

## Two new Rhynchonellid (Brachiopod) species from the Frasnian Shetienchiao (1) Formation of central Hunan, China

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### Abstract

Two new species, one of them the type species of a new genus, *Parvaltissimarostrum*, are described from the Frasnian Shetienchiao Formation of central Hunan Province, China. *Navalicia rectangularis* n.sp. of middle-late Frasnian age is found in the highest part of the middle member and in the lower part of the upper member of the formation, and is associated with other brachiopods. *Parvaltissimarostrum minimum* n.gen., n.sp. of late Frasnian age derives from the upper member of the same formation, which contains also numerous corals and other brachiopods.

**Key-words:** rhynchonellids – brachiopods – Devonian – Hunan – systematics – stratigraphy

### Résumé

Deux nouvelles espèces, dont l'une est l'espèce-type d'un nouveau genre, *Parvaltissimarostrum*, sont décrites dans la Formation Shetienchiao d'âge frasnien de la partie centrale de la Province du Hunan en Chine. *Navalicia rectangularis* n.sp. d'âge frasnien moyen-supérieur se trouve dans les couches supérieures du membre moyen et dans la partie inférieure du membre supérieur de la formation en association avec d'autres Brachiopodes. *Parvaltissimarostrum minimum* n.gen., n.sp. d'âge frasnien supérieur provient du membre supérieur de la même formation, riche aussi en Coraux et en autres Brachiopodes.

**Mots-clefs:** Rhynchonellides – Brachiopodes – Dévonien – Hunan – systématique – stratigraphie

### Introduction

The Shetienchiao Formation is the only formation recognized in the Frasnian of the central part of Hunan Province. Many of its rhynchonellids, and, more generally, of its brachiopods, have not been described so far or are in need of reassessment. Much work is needed. It is only by defining clear and restricted biostratigraphical units based on brachiopods that correlation will prove to be possible with similar subdivisions of the Frasnian Stage in various other parts of the world.

This paper represents a contribution to the collective endeavour undertaken in this direction.

### *Navalicia rectangularis* n.sp. (Plate 1, Figures 1-10; Text-figure 1)

#### REMARKS

The fine radial striation observed in the new species is a character that must be added to the definition of the genus *Navalicia* SARTENAER, 1989; recrystallization of the shell is the plausible explanation for the absence of this striation on the numerous specimens of the type species, *N. compacta* SARTENAER, 1989. The new species also indicates that the front margin described as unipli- cate, and exceptionally parasulcate, when the genus was established, may also be sulcate.

#### SYNONYMY

1989 Espèce de la Province du Hunan en Chine – SARTENAER, p. 61, p. 66, p. 74.

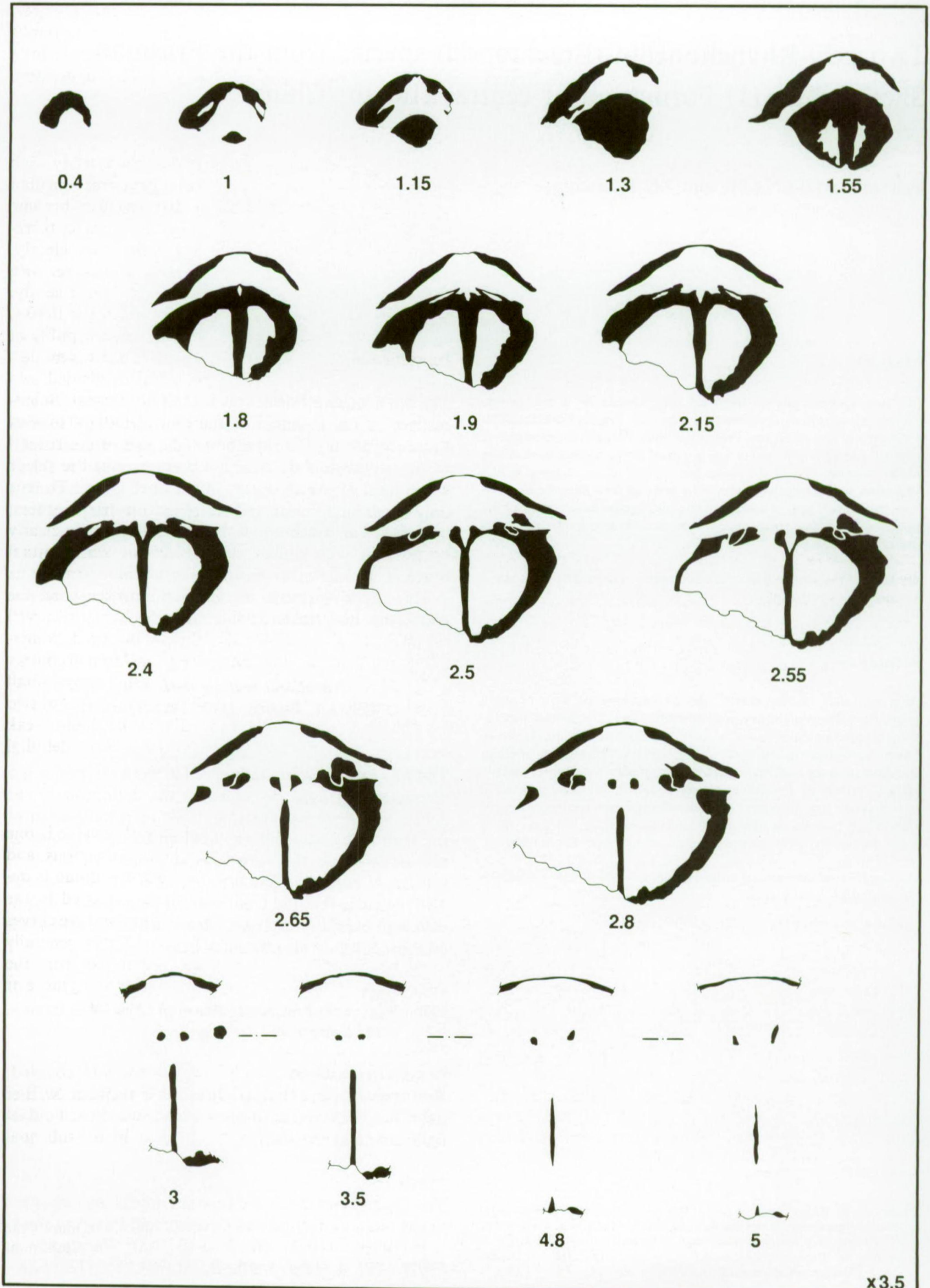
#### DERIVATIO NOMINIS

*Rectangularis*, *is*, *e* (Latin, adjective) = rectangular. The name has been chosen to draw attention to the characteristic shape of the shell.

#### TYPES

The figured and measured type specimens are deposited in the Nanjing Institute of Geology and Palaeontology. Holotype, 110731 (Pl. 1, Figs. 1-5); Paratypes A, 110732 (Pl. 1, Figs. 6-10), B, 112784, C, 112785, D,

(1) Since 1958, pinyin is used in China; therefore, the correct spellings of the localities mentioned in this paper are Qiziqiao, Shetianqiao, Tianmashan, Xiangxiang, and Xinhua. Nevertheless, Chinese scientists still use the old spelling for lithostratigraphical units introduced before 1958, i.e. Shetienchiao and Chitzechiao Formations.



112799 (Text-fig. 1). Marls and calcareous mudstones in the top of the middle member of the Shetienschiao Formation of Frasnian age in the Tianmashan section, Xinhua County, central part of Hunan Province, China, loc.ADS-781. Collector: XU Han-kui, 1977.

Plaster casts of the types have been made and are deposited in the Royal Institute of Natural Sciences of Belgium in Brussels under the number I.G.27714. A plaster cast of paratype D was made before grinding and is joined to the remainder of the specimen.

#### LOCUS TYPICUS

Tianmashan, 27°80'N, 111°20'E, Xinhua County, central part of Hunan Province, China.

#### STRATUM TYPICUM

Twenty metres of marls and calcareous mudstones in the top of the middle member (see Text-fig.3, p.95 in YU & al., 1990) of the Shetienschiao Formation of Frasnian age.

#### MATERIAL. STATE OF PRESERVATION

Twenty two specimens.

In the *locus typicus* four specimens have been collected higher (ADS-792, in the lower part of the upper member of the Shetienschiao Formation) than the seven specimens from the *stratum typicum*. Eleven specimens derive from the upper part of the middle member of the Shetienschiao Formation in the Qiziqiao section (ADS-824), also in the central part of Hunan Province. Eight specimens, including six specimens from the *stratum typicum*, are in a satisfactory state of preservation; the remainder are fragmentary.

#### DIAGNOSTIC CHARACTERS

Transversely subrectangular to subquadratic. Ventral flanks tending to become flat to slightly concave in their postero-lateral parts. Almost constant number of well marked costae.

#### DESCRIPTION

##### *General external characters*

Medium sized. Thick-set, but never inflated. Inequi-valve, the thickness of the pedicle valve being about one third the thickness of the shell. Front margin sulcate, exceptionally uniplicate or parasulcate. Transversely subrectangular to subquadratic in ventral and dorsal views, with rounded angles and lateral borders shaped as parentheses; as these parentheses seldom correspond to each other, the contour of the shell is generally asymmetrical. In cardinal view, contour of shell is a half-ellipse in the pedicle valve and a dome in the brachial valve. Dorsal umbonal region usually tangential to a vertical plane, only exceptionally extending beyond the pedicle

beak. Commissure sharp. At the lateral commissures, which are located high as seen in lateral profile, flanks join at an angle always lower, but sometimes very little lower, than 90°. Cardinal line is slightly undulated, almost straight.

##### *Pedicle valve*

Contour of pedicle valve is a low to moderately high half-ellipse in longitudinal and transverse median sections. Postero-lateral parts of flanks tend to become flat, and are even exceptionally slightly concave; therefore, the ventral umbonal region stands out clearly, although it is not particularly inflated. Elsewhere, with the exception of the apical region, flanks slope gently. Well marked sulcus, clearly separated from the flanks, wide at front, beginning more or less imperceptibly at about one third the length of the shell. Sulcus is moderately deep, rarely deep. Bottom of sulcus divided into two concave parts by a median swelling (costa). Sulcus widens rapidly, and reaches its greatest width (60 to 66% of the width of the shell) at the junction of the frontal and lateral commissures. In its anterior part the sulcus passes to the flanks through hog-backed edges. Tongue trapezoidal, moderately high to high with sharp borders, standing out clearly. The top of the tongue is clearly depressed by the furrow separating the two lobes (costae) of the fold. Crest of tongue tends to become vertical; its median swelling (costa) extends sometimes beyond the borders of the tongue, which are commonly recurved posteriorly. Beak small, wide, slightly incurved, sometimes overhanging the cardinal line, but seldom in contact with the dorsal umbonal region. Beak resorbed by a small circular foramen. Interarea ill-defined, composed of two "lunules" separated from the flanks by blunt beak ridges, which fade out rapidly laterally. Short deltidial plates observed in transverse serial sections.

##### *Brachial valve*

Moderately high, rarely high. Curve of the valve is one quarter of an ellipse in longitudinal median sections, and a dome in transverse median sections; the dome is deformed by the fold. Greatest thickness reached in the anterior half of the shell; from this point the valve curves gently toward the commissure. Slope of flanks generally abrupt. Well marked fold, clearly separated from the flanks, moderately high, wide at front, beginning more or less abruptly at some distance from the beak.

##### *Ornament*

Of the ten specimens on which costae could be counted, nine have 2/1, and one has 3/2, median costae. Neither parietal nor lateral costae have been observed. Fold of two wide, moderately high (sometimes high), subequal

Fig. 1. — *Navalicia rectangularis* n.sp. Camera lucida drawings of serial transverse sections; figures are distances in mm of the section forward of the crest of the ventral umbo. Paratype D, 112799. Measurements: l = 23.1 mm; w = (26.8) mm; t = 17.7 mm.

lobes (costae) separated by a wide and deep furrow corresponding to a moderately high swelling (costa) in the sulcus; in the specimen with 3/2 median costae, one lobe of the fold is divided by a narrow and shallow furrow to which corresponds an intercalated costa in the sulcus. Costae start about on a level with sulcus and fold. A faint radial striation is present as observed in three specimens, including the holotype.

#### Dimensions

Measurements of four specimens:

in mm	Para-type C	Para-type A	Holo-type	Para-type B
l	23.8	21.5	20.6	?
w	28.3	26.8	25.7	(25.5)
lpv unrolled	36	31.5	31	?
t	19.7	17.3	17.2	(17.6)
tpv	7.5	5.7	4.9	4.8
tbv	12.2	11.6	12.3	(12.8)
l/w	0.84	0.8	0.8	?
t/w	0.70	0.65	0.67	0.69
t/l	0.83	0.8	0.83	?
apical angle	141°	(150°)	160°	143°
angle of the cardinal commissure	152°	?	165°	149°

The abbreviations used are: l = length; w = width; t = thickness; pv = pedicle valve; bv = brachial valve. Measurements shown in parentheses indicate a reasonable estimate of a damaged specimen.

The first column refers to the largest specimen at our disposal. Highest part of pedicle valve is located between 28 and 33% of the length of the shell. Greatest thickness of the shell is located in the anterior part of the shell at a variable point posterior to the frontal commissure; from this point the brachial valve curves gently toward this commissure. Width is always the largest dimension. Maximum width of shell occurs at a point between 46 and 53% of the length of the shell anterior to the ventral beak. The apical angle varies from 140° to 160°, and the angle of the cardinal commissure from 148° to 165°.

#### Internal characters

The following internal characters of the genus are easily observed in transverse serial sections: shell thick in the apical region; dental plates thick to very thick maintained as stout spurs anteriorly; reduced umbonal cavities; strong and short teeth; well developed denticula; closely joined valves; blade-shaped septum, thin except in its posterior part; short divided hinge plate; low to moderately deep crural trough; inconspicuous crural bases; long crura remaining close to each other.

#### COMPARISONS

*Navalicia rectangularis* n.sp. may be distinguished from *N. compacta* SARTENAER, 1989 by the following external

features: somewhat smaller thickness of the brachial valve; frontal margin commonly sulcinate; transverse contour, in ventral and dorsal views, almost exclusively subrectangular, and more systematically asymmetrical; dorsal umbonal region generally tangential to a vertical plane, and extending only exceptionally beyond the pedicle beak; ventral flanks tending to become flat, and even exceptionally slightly concave, in their postero-lateral parts; sulcus and fold usually better marked in their posterior part and starting commonly nearer to the beaks; well marked median lobes and median swelling (costae), and furrows; tongue always trapezoidal; crest of tongue exceptionally tangential to a vertical plane; ventral beak rarely in contact with the dorsal umbonal region; generally moderately high brachial valve; curve of the brachial valve less variable in longitudinal median sections; less variable number of costae; length of shell relatively larger as indicated by the l/w and t/l ratios. See Remarks (above, p. 123) for the fine radial striation.

#### GEOGRAPHIC LOCATION AND STRATIGRAPHIC POSITION

In the Tianmashan section (see Text-fig. 3, p. 95 in YU & al., 1990) of Xinhua County (27°80'N, 111°20'E) in the central part of Hunan Province, the Shetienchiao Formation, the only formation recognized in the Frasnian, is subdivided into: (1) a lower member, 196 m thick, composed of thin- to medium-bedded limestones, siliceous shales and siliceous beds; (2) a middle member of which only the highest part (marls and calcareous mudstones) is exposed, most of the member being usually covered by Quaternary deposits in the Xinhua region; (3) an upper member, 250 m thick, composed of mudstones with intercalated marly beds.

The lower member is rich in tentaculites (*Homoctenus acutus* LYASHENKO, 1959, *H. ultimus ultimus* ZAGORA, 1966, *H. tenuicinctus neglectus* SAUERLAND, 1983, and *Polycylindrites tenuigradatus* (LYASHENKO, 1959), which indicate, according to RUAN Yi-ping (personal communication to the junior author), a middle Frasnian age. The marly beds of the upper member contain brachiopods [*Ptychomaletioechia* shetienchiaoensis (TIEN, 1938), *Chonetes* sp., *Cyrtospirifer* sp., and *Tenticospirifer* sp.] and corals (*Phillipsastraea macouni* SMITH, 1945 and *Hunanophrentis uniformis* SUN, 1958). The highest part of the middle member, in which the most (six) satisfactorily preserved specimens of *Navalicia rectangularis* n.sp. have been collected, contains only other brachiopods, such as *Coeloterorhynchus*? sp., *Hypothyridina hunanensis* WANG, 1955, *Atrypa douvillei* MANSUY, 1912, *Synatrypa* sp., *Athyris* sp., *Praewaagenoconcha yongfuensis* NI, 1977, *Cyrtospirifer* sp., and *Tenticospirifer subhayasakai* (GRABAU, 1931).

According to WANG Chen-yuang (personal communication to the junior author), conodonts from the *Ancyrognathus triangularis* and the *Palmatolepis gigas* Zones are abundant in the Shetienchiao Formation in the Tianmashan section: *Icriodus symmetricus* BRANSON & MEHL, 1934, *I. brevis* STAUFFER, 1940, *I. eslaensis* VAN ADRICHEM BOOGAERT, 1967, *Palmatolepis puncta-*

ta (HINDE, 1879), *Polygnathus webbi* STAUFFER, 1938, *P. aequalis* KLAPPER & LANE, 1985, *P. pacificus* SAVAGE & FUNAI, 1980, etc. Unfortunately, the exact position of the beds in which samples have been taken is not known.

In the Qiziqiao section (see Text-fig. 3, p. 94 in YU & al., 1990), which is described below, *Navalicia rectangularis* n.sp. is also found in the upper part of the middle member of the Shetienchiao Formation.

In view of the lack of precision of these preliminary data it is useful to note the stratigraphical distribution of *Navalicia compacta* SARTENAER, 1989, the type species of the genus *Navalicia* SARTENAER, 1989: i.e. in the *Ancyrognathus triangularis* Zone and, possibly, according to not yet substantiated information found in the literature, the Lower and Upper *Palmatolepis gigas* Zones.

### *Parvaltissimarostrum* n.gen.

#### DERIVATIO NOMINIS

*Parvus*, a, um (Latin, adjective) = small; *altissimus*, a, um = adjective in the superlative of *altus*, a, um (Latin) = high; *rostrum* (Latin, neuter) = beak. The name has been chosen to draw attention to the small size and to the thickness of the shell.

#### TYPE SPECIES

*Parvaltissimarostrum minimum* n.gen., n.sp.

#### SPECIES ATTRIBUTED TO THE GENUS

Only the type species is attributed to the genus.

#### DIAGNOSIS

Very small shell with irregular hexahedral shape. Acuminate. Strongly inequivalve. Contour of shell like a helmet in cardinal view. Anterior half of pedicle valve deeply excavated by a prominent and wide tongue starting at some distance from the beak. Borders of tongue recurved posteriorly. Very high fold standing well above the flanks of the brachial valve, and starting in the umbonal region. Highest point of shell at anterior commissure, and posterior to the frontal extremity of the shell. Wide apical angle. Few low costae. Internal structures robust. Long, widely spaced dental plates. Stout teeth. Long lamellar septum. Deep septalium. Stout and short outer hinge plates. Delicate, separate or contiguous or overlapping inner hinge plates.

#### DESCRIPTION

Shell very small with irregular hexahedral shape. Acuminate. Strongly inequivalve, the brachial valve being five to eleven times – generally six to ten times – thicker than the pedicle valve. Frontal margin uniplicate. Subpentagonal in ventral view, the pentagon being irregular and more or less transversely stretched. Generally lateral sides of pentagon are convex and asymmetrical, base is slightly to strongly concave, and angles rounded, with the exception of the top angle; otherwise the ventral beak is less projecting, and the top angle is also rounded. In

dorsal view the dorsal umbonal region modifies this contour in a pentagonal-elliptical shape. Contour of shell like a Celtic helmet in cardinal view. Dorsal umbonal region mostly projected posteriorly, otherwise tangential to a vertical plane. Sometimes the dorsal umbonal region extends beyond the ventral beak, sometimes not. Commissure sharp. At the lateral commissures, which are located very low in the shell, flanks join at an angle higher than 90°. Postero-lateral margins concave near the commissure. Cardinal line nearly straight.

Very shallow pedicle valve. Sulcus and tongue cannot be differentiated – we consider henceforth the whole as the tongue – and excavate the anterior half of the valve. The other half is the flanks and the umbonal region, which, together, have the shape of a boomerang in ventral view; when the tongue starts nearer to the beak, flanks are shaped like the wings of flies. From the pronounced umbonal region, flanks slope first abruptly, and then gently, towards the lateral commissures, and, sometimes, become flat or even slightly concave near these commissures; in the cardinal region flanks slope always abruptly towards the cardinal commissure where the valve becomes concave. Prominent tongue starting imperceptibly at some distance from the beak, widening and deepening rapidly and strongly; tongue very wide at front. Antero-dorsal end of tongue at the front margin tends to narrow to a sharply acuminate – generally ogival – crest, which is the highest point of the valve. Crest of tongue tends to become vertical or is recurved posteriorly. The sharp borders of the tongue are always recurved posteriorly, but, sometimes, the curve is modified in its upper half. Tongue moderately deep to deep. Bottom of tongue generally concave, sometimes flat at front. Beak small, stout, straight or nearly straight or suberect. Wide and high interarea with beak ridges only clearly marked in the beak area. Discrete narrow deltidial plates. Foramen large and rounded.

Brachial valve very high and acuminate, highest point at anterior commissure in median line. From the umbonal region, which is sometimes tangential to a vertical plane, and sometimes projected posteriorly, the valve rises abruptly, in median longitudinal sections, to the highest point at anterior commissure; in many specimens there is an inflexion at a point variably located – it may be near the frontal commissure – between the umbonal region and the frontal commissure. Very high acuminate fold rising up abruptly well above the flanks and wide at front. Fold starts imperceptibly in the umbonal region at some distance from the beak, and is then separated from the lateral slopes of the shell by a slight but clear deflection. Flanks are less steep than the sides of the fold and become concave postero-laterally. Top of fold angular to angular-rounded.

Most shells are costate. Few simple, wide, very low angular to angular-rounded costae. Only the costa or the two costae at the crest of the fold and of the tongue can be considered median with certainty, while the others must be described as parietal on account of the acuminate shape of both fold and tongue; in the present case

this distinction is however arbitrary, and, therefore, all costae on fold and tongue are considered as median. Commissure is indented by the costae, but the indentation of the external median costae and of the lateral costae is slight; it is even exceptionally absent for the latter. The most external median costa exceptionally does not indent the commissure as is often the case with the most internal of the two most internal lateral costae; these costae are called adventitious. In some rare cases lateral costae are so weak that they give the impression of close-set, flattened costellae. Median costae, with the exception of the central or the two central ones, are asymmetrical. External median, and lateral costae, are sometimes so evanescent that they are almost indiscernible. The external lateral costa is generally a mere indentation of the commissure. Median costae and internal lateral costae start posterior to mid-unrolled length of valves in the specimens in which they have been best observed.

Width is the greatest dimension, and length the smallest. Thickness is only exceptionally close to width. Greatest width forward of mid-length. Top of shell at frontal commissure, where the extremity of the central costa(e) is sometimes slightly deflected towards the commissure. The borders of the tongue being always recurved posteriorly, the top of the shell is located at a point posterior to the frontal extremity of the shell. Wide apical angle and angle of the cardinal commissure.

Robust internal structures for a very small and delicate genus. Dental plates divergent to subparallel posteriorly, becoming slightly convergent anteriorly; they are widely spaced and support the teeth to plane of articulation. Umbonal cavities wide. Teeth widely spaced, short, wide and very stout, entering more or less perpendicularly into the dental sockets in transverse serial sections. Well marked denticula. Long and lamellar septum supporting a deep and more or less narrow septalium, and becoming detached from the septalial plates very near to the beak. Short and stout outer hinge plates characteristically sloping towards each other. Anterior part of septalium covered by delicate inner hinge plates which can become contiguous or even overlap without ever merging to form a connectivum. Short and wide dental sockets. Crural bases result from the progressive shortening of the outer hinge plates. Short delicate crura becoming not much apart anteriorly, and slightly curved at distal ends; they are roughly subtriangular in transverse serial sections.

#### COMPARISONS

The following characteristic features, considered separately or combined, make it easy to distinguish the new genus from genera, which, by their external shape, are

close to it or somewhat similar such as *Ladogioides* McLAREN, 1961 of late Givetian-early Frasnian age, *Ladogia* NALIVKIN, 1941 of early Frasnian age, *Coelotrorhynchus* SARTENAER, 1966 of middle-late Frasnian age, *Cavatisinurostrum* SARTENAER, 1972 and *Zilimia* NALIVKIN, 1947 of early Famennian age, and *Physetorhyncha* SARTENAER & ROZMAN, 1968 of middle-late Famennian age: very small size, lack of fine radial striation, length of costae, long and lamellar septum, narrow and deep septalium covered in its anterior part by delicate inner hinge plates which may become contiguous or even overlap.

#### *Parvaltissimarostrum minimum* n.gen., n.sp. (Plate 1, Figures 11-40; Text-figure 2)

#### SYNONYMY

- 1983 *Ladogia* sp. – XU & LIU in YU & al., p. 270;  
1987 *Ladogia* sp. – LIU, p. 465;  
1990 *Ladogia* sp. – XU & LIU in YU & al., text-fig. 3, p. 94, p. 96.

#### DERIVATIO NOMINIS

*Minimus, a, um* = adjective in the superlative of *parvus, a, um* (Latin) = small. The name has been chosen to draw attention to the very small size of the species.

#### TYPES

The figured and measured type specimens are deposited in the Nanjing Institute of Geology and Palaeontology.

Holotype, 112786 (Pl. 1, Figs. 11-15); Paratypes A, 112787 (Pl. 1, Figs. 16-20), B, 112788 (Pl. 1, Figs. 21-25), C, 112789 (Pl. 1, Figs. 26-30), D, 112790 (Pl. 1, Figs. 31-35), E, 112791 (Pl. 1, Figs. 36-40), F, 112792, G, 112793, H, 112794, I, 112795, J, 112796 (Text-fig. 2A), K, 112797 (Text-fig. 2B), L, 112798 (Text-fig. 2C). Thin-bedded limestone, nodular limestone, marls and calcareous mudstones of the upper member of the Shetienschiao Formation of Frasnian age in the Qiziqiao section, Xiangxiang County, central part of Hunan Province, China, loc. ADS-855. Collector: XU Han-kui, 1977.

Plaster casts of these primary types have been made and are deposited in the Royal Institute of Natural Sciences of Belgium in Brussels under the number I.G.27712.

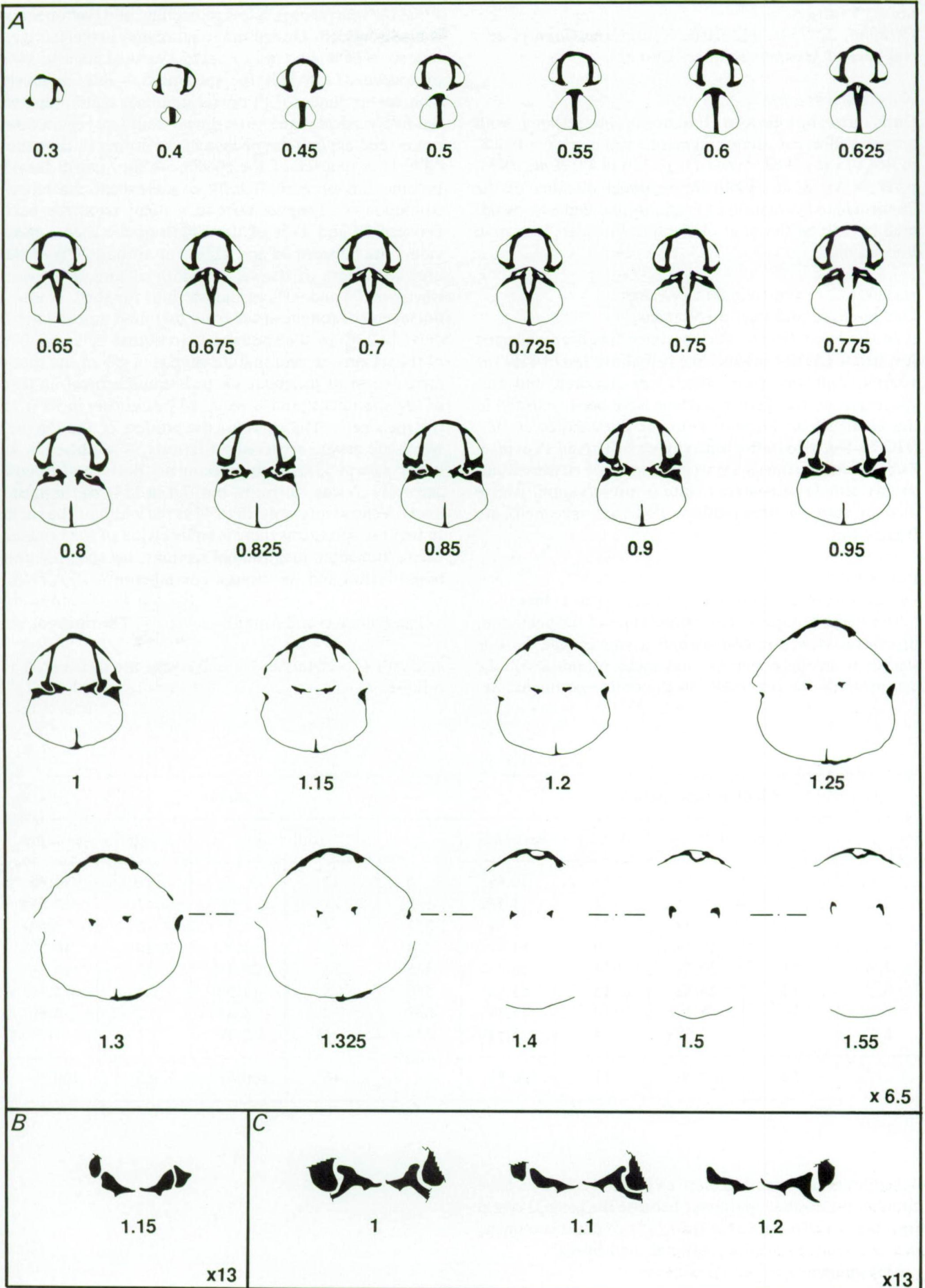
Plaster casts of paratypes J and L were made before grinding and are joined to the remainder of the specimens.

Fig. 2. – *Parvaltissimarostrum minimum* n.gen., n.sp. Camera lucida drawings of serial transverse sections; figures are distances in mm of the section forward of the crest of the ventral umbo.

A, Paratype J, 112796; measurements: l = 6.8 mm; w = 9.3 mm; t = 7.4 mm;

B, Paratype K, 112797; measurements: l = 7 mm; w = 9 mm; t = 7.9 mm;

C, Paratype L, 112798; measurements: l = 6.7 mm; w = 9.3 mm; t = 8.5 mm.



## LOCUS TYPICUS

Qiziqiao, 27°75'N, 112°20'E, Xiangxiang County, central part of Hunan Province, China.

## STRATUM TYPICUM

Dark grey thin-bedded limestone, intercalated with greyish yellow calcareous mudstone and marls (= bed 8, p. 465 in LIU, 1987 = bed 11, p. 270 in YU & al., 1983, p. 96 in YU & al., 1990) in the upper member of the Shetienchiao Formation of Frasnian age. Bed 8 is considered by LIU as the base of the late Frasnian Yangqiao Formation.

## MATERIAL. STATE OF PRESERVATION

One hundred and twelve specimens.

In the *locus typicus* one specimen has been collected just below (ADS-854) and one just above (ADS-856) the *stratum typicum*, from which one hundred and five specimens derive. Five specimens have been collected in the Shetienchiao Formation in the Shetianqiao section (HC 26-16), also in the central part of Hunan Province. Fifty seven specimens are in good state of preservation, twenty nine in satisfactory state of preservation, twelve in poor state of preservation. Fourteen specimens are fragmental.

## DESCRIPTION

As for the genus. Additional details are as follows.

In 83% of the specimens, lateral sides of the pentagon, in ventral view, are convex and asymmetrical, base is slightly to strongly concave, and angles rounded with the exception of the top angle; in the other specimens, i.e.

17%, the ventral beak is less projecting, and the top angle is also rounded. Dorsal umbonal region projected posteriorly in 66%, and tangential to a vertical plane in 34% of specimens. In half the specimens – this obviously includes specimens with dorsal umbonal region tangential to a vertical plane – the dorsal umbonal region does not extend beyond the pedicle beak; it does in the other half. In a quarter of the specimens the ventral flanks become flat or even slightly concave near the lateral commissures. Tongue starts at a point from the beak between 29 and 48% of the length of the shell – most values are between 35 and 42% – or around 20% of the unrolled length of the valve. Width of tongue at front is between 70 and 90% of the width of the shell. Antero-dorsal end of tongue at the front margin is an equilateral ogive in 23% of the specimens, an obtuse ogive in 70% of the specimens, and spatula-shaped in 7% of the specimens. Crest of tongue tends to become vertical in 38% of the specimens, and is recurved posteriorly in 62% of the specimens. The curve of the borders of the tongue, which are always recurved posteriorly, is modified in its upper part in 15% of the specimens. Bottom of tongue generally concave at front, but flat in 15% of the specimens. Ventral interarea 38 to 45% the width of the shell. In half the specimens there is an inflexion of the brachial valve, in median longitudinal sections, between the umbonal region and the frontal commissure.

The general costal formula is  $\frac{4-7}{3-6}; \frac{0-4}{0-5}$ . The ratios of the

median (+ parietal) and lateral costae are distributed as follows:

Median (and parietal)					Lateral				
	Adults only		Adults + juveniles			Adults only		Adults + juveniles	
	0	7	13.0%	14		20.0%	0	12	26.0%
2/1			1	1.5%	1/2	1	2.0%	1	1.5%
3/2	1	2.0%	3	4.0%	2/3	4	8.5%	5	7.5%
4/3	8	15.0%	10	14.0%	3/4	5	11.0%	10	15.5%
5/4	11	20.0%	14	20.0%	4/5	13	28.5%	17	26.0%
6/5	13	24.0%	15	21.0%	5/6	8	17.5%	9	14.0%
7/6	10	18.5%	10	14.0%	6/7	2	4.5%	2	3.0%
8/7	4	7.5%	4	5.5%	7/8	1	2.0%	1	1.5%
	54	100.0%	71	100.0%		46	100.0%	65	100.0%

Juvenile specimens are costate as in adults, but we have counted the costae separately, because the general costal formula is a grouping of at least 75% of adult specimens in the categories median, parietal, and lateral.

Measurements of ten specimens:



in mm	Para-type D	Holo-type	Para-type B	Para-type C	Para-type E	Para-type A	Para-type F	Para-type G	Para-type H	Para-type I
l	6.7	6.6	6.6	6.5	6.5	6.3	6.	5.6	6.1	5.8
w	8.5	8.9	8.6	9.4	8.7	9.2	7.8	(8.3)	7.	6.9
lpv unrolled	11.5	12.5	11.5	11.5	11.2	12	(11.)	10.7	9.8	7.2
t	7.6	8.8	8.3	7.5	7.1	8.2	7.4	7.1	5.8	3.5
tpv	0.7	0.85	1.2	0.9	0.85	0.7	1.2	0.6	1.	0.6
tbv	6.9	7.95	7.1	6.6	6.25	7.5	6.2	6.5	4.8	2.9
l/w	0.79	0.74	0.77	0.69	0.75	0.68	0.77	(0.67)	0.87	0.84
t/w	0.89	0.99	0.97	0.80	0.82	0.89	0.95	(0.86)	0.83	0.51
t/l	1.15	1.35	1.25	1.15	1.1	1.3	1.25	1.25	0.95	0.6
apical angle	(115°)	129°	(120°)	125°	127°	124°	?	115°	108°	112°
angle of the cardinal commissure	?	135°	?	129°	132°	129°	?	119°	113°	117°

The abbreviations used are: l = length; w = width; t = thickness; pv = pedicle valve; bv = brachial valve. Measurements shown in parentheses indicate a reasonable estimate on a damaged specimen.

The first six columns refer to the photographed specimens, the last two to immature specimens. Greatest width forward of mid-length between 53 and 68% – most values between 60 and 64% – of the length of the shell. The borders of the tongue being always recurved posteriorly, the top of the shell is located at a point between 14 and 49% posterior to the frontal extremity of the shell.

#### GEOGRAPHIC LOCATION AND STRATIGRAPHIC POSITION

In the Qiziqiao section (see Text-fig. 3, p. 94 in YU & al., 1990) of Xiangxiang County (27°75'N, 112°20'E) in the central part of Hunan Province, from which the bulk of the collection of *Parvaltissimarostrium minimum* n.gen., n.sp. derives, the Shetienchiao Formation is subdivided into: (1) a lower member, 218 m thick, composed of medium- to thick-bedded sandstone, and argillaceous siltstone with a few intercalated marly beds; (2) a middle member, 135 m thick, composed of medium- to thick-bedded limestone; (3) an upper member, 97 m thick, composed of thin-bedded limestone, nodular limestone, marls and calcareous mudstone.

The lower member is rich in brachiopods [*Atrypa* (*Planatrypa*) sp., *A. (Hyponeatrypa)* sp., *Spinatrypa* sp., *Cyrtospirifer sinensis* (GRABAU, 1931), *C. sp.*] and corals

(*Sinodisphyllum variabile* SUN, 1958, *S. simplex* SUN, 1958). The middle member contains only abundant corals: *Hexagonaria schuchertii* (SMITH, 1945), *H. orientalis* (SUN, 1958), *H. philomena* GLINSKI, 1955, *Disphyllum caespitosum cylindricum* JIANG, 1982, *D. irregulare* YOH, 1957, "*Peneckiella*" sp., and *Wapitiphyllum* sp. The upper member, in which abundant *Parvaltissimarostrium minimum* n.gen., n.sp. have been collected in bed 11, 44.8m thick and bed 12, 4m thick (see p.270 in YU & al., 1983, p. 96 in YU & al., 1990; see also bed 8, p. 465 in LIU, 1987), contains abundant other brachiopods [*Ptychomaletiochia* "shetienchiaoensis" (TIEN, 1938), *Hypothyridina* sp., *Atrypa* sp., *Spinatrypa* sp., *Tenticospirifer vilis* (GRABAU, 1931), *T. tenticulum* (DE VERNEUIL, 1845), *T. cf. gortanii* (PELLIZZARI, 1913)], and corals [*Pseudozaphrentis difficilis* SUN, 1955, *Disphyllum geinitzi* LANG & SMITH, 1935, *Mictophyllum giganteum* SUN, 1955, *Phillipsastraea macouni* SMITH, 1945, *Hunanophrentis uniformis* SUN, 1958, *Hexagonaria bompasi* (SMITH, 1945), and *Wapitiphyllum* sp.]; the upper member is considered late Frasnian in age.

The position in the Shetienchiao Formation of the specimens collected in the Shetianqiao section is unknown.

#### References

- GRABAU, A.W., 1931-33. Devonian Brachiopoda of China. I. Devonian Brachiopoda from Yunnan and other districts in South China. *Palaeontologia Sinica*, Series B, 3(3), 545 pp.
- LIU, Z., 1987. On the lithostratigraphic units of the Shetianqiao Stage in central Hunan. *Geological Review*, 33(5): 462-467.
- MANSUY, H., 1912. Etude géologique du Yun-Nan oriental, 2e partie: Paléontologie. *Mémoires du Service Géologique de l'Indochine*, 1(2), 147 pp.
- MCLAREN, D.J., 1961. Three new genera of Givetian and Frasnian (Devonian) rhynchonelloid brachiopods. *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique*, 37(23), 7 pp.
- MURCHISON, R.I., DE VERNEUIL, E. & DE KEYSERLING, A., 1845. Géologie de la Russie d'Europe et des Montagnes de l'Oural, 1, 700 pp., 2, 500 pp.
- NALIVKIN, D.V., 1941. Brachiopody Glavnogo Devonskogo Polya. In: Fauna Glavnogo Devonskogo Polya, I. Paleontologicheskii Institut, Akademiya nauk SSSR: 139-226.

- NALIVKIN, D.V., 1947. Klass *Brachiopoda*. In: NALIVKIN, D.V. (red.), Atlas rukovodyashchikh form iskopaemykh faun SSSR, t. 3: Devonskaya sistema. Gosgeolizdat, Moskva, Leningrad: 63-134.
- PELLIZARI, G., 1913. Fossili paleozoici antichi dello Scensi (Cina). *Rivista italiana di Paleontologia*, 19(2): 33-48.
- SARTENAER, P., 1966. Frasnian Rhynchonellida from the Ozbak-Kuh and Tabas regions (East Iran). *Reports of the Geological Survey of Iran*, 6: 25-53.
- SARTENAER, P., 1972. De l'importance stratigraphique des Rhynchonellides famenniens situés au-dessus de la Zone à *Ptychomaletoechia dumonti* (GOSSELET, J., 1877). Première note: *Cavatisinurostrum* n.gen. *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique*, 48, *Sciences de la Terre*, 2, 22 pp.
- SARTENAER, P., 1989. Deux genres Rhynchonellides nouveaux d'âge frasnien moyen et supérieur, résultant du brisement de *Calvinaria* STAINBROOK, 1945. *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique*, 59, *Sciences de la Terre*: 61-77.
- SARTENAER, P. & ROZMAN, Kh. S., 1968. Physetorhyncha – novyi rod pozdnefamenskikh rinkhonellid. *Paleontologicheskii Zhurnal*, 2: 137-139.
- TIEN, C.C., 1938. Devonian Brachiopoda of Hunan. *Palaeontologia Sinica*, New Series B, 4 (Whole Series, 113), 192 pp.
- YANG, J.-z. & WANG, Y., 1955. Standard fossils of China, 2: Bryozoans – Brachiopods, 171 pp.
- YU, C.M., XU, H.K., PENG, J., XIAO, S.T. & LIU, Z.H., 1983. Devonian of Hunan with bearing on ore deposits. In: Papers presented at the Symposium on siderite ore deposits. Science Press, Beijing: 262-298.
- YU, C., XU, H., PENG, J., XIAO, S. & LIU, Z., 1990. Devonian stratigraphy, palaeogeography and mineral resources in Hunan. *Palaeontologia Cathayana*, 5: 85-138.

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#### PLATE 1

a = ventral view; b = dorsal view; c = frontal view; d = apical view; e = lateral view

#### *Navalicia rectangularis* n.sp.

Figures are x1

Figs. 1-5. – Holotype, 110731. Costal formula:  $\frac{2}{1}$ .

Figs. 6-10. – Paratype A, 110732. Costal formula:  $\frac{2}{1}$ .

#### *Parvaltissimarostrum minimum* n.gen., n.sp.

Figures are x3

Figs. 11-15. – Holotype, 112786. Costal formula:  $\frac{8}{7}$ ; 0.

Figs. 16-20. – Paratype A, 112787. Costal formula: 0; 0.

Figs. 21-25. – Paratype B, 112788. Costal formula:  $\frac{6}{5}$ ;  $\frac{1}{2}$ .

Figs. 26-30. – Paratype C, 112789. Costal formula: 0; 0.

Figs. 31-35. – Paratype D, 112790. Costal formula:  $\frac{3}{2}$ ;  $\frac{3}{7}$ .

Figs. 36-40. – Paratype E, 112791. Costal formula:  $\frac{?}{5}$ ;  $\frac{4}{?}$ .

