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EARLY PERMIAN BRACHIOPODS OF GONDWANA AFFINITY FROM THE DINGJIAZHAI FORMATION OF THE BAOSHAN BLOCK, WESTERN YUNNAN, CHINA

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Riassunto. In questo articolo vengono considerate e figurate 28 specie appartenenti a 26 generi diversi provenienti da 12 località isolate della Formazione Dingjiazhai nel Blocco Baoshan, affiorante nello Yunnan occidentale, Cina. Sono descritte 4 nuove specie *Bandoproductus qingshuigouensis* n. sp., *Callytharrella dongshanpoensis* n. sp., *Trigonotreta semicircularis* n. sp. e *Punctocyrtella? yunnanensis* n. sp. Sulla base della distribuzione stratigrafica delle specie di brachiopodi nell'ambito della Formazione Dingjiazhai, sono riconoscibili tre associazioni di fossili. In ordine ascendente esse sono: Associazione a *Bandoproductus qingshuigouensis-Marginifera semigratiosa* di età Asseliana, Associazione a *Punctocyrtella australis-Punctospirifer afghanus*, la cui età più probabile si estende dal più tardo Asseliano al Sakmariano inferiore, ed infine l'Associazione a *Callytharrella dongshanpoensis*, di età Sakmariano superiore -Artinskiano. La fauna a brachiopodi del Permiano inferiore contenuta nella Fm. Dingjiazhai nel suo insieme dimostra che esistono forti legami a livello specifico e generico con quelle del Gondwana e del Perigondwana, ma anche indica che si ebbero limitati ma significativi legami con quelle della Paleo-Tetide orientale.

Abstract. Twenty-eight species belonging to twenty-six genera and two unidentifiable genera are reported and figured from twelve isolated localities of the Dingjiazhai Formation in the Baoshan Block, western Yunnan, China. Four new species, *Bandoproductus qingshuigouensis* n. sp., *Callytharrella dongshanpoensis* n. sp., *Trigonotreta semicircularis* n. sp. and *Punctocyrtella? yunnanensis* n. sp., are described. Based on the stratigraphic distribution of the brachiopod species throughout the Dingjiazhai Formation, three assemblages are recognisable, which in ascending order are: *Bandoproductus qingshuigouensis-Marginifera semigratiosa* Assemblage (Asselian age), *Punctocyrtella australis-Punctospirifer afghanus* Assemblage (most likely latest Asselian-Early Sakmarian) and *Callytharrella dongshanpoensis* Assemblage (Late Sakmarian-Artinskian). The Early Permian Dingjiazhai brachiopod fauna as a whole demonstrates strong generic and specific links with those of Gondwanan and Perigondwanan faunas, but also demonstrates limited but significant links with those of the eastern Palaeotethyan faunas.

Introduction.

The western Yunnan region comprises a number of allochthonous continental blocks that are bounded by fault and suture zones. At least both the Baoshan and Tengchong Blocks have been interpreted to have formed parts of the greater Gondwana, being displaced to their present positions since Permian (Jin X., 1994; Wopfner, 1996; Shi & Archbold, 1995; Metcalfe, 1997). Biostratigraphical studies of various faunas and their palaeobiogeographical affinities in these blocks are critical to the understanding of their dispersion history. The brachiopods described in this paper were collected by one of us (ZKY) from three informal members (Members A-C) of the Dingjiazhai Formation of the Baoshan Block between the Nujiang and Kejie Fault Zones (Fig. 1).

The Dingjiazhai Formation was formerly assigned to the Late Carboniferous (Bashkirian-Gzhelian) based on the presence of fusulinid *Triticites* species in the upper part of this formation (e.g., Yang Z., 1983; Fang R. & Fan, 1993; Fang R., 1994). On the other hand, Nie et al. (1993) argued that some of the fossil remains in the Dingjiazhai Formation, such as the brachiopod "*Syringothyris*", the "Carboniferous" fusulinid *Triticites* species and some corals, were reworked from the underlying Lower Carboniferous Yunruijie Formation or eroded Upper Carboniferous strata, and that the Dingjiazhai Formation is of Sakmarian to Artinskian age. Shi et al. (1996) described eleven brachiopod species from the upper member of the Dingjiazhai Formation at two localities near Youwang in the Shidian area of the Baoshan Block, and considered that the brachiopod assemblage is of late Sakmarian age. They also ques-

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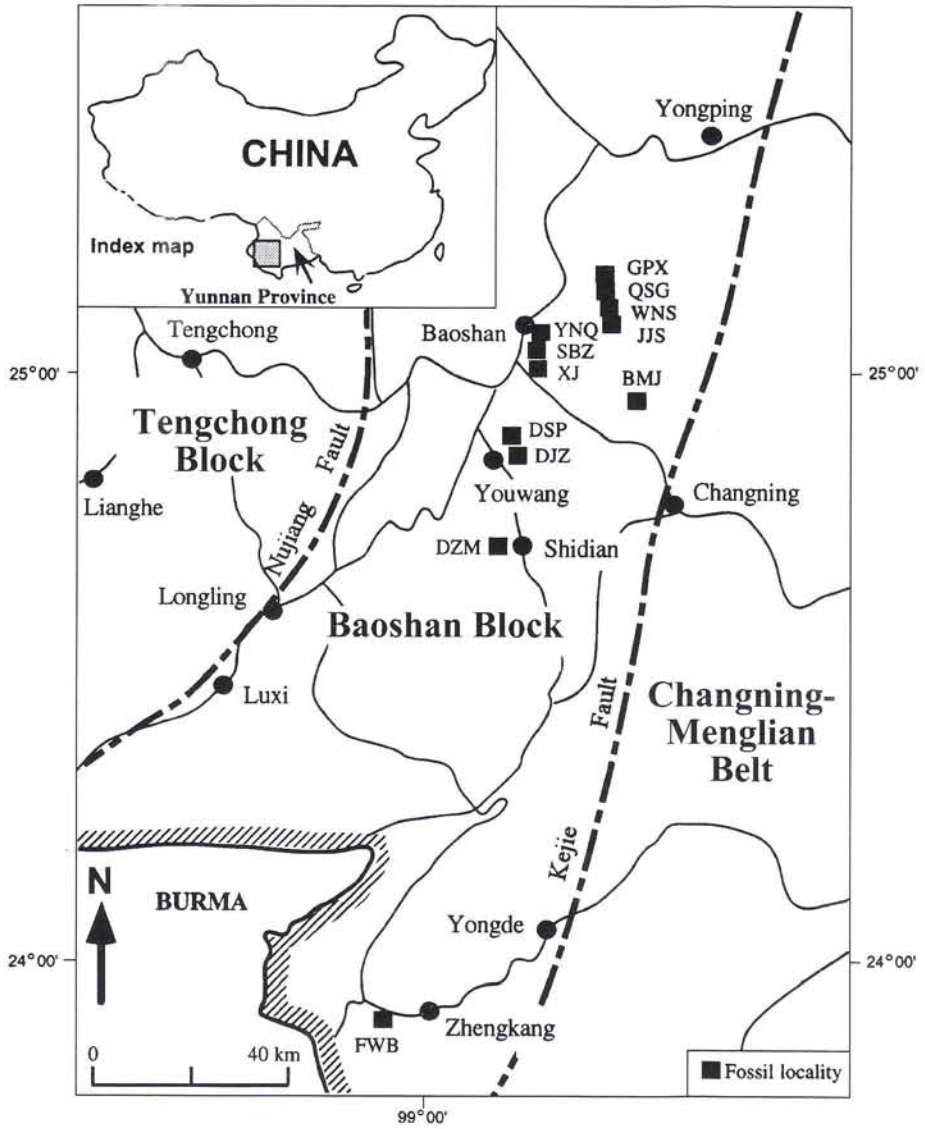

Fig. 1 - Map showing localities of fossil materials investigated from the Baoshan Block. GPX-Guanpoxiang, QSG-Qingshuigou, WNS-Woniusi, JJS-Jinjisi, YNQ-Yangnaiqiao, SBZ-Sanbazi, XJ-Xinjie, BMJ-Bingmajie, DSP-Dongshanpo, DJZ-Dingjiazhai, DZM-Dazhai meng, FWB-Fengweiba.

tioned the possibility that the Dingjiazhai brachiopods and fusulinids were reworked from the underlying formations. In a further detailed study based on both sedimentological and palaeontological features, Fang Z. et al. (2000) have also concluded that the Dingjiazhai Formation contains no evidence to support the 'reworking' hypothesis.

The figured material in this paper is registered by the prefix NIGP and housed in the Nanjing Institute of Geology and Palaeontology of Chinese Academy of Sciences. In total, 134 specimens (NIGP130854-130987) are registered. These specimens were collected from twelve isolated but closely spaced (except for locality FBW, see Fig. 1) localities representing the three lithostratigraphic members of the Dingjiazhai Formation (Fig. 2, Table 1).

Stratigraphy.

The Dingjiazhai Formation (Geological Survey of Yunnan or GSY hereafter, 1980) is widely distributed in western Yunnan. It varies from 100 to 340 m in thickness, representing a transgressive sequence consisting of diamictite, pebbly mudstone, quartzose sandstone, siltstone, shale and limestone. It is overlain by basalt and some pyroclastic rocks of the Woniusi Formation and unconformably underlain by the Visean Yunruijie Formation (Fig. 2). The type locality is situated at Dingjiazhai (DJZ) village about 2.5 km northeast of Youwang in the Baoshan Block (Fig. 1). According to GSY (1980), three members yet to be informally named, are readily distinguishable at the type locality of the formation based on lithology (Fig. 2). The lower member (Member A) is about 35-50 m thick at the type locality area and consists mainly of dark-grey and non-stratified glacial-marine diamictites. The clasts occupy about 30-50% of the diamictites and are mostly limestone fragments and cherts, angular to subangular, ranging in size from 1 to 15 cm in diameter (Fang R. & Fan, 1994).

The middle member (Member B) is about 80 m thick and commences with purple pebbly mudstones

and siltstones about 6.3 m thick. Upwards this member grades into pale grey mudstones and siltstones with scarce, non-sorted pebbles. In the upper part of the member there are some limestone lenses intercalated with black shales. As a whole, the proportion of clasts in this member has reduced to 3-5% (Jin X., 1994). Very few brachiopods (Fang R. & Fan, 1994) have been documented from this member prior to the present study.

The upper member (Member C) is only about 3 m thick and is composed of bioclastic limestones with abundant brachiopods, and some corals, fusulinids and limited conodonts (see below).

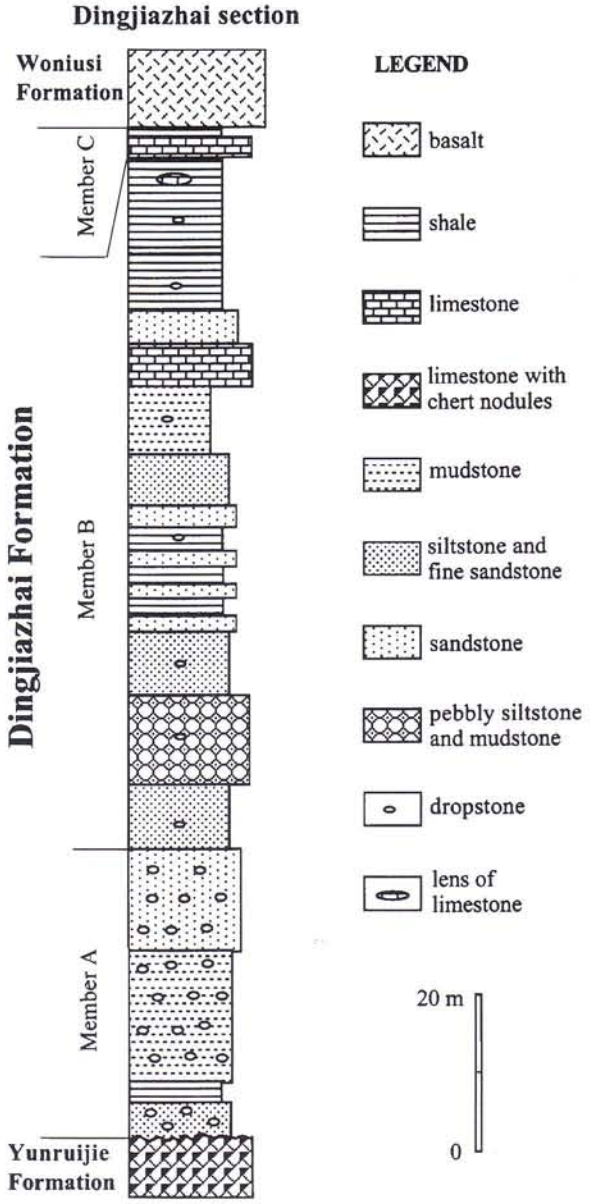

Fig. 2 - The type section at Dingjiazhai near Youwang, showing the major lithologies of the Dingjiazhai Formation (data after Fang R. & Fan, 1994).

Brachiopod assemblages and their ages.

Until now biostratigraphic zonation of the megafaunas of the Dingjiazhai Formation has not been attempted due to lack of fossil data from the lower and middle members of the formation. In this paper we have now obtained brachiopod species throughout the entire formation, which, in conjunction with the study of Shi et al. (1996) on the brachiopods from the uppermost part of the formation, enables us to divide the brachiopod succession of the Dingjiazhai Formation into three assemblages, which corresponds well with the three lithostratigraphic members outlined above.

Bandoproductus qingshuigouensis-Marginifera semigratiosa Assemblage.

This assemblage is represented by brachiopods from the lower member (Member A) of the Dingjiazhai Formation and is characterised by abundant occurrences of *Bandoproductus qingshuigouensis*, *Marginifera semigratiosa* and *Orthotichia magnifica*. In total, fourteen species and an unidentifiable genus have been found, ten of which are restricted to this assemblage. Among the species restricted to the assemblage, *Marginifera semigratiosa* and *Brachythyrina peregrina* were first reported by Reed (1927) from unspecified Lower Permian strata of Ta-Li-Shao in Yunnan. *Dielasma glabrum* is known from the Late Carboniferous Weining Formation of Sichuan Province, South China (Tong, 1978). *Orthotichia magnifica* occurs widely in the Gzhelian (latest Carboniferous) to Artinskian Maping Formation in southwest China. *Spirelytha petaliformis* was first recorded from the Sakmarian-Artinskian Tashkazyk Formation of southeast Pamir (Grunt & Dmitriev, 1973; Grunt & Novikov, 1994) and has since also been reported from the Late Sakmarian of western Peninsular Malaysia (Shi & Waterhouse, 1991; Shi et al., 1997) and the Asselian-Early Sakmarian Gircha Formation in Karakorum, Pakistan (Angiolini, 1995). *Bandoproductus* species are known from pebbly mudstones (?Asselian-Sakmarian) in southern Thailand (Waterhouse, 1982), the Pondo Series in Xizang (Tibet) (Jin D. & Sun Y., 1981), the late Sakmarian upper Singa Formation of Langkawi Island, northwestern Peninsular Malaysia (Shi et al., 1997), the Asselian *Lyonia bourkei* Zone and the late Sakmarian *Bandoproductus walkomi* Zone in eastern Australia (Briggs, 1998). *Bandoproductus* has never been reported from pre-Asselian and its first appearance may be considered the beginning of the Permian in the Gondwanan region. Therefore, in view of the evidence discussed above, this assemblage is most likely Asselian in age, although direct evidence for this conclusion is lacking.

Species	Member			Localities											
	A	B	C	GPX	QSG	WNS	YNQ	JJS	SBZ	XJ	BMJ	DSP	DJZ	DZM	FWB
Orthotichia magnifica Grabau	X										X				
Eolissochonetes ? sp.	X				X										
Rugosochonetinae gen. et sp. indet.	X			X	X										
Marginifera semigratiosa (Reed)	X				X						X				
Linoproductus sp.	X				X						X				
Bandoproductus qingshuigouensis n. sp.	X				X										
Fusispirifer sp.	X			*	X										
Brachythyrina peregrina (Reed)	X			X	X					X	X				
Crurithyris sp.	X			X											
Punctocyrtella ? *yunnanensis* n. sp.	X										X				
Dielasma ? cf. *glabrum* Tong	X				X										
Neospirifer cf. *orientalis* (Chao)	X	X		X									X		
Spirelytha petaliformis (Pavlova)	X	X									X			X	X
Cimmeriella mucronata (Fang)	X	X	X							X		X	X		X
Costatumulus sp.	X		X		X								X		
Trigonotreta semicircularis n. sp.		X							X				X		
Martinia decora (Phillips)		X											*		X
Phricodothyris sp.		X													X
Syringothyrididae gen. et sp. indet.		X					X								
Punctocyrtella australis (Thomas)		X				X	X		X				X		
Punctospirifer afghanus Termier et al.		X					*						X		
Uncinunellina? Sp.		X											X		
Dielasma? sp.		X											X		
Elivina yunnanensis (Shi, Fang & Archbold)		X	X					X				X	X		X
Cleiothyridina laminosa Fang		X	X									X	X		
**Acrititreta*? sp.			*										*		
**Transennatia* sp.			*										*		
**Cyrtella*? sp.			*										*		
**Tivertonia*? sp.			*										*		
**Pyramidthyris*? sp.			*										*		
Rugoconcha sp.			X										X		
Levipustula ? sp.			X										X		
Callytharrella dongshanpoensis n. sp.			X									X	X		
Nantanella elegantula Grabau			X									X	X		
Hustedia sp.			X									X	X		

Tab. 1 - Occurrences of brachiopod species from the three members of the Dingjiazhai Formation in the Baoshan Block. [The species marked with * were only recorded by previous studies. Data are from Nie et al. (1993); Fang R. & Fan (1994) and Shi et al. (1996)]. GPX-Guanpoxiang, QSG-Qingshuigou, WNS-Woniusi, JJS-Jinjisi, YNQ-Yangnaiqiao, SBZ-Sanbazi, XJ-Xinjie, BMJ-Bingmajie, DSP-Dongshanpo, DJZ-Dingjiazhai, DZM-Dazhaimeng, FWB-Fengweiba.

Punctocyrtella australis-Punctospirifer afghanus Assemblage.

This assemblage includes brachiopods from several horizons spanning the whole middle Member (Member B) in the Dingjiazhai Formation. It is dominated by the two named species and *Martinia decora*. Eight species are restricted to this assemblage. *Punctospirifer afghanus* occurs in the Asselian-Early Sakmarian of Wardak, central Afghanistan (Termier et al., 1974) and the Asselian-Early Sakmarian Gircha Formation of the Karakorum Range, Pakistan (Angiolini, 1995). *Punctocyrtella australis* is known from the late? Asselian to Early Sakmarian Lyons Group and the Late Sakmarian Callytharra Formation of the Carnarvon Basin, Western Australia (Thomas, 1971). This species is comparable to *P.* ? *nagmargensis*, *P. koopi* and *P. spinosa* in generalities although the generic assignment of the former species between *Punctocyrtella* and *Cyrtella* is still pending. *P.* ? *nagmargensis* is from the Agglomeratic Slate in Kashmir (Bion, 1928), considered to be late Asselian to Sakmarian in age (Sheng & Jin Y., 1994) and similar specimens were reported from the Sakmarian in southeastern Oman (Angiolini, 1997). *P. koopi* is known from the Late Sakmarian Cuncudgeric Sandstone in the southern Canning Basin, Western Australia (Archbold, 1990). *P. spinosa* was documented from the late Sakmarian of Wardak (Afghanistan) and southeastern Oman (Legrand-Blain, 1968; Termier et al., 1974; Angiolini, 1997). The presence of Syringothyrididae is not totally unexpected since younger, Late Carboniferous to Early Permian occurrences of the genus, albeit rare, have been reported. For instance, *Syringothyris*? *lydekkeri* (Diener, 1915) was originally described from the *Fenestella* beds and equivalents of Kashmir, of Late Carboniferous (Bashkirian) age (see Garzanti et al., 1998). The same species was also reported from the Asselian-Early Sakmarian Agglomeratic Slate in Kashmir by Bion (1928). Other Permian

occurrences of Syringothyrididae species have also been reported (Mansuy, 1912; Reed, 1927; Merla, 1934; Muir-Wood & Oakley, 1941; Waterhouse, 1966, 1978) although in no case was the identity clearly established.

Therefore, in view of its stratigraphic position and the stratigraphic ranges of several key species reviewed above, we consider the *Punctocyrtella australis-Punctospirifer afghanus* Assemblage to be most likely latest Asselian to early Sakmarian in age in consistency with the more certain Late Sakmarian-Artinskian age of the overlying *Callytharrella dongshanpoensis* Assemblage (see below). This conclusion is compatible with the age determination based on palynomorphs from the same member (Yang W., 1999). Yang has recognised a small palynomorph assemblage which he correlated with the *Pseudoreticulatispora confluens* Zone of Western Australia, of latest Asselian to Early Sakmarian age (Backhouse, 1998).

Callytharrella dongshanpoensis Assemblage.

This assemblage refers to brachiopods from the upper Member (Member C) of the Dingjiazhai Formation. Fourteen species have been reported from this assemblage, among which four are shared with the underlying assemblages. This assemblage is characterised by the co-occurrences of *Callytharrella dongshanpoensis, Nantanella elegantula* and *Elivina yunnanensis. Callytharrella* species are known from the Late Sakmarian Callytharra Formation of the Carnarvon Basin, Western Australia (Archbold, 1985), the Late Sakmarian Bisnain assemblage of Timor (Archbold & Barkham, 1989), the Artinskian-Roadian Tunlonggongba Formation in the Rutog-Duoma region of Tibet (Xizang) (Sun, 1983), the Kungurian-Roadian of Karakorum of Pakistan (Angiolini in Gaetani et al., 1995) and the Late Sakmarian *Spinomartinia prolifica* Assemblage of the Ko Yao Noi Formation of southern Thailand (Waterhouse, 1981; Shi et al., 1996). *Nantanella elegantula* is present in the Gzhelian to Sakmarian Maping Formation of Guangxi, South China. *Elivina yunnanensis* is comparable with *Elivina bisnaini* Archbold from the Late Sakmarian Bisnain Assemblage of Timor (Shi et al., 1996).

Shi et al. (1996) proposed a Late Sakmarian age for the brachiopods from the uppermost Dingjiazhai Formation based on correlation of the brachiopods with other brachiopod faunas, especially those of the Callytharra Formation and equivalents of Western Australia and the Bisnain assemblage of Timor. This age determination agrees well with the associated fusulinids. According to the recent systematic study by Wang (in Fang Z. et al., 2000), the fusulinid fauna includes *Eoparafusulina pseudosimplex* (Chen), *E. pusilla* (Schellwien), *E. contracta* (Schellwien), *Schwagerina schencki* Skinner & Wilde, *S. quasivulgaris* Lin, *S.* cf. *paranana* Zhou et al., and *Triticites stuckenbergi* Rauser and can be correlated with the *Robustoschwagerina schellwieni-R. ziyunensis* Zone of southwest China, of latest Sakmarian age. In addition to the fusulinids and brachiopods, a small conodont fauna, originally including *Sweetognathus inornatus* (Ritter) and *Mesogondolella* cf. *bisselli* (Clark and Behnken) (Wang et al., 1999), has also been recovered from the same interval. Recently, the specimens of the above two conodont species have been re-identified as three different species. They are *Sweetognathus bucaramangus* (Rabe), a primitive *S. whitei* (Rhodes) and *Mesogondonella bisselli* (Wang Xiangdong, pers. comm., 2000). According to the newest time scale of the Permian System (Jin Y. et al., 1999, table 2), the *Mesogondonella bisselli* Zone is of late Sakmarian in age, whereas the *S. whitei* Zone is restricted to Artinskian. Thus, the *Callytharrella dongshanpoensis* Assemblage is most likely late Sakmarian to Artinskian in age.

Palaeobiogeographical and palaeogeographical implications.

The correlations of the Dingjiazhai brachiopods outlined above clearly indicate a strong Gondwanan and Perigondwanan palaeobiogeographical affinity for western Yunnan during the Early Permian (Asselian-Sakmarian), as already pointed out by Shi et al. (1996). The brachiopod fauna of the Dingjiazhai Formation as a whole consists mainly of Gondwanan (or Perigondwanan), antitropical (in the sense of Shi & Grunt, 2000), and some wide-ranging taxa. Among the Gondwanan elements, *Callytharrella, Bandoproductus, Trigonotreta* and *Punctocyrtella* are most characteristic. Antitropical genera encompass *Spirelytha, Cyrtella, Syringothyris, Elivina* and probably *Cimmeriella* (Lazarev, pers. Comm., 2000), which occur in both Gondwanan and Boreal Realms and adjacent transitional zones, but are almost completely absent from the intervening Palaeoequatorial Realm. Other genera such as *Marginifera, Linoproductus, Martinia, Cleiothyridina* and *Dielasma* appear to have wide geographic distributions during the Permian.

On the other hand, some links between the Dingjiazhai fauna and those of the Cathaysian Province, South China in particular, can be also noted. Brachiopod species furnishing this linkage include, notably, *Orthotichia magnifica* and *Nantanella elegantula*, which were only recorded from the Maping Formation of South China before. These relatively few but significant species links with South China are also consistent with the fact that (1) the Dingjiazhai brachiopod fauna lacks some typical Gondwanan genera (e.g., *Wyndhamia* and *Tomiopsis*) and (2) that fusulinids are also present at least in the upper part of the Dingjiazhai Formation. We

interpret these features of the Dingjiazhai fauna as characteristic of a biogeographically transitional fauna between the typical cold to cool-water Gondwanan Realm and the warm-water Palaeoequatorial Realm, as defined by Shi et al. (1995). The transitional feature of the Dingjiazhai fauna further implies that the Baoshan Block was located in the Perigondwanan region with a greater but progressively diminishing proximity with Gondwanaland and increasing proximity with Cathaysia through the Permian.

Systematic palaeontology and notes.

For the sake of keeping the paper within a reasonable length, only new species are fully described below and in some cases descriptions and/or comments are also provided for some existing species and/or genera where sufficient material is available and revision of these taxa is necessary. Some species are not mentioned except in Table 1. All reported species are however figured. The systematic study follows the classification of Brunton et al. (2000) for the productids, Carter et al. (1994) for the spiriferids and Moore (1965) for all others. Taxonomic classifications above family level are not listed.

Family Productidae Gray, 1840

Subfamily Dictyoclostinae Stehli, 1954

Genus *Callytharrella* Archbold, 1985

Callytharrella dongshanpoensis n. sp.

Pl. 1, figs. 11-14, 16

1993 *Stereochia litostyla* Grant - Nie et al., pl. 1, figs. 1-5
1996 *Callytharrella* sp. - Shi et al., p. 89, figs. 4B-E

Holotype. A ventral valve (NIGP130865) (Pl. 1, fig. 11).

Type-level. Member C of the Dingjiazhai Formation.

Type-locality. DSP, Youwang in the Shidian area, western Yunnan, China.

Other material. Two incomplete ventral valves (NIGP130866, 130867), two incomplete external moulds of dorsal valves (NIGP 130868, 130869); two incomplete dorsal valves (NIGP130870, 130871) and three fragments of dorsal interiors (NIGP130872-130874).

Derivatio nominis. After the locality name, Dongshanpo (DSP) in Youwang, Shidian.

Diagnosis. Large for genus; ears distinct; ornamentation fine, with moderately developed sulcus; spine bases prominent.

Description. Shell about 41 mm long and 62 mm wide, transversely subquadrate in outline, widest at hinge; ears large, nearly flat, well demarcated from visceral region by groove; cardinal extremities acute. Ventral visceral region moderately convex in profile; beak low and blunt; umbonal slopes strongly inclined; sulcus wide and shallow, beginning from beak; trail geniculate, with prominent sulcus. Dorsal valve strongly geniculate, visceral region nearly flat or slightly concave; ears large and flat; fold wide and flattened; visceral regions of both valves strongly reticulate; rugae fine, disappearing on anterior part of visceral region and trail; costae also fine on visceral region, but coarser anteriorly, numbering 6-7 on umbo and 2-3 in 5 mm on trail, convergent in sulcus on trail, commonly bifurcated anterior to spines on trail; ventral spines numerous, scattered on visceral region and trail, projecting anteriorly or laterally; a small cluster on ears; spine bases slightly swollen. Dorsal interior with prominent cardinal ridges beginning from the shaft of cardinal process; cardinal process short, trilobate, supported by median septum which continues forward for about 8.5 mm.

Discussion. The fine reticulation on the visceral regions of both valves, convergent costae in the sulcus

PLATE 1

(All figures are natural size unless otherwise illustrated, same after herein for plates)

Fig. 1-4 - *Orthotichia magnifica* Grabau; from Member A, BMJ - 1, dorsal exterior, NIGP130854; 2, dorsal exterior, NIGP130855; 4, 5, dorsal exterior and interior, NIGP130857.

Fig. 5, 6 - *Eolissochonetes*? sp.; from Member A; QSG - 5, internal mould of a ventral valve, NIGP130858; 6, internal mould of a ventral valve, NIGP130859.

Fig. 7-9 - *Rugosochonetinae* gen. et sp. indet. - 7, external mould of a dorsal valve, NIGP130861, x5; from Member A; QSG; 8, external mould of a dorsal valve, NIGP130862, x4, from Member A, GPX; 9, external mould of a dorsal valve, NIGP130860, x3, from FHA, GPX.

Fig. 10 - *Levipustula* ? sp. - ventral exterior, NIGP130864, x1.5, from Member C, DJZ.

Fig. 11-14, 16 - *Callytharrella dongshanpoensis* n. sp. - 11, ventral exterior, NIGP130865, holotype, from Member C, DSP; 12, anterior view of a ventral valve, NIGP130867, from Member C, DJZ; 13, external mould of a dorsal valve, NIGP130869, from Member C, DSP; 14, ventral exterior, NIGP130866, from Member C, DSP; 16, dorsal interior, NIGP130872, (x1.5, from Member C, DJZ.

Fig. 15 - *Rugoconcha* sp. - ventral exterior, NIGP130863, x2, from Member C, DJZ.

Fig. 17 - *Bandoproductus qingshuigouensis* n. sp. - ventral exterior, NIGP130891, from Member A, QSG.

Fig. 18-22 - *Linoproductus* sp. - 18, anterior view of a ventral valve, NIGP130884, from Member A, BMJ; 19, 20, posterior and ventral views of a ventral valve, NIGP130883, from Member A, BMJ; 21, 22, ventral and posterior views of a ventral valve, NIGP130885, from Member A, QSG.


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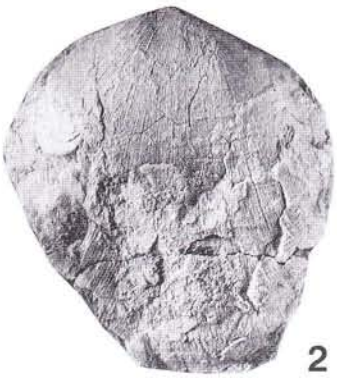
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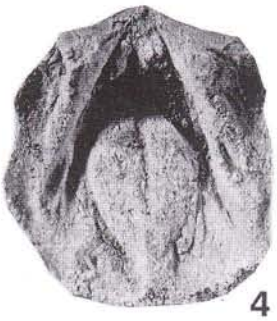
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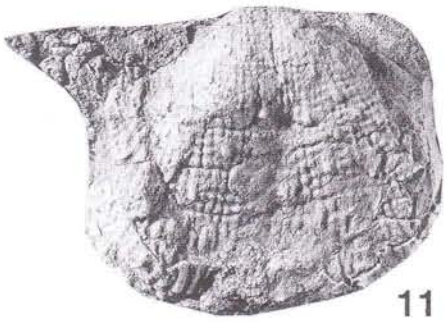
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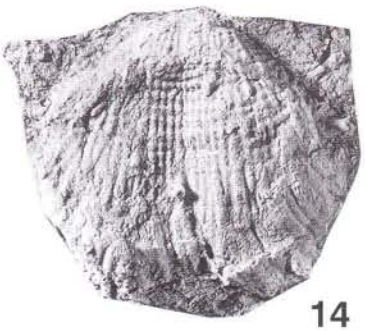
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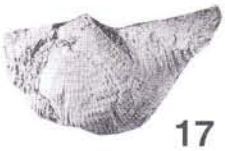
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and prominent ears of the present materials characterise the genus *Callytharrella*. *Costiferina sinensis* Sun (1983, p. 125, pl. 16, figs. 8-10), from the Tunlonggongba Formation in the Rutog-Duoma region, southern Tibet (Xizang), is clearly not *Costiferina* in terms of its fine reticulation and convergent costae in the sulcus and has been assigned to *Callytharrella* by Archbold (1985) and Angiolini in Gaetani et al. (1995) or *Pseudoantiquatonia* Zhan & Wu, 1982 by Jiang & Yan (1992). A close comparison shows that the Tibetan (Xizang) species appears to have smaller, less extensive ears, more incurved lateral profile, sharply inclined flanks, inconspicuous spines and more complicated costae on the ventral trail. The specimens from the Xiaoxinzhai Formation, Gengma, Tengchong of western Yunnan, figured as *Costiferina obesa* Fang (in Fang R. & Fan, 1994, p. 81, pl. 20, fig. 2), *C. xiaoxinzhaiensis* Fang (in Fang R. & Fan, 1994, p. 81, pl. 20, fig. 3; pl. 21, figs. 1-3) and *C. yunnanensis* Fang (in Fang R. & Fan, 1994, p. 82, pl. 21, fig. 4; pl. 22, figs. 1-3), are probably congeneric with the present species in terms of their fine and delicate reticulation on the visceral region of both valves, convergent costae in the sulcus and more or less extensive ears, but the Xiaoxinzhai specimens appear to have fewer spines on their surface and less prominent sulcus. *Callytharrella callytharrensis* Archbold (1985) from the Callytharra Formation in Western Australia differs from the present new species in its larger size, more prominent sulcus and coarser ornamentation. *Stereochia* species are also somewhat similar to the present species, but can be readily distinguished by means of their smaller quadrate ears with few spines, smaller size, less transverse outline, less prominent trail and coarser costae.

Family Productellidae Schuchert in Schuchert & LeVene, 1929

Subfamily Marginiferinae Stehli, 1954

Genus *Marginifera* Waagen, 1884

Marginifera semigratiosa (Reed, 1927)

Pl. 2, figs. 1-5

1927 *Productus (Marginifera) semigratiosus* Reed, p. 121, pl. 12, figs. 1-5

Discussion. *Marginifera semigratiosa* closely resembles *M. involuta* (Tschernyschew, 1902, p. 645, pl. 58, figs. 4-5) from the Asselian and Sakmarian beds of the Urals and Timan Mountains of Russia and the Upper Carboniferous of Shandong, North China (Ozaki, 1931, p. 137, pl. 12, fig. 22) by its fine costellae and profile, but differs in the presence of a row of coarse spines between the ears and the visceral region and less prominent sulcus on the trail. *M. morrisi* Chao (1927, p. 152, pl. 15, figs. 28-30) from the Middle Permian Zhesi Formation of Inner Mongolia is also closely similar to *M. semigratiosa* with its fine costellae and strongly curved profile; but the former has shorter ears and a more subquadrate outline.

Family Linoproductidae Stehli, 1954

Subfamily Linoproductinae Stehli, 1954

Genus *Bandoproductus* Jin & Sun, 1981

Bandoproductus qingshuigouensis n. sp.

Pl. 1, fig. 17; Pl. 2, figs. 6-9

?1982 *Cancrinelloides monticulus* Waterhouse (partim), p. 344, pl. 1, fig. 19, 20

Holotype. A ventral valve (NIGP130887) (Pl. 2, fig. 9).

Type-locality. QSG in the Baoshan area, western Yunnan.

Type-level. Member A of the Dingjiazhai Formation.

Other material. Four ventral valves (NIGP130888-130891).

Derivatio nominis. After the locality name, Qingshuigou (QSG) in the Baoshan area.

Diagnosis. Slightly transverse shell with moderately concavo-convex globose profile; greatest width at hinge; row of large spines along ventral hinge; concentric rugae prominent but irregular on visceral region.

PLATE 2

Fig. 1-5 - *Marginifera semigratiosa* (Reed) - 1-3, ventral, dorsal and lateral views of a shell, NIGP130875, x2, from Member A, BMJ; 4, ventral exterior, NIGP130876, x2, from Member A, BMJ; 5, ventral exterior, NIGP130881, x2, from Member A, BMJ.

Fig. 6-9 - *Bandoproductus qingshuigouensis* n. sp.; from Member A, QSG - 6, ventral exterior, NIGP130888; 7, ventral exterior, NIGP130889; 8, ventral exterior, NIGP130890; 9, ventral exterior, NIGP130887, holotype.

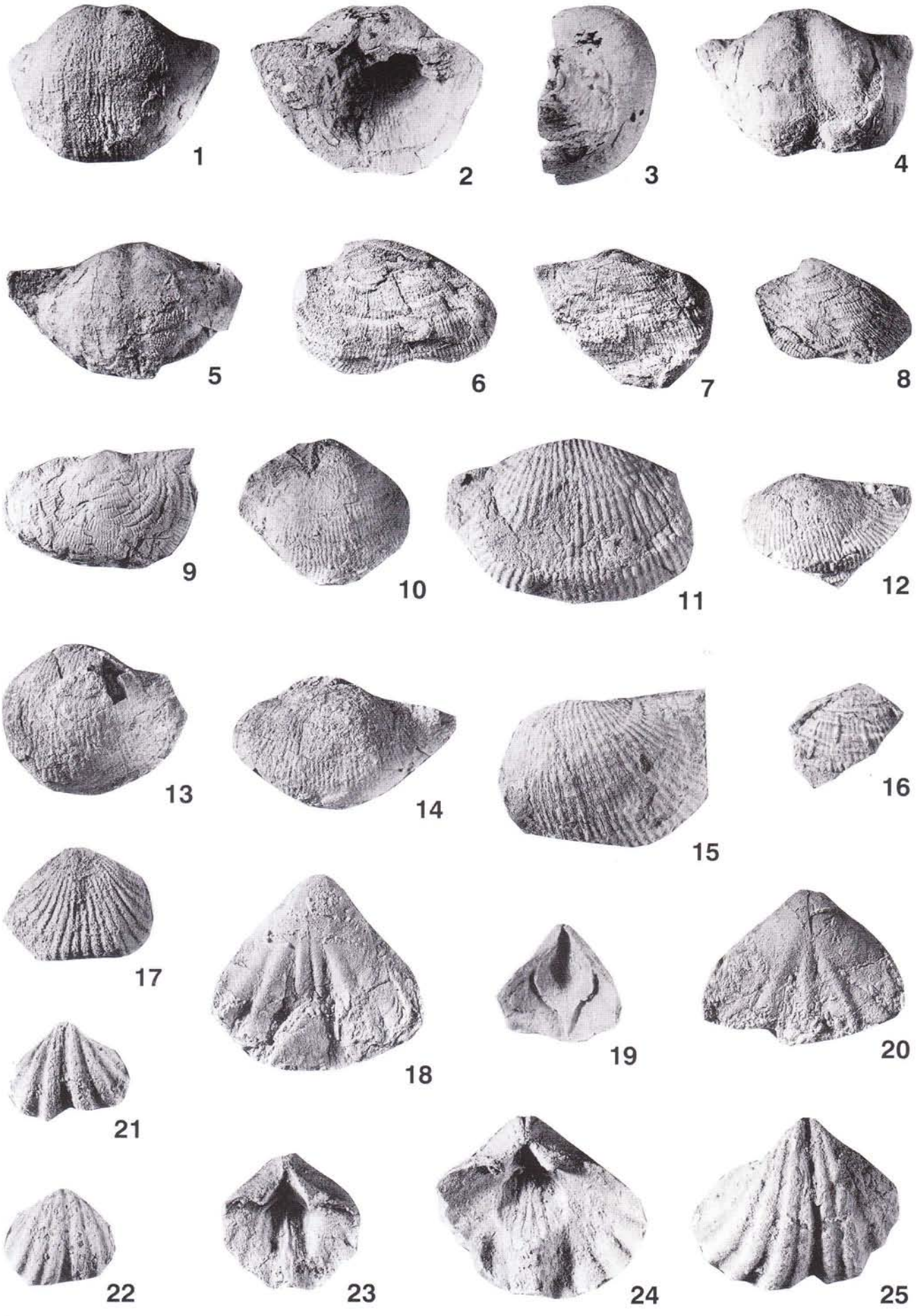
Fig. 10-15 - *Cimmeriella mucronata* (Fang) - 10, ventral exterior, NIGP130896, x2, from Member A, XJ; 11, ventral exterior, NIGP130901, x2, from Member B, FWB; 12, ventral exterior, NIGP130898, x1.5, from Member C, DJZ. 13, ventral exterior, NIGP130895, x2, Member C, DSP; 14, ventral exterior, NIGP130894, from Member C, DSP; 15, ventral exterior, NIGP130899, x2, from Member B, FWB.

Fig. 16 - *Costatumulus* sp. - ventral exterior, NIGP130893, x3, from Member A, QSG.

Fig. 17 - *Uncinunellina* ? sp. - dorsal exterior, NIGP130902, x1.5, from Member B, DJZ.

Fig. 18-20 - *Nantanella elegantula* Grabau - 18, ventral exterior, NIGP130907, x2, from Member C, DSP; 19, ventral interior, showing the spondylium setting on the valve floor and supported by a median septum anteriorly, NIGP130905, x2, from Member C, DSP; 20, ventral exterior, NIGP130904, x1.5, from Member C, DJZ.

Fig. 21-25 - *Elivina yunnanensis* Shi, Fang & Archbold - 21, ventral exterior, NIGP130917, x2, from Member C, DJZ; 22, ventral exterior, NIGP130910, x1.5, from Member C, DSP; 23, ventral interior, NIGP130922, x2, from Member C, DJZ; 24, 25, ventral interior and exterior, NIGP130926, x2, from Member B, FWB.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Description. Shell average size, subquadrate or semicircular in outline, moderately concavo-convex in profile; greatest width at hinge; cardinal extremities quadrate; anterior margin broadly rounded. Ventral valve somewhat globose, maximum convexity at umbo; beak low; ears flattened, well demarcated from visceral region, ornamented with prominent rugae and a row of coarse spines along hinge line; visceral region somewhat triangular in outline; umbonal slope strongly inclined; lateral and anterior slopes gently inclined; geniculation inconspicuous; surface finely costellate; costellae numbering 7 in 5 mm near anterior margin; rugae weakly developed on visceral region, not continuous; spines on visceral region of both valves unknown.

Discussion. This new species is readily distinguished from *B. hemiglobicus* Jin Y. & Sun D. (1981) by its more prominent visceral region and more transverse outline. Waterhouse (1978, p. 76, pl. 11, figs. 13-18) described several specimens as *?Cancrinella* sp. from the Nisal Member of the Nanguang Formation in Nepal and he later (Waterhouse, 1983, p. 130) renamed them *Cancrinelloides (Bandoproductus) inflata* on the basis of its having a row of well developed spines along the ventral hinge. The Nepalese species appears to have a shorter hinge line and more prominent tear-shaped spine bases. *Cancrinelloides monticulus* Waterhouse (1982, p. 344, pl. 1, figs. 17-20; pl. 2, figs. 1-5) from the ?Asselian-Sakmarian pebbly mudstones of southern Thailand probably includes two types. The specimens in pl. 1, figs. 17, 18 and pl. 2, figs. 1-5 have tear-shaped spine bases on the ventral valve, whereas the specimens in pl. 1, figs. 19, 20 have more continuous costellae, fewer spine bases on the visceral region and a prominent row of spines along the hinge. This latter type is probably conspecific with our new species.

Genus *Cimmeriella* Archbold & Hogeboom, 2000

Cimmeriella mucronata (Fang R., 1994)

Pl. 2, figs. 10-15

1981 *Stepanoviella flexuosa* Waterhouse - Jin Y. & Sun D., p. 140, pl. 5, figs. 7-8
1993 *Stepanoviella hemisphaerium* (Kutorga) - Nie et al., pl. 1, figs. 6-8
1994 *Stepanoviella flexuosa* - Fang R., p. 267, pl. 1, figs. 6-9
1994 *Stepanoviella mucronata* Fang R., p. 268, pl. 1, figs. 10-13
1996 *Globiella youwangensis* Shi et al., p. 92, fig. 4F

Discussion. This species was originally described as *Stepanoviella mucronata* by Fang R. (1994, p. 268, pl. 1, figs. 10-13). Both *Stepanoviella* and *Globiella* are characterised by possession of very fine costellae. Material of *Globiella hemisphaerium* (Kutorga), collected by one of us (GRS) from the lower Kazanian of the Russian Platform, shows 11 costellae per 5mm at midvalve. This species is characterised by small ears, more elongate outline and more globular appearance.

On the other hand, our western Yunnan specimens and, in fact, most of the materials from Gondwana that have been variably assigned to *Globiella* or *Stepanoviella* (Waterhouse, 1970; Jin Y., 1979; Jin Y. & Sun D., 1981; Archbold, 1983), are characterised by much coarser costellae numbering 7 per 5mm at midvalve and more transverse outline and thus do not belong to either true *Globiella* or *Stepanoviella*. In addition, Archbold & Hogeboom (2000) stated that mature *Globiella* is characterised by deeply impressed, markedly-striated anterior diductor scars unlike those of "*Globiella*" or "*Stepanoviella*" species reported from the Perigondwanan region, therefore proposed *Cimmeriella* with *Productus tenuistriatus* var. *foordi* Etheridge (1903) as the type species to accommodate the species previously assigned to "*Stapanoviella*" or "*Globiella*" from the Lower Permian in the Perigondwanan region.

Cimmeriella youwangensis Shi et al. (1996, p. 92, fig. 4F) from the Dingjiazhai Formation is considered conspecific with *C. mucronata* (Fang) in terms of their comparable external characters including the transverse outline, same costellae and their similar occurrences. The other synonyms of this species have been discussed by Shi et al. (1996) and are therefore not repeated here. *C. mucronata* appears variable in outline. For instance, the specimens figured by Jin Y. & Sun D. (1981) and Shi et al. (1996) are subquadrate, whereas the present specimens and those figured by Fang R. (1994) are mostly more transverse.

Family Stenoscismatidae Oehlert, 1887

Genus *Nantanella* Grabau, 1936

Nantanella elegantula Grabau, 1936

Pl. 2, figs. 18-20

1936 *Nantanella elegantula* Grabau, p. 82, pl. 17, figs. 1-7
1977 *Nantanella elegantula* - Yang et al., p. 393, pl. 156, figs. 6a-c
1993 *Stenoscisma* sp. Nie et al., pl. 1, fig. 22
1994 *Stenoscisma* sp. Fang R., 1994, p. 268, pl. 2, figs. 7-8
1996 *Stenoscisma* sp. Shi et al., p. 93, figs. 4G, I, M-N

Discussion. Externally, *Nantanella* is close to *Stenoscisma* Conrad as well as many other rhynchonellid forms in its outline, profile and costation pattern, but has a sessile spondylium anteriorly supported by a median septum in the ventral valve, and a median septum supporting the hinge plate in the dorsal valve (Grabau, 1936, p. 71). The well preserved and posteriorly sessile spondylium in the ventral valve of the present collection (Pl. 2, fig. 19) unmistakably suggests *Nantanella*. The spondylium of *Stenoscisma* is usually highly raised and narrower (see Grant, 1965, pl. 22, fig, 3a). Our specimens agree well with the type specimen of *N. elegantula*

Grabau from the Maping Formation of Nantan, Guangxi, in that both have two costae in the sulcus and a somewhat pentagonal or slightly triangular outline. *N. mapingensis* Grabau, also from the Maping Formation, closely resembles *N. elegantula*, but has more costae and a more transverse outline.

Family Spiriferellidae Waterhouse, 1968

Subfamily Spiriferellinae Waterhouse, 1968

Genus *Elivina* Fredericks, 1924

Elivina yunnanensis Shi, Fang R. & Archbold, 1996

Pl. 2, figs. 21-25; Pl. 3, figs. 1-4

1993 *Spiriferella salteri* Tschernyschew - Nie et al., pl. 1, figs.12-15
1994 *Spiriferella unicosta* Chang - Fang R., p. 269, pl. 2, figs.10-12
1994 *Spiriferella qubuensis* Chang - Fang R., p. 269, pl. 2, figs. 13-14
1994 *Enteletes tschernyschewi* Diener - Fang R., p. 267, pl. 1, figs. 1-2
1996 *Elivina yunnanensis* Shi et al., p. 98, figs. 5D-M

Discussion. The type species of *Elivina*, *E. tibetana* Diener (1897) from the Chitichun Limestone of southern Tibet (Xizang), has an elongate outline, relatively narrow and thin umbonal region and bifurcating costae, which clearly distinguish it from the present species. *E. yunnanensis* also recalls *E. hoskingae* from the Late Sakmarian Callytharra Formation of Western Australia (Archbold & Thomas, 1985, p. 44, figs. 3A-Y) in its smaller size, suboval outline and distinct, deeply impressed muscle field, but differs in its simpler costae, and narrow sulcus bearing fewer costae. *E. yunnanensis* is readily distinguished from *Spiriferella unicostata* Chang and *S. qubuensis* Chang in its smaller size, more rounded outline, simpler costae and narrower hinge line. The specimens figured as *Enteletes tschernyschewi* by Fang R. (1994) are most likely conspecific with the present species in terms of their outline and costation which begins from the beak. Fang R. (1994) described his specimens as having fine costellae on the plications. Actually, some specimens of *E. yunnanensis* do have fine costellae if the surface of the shell is slightly etched (see Pl. 2, fig. 22).

Family Trigonotretidae Schuchert, 1893

Subfamily Trigonotretinae Schuchert, 1893

Genus *Trigonotreta* Koenig, 1825

Trigonotreta semicircularis n. sp.

Pl. 3, figs. 5-8

Holotype. An internal mould of a ventral valve (NIGP130936) (Pl. 3, fig. 5).

Paratypes. A complete internal mould of a dorsal valve (NIGP130937), a complete internal mould of an immature dorsal valve (NIGP130938), and an incomplete internal mould of a dorsal valve (NIGP130939).

Type-level. Member B of the Dingjiazhai Formation

Type-locality. DJZ in Youwang, Shidian, western Yunnan.

Derivatio nominis. In terms of its semicircular outline.

Diagnosis. Semicircular to slightly elliptical outline, cardinal extremities square-shaped or nearly so, bundles of fascicles consisting of 3 costae only.

Description. Shell large, greatest width at hinge or slightly anterior to hinge; cardinal extremities rounded or nearly so. Ventral beak pointed, slightly curved dorsally; sulcus beginning from beak, V-shaped in immature shells, narrow, deepening anteriorly. Dorsal valve semicircular in outline, moderately convex in profile; fold prominent, well rounded in cross section; surface with 4-6 pairs of low fascicles and fine costae; each fascicle consisting of three costae extending to near anterior margin, usually with the median costa coarser than the other two; growth lamellae well developed on both valves. Ventral interior with two dental plates.

Discussion. This species is most similar to *Spirifer fasciger* var. *paucicostulata* (Reed, 1925, p. 43, pl. 6, fig. 1), which is reassigned to *Trigonotreta paucicostulata* by Angiolini (1995), in terms of its semicircular outline, less pointed umbo and square-shaped cardinal extremities. However, *T. paucicostulata* has fascicles of up to 6 costae on the ventral valve. *T. lyonsensis* Archbold & Thomas (1986, p. 151, figs. 15A-F) from the latest Asselian-Sakmarian Lyons Group in the Carnarvon Basin, Western Australia, is readily distinguishable from the western Yunnan species in its transverse outline and acute and alate cardinal extremities. *T. stokesi* Koenig (1825, p. 3, pl. 6, fig. 70) differs from the present species in its more rounded outline and more prominent costae. *Spirifer narsahensis* (Reed, 1928, p. 379) from the Sakmarian Umaria Beds of Peninsular India, the Jilong Formation of southern Tibet (Xizang) (Jin Y., 1979) and *T. orientalis* Singh & Archbold (1993) from the Sakmarian of the eastern Himalaya have much coarser median costa in the three-bundle fascicles than those of the present species.

A ventral valve figured as *Trigonotreta* sp. by Shi et al. (1996) is somewhat similar to the present species in outline, but further comparison in costation is hampered because of its poor preservation.

Subfamily Neospiriferinae Waterhouse, 1968

Genus *Neospirifer* Fredericks, 1924

Neospirifer cf. **orientalis** (Chao, 1929)

Pl. 3, figs. 13-15

1929 *Spirifer orientalis* Chao, p. 11, pl. 2, fig. 8
1936 *Spirifer orientalis* - Grabau, p. 203, pl. 22, fig. 3
1944 *Spirifer (Neospirifer)* cf. *orientalis* - (Reed, pl. 27, fig. 9
1977 *Neospirifer orientalis* - Yang D. et al., p. 441, pl. 175, figs. 8a, b
1978 *Neospirifer orientalis* - Tong, p. 256, pl. 90, fig. 1

Discussion. The western Yunnan specimens match the type material of *Neospirifer orientalis* Chao (1929) in all observed features except that the latter appears to have relatively rounded cardinal extremities and a smaller size, although Chao (1929) described the hinge-line as marking the greatest width. *N. orientalis is* similar to some specimens of *N. cameratus* (Morton) (Tschernyschew, 1902, pl. 5, figs. 1-9), but Tschernyschew's specimens have a relatively lower interarea. *N. ambiensis* (Waagen, 1883, pl. 48, figs. 1a-e) is also comparable to the present species in size, outline and hinge-line, but has stronger fascicles, more prominent sulcus and fold, and finer costellae.

Family Choristitidae Waterhouse, 1968

Subfamily Angiospiriferinae Legrand-Blain, 1985

Genus *Brachythyrina* Fredericks, 1929

Brachythyrina peregrina (Reed, 1927)

Pl. 3, figs. 9-12

1927 *Spirifer peregrinus* Reed, p. 137, pl. 13, figs. 1-9; pl. 15, fig. 12

Discussion. The present specimens are very similar to those described by Reed (1927) from western Yunnan. This species differs from *B. strangwaysi* (de Verneuil, 1845, p. 164, pl. 6, fig. 1) in its somewhat semicircular outline and bifurcated flank costae, unlike the very transverse cardinal extremities and simple costae of the latter. Specimens figured as *B. rectangula* (Kutorga) by Chao (1929, p. 60, pl. 8, fig. 3) and by Grabau (1934, p. 78, pl. 5, figs. 9, 10) from the Wangjiaba Limestone and the Maping Formation in Guizhou and Guangxi are comparable in their bifurcating costae on the flanks but has a more transverse outline than that of the western Yunnan species.

Family Elythidae Fredericks, 1924

Subfamily Toryniferinae Carter in Carter et al., 1994

Genus *Spirelytha* Fredericks, 1924

Spirelytha petaliformis

(Pavlova in Grunt & Dmitriev, 1973)

Pl. 4, figs. 4-8

1973 *Kitakamithyris petaliformis* Pavlova in Grunt & Dmitriev, p. 136, pl. 10, figs. 2-5

1993 *Spirelytha petaliformis* - Angiolini, p. 294, pl. 5, fig. 7, 8; pl. 6, figs. 1, 2

1995 *Spirelytha petaliformis* - Angiolini, p. 200, pl. 5, figs. 11-16; pl. 10, figs. 5, 6

Discussion. Externally, the present specimens are comparable with those described by Pavlova (in Grunt & Dmitriev, 1973) from the Tashkazyk Formation in Southeast Pamir and by Angiolini (1993, 1995) from the Gircha Formation in the Karakorum Range, Pakistan in terms of their prominent concentric lamellae, of which each carries a row of biramous spines about 1 per mm. *S. petaliformis* is closely similar to *S. fredericksi* Archbold & Thomas from the Callytharra Formation and the Fossil Cliff Member in Western Australia in outline, but the Australian species has a very long adminicula and relatively rare spines on lamellae.

Family Syringothyrididae Fredericks, 1926

Syringothyrididae gen. et sp. indet.

Pl. 4, figs. 15, 16

Discussion. An incomplete ventral valve (NIGP 130960) clearly indicates the presence of a species of Syringothyrididae. The valve is of average size, estimated about 55 mm in width; interarea flat and erect, more than 30 mm in height, with a prominent narrowly triangular delthyrium. Shoulders are angular. Sulcus is prominent. Costae on lateral flanks are simple, approximately three in 5 mm at middle part. Ventral interior has two prominent dental plates, short, each about 8 mm long, and clearly convergent toward the valve floor. The syrinx is unknown.

PLATE 3

Fig. 1-4 - *Elivina yunnanensis* Shi, Fang & Archbold; from Member B, FWB - 1, posterior view of a conjoined shell, NIGP130927; 2, dorsal exterior, NIGP130931; 3, ventral exterior, NIGP130929; 4, ventral exterior, NIGP130930, x1.5.

Fig. 5-8 - *Trigonotreta semicircularis* n. sp. - 5, ventral view, x1.5, NIGP130936, holotype, from Member B, DJZ; 6, dorsal view, NIGP130938, paratype, x1.5, from Member B, DJZ; 7, dorsal view, NIGP130939, paratype, from Member B, SBZ; 8, dorsal view, NIGP130937, paratype, from Member B, DJZ.

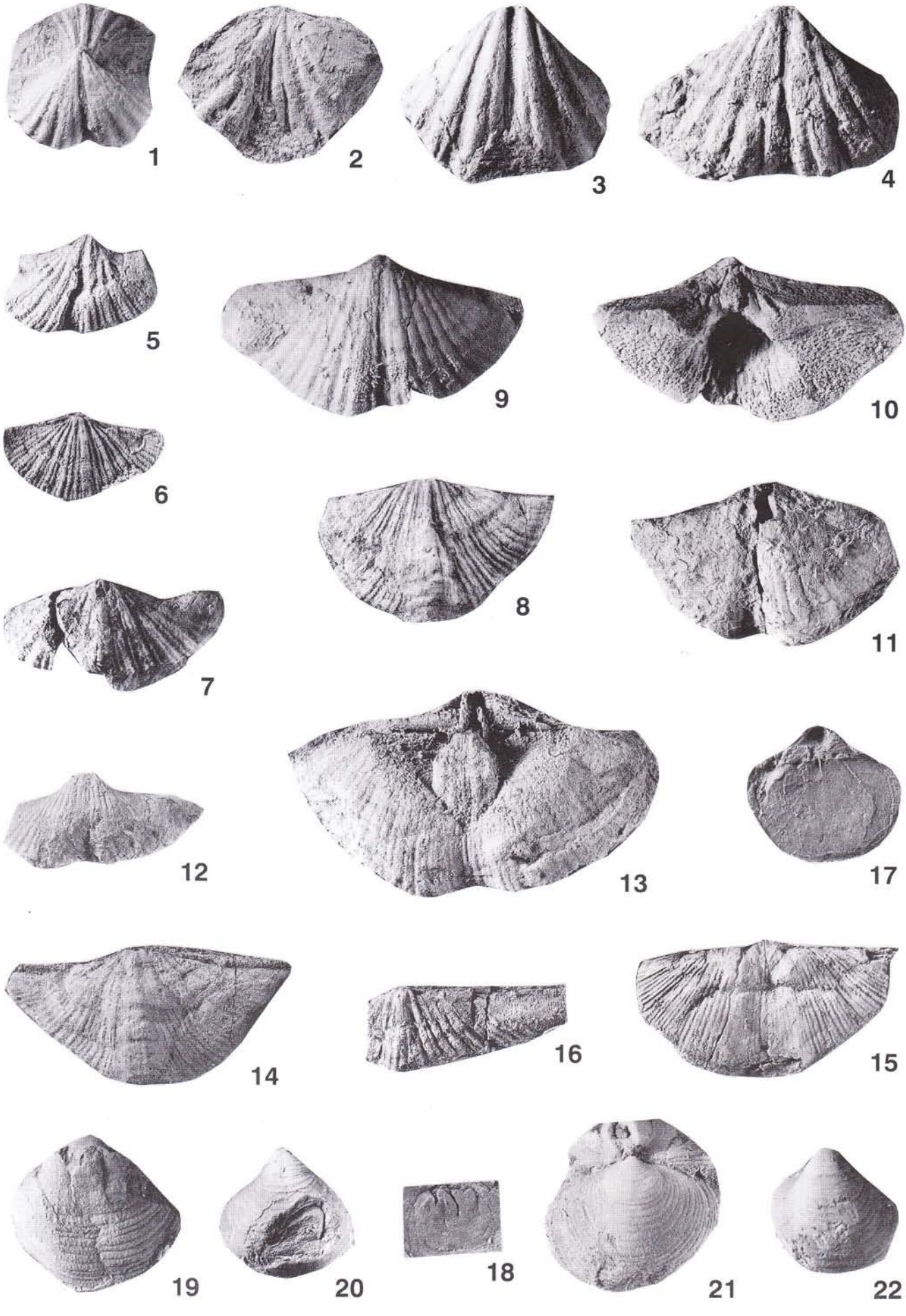
Fig. 9-12 - *Brachythyrina peregrina* (Reed) - 9, 10, ventral exterior and interior, NIGP130940, x1.5, from Member A, BMJ; 11, ventral exterior, NIGP130943, from Member A, QSG; 12, ventral exterior, NIGP130944, from Member A, XJ.

Fig. 13-15 - *Neospirifer* cf. *orientalis* (Chao) - 13, internal mould of ventral valve, NIGP130933, from Member B, DJZ; 14, dorsal exterior, NIGP130932, from Member B, DJZ; 15, ventral exterior, NIGP130934, from Member A, GPX.

Fig. 16 - *Fusispirifer* sp. - dorsal exterior, NIGP130935, from Member A, QSG.

Fig. 17, 18 - *Crurithyris* sp.; from Member A, GPX - 17, external mould of a dorsal valve, NIGP130949, x3; 18, internal mould of a dorsal valve, NIGP130950, x3.

Fig. 19-22 - *Phricodothyris* sp.; from Member B, FWB - 19, 21, ventral and dorsal exteriors, NIGP130951, x1.5, x2; 20, ventral exterior, NIGP130954, x1.5; 22, ventral exterior, NIGP130952, x1.5.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The western Yunnan specimen is likely a representative of *Syringothyris* or *Cyrtella* in terms of its high interarea and relatively short, convergent dental plates; however, its identity between Syringothyridinae and Permasyringxinae cannot be confirmed at present due to the lack of information on the syrinx, which is presumably not preserved or absent.

Species of Syringothyrididae are rare in the Lower Permian. Liu & Waterhouse (1985) reported two unidentifiable species from the possibly Sakmarian Houtoumiao Formation in Inner Mongolia. But the transverse section of the Inner Mongolian specimens reveal that it may be different from the present Yunnan specimen in its divergent dental plates (see Liu & Waterhouse, 1985, pl. 7, fig. 3). Waterhouse (1978) also tentatively assigned two specimens from the *Spiriferella rajah* Zone in the Senja Formation of northwest Nepal to *Syringothyris*. These two poorly-preserved Nepalese specimens have a more transverse outline than the present Yunnan specimen. The present specimen is possibly identical with the Himalayan shells named *S. lyddekeri* (Diener, 1903, 1915) from the Bashkirian *Fenestella* Shale of Kashmir and the Lower Permian of the Himalayas, judging from the illustrations of poorly-preserved materials by Muir-Wood & Okaley (1941) and Waterhouse (1966).

Subfamily Permasyrinxinae Waterhouse, 1986

Genus *Punctocyrtella* Plodowski, 1968

Punctocyrtella australis (Thomas, 1971)

Pl. 4, figs. 9-14; Pl. 5, figs. 1-3, 5

1971 *Cyrtella nagmargensis australis* Thomas, p. 151, pl. 11, figs. 3-6; pl. 27, fig. 2

1993 *Syringothyris* sp. Nie et al., pl. 1, figs. 16-18

Discussion. The relationship between *Cyrtella* Fredericks (1924) and *Punctocyrtella* Plodowski (1968) is still unclear. *Punctocyrtella* has been overwhelmingly considered a synonym of *Cyrtella* (Thomas, 1971; Waterhouse, 1987; Archbold & Gaetani, 1993; Angiolini, 1995), but it may be distinguishable from *Cyrtella* by very transverse outline, lower and apsacline ventral interarea instead of high and orthocline one, shorter ventral adminicula and its distinctive micro-ornament which consists of fine concentric line with dense upright spines (Plodowski, 1968; Angiolini, 1997). *Punctocyrtella australis* is characterised by its extremely transverse wedge-shaped outline, simple and moderate fold and relatively finer costae on flanks. *P.* ? *nagmargensis* (Bion, 1928; Reed, 1932) from the Agglomeratic Slate of Kashmir differs from *P. australis* in its distinctive furrow on the fold and relatively coarser flank costae. *P. koopi* (Archbold, 1990, p. 9, figs. 5A-E) from the Early Permian Cuncudgeric Sandstone (Sterlitamakian) in the southern Canning Basin has much more prominent fold and therefore more strongly uniplicate anterior commissure than *P. australis*. Several specimens described as *P. nagmargensis* by Hu (1983, p. 109) from the Early Permian Qudi Formation (Sakmarian) in Rutog, Tibet (Xizang) are probably conspecific with or closely comparable to the present species in terms of their finer flank costae. Specimens figured as *P. spinosa* Plodowski from the Lower Permian in southeastern Pamir by Grunt & Dmitriev (1973) is also closely similar to the present western Yunnan specimens, but the Pamir species is smaller, and has a more prominent fold. Another Pamir species, *P. gigantea* Grunt (1993, p. 161, figs. 1a-f), also from the Early Permian Tashkazyk Formation, differs from *P. australis* in its large size, more transverse outline and coarser costae.

Punctocyrtella? yunnanensis n. sp.

Pl. 5, figs. 4, 6-8, 10, 11

Holotype. An incomplete ventral valve (NIGP130969) (Pl. 5, figs. 4, 6).

Type-level. Member A of the Dingjiazhai Formation.

Type-locality. BMJ, Baoshan, western Yunnan.

Other material. Two incomplete worn ventral valves (NIGP130970, 130971).

Derivation nominis. After the provincial name, Yunnan.

Diagnosis. Transverse in outline; interarea relatively low and narrowly triangular; sulcus narrow, shallow and smooth; costae on flanks simple, but some bifurcating, adminicula short, slightly divergent.

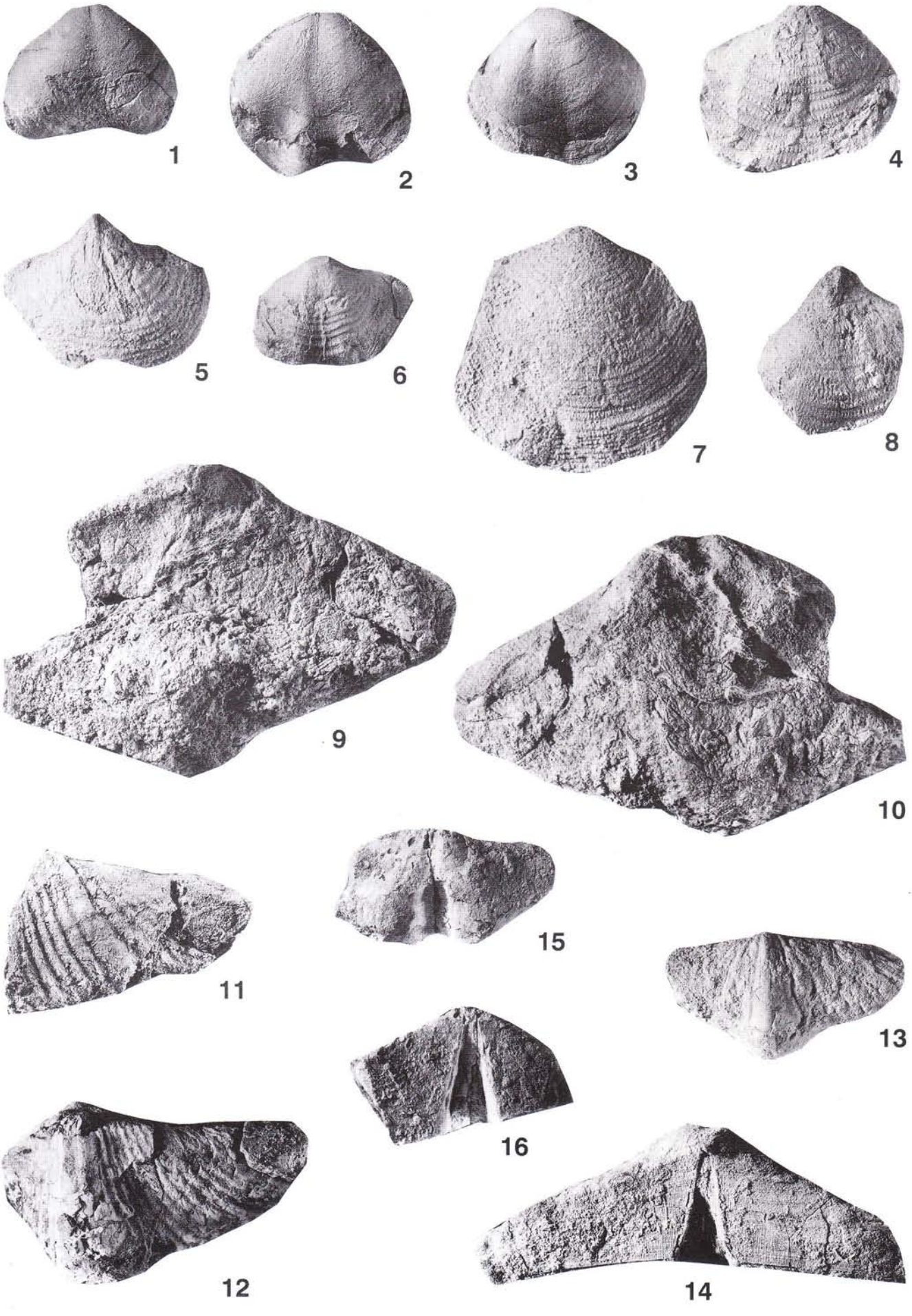
PLATE 4

Fig. 1-3 - *Martinia decora* (Phillips); from Member B, FWB - 1, ventral exterior, NIGP130946; 2, ventral exterior, NIGP130947; 3, ventral exterior, NIGP130945.

Fig. 4-8 - *Spirelytha petaliformis* (Pavlova) - 4, ventral exterior, NIGP130957, x1.5, from Member A, BMJ; 5, ventral exterior, NIGP130956, x1.5, from Member A, BMJ; 6, ventral exterior, NIGP130955, from Member B, DZM; 7, dorsal exterior, NIGP130959, x2, from Member B, FWB; 8, ventral exterior, NIGP130958, x2, from Member A, BMJ.

Fig. 9-14 - *Punctocyrtella australis* (Thomas) - 9, 10, ventral and dorsal exteriors, NIGP130961, from Member B, YNQ; 11, internal mould of a dorsal valve, NIGP130966, from Member B, DJZ; 12, dorsal exterior, showing the groove on the fold, NIGP130964, from Member B, SBZ; 13, dorsal exterior, NIGP130967, from Member B, YNQ; 14, dorsal view of an incomplete ventral valve, showing the interarea, NIGP130962, from Member B, WNS.

Fig. 15, 16 - Syringothyrididae gen. et sp. indet. - ventral and posterior views of a ventral valve, NIGP130960, from Member B, YNQ.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Description. Shell very large, more than 40 mm long and about 100 mm wide, extremely transverse in outline; greatest width probably at hinge. Ventral valve moderately convex in profile; greatest convexity slightly anterior to umbo; beak bluntly pointed and curved; interarea low, narrowly triangular, concave, with concavity increasing toward ventral beak; delthyrium triangular, open or probably partly covered by delthyrial cover on the top; beak ridges angular; sulcus originating from umbo, narrow, shallow and mostly likely smooth; flank gently declined, with about 30 relatively fine and simple costae; some costae bifurcating once; growth lamellae well developed. Ventral interior with ovate and deeply impressed muscle scar, probably with a short median ridge at the apex; dental plates strong and thick slightly convergent ventrally; adminicula mostly embedded in thickened shell, very short, slightly divergent ventrally.

Discussion. The present three ventral valves are tentatively referred to *Punctocyrtella* in terms of their transverse outline, smooth sulcus, prominent interarea and the absence of a syrinx. However, they appear to differ from all other species of *Punctocyrtella* in its relatively lower interarea, bifurcation of inner costae on flanks, and a narrower and shallower sulcus. Some species of *Brachythyrina* Fredericks are somewhat similar to this species in terms of their bifurcating costae on the flanks and relatively lower interarea, but differ in their costate sulcus and fold externally.

Family Punctospiriferidae Waterhouse, 1975

Subfamily Punctospiriferinae Waterhouse, 1975

Genus *Punctospirifer* North, 1920

Punctospirifer afghanus Termier, Termier, de Lapparent & Marin, 1974

Pl. 5, figs. 9, 12, 13

1974 *Punctospirifer afghanus* Termier et al., p. 80, pl. 6, fig. 1; pl. 16, fig. 1

1995 *Punctospirifer afghanus* - Angiolini, p. 194, pl. 5, figs. 4-6, 10

Discussion. The present specimens are presumably punctate. The transverse and triangular outline, a few subangular plications on flanks, and gently convex profile of the present specimens suggest *Punctospirifer*. These specimens are very similar in outline, size and plications to those described by Termier et al. (1974) from Afghanistan and by Angiolini (1995) from Karakorum. *Spiriferellina* sp. of Fang (1994) from the middle part of the Dingjiazhai Formation appear to differ in having more plications on its flanks.

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PLATE 5

Fig. 1-3, 5 - *Punctocyrtella australis* (Thomas) - 1, 2, dorsal and ventral views of a ventral valve, NIGP130963, from Member B, WNS; 3, dorsal exterior, NIGP130968, from Member B, SBZ; 5, dorsal exterior, NIGP130965, from Member B, SBZ.

Fig. 4, 6-8, 10, 11- *Punctocyrtella ? yunnanensis* n. sp.; from Member A, BMJ - 4, 6, ventral exterior and interior, NIGP130969; 7, 8, ventral exterior and interior, NIGP130970; 10, 11, ventral exterior and interior, NIGP130971.

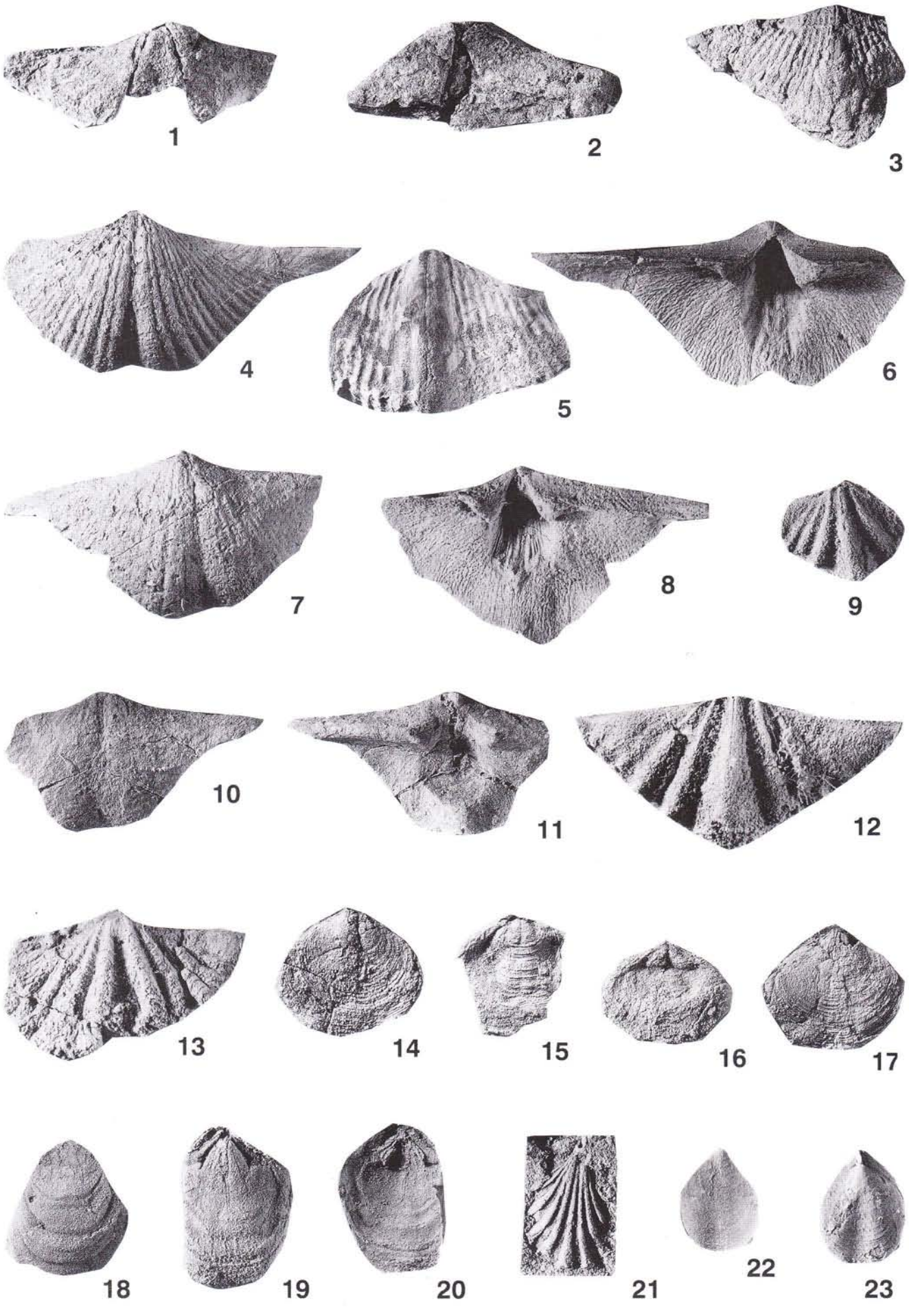
Fig. 9, 12, 13 - *Punctospirifer afghanus* Termier, Termier, de Lapparenti &.Martin; from Member B, DJZ - 9, internal mould of a dorsal valve, NIGP130974, x1.5; 12, internal mould of a dorsal valve, NIGP130973, x1.5; 13, ventral exterior, NIGP130972, x1.5.

Fig. 14-17 - *Cleiothyridina laminosa* Fang; from Member C, DSP - 14, ventral exterior, NIGP130977, (x1.5; 15, dorsal exterior, NIGP130980, x1.5; 16, dorsal exterior, NIGP130979, x1.5,; 17, ventral exterior, NIGP130978, x1.5.

Fig. 18-20 - *Dielasma* ? sp.; from Member B, DJZ - 18, ventral interior, NIGP130987; 19, dorsal interior, showing the socket ridges, NIGP130986; 20, latex of the specimen NIGP130986.

Fig. 21 - *Hustedia* sp. - internal mould of a dorsal valve, NIGP130982, (x3, from Member C, DJZ.

Fig. 22 -23 - *Dielasma* ? cf. *glabrum* Tong - ventral and dorsal exterior, NIGP130983, (x3, from Member A, QSG.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