 12.

1984 *Bertillonella subcircularis* Stewart & Hendrix 1945; Wang: 30, pl. 3, fig. 6.

1987 *Bertillonella subcircularis* Stewart & Hendrix 1945; Wang: 315, pl. 2, fig. 12.

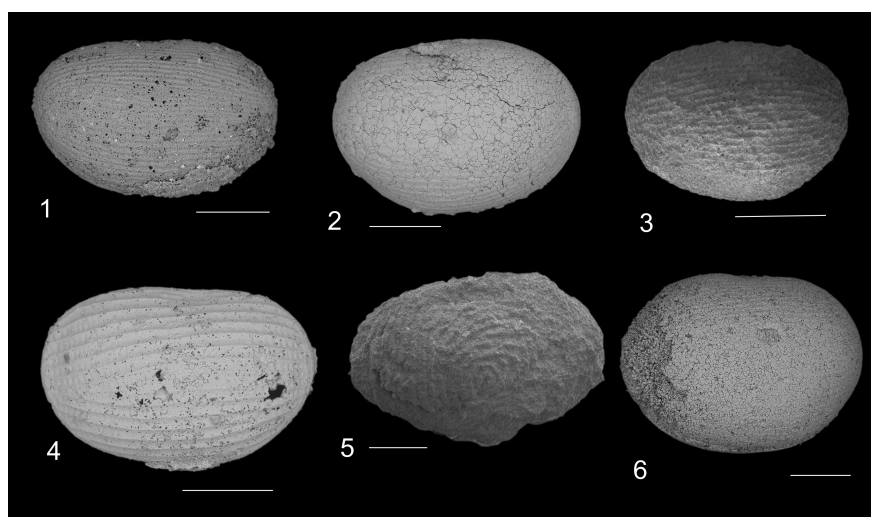


Plate 4. (1, 2) *Richterina striatula* (Richter, 1848). (1) Right lateral view of complete carapace, YD15033, Frasnian–Famennian, Yangdi section (Bed 1). (2) Right lateral view of complete carapace, ND15018, Frasnian, Nandong section (Bed 65). (3, 4) *Richterina (Volkina) zimmermanni* (Volk, 1939). (3) Right lateral view of complete carapace, ND15019. (4) Right lateral view of right valve, ND15020; Frasnian, Nandong section (Bed 60). (5) *Rabiella volki* (Rabien, 1958). Right valve, YD15034, Frasnian, Yangdi section (Bed 1). (6) *Nehdentomis* aff. *tenera* (Gürich, 1896). Right lateral view of complete carapace, ND15021, Frasnian, Nandong section (Bed 65). Scale bars represent 200 μm .

2009 *Bertillonella subcircularis* Stewart & Hendrix 1945; Wang: 39, pl. 12, figs. 10, 11.

Material: Three carapaces and 12 valves.

Description: Carapace subelliptic. DB straight to slightly curved; AB and PB rounded and nearly equal; VB regularly convex. Surface with 15–20 concentric ribs; outer ribs extending parallel to margins; central ones are less-developed, arranged in circular or oval pattern.

Dimensions: $L = 1.00\text{--}1.30\text{ mm}$, $H = 0.96\text{--}1.10\text{ mm}$, $W = 0.36\text{--}0.45\text{ mm}$.

Occurrence: Late Devonian of Ohio and Virginia, USA; Middle–Late Devonian of Guangxi (Yangdi and Nandong sections), South China.

Genus *Richterina* Gürich, 1896

Richterina striatula (Richter, 1848)
(Plate 4, figs. 1, 2)

1848 *Cytherina striatula* Richter: 64, pl. 5, fig. 56.

1913 *Richterina striatula* Reinh. Richter; Paeckelmann: 192, pl. 3, fig. 6.

1939 *Richterina (Richterina) striatula* (Richter); Kummerow: 60, pl. 7, fig. 6.

1954 *Richterina (Richterina) striatula* (Reinh. Richter 1848); Rabien: 119, pl. 2, fig. 15; pl. 4, fig. 37.

1978 *Richterina (Richterina) striatula* (Richter); Gooday: 110, pl. 1, figs. 1–3.

1979 *Richterina (Richterina) striatula* (Richter, 1848); Olempska: 139, pl. 30, fig. 10.

1984 *Richterina (Richterina) striatula* (Richter); Wang: 53, pl. 12, fig. 3A–D.

1985 *Richterina striatula* (Richter); Casier: pl. 3, fig. 43.

1992 *Richterina (Richterina) striatula* (Richter, 1848); Olempska: fig. 2A–I, fig. 3A–D.

2009 *Richterina striatula* (Richter 1848); Wang: 76, pl. 26, figs. 10–12.

Material: 12 carapaces and 12 valves.

Description: Carapace oval. DB regularly convex, CA obtuse; AB and PB rounded and equal; VB regularly concave. Surface with about 25 longitudinal ribs; outer ribs extending parallel to margins; central ones are less-developed, arranged in circular or oval pattern.

Dimensions: $L = 0.50\text{--}0.60\text{ mm}$, $H = 0.36\text{--}0.40\text{ mm}$, $W = 0.25\text{--}0.28\text{ mm}$.

Occurrence: Late Devonian of Germany, Poland, France, Belgium, and Algeria; Late Devonian, Guangxi (Yangdi and Nandong section), South China.

Richterina (Volkina) zimmermanni (Volk, 1939)

(Plate 4, figs. 3, 4)

1939 *Entomis* (*Nehdentomis*) *zimmermanni* Volk: 250, pl. 1, fig. 10.

1954 *Richterina* (*Volkina*) *zimmermanni* (Volk); Rabien: 110, pl. 2, fig. 14; pl. 4, figs. 33, 34.

1975 *Richterina* (*Volkina*) *zimmermanni* (Volk); Casier: pl. 3, fig. 2a–c.

1982 *Richterina* (*Volkina*) *zimmermanni* (Volk); Casier: pl. 2, fig. 6.

1984 *Richterina* (*Volkina*) *zimmermanni* (Volk); Wang: 51, pl. 12, figs. 1–3.

2002 *Richterina* (*Volkina*) *zimmermanni* (Volk); Olempska: 262, fig. 9C–E.

2009 *Richterina* (*Volkina*) *zimmermanni* (Volk); Wang: 70, pl. 25, figs. 1–3.

2011 *Richterina* (*Volkina*) *zimmermanni* (Volk); Nazik & Groos-Uffenorde: 172, pl. 1, fig. 9.

Material: 15 carapaces and six valves.

Description: Carapace ovate. DB straight to slightly curved, CA obtuse; AB and PB rounded and nearly equal; VB regularly convex. Surface with about 15–20 longitudinal ribs; outer ribs extending parallel to margins; central ones are less-developed, arranged in oval pattern.

Dimensions: $L = 0.68\text{--}0.86\text{ mm}$, $H = 0.49\text{--}0.61\text{ mm}$; $W = 0.30\text{--}0.48\text{ mm}$.

Occurrence: Late Devonian of Germany, Poland, France, Belgium, Algeria, Turkey, and Guangxi (Liujiang and Wuzhishan formations of Nandong section), South China.

Genus *Rabienella* Gründel, 1962

Rabienella volki (Rabien, 1958)

(Plate 4, fig. 5)

1958 *Waldeckella volki* Rabien; Rabien & Rabitz: 173, pl. 1, fig. 2.

1987 *Rabienella volki* (Rabien); Wang: 311, pl. 1, figs. 4–8.

1989 *Rabienella volki* (Rabien); Groos-Uffenorde and Wang: pl. 2, fig. 13.

2009 *Rabienella volki* (Rabien); Wang: 50–51, pl. 17, figs. 4–8.

Material: Five valves.

Description: Carapace oval. DB regularly convex; AB and PB rounded and equal; VB regularly concave. Surface

with about 15 concentric ribs; outer ribs extending parallel to margins; central ones arranged in circular or oval pattern.

Dimensions: $L = 0.95\text{--}1.00\text{ mm}$, $H = 0.54\text{--}0.57\text{ mm}$.

Occurrence: Late Devonian of Germany and Guangxi (Xiangtian Formation of Yangdi section), South China.

Genus *Nehdentomis* Matern, 1929

Nehdentomis aff. *tenera* (Gürich, 1896)

(Plate 4, fig. 6)

Material: Five carapaces and three valves.

Description: Carapace ovate. DB straightened to slightly curved; AB and PB rounded and nearly equal; VB regularly convex. Surface with longitudinal ribs; central ones are less developed.

Dimensions: $L = 0.73\text{--}0.88\text{ mm}$, $H = 0.55\text{--}0.65\text{ mm}$, $W = 0.30\text{--}0.37\text{ mm}$.

Occurrence: Late Devonian, Guangxi (Wuzhishan Formation of Nandong section), South China.

Remarks: The specimens resemble *Nehdentomis tenera* (Gürich, 1896) from the Early Devonian of South China (Wang, 2009) in outline and longitudinal ribs, but differs by larger radius of curvature of AB and PB, and *N. tenera* is more elongate. It may belong to a new species.

7 Conclusions

Forty-eight benthic and pelagic ostracod species belonging to 28 genera from the Late Devonian of the Yangdi and Nandong sections in South China are described and figured. These two sections are well documented for the sedimentology and the biostratigraphy. In total, 31 species belonging to 19 genera from the Yangdi section and 19 species belonging to 15 genera from the Nandong section are reported. The ostracod assemblage from the Nandong section can be attributed to the *rhenana–linguiformis* conodont zones. *Richterina striatula* (Richter, 1848) first appeared earlier than in previous reports and should be present in the late Frasnian *linguiformis* Zone. The smooth-podocopid association is accompanied by allegedly pelagic entomozoids in the Xiangtian and Wuzhishan formations exposed in the Yangdi section, and that implies an environment of carbonate platform to slope followed by a shallowing upward succession attested by the disappearance of the entomozoids. In the Nandong section, the ostracod assemblage is dominated by abundant entomozoaceans, suggesting a basin environment.

Data availability. No data sets were used in this article.

Competing interests. The authors declare that they have no conflict of interest.

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