# Latest Frasnian Atrypida (Brachiopoda) from South China

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In South China latest Frasnian (*Palmatolepis linguiformis* Zone) the representatives of the order Atrypida (Brachiopoda) are most common in central Hunan Province. They are relatively rare in other parts of South China due to unfavourable ecologic conditions. Unlike most previously reported sections, including some sections in South China, the four Frasnian-Famennian (F-F) boundary sections examined here do not show any evidence for black shale. Atrypids are abundant and relatively diverse about 15 to 20 m below the F-F boundary (six species), and very rare about 1–2 m below the boundary (with only two species). It seems that the disappearance of most atrypids occurred well before the F-F boundary. Nine species (including *Iowatrypa? qidongensis* sp. n.), assigned to six genera, are discussed and described.

K e y w o r d s: Brachiopoda, Atrypida, taxonomy, biostratigraphy, biogeography, mass-extinction, Frasnian, Devonian, South China.

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## Introduction

In central Hunan, South China, due to the lack of conodont zonal fossils, Frasnian and Famennian strata have been long distinguished by their benthic faunas, i.e. rhynchonellid brachiopods *Yunnanellina* and *Yunnanella* (= *Nayunnella* Sartenear, 1961) in the Famennian, and atrypids and corals in the Frasnian. *Yunnanellina hanburyi* (Davidson, 1853) usually appears about 10 m above the Frasnian-Famennian (F-F) boundary as evidenced from the Xikuangshan, Chongshanpu, and Jiangjiaqiao sections in central Hunan (Ma 1995). However, precise atrypid stratigraphic and abundance data concerning the Frasnian, especially the latest Frasnian, were not well documented in China. This paper shows the distribution pattern, and taxonomy of the latest Frasnian Atrypida from South China, with reference to four sections in Guangxi and Hunan Provinces (Fig. 1).

All specimens figured in this paper are deposited in the Department of Geology, Peking University (abbreviated PUM).


Fig. 1. Map showing localities mentioned in the text. 1 – Chongshanpu section; 2 – Jiangjiaqiao section; 3 – Baqi and Maanshan sections.

## Geological setting of the Frasnian in South China

During the Frasnian, South China was a shallow carbonate platform separated by narrow, deeper water areas (see Hou *et al.* 1988: fig. 2). The carbonate platform may be subdivided into limestone facies and shaly facies. The limestone facies is mainly composed of high-energy and/or high-salinity sediments including various sparry and micritic limestones and/or dolomites, with abundant reef-building organisms (stromatoporoids and corals) and a few brachiopods. In this facies the F-F boundary is usually not well defined; fossils are very sparse at the F-F interval, for example at the Dushan section in Guizhou Province and the Zhaotong and Wenshan sections in northeastern and southeastern Yunnan Province (Liao *et al.* 1979). The shaly facies is composed of various lithologies including calcareous shale, marl, and marly limestone with abundant corals, brachiopods, and other taxa. This facies is mainly distributed in Hunan Province so that the Upper Devonian is also known as the Hunan Series in China.

## Stratigraphy of studied sections

### Chongshanpu Section

This site was located in the shaly facies area during the Frasnian. The lower and middle parts of the section are mainly made up of silty shale and mudstone; the upper part is composed of marl and shale.

Total thickness of the Frasnian strata is about 500–600 m. The F-F interval, measured from the top to bottom, is as follows (Fig. 2):

T7 Grayish green mudstone and shale with marl and shelly limestone intercalations with cyrtospiriferid brachiopod molds; *Yunnanellina hanburyi* first occurs at a level 3.4 m above the base. > 8 m

T6 Thin-bedded shelly limestone interbedded with shale, the former yielding abundant cyrtospiriferids. *Productella lachrymosa* var. *asiatica* Tien, 1938 has been found at the base and 1.1 m upwards. 6.5 m

T5 Gray shelly limestone yielding cyrtospiriferids and *P. l.* var. *asiatica*. 0.5 m

T4 Yellowish weathering shale, with shelly marl intercalations with cyrtospiriferid molds. 2.5 m

T3 Marl yielding common cyrtospiriferids and abundant rugose corals including *Disphyllum dupliforme* Kong, 1978, *Phillipsastrea macouni* Smith, 1945, *Sinodisphyllum variable* Sun, 1958. Rare *'Radiatrypa maanshanensis'* Yang & Chen, 1988 and *Desquamatia shetienchiaoensis* (Tien, 1938) are present in the lower part. 0.8 m

T2 Marl, with minor shale intercalations. Relatively abundant cyrtospiriferid molds and a few bivalves. 2.4 m

T1 Grayish green shale, with cyrtospiriferids and bryozoans in some horizons. ~10.0 m

T0b Gray thin-bedded micrite. ~2.0 m

T0a Marl, with micrite nodules to 10–20 cm in size. Brachiopods and rare solitary corals. *Spinatrypa* cf. *ningxiangensis* Zhao, 1977, *Spinatrypa* sp. A, and *Costatrypa* sp. are common. *Hypothyridina hunanensis* Wang, 1956, *Cyrtospirifer* sp., and *Tenticospirifer* sp. are very rare. ~5 m

This F-F interval is similar to that of the Xikuangshan section, where the F-F boundary has been defined based on conodonts, brachiopods, corals, and geochemical features (Bai *et al.* 1994: pp. 90–93). *Yunnanellina hanburyi* first occurs about 10 m above the coral bed in both sections. In addition, *Productella lachrymosa* var. *asiatica* is frequently found in the Famennian in central Hunan. Thus the F-F boundary in the Chongshanpu section most probably lies within bed T4 based on occurrences of *Y. hanburyi*, *P. l.* var. *asiatica*, and rugose corals.

Beds T0a to T3 can be assigned to the *Palmatolepis linguiformis* conodont Zone based on correlation with the Shetianqiao section, which is only 15 km away southwestwards. Both sections are located in the same facies. At the Shetianqiao section, the total Frasnian is 580 m thick (Zhao *et al.* 1978), the same as that of the Chongshanpu section; the upper 2/3 of the interval belongs to the *Palmatolepis gigas* Zone (Shen 1982) (= *Palmatolepis rhenana* Zone, see Racki 1998: fig. 1).

## Jiangjiaqiao Section

This section is also located in the shaly facies. The lower part, 70–90 m thick, is made up of grayish black thin-bedded siliceous shale interbedded with cherts, yielding abundant bivalves *Buchiola* sp.; the middle part, about 200–250 m thick, is mainly composed of grayish yellow and grayish blue thin-bedded marl and marly limestone, yielding abundant *Buchiola* sp. and ammonoid *Manticoceras* sp., a few corals, and brachiopods; the upper part, 200–250 m thick, has a similar lithologic composition to that of the middle part, but yields abundant brachiopods, a few cephalopods, corals, and ostracods. The total Frasnian thickness is about 500–600 m. The F-F interval is as follows (Fig. 2):

C7 Grayish green mudstone and shale with several layers of shelly marl intercalations yielding abundant brachiopods including *Praewagenoconcha* sp., *Productella lachrymosa* var. *asiatica*, *Yunnanellina hanburyi*, *Cyrtiopsis davidsoni* Grabau, 1923, *C. spiriferoides* Grabau, 1931, and other cyrtospiriferids. The first *Yunnanellina* occurs at 1.2 m above the base of this bed. 3.7 m

C6 Grayish green shale without any fossils observed. 7.4 m

C5 Mudstone or marl (weathered to yellow in color). 2.8 m

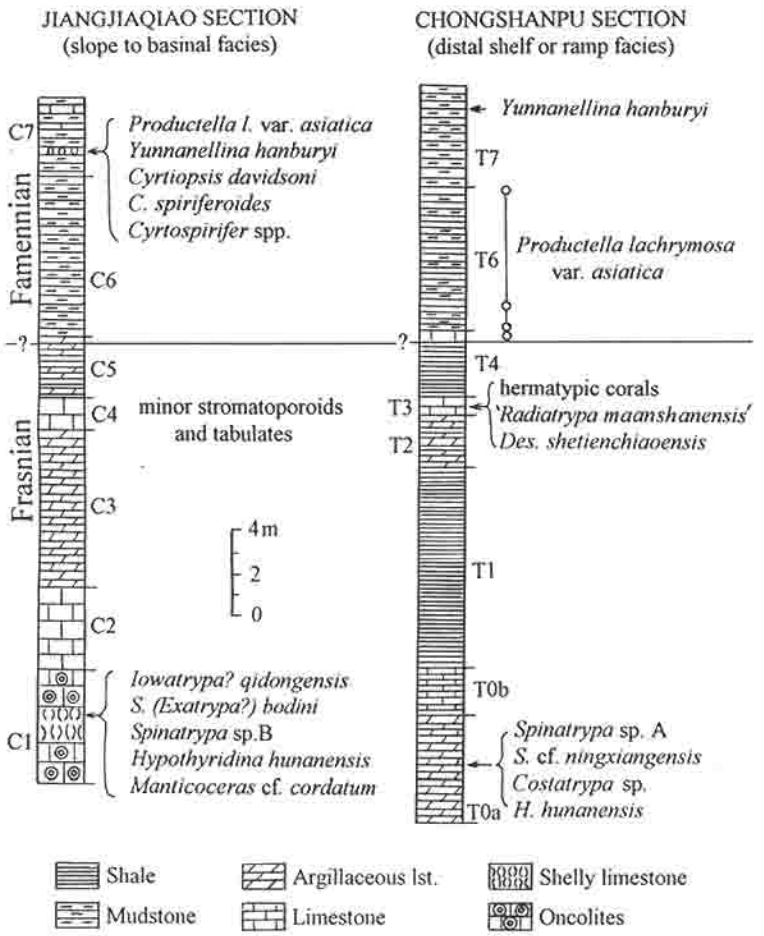



Fig. 2. Distribution of atrypids and other fossils across the F-F boundary at the Jiangjiaqiao and Chongshanpu sections.

| | | |
|---|---|---|
| C4 | Gray dense massive limestone with some stromatoporoids, bryozoans, crinoids, and tabulate coral *Sinopora* sp. | 1.5 m |
| C3 | Gray marl (mostly covered), with rare cyrtospiriferids. | 7.1 m |
| C2 | Gray, massive micritic limestone hosting nautiloids and sponges. | 3.8 m |
| C1 | Alternating gray oncolitic limestone and shelly limestone yielding abundant brachiopods, a few ammonoids, gastropods, ostracods, and crinoids. The atrypid brachiopods are *Spinatrypina* (*Exatrypa*?) *bodini* (Mansuy, 1912), *Iowatrypa*? *qidongensis* sp. n., and *Spinatrypa* sp. B; other brachiopods include *Productella* sp., *Gypidula* sp., *Hypothyridina hunanensis*, *Cyrtospirifer* sp., *Athyris supervittata* Tien, 1938. | 5.0 m |

The ammonoids in bed C1 are conspecific with *Manticoceras* cf. *cordatum* (G. & F. Sandberger, 1850) commonly identified elsewhere in South China. The middle and upper parts of the Frasnian strata in South China all belong to the *M. cordatum* Zone, which corresponds to the *M. cordatum* and *Crickites holzapfeli* Zones in Europe. The Jiangjiaqiao specimens are very similar to *Manticoceras drevermanni* Wedekind, 1913 except for its smaller size. *M. drevermanni* was originally described from I-δ levels at Bicken, which can be correlated with the Upper *P. gigas* Zone through Lower

*Palmatolepis triangularis* Zone (House & Ziegler 1977). The F-F boundary at Jiangjiaqiao can not be precisely determined. It probably should be positioned at the top of bed C5 as suggested by the occurrences of *Yunnanellina hanburyi* in bed C7 and stromatoporoids and *Sinopora* sp. in bed C4. Beds C1 through C4 can be assigned to the *P. linguiformis* Zone, or even to the upper part of this zone judging from the total Frasnian thickness and the ammonoid discovered.

## Baqi Section

This section was located in a transition zone between the shallow carbonate platform and the deeper pelagic shaly facies. The F-F interval was recorded in Bai *et al.* (1994) and is given below (from the top to bottom), with some modifications.

| | | |
|---|---|---|
| B8 | Red micrite intercalated with gray sparry limestone. | 2.0 m |
| B7 | Light gray massive sparry limestone with red thin-bedded micrite at bottom yielding rare brachiopods; *Palmatolepis minuta schleizia* Helms, 1963, species of the Upper *Palmatolepis rhomboidea* Zone (Famennian), has been found near the top. | 12.0 m |
| B6 | Light gray massive sparry limestone. | 3.2 m |
| B5 | Light gray thick-bedded sparry limestone with abundant brachiopods at top: *'Radiatrypa maanshanensis'*, *Spinatrypa* sp. B, *Pugnax* sp., *Athyris supervittata*, *Athyris gurdoni* var. *transversalis*, *Gypidula* sp., *Hypothyridina* sp. They are associated with predominantly Frasnian conodonts: *Polygnathus webbi* Stauffer, 1938, *P. linguiformis* Müller, 1956, and *Icriodus alternatus* alternatus Branson & Mehl, 1934. The gray shelly sparry limestone has numerous centimeter-scale cracks filled with red micrite which yields *P. rhomboidea* Sannemann, 1955, a conodont of the Lower *P. rhomboidea* Zone. | 1.8 m |
| B4 | Red thin-bedded micrite intercalated with gray sparry limestone. | 2.0 m |
| B3 | Gray massive sparry limestone. | 1.5 m |
| B2 | Red thin-bedded micrite with gray sparry limestone intercalations. | 0.7 m |
| B1b | Gray thick-bedded sparry limestone with brachiopods at top: *Desquamatia (Synatrypa) kimberleyensis* (Coleman, 1951), *Spinatrypa* sp. B, *'Radiatrypa maanshanensis'*, *Gypidula* sp., *Athyris gurdoni* var. *transversalis* Tien, 1938, *'Camarotoechia' shetienchiaoensis* Tien, 1938, *Striatopugnax* cf. *triplicata* Chen, 1978. The sparry limestone also has numerous centimeter-scale cracks filled with red micrite which yields a mixed Frasnian and Famennian conodont fauna: *P. rhenana nasuta* Müller, 1956, *P. juntianensis* Han, 1987, and *P. tenuipunctata* Sannemann, 1955. | 4.4 m |
| B1a | Red thin-bedded micrite intercalated with gray sparry limestone. | 0.7 m |
| B0 | Gray massive sparry limestone. | 0.7 m |

This section is characterized by alternating variously aged conodont zones due to synsedimentary slumping and turbidites (for detailed conodont zonation of this section see Bai *et al.* 1994: pp. 79–83). It seems that the gray sparites from units B0 to B5 are mainly of Frasnian age (*P. linguiformis* Zone), whereas the red micrites are of Famennian age (mainly Lower *P. rhomboidea* Zone). It is probable that the late Frasnian gray sparry limestone was deposited and then slightly eroded at the platform margin, producing a microkarst surface, and slid downslope at different times from the *P. triangularis* Zone through the Lower *P. rhomboidea* Zone, during which intense fragmentation occurred, resulting in many different-sized breccias surrounded by the Famennian red micrite (matrix) as evidenced at the Qiaotou section, 4.5 km away from the Baqi section. Therefore, the atrypids in the Baqi section should probably be late Frasnian (*P. linguiformis* Zone) in age.

In the above three sections and several additional sections examined in the carbonate platform, black shale horizon near the F-F boundary (Upper Kellwasser Horizon; Racki 1998) is not present, except for the Xikuangshan section where a one meter thick grayish black shale is present (Bai *et al.* 1994). It seems that the black shale, generally tens of centimeters thick, mainly appeared in the basinal-pelagic facies as in the Nandong and Xiangtian sections of South China.

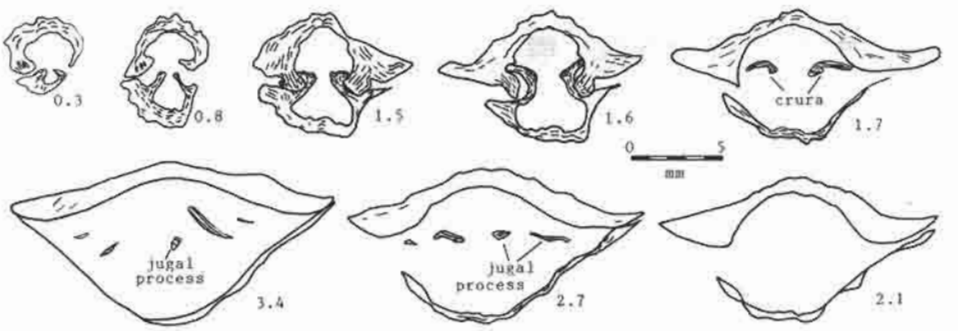



Fig. 3. Transverse serial sections of *Spinatrypa* cf. *ningxiangensis*. Numbers refer to distance in mm from ventral apex. Note that the entire spiralium is not shown. Sample T-H-1, PUM 96005.

# Systematic palaeontology

## Comments on known species

***Spinatrypa* cf. *ningxiangensis* Zhao (in Yang *et al.* 1977)** (Figs 3, 4A–F). — 16 complete shells, most of which are compressed or damaged; three damaged pedicle valves; a few slabs with some disarticulated or complete shells. All specimens are from bed T0a of the Chongshanpu section, 15–20 m below the F-F boundary (Fig. 2), which probably lies in the *P. linguiformis* Zone. In addition, over one hundred specimens including some juveniles were collected from the Shetianqiao section at the same level, i.e. about 20 m below the F-F boundary.

These specimens generally agree with *S. ningxiangensis* in their overall shell form. The difference lies in the shell size and lateral profile. *S. ningxiangensis* (with a shell length of 23–29 mm and width of 25–31 mm) is much bigger and has a more strongly convex brachial valve than *S.* cf. *ningxiangensis*. The present species is very similar to *Spinatrypa variaspina* Copper, 1967, whose internal structure is not known (see Copper 1967a). In the present species, the pedicle valve is greatly thickened by secondary calcite. On the inner surface of the tooth there is a notch for reception of a socket ridge; in the brachial valve, no cardinal process and median septum are observed. Jugal processes are disjunct. The whorl number of the spiralium is unknown due to strong recrystallization in the sectioned specimen, possibly about 10 or more whorls may be present judging from observed traces of the spiralium.

***Spinatrypa* sp. A** (Fig. 4G–K). — Ten more or less complete shells; four pedicle valves and a brachial valve, which are from the same locality and stratum as *Spinatrypa* cf. *ningxiangensis*.

In the present species, the ventral beak is small and low, curved over brachial valve, with a mesothyridid foramen; conjunct deltidial plates are present. Internally there are no dental plates nor dental notches. Muscle field oval, deeply depressed. The brachial valve greatly thickened by secondary calcite, especially in the posterior part. A low median septum is observed, with a furrow at its crest. Spiralium narrowly conical, with about 10 whorls. Jugal processes disjunct.

*Spinatrypa* sp. A is similar to the Middle Devonian *Atrypa aspera* var. *kwangsiensis* Grabau, 1931 in general outline, but in the former species the brachial valve is much more convex than the pedicle valve, and a ventral sulcus is well developed. It differs from *S.* cf. *ningxiangensis* in having a square outline, well developed fold and sulcus, and more convex brachial valve, and, internally, a median ridge in brachial valve.

***Spinatrypa* sp. B** (Fig. 5A–J). — Fifteen complete and more or less damaged shells, several valves and fragments:

- sample B5/1.7 from the Baqi section with four specimens and two fragments (from the Frasnian block slumped into the Lower *P. rhomboidea* Zone);
- sample B1b/4.2 from the Baqi section with two complete specimens and two pedicle valves (from the Frasnian block slumped into the Lower *P. rhomboidea* Zone);

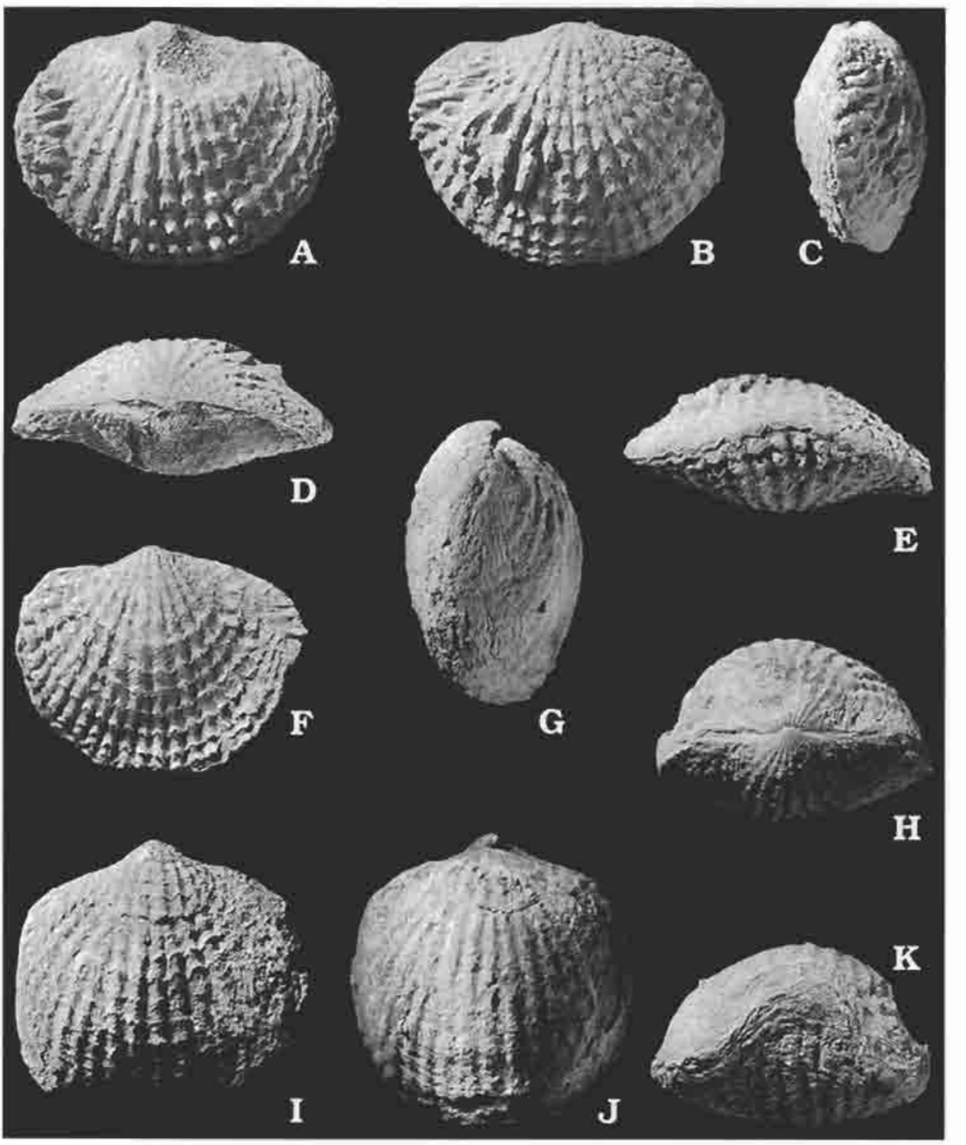
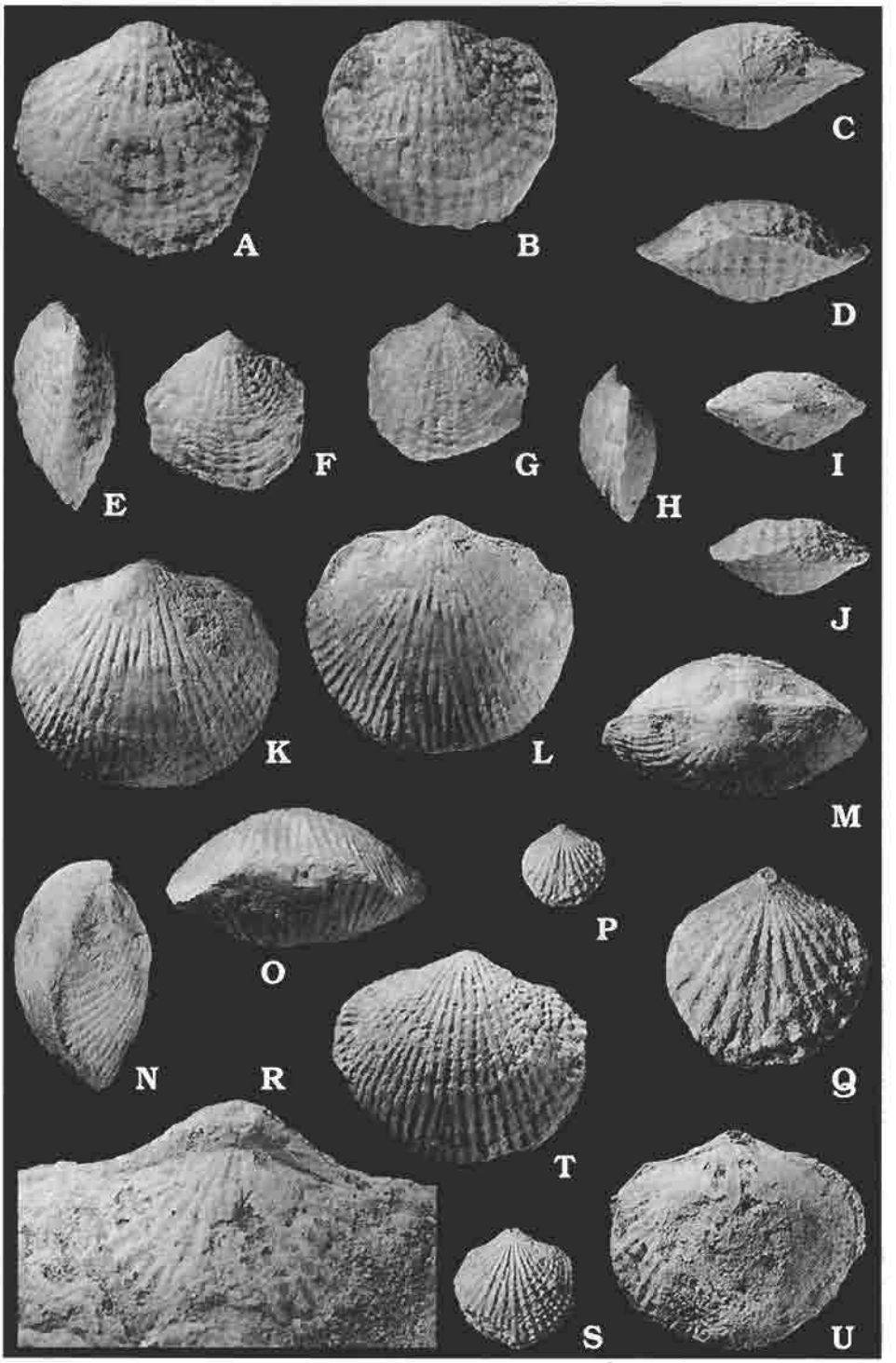



Fig. 4. **A–F**. *Spinatrypa* cf. *ningxiangensis*. **A–E**. Ventral, dorsal, lateral, posterior, and anterior views (PUM 96007); note spines; ventral beak is damaged. **F**. Ventral view of a younger shell (PUM 96008). Bed T0a of the Chongshanpu section, *P. linguiformis* Zone, Frasnian. **G–K**. *Spinatrypa* sp. A, lateral, posterior, ventral, dorsal, and anterior views of PUM 96011; same locality and stratum. All × 2.

– sample C1-0 with nine more or less damaged specimens which come from the *P. linguiformis* Zone of the Jiangjiaqiao section (bed C1 in Fig. 2).

The present species differs from the Middle Devonian *Atrypa bodini* Mansuy, 1912 in having a curved ventral beak (in young specimens however, ventral beak is straight) and coarser ribs which are wider than interspace. It differs from *S.* cf. *ningxiangensis* in having a rounded outline, greatest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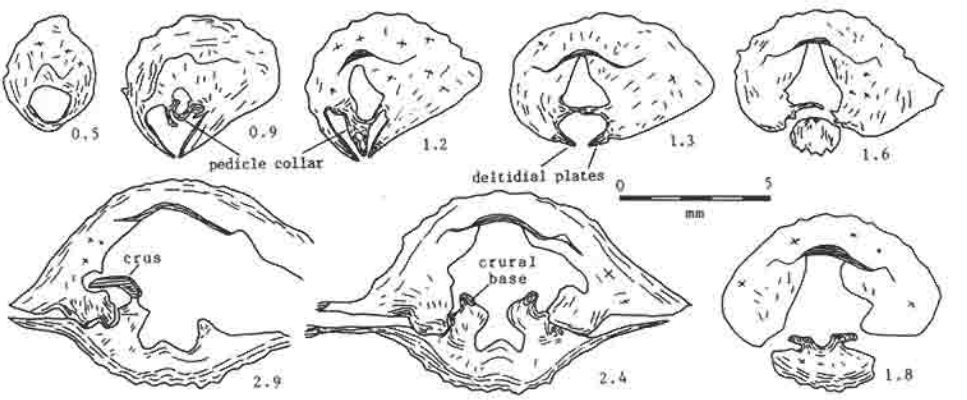


Fig. 6. Transverse serial sections of *Spinatrypina* (*Exatrypa*?) *bodini*. Numbers refer to distance in mm from ventral apex. Sample C1-0, PUM 96002.

width at midlength, shorter hinge line, nearly equal convexity of the two valves, and smaller size. It is distinguished from *Atrypa aspera* var. *kwangsiensis* in having more ribs (25 versus 13–15). It is different from *S.* sp. A in being nearly equibiconvex and having a shorter hinge line.

***Spinatrypina* (*Exatrypa*?) *bodini* (Mansuy, 1912)** (Figs 5K–U, 6). — Extremely abundant complete specimens of various growth stages (several hundreds), most of which are exfoliated. All shells from bed C1 (sample C1-0) of the Jiangjiaqiao section, which is correlated with the *P. linguiformis* Zone (Fig. 2).

Concentric growth lamellae and traces of frill are observed in better preserved specimens. Traces of frill are also observed (Fig. 5T). Ventral beak slightly curved (straight in juveniles), with a permesothyridid foramen surrounded anteriorly by conjunct deltidial plates (Fig. 5R), but in some specimens the pedicle opening is greatly enlarged (Fig. 5U). Internally, a pedicle collar is well developed in the pedicle valve. Muscle field triangular, depressed. A large notch present at inner base of tooth for reception of crus, and there is one fossette on outer surface of the tooth for reception of the outer socket ridge of brachial valve. A low dorsal median ridge observed. Total whorl number of spiralium not known as it broke off in the sectioned specimen; there are about 7 whorls in a 12.5 mm wide specimen.

The shell form of the present species is similar to *Atrypa douvillii* Mansuy, 1912, originally described from the Middle Devonian of eastern Yunnan, China. However, in the latter the width is as great as the length or even smaller; the number of plications increase only by bifurcation. It is different from *Spinatrypina (Exatrypa) robusta* Copper, 1967 (see Copper 1967b) in the presence of well developed pedicle collar, the absence of dental cavities, and the sharply laterally bent crura.

***Costatrypa* sp.** (Figs 7, 8B–K). — Eight more or less complete shells and several fragments; two pedicle valves. All from bed T0a of the Chongshanpu section, 15–20 m below the F-F boundary (Fig. 2), which probably lies in the *P. linguiformis* Zone.

Fig. 5. **A–J**. *Spinatrypa* sp. B; all specimens exfoliated. **A**. Ventral view of PUM 93549 (beak broken); B5/1.7, Baqi section, Frasnian limestone slumped into Famennian *P. rhomboidea* Zone. **B–E**. Ventral, posterior, anterior, and lateral views of PUM 93550 (ventral beak broken); B1b/4.2, Baqi section, Frasnian limestone slumped into Famennian Lower *P. rhomboidea* Zone. **F–J**. Ventral, dorsal, lateral, posterior, and anterior views of a young shell (PUM 93551); Same locality and stratum as PUM 93550. **K–U**. *Spinatrypina* (*Exatrypa*?) *bodini*; sample C1-0, Jiangjiaqiao section, *P. linguiformis* Zone, Frasnian. **K–O**. Ventral, dorsal, posterior, lateral, and anterior views of PUM 96039, exfoliated specimen; ventral beak poorly preserved. **P–Q**. Dorsal view of a juvenile (PUM 96024); note a rounded mesothyridid foramen flanked by deltidial plates. **R**. Dorsal view of posterior showing conjunct deltidial plates and mesothyridid foramen (PUM 96040). **S**. Dorsal view of another juvenile (PUM 96023) showing deltidial plates, foramen, and ornamentation. **T–U**. Ventral and dorsal views of PUM 96020; note enlarged pedicle opening. **A–P**, × 2; **Q**, **R**, × 5.

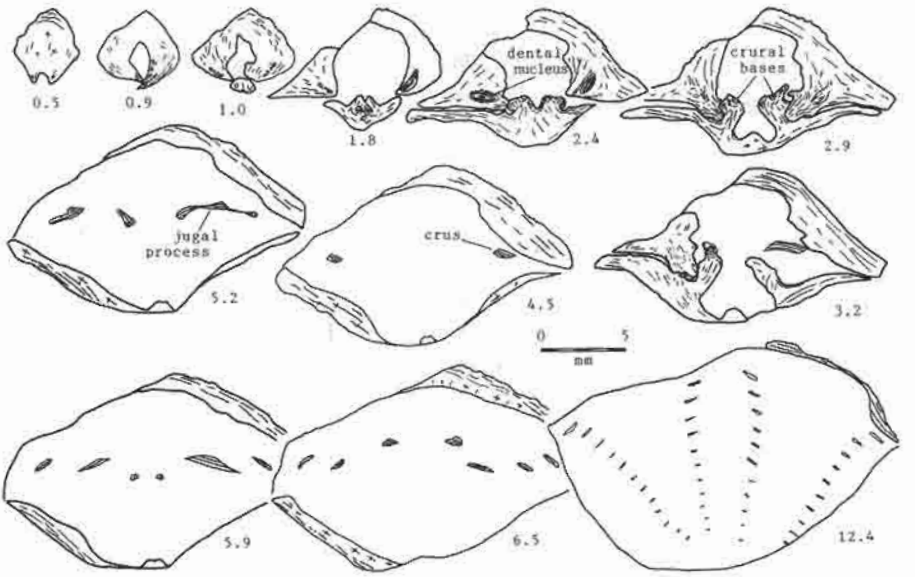


Fig. 7. Transverse serial sections of *Costatrypa* sp. Numbers refer to distance in mm from ventral apex. Sample T-H-1, PUM 96003.

The assignment of the present species to *Costatrypa* Copper, 1973 is based on the following characters: straight and long hinge line, adpressed beak, undulose ribs, no proper foramen, the presence of dental nuclei and distinct crural bases, disjunct jugal processes, and about 12 whorls of spiralium directing dorso-medially. However, the present species possesses conjunct deltidial plates which are not present in *Costatrypa* (see Copper 1973). *Costatrypa* sp. is similar to *Atrypa richthofeni* (Kayser, 1883), originally described from the Middle Devonian of South China. The latter has finer plications and concave flanks on the pedicle valve. Middle Devonian *'Atrypa desquamata* mut. *hunanensis'* Grabau, 1931 may be distinguished from the present species in having finer costae and a curved beak which never extends over the hinge line. *Desquamatia shetienchiaoensis* is different from the *Costatrypa* sp. in lacking sinus and fold, a high and nearly straight ventral beak, rounded cardinal extremities, finer costae, and very weak concentric lines. The young specimen of the present species shows an imbricate rib pattern (Fig. 8B–F); ventral beak is nearly straight, with a mesothyridid foramen surrounded by a pair of deltidial plates. These features are similar to *Anatrypa timanica* figured by Alekseeva (1962), and *Iowatrypa rotundicollis* Godefroid, 1994 to a lesser extent. The latter is ventribiconvex to planoconvex.

***Desquamatia (Synatrypa) kimberleyensis* (Coleman, 1951)** (Fig. 9I). — Three incomplete shells. Surface covered with about 55 radiating costae, with 6–7 per 5 mm in the middle part and 4–5 per 5 mm at anterior margin. The overall shell form and size are identical with the type specimen of *Desquamatia (Synatrypa) kimberleyensis* figured by Grey (1978). The present specimens come from the Baqi section, sample B1b/4.2 (a Frasnian block slumped into the Lower *P. rhomboidea* Zone).

***Desquamatia shetienchiaoensis* (Tien, 1938)** (Fig. 8A). — Two compressed shells from bed T3 of the Chongshanpu section (Fig. 2), about 1–2 m below the F-F boundary, near top of the *P. linguiformis* Zone. The figured specimen is identical with the type specimen in its rounded outline, ornamentation characteristics, and size (Tien 1938).

***'Radiatrypa maanshanensis'* Yang & Chen (in Jia *et al.* 1988)** (Fig. 9A–H, J–N). — Yang & Chen published only the photo of this species, without description. Below a short description is given

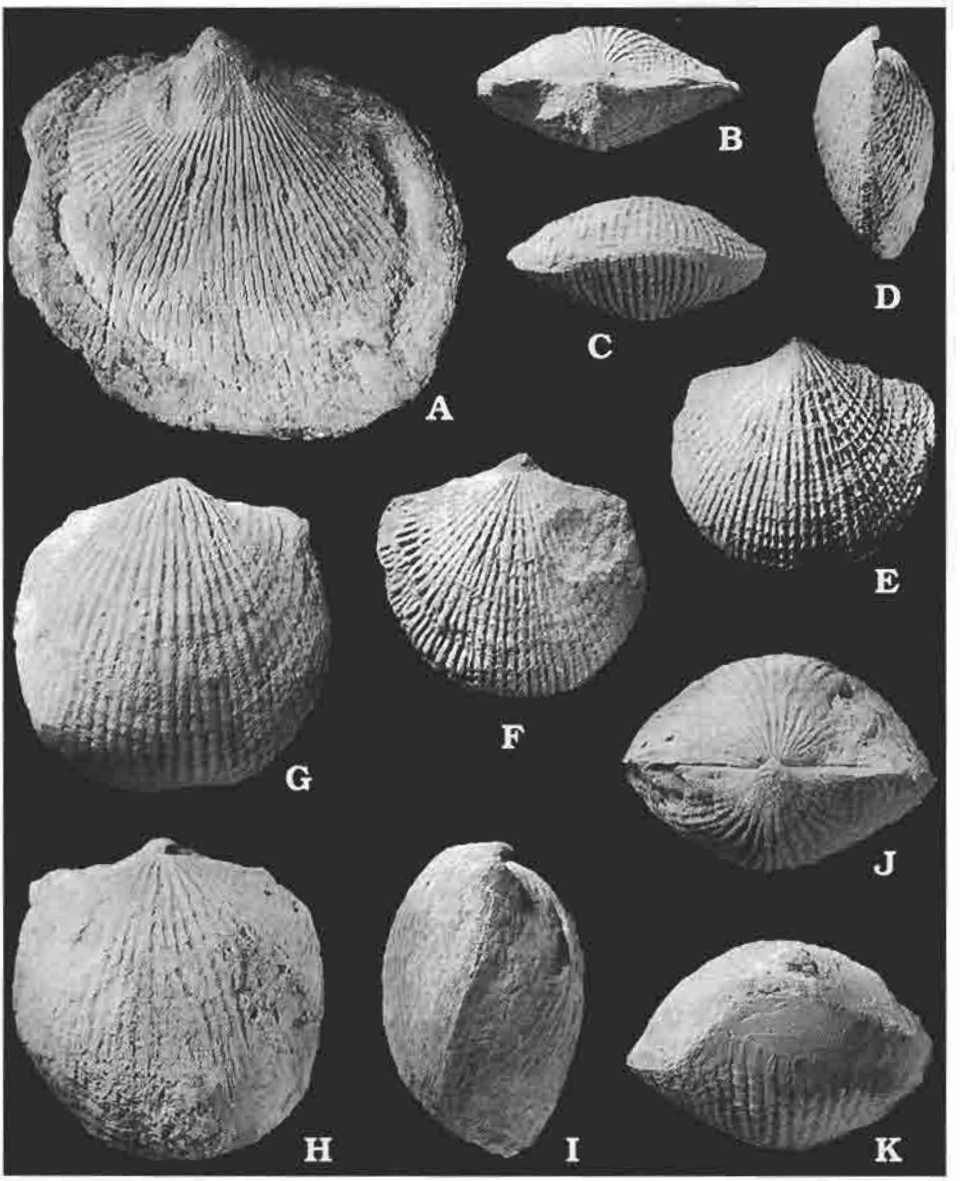


Fig. 8. **A**. *Desquamatia shetienchiaoensis*, ventral view of PUM 93548; lower part of bed T3 of the Chongshanpu section, near top of *P. linguiformis* Zone. **B–K**. *Costatrypa* sp., bed T0a of the Chongshanpu section, *P. linguiformis* Zone. **B–F**. A younger shell (PUM 96026) in posterior, anterior, lateral, ventral, and dorsal views; note the nearly straight ventral beak and small pedicle opening flanked by deltidial plates. **G–K**. Ventral, dorsal, lateral, posterior, and anterior views of an adult specimen (PUM 96025); note the incurved ventral beak; anterior is damaged. All × 2.

based on specimens from the Chongshanpu and Baqi sections, which lie close to the locality Maanshan yielding the specimens of Yang and Chen.

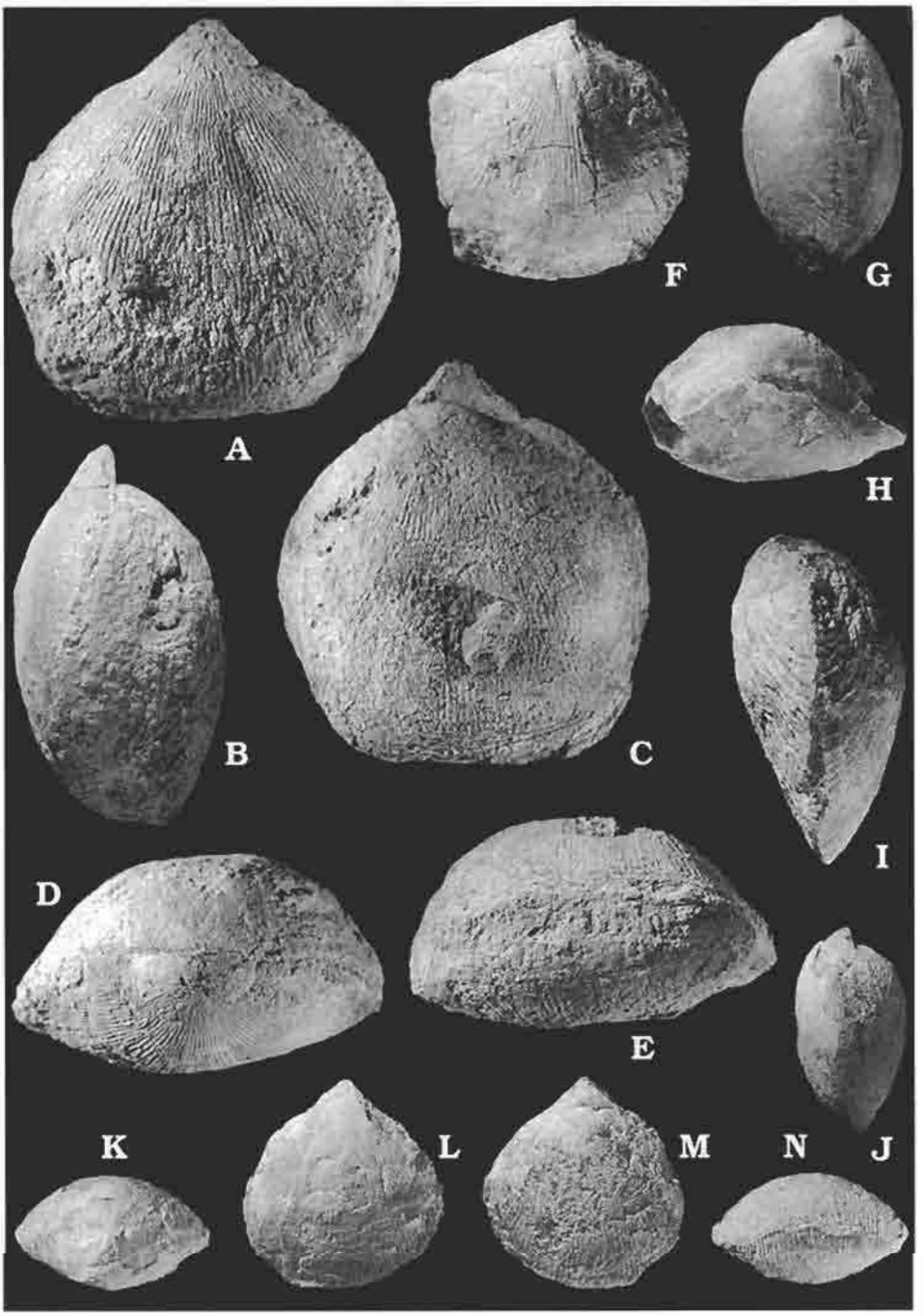


Fig. 9. **A–H, J–N.** *'Radiatrypa maanshanensis'*. **A–E.** Ventral, lateral, dorsal, posterior, and anterior views of PUM 93547; note the straight and high ventral beak; lower part of bed T3, Chongshanpu section, near top of *P. linguiformis* Zone, Frasnian. **F–H.** Dorsal, lateral (brachial valve on left and pedicle valve on right only for this figure), and anterior views of an exfoliated specimen (PUM 93553); ventral beak is damaged;

Shell suboval in outline with a sharp posterior end, slightly dorsibiconvex in lateral profile, slightly to medium uniplicate in anterior view. Hinge line short and curved; cardinal extremities rounded. Ventral beak straight and high.

Surface covered with numerous (more than 80) fine bifurcating costae, with 12 costae per 5 mm in the middle part of the shell, and 11 costae per 5 mm near anterior margin. Costae wider than interspaces. Ventral sulcus very shallow, only present at the anterior margin; dorsal fold absent. Interiors unknown.

The Baqi specimens well accord with the specimen illustrated by Yang and Chen in Jia *et al.* (1988) in size and general form. The Chongshanpu specimen (93547) is much bigger; its anterior part is bent towards the brachial valve, but a sinus and fold are absent; in addition, dense indistinct growth lamellae or lines are present at anterior margin. Despite these defferences, the similarity to the type in general form allows the above assignment.

Totally, there are four complete shells and one fragment. Specimens from the Baqi section (samples B5/1.7 and B1b/4.2) occur in gray massive sparry limestone of Frasnian age (*P. linguiformis* Zone) which slumped into the Famennian deposits.

The Chongshanpu specimen comes from lower part of bed T3, about 1–2 m below the F-F boundary, near top of the *P. linguiformis* Zone, associated with abundant hermatypic corals.

The specimen of the species figured in Jia *et al.* (1988) comes from the Maanshan section about 7 km away from the Baqi section. It represents an open outer carbonate platform facies. The F-F sequence was reported by Jia *et al.* (1988) and Bai *et al.* (1994). The brachiopod occurs in a light gray massive coarse grained sparry limestone bed of Famennian age (Middle *P. triangularis* Zone) yielding very abundant brachiopods which may represent a brachiopod bank deposit. However, the brachiopods may have been reworked as well. The reasons for this are: (1) the brachiopod shells are commonly fragmented and abraded, and (2) they are associated with Frasnian conodonts, which are very abundant below in the section (Bai *et al.* 1994: fig. 7-7).

## Description of a new species

### *Iowatrypa? qidongensis* sp. n.

Figs 10, 11, 12A–N.

Holotype: PUM 96031; Fig. 12A–E.

Type locality: Shizipai Hill near Shizichong village, Buyunqiao township, Qidong County, central Hunan.

Type horizon: Bed C1 of the Jiangjiaqiao section which is correlated with the *P. linguiformis* Zone.

Derivation of the name: indicates the county to which the type locality belongs.

**Material.** — About 70 complete and more or less damaged shells, most of which are juveniles.

**Description.** — Shell small to medium sized, nearly rounded in outline, usually equibiconvex to slightly ventribiconvex, especially in young specimens. Hinge line is straight, about 2/3 shell width; cardinal extremities rounded.

Surface covered with numerous costae, about 12 costae per 5 mm in the middle part of the shell. Shallow ventral sulcus and low dorsal fold present at the anterior margin. Closely spaced concentric growth lamellae are observed in some well preserved specimens.

Ventral beak small, low, and curved on the brachial valve. Neither interarea nor deltidial plates (or only traces of them) are observed. Pedicle opening missing or minute. On brachial valve, there is often a central furrow present at the umbonal area.

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sample B5/1.7, Baqi section; Frasnian limestone slumped into Famennian *P. rhomboidea* Zone. **J–N.** Lateral, posterior, ventral, dorsal, and anterior views of a young exfoliated specimen (PUM 96030); note the straight and high ventral beak; same locality and stratum as PUM 93553. **I.** *Desquamatia (Synatrypa) kimberleyensis*. Lateral view of an incomplete exfoliated specimen (PUM 96044); sample B1b/4.2, Baqi section; Frasnian limestone slumped into Famennian Lower *P. rhomboidea* Zone. All × 2.

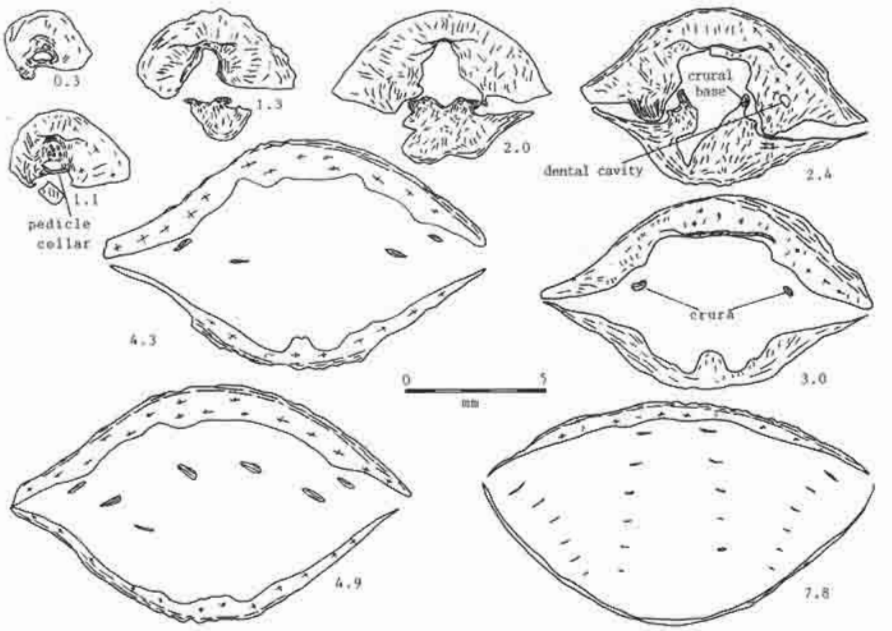


Fig. 10. Transverse serial sections of *Iowatrypa*? *qidongensis* sp. n. Numbers refer to distance in mm from ventral apex. Sample C1-0, Jiangjiaqiao section; PUM 96001. Note pedicle collar and trace of dental cavity. Jugal processes were not observed, probably due to breakdown.

Internally, pedicle valve greatly thickened by secondary calcite in the posterior part. A simple pedicle collar or layer present. Teeth strongly fused into shell wall, with a small dental cavity anteriorly. In brachial valve, hinge plates or pads are fused to shell wall; crural bases ball-like; a low median ridge present at posterior part, anteriorly with a central furrow on crest. Jugal processes disjunct. Spiralium points dorso-medially, with 5–6 whorls.

Dimensions (in mm):

| Cat. No. | W | L | T |
|---|---|---|---|
| 96001 | 14.4 | 13.3 | 8.7 |
| 96006 | 12.7 | 13.4* | 8.0* |
| 96031 | 14.9* | 14.4 | 9.1 |
| 96032 | 11.0 | 10.2 | 6.3 |
| 96033 | 11.6 | 10.5 | 6.0 |
| 96034 | 9.2 | 8.7 | 5.3 |
| 96035 | 8.9 | 8.3 | 5.6 |
| 96036 | 8.4 | 9.4 | 5.3 |
| 96037 | 7.1 | 7.3 | 3.8 |
| 96038 | 6.9 | 6.7 | 3.0 |

Explanation: W – width; L – length; T – thickness; * – approximate figures.

**Remarks**. — The small size, lateral profile, ornamentation, and spire whorl number of the present species suggest an assignment to *Iowatrypa*; However, interarea, deltidial plates and a proper foramen are missing; in addition, beak is adpressed, and crural bases are ball-like. All these features are quite different from those illustrated by Copper & Chen (1995) for the type species, *Iowatrypa owenensis* (Webster, 1921). It is also difficult to place the specimen under discussion in *Costatrypa* because of its small size, finer ornamentation, and lateral slightly ventribiconvex profile. The new species is similar to *Desquamatia xinhuaensis* Zhao (in Yang *et al.* 1977) in general form, but the latter

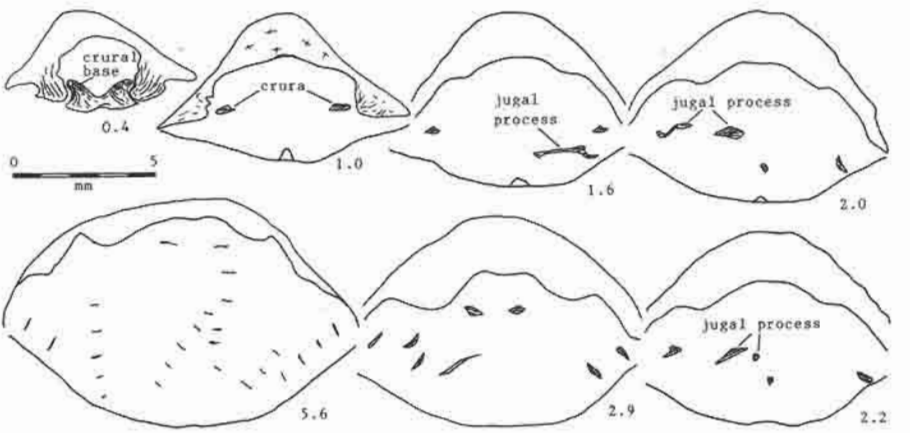


Fig. 11. Transverse serial sections of *Iowatrypa? qidongensis* sp. n. Numbers refer to distance in mm from ventral apex. Sample C1-0, Jiangjiaqiao section; PUM 96006, a strongly exfoliated specimen with only internal calcite crystal layer preserved. Note the false position of spiralium due to its break-off.

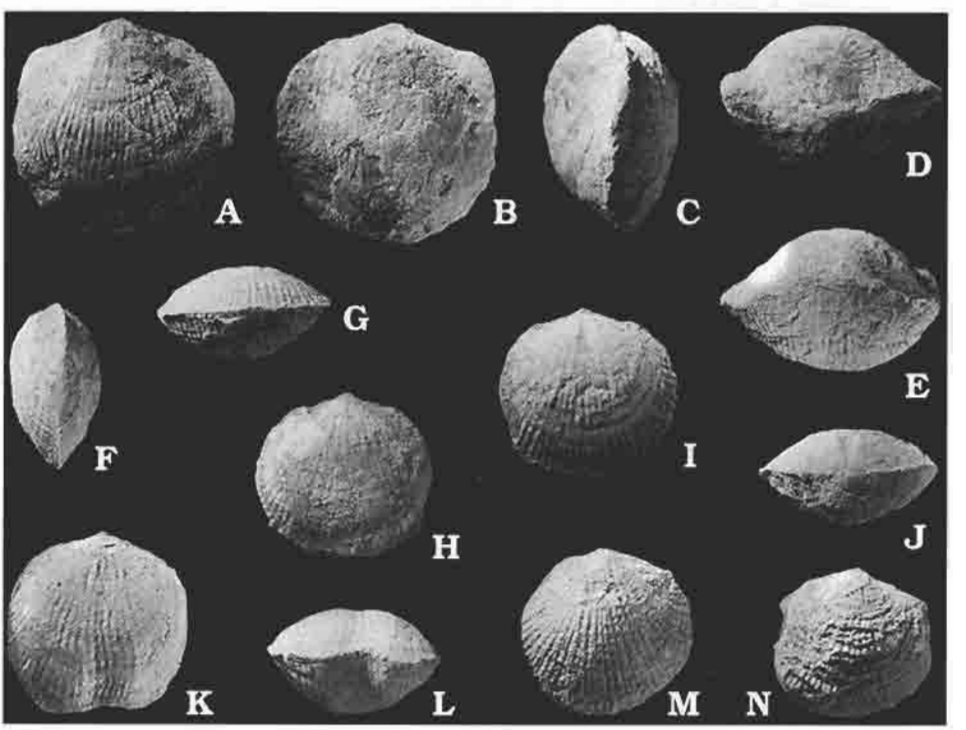


Fig. 12. *Iowatrypa? qidongensis* sp. n. Bed C1 of the Jiangjiaqiao section, *P. linguiformis* Zone. **A–E**. Ventral, dorsal, lateral, posterior, and anterior views of the holotype (PUM 96031); note the low ventral beak; specimen exfoliated. **F–J**. Lateral, anterior, ventral, dorsal, and posterior views of a young shell (paratype, PUM 96033); specimen exfoliated. **K–L**. Dorsal and anterior views of a growth bizarre form (PUM 96041) showing a central sulcus on both valves; specimen exfoliated. **M**. Ventral view of a young shell (paratype, PUM 96042) showing fine ribs and delicate growth lamellae. **N**. Ventral view of another young shell (paratype, PUM 96043) showing well developed growth lamellae extending as frills. All × 2.

lacks sinus and fold, without concentric lamellae, has a straight ventral beak and slender and long dental plates. It is also very similar to *Atrypa poljanica* Lyashenko, 1959. However, the latter has a strongly uniplicate anterior and strongly dorsibiconvex shell (Lyashenko 1959); young specimens in *Atrypa poljanica* are much thinner than those of *Iowatrypa? qidongensis* sp. n.

**Distribution**. — All specimens from bed C1 of the Jiangjiaqiao section, about 15 m below the F-F boundary, which is correlated with the *P. linguiformis* Zone.

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