Middle Cambrian lingulate brachiopods from the Tarbagatay Range, Kazakhstan

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Early Middle Cambrian (Amgian) lingulate brachiopods from the Tarbagatay Range in eastern Kazakhstan represent mostly endemic taxa, which may suggest that the Tarbagatay Range was relatively isolated from adjacent terranes during that time; only *Kleithriatreta* indicate similarity with the Australian part of Gondwana, as well as with the south and central Kazakhstanian terranes. Late Middle Cambrian (Mayan) taxa from the same area are mostly cosmopolitan. *Kostjubella relaxata* gen. et sp. n., *Prototreta* (?) *dolosa* sp. n. and *Stilpnotreta galinae* sp. n. are proposed.

Key words: Brachiopoda, Acrotretida, Middle Cambrian, taxonomy, Kazakhstan.

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Introduction

Middle Cambrian lingulate brachiopod faunas have been described from most continents (e.g., Henderson & MacKinnon 1981; Ushatinskaya 1994; Koneva 1986; Zell & Rowell 1988; Popov 1985). Nevertheless, published descriptions of Middle Cambrian lingulates from Kazakhstan have been restricted mostly to its southern boundary, the Malyi Karatau Range (Koneva 1986). The first record of fossiliferous Cambrian strata in the western Tarbagatay Range was published by Sevrjugin (1974), who gave a list of trilobites (identified by N.K. Ivshin, Institute of Geological Sciences, Alma-Ata) and some brachiopods. However, this short note was not fol-

lowed by any extensive study of the fauna and knowledge of Cambrian palaeontology of the Tarbagatay Range has remained inadequate. The present paper provides the first description of the lingulate brachiopod faunas from the Tarbagatay Range.

Geological setting and localities

The brachiopods studied are from the north and northwest of Mountain Kostjube, western Tarbagatay Range (Fig. 1). In the Chingiz and Tarbagatay ranges, the Middle and Late Cambrian deposits are exposed within a narrow belt, about 300 km long and 30–50 km wide, which is usually referred to as the Ordatas tectonic subzone (Zvontsov & Frid 1991). The rocks within the unit are strongly dislocated and consist mostly of basalts, andesitic volcanic rocks and tuffs, volcanic mass flow deposits, as well as volcanomictic sandstones and cherts. The Ordatas tectonic subzone most likely represents an early Palaeozoic composite subduction complex and suture, presumably of late Ordovician age; it separates the south-western and north-eastern subunits of the Yermentau-Chingiz-Tarbagatay tectonofacies unit of Šengör *et al.* (1993).

In the Tarbagatay Range, the fossiliferous Cambrian strata are exposed in two blocks with faulted contacts (Fig. 2; see Sevrjugin 1974 for details). The stratigraphic terminology of the Cambrian in the area varies considerably; it was revised recently by Zvontsov & Frid (1991), but the Middle Cambrian strata north of the Mountain Kostjube were not considered in their paper; the lithostratigraphic subdivisions established by Zvontsov & Frid (1991) have proved to be difficult to use in that region.

The Middle Cambrian brachiopods studied were etched from the following two samples from two localities (collected by Sevrjugin during 1964–1965):

(1) A lens-like limestone interlayer, about 0.5–1 m thick (sample 1080-U; Figs 1–2), from an outcrop about 1 km north of Mountain Kostjube ('Unit 7' in the description of Sevrjugin 1974: pp. 18–19); it occurs in the lower part of a volcanic sequence, about 780 m thick, consisting mostly of basalts and tuffs, with several thin interlayers of volcanomictic sandstones and jasper.

The lingulate assemblage from this sample is associated with the trilobites *Chondragraulops minussensis* Lermontova, 1940, *Kootenia* ex gr. *gaspensis* Rasetti, 1948, *K. minima* Ivshin, 1957 and *Erbia* cf. *sibirica* (Schmidt, 1886). According to Ivshin (in Sevrjugin 1974), the assemblage is of early Middle Cambrian (Amgian) age. A similar limestone lens, about 250 m east-south-east (sample 315; Fig. 2) contains *Chancelloria* sp., *Stenothecoides obliquus* Koneva, 1979, and the gastropods *Helcionella* sp. and *Pelagiella* sp. (Koneva 1979).

(2) A second brachiopod-bearing limestone lens (sample 308-B), also from within a volcanic sequence, consisting mainly of basalts, was col-

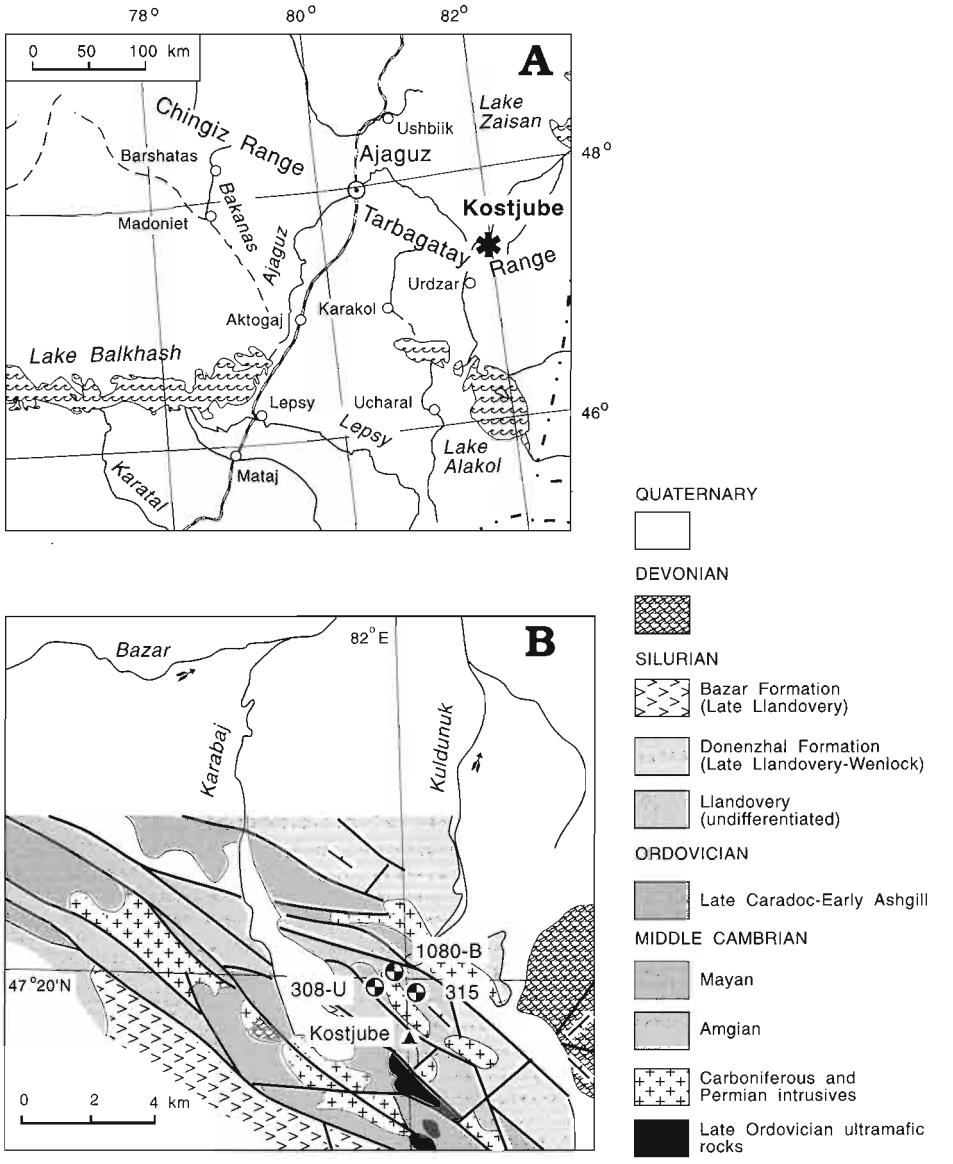


Fig. 1. **A**. Map of eastern Central Kazakhstan showing the position of Mountain Kostjube in Tarbagatay Range. **B**. Geological map showing distribution of the Palaeozoic deposits in Tarbagatay Range and the position of the Middle Cambrian localities and samples on the northern and north-eastern slope of Mountain Kostjube (after Sevrjugin 1974, modified).

lected from a section about 650 m south-west of the first locality (Figs 1–2). The lingulates are associated with the trilobites *Corynexochus* sp. and *Solenopleura* sp. and some new taxa, which are characteristic of the late Middle Cambrian (Mayan) strata in Kazakhstan (Ivshin in Sevrjugin 1974: p. 220).

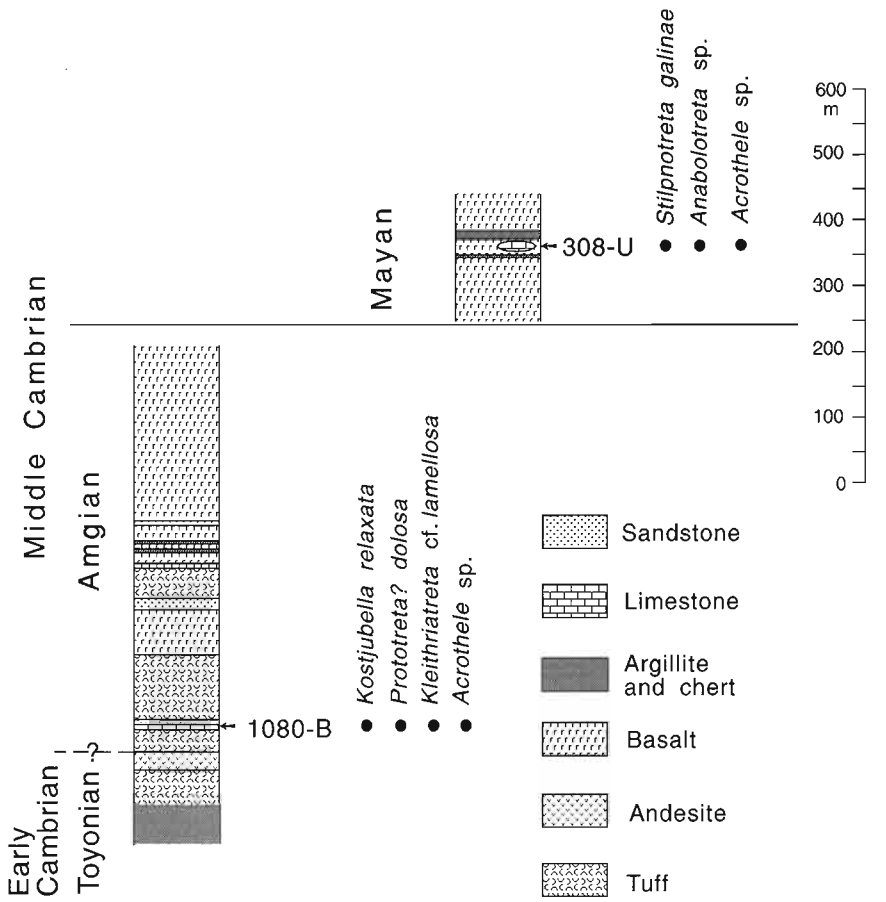


Fig. 2. Stratigraphic columns (after Sevrjugin 1974, modified) showing position of samples and distribution of taxa.

Brachiopod faunal affinities

With the exception of the cosmopolitan *Acrothele*, most of the Amgian lingulates (sample 1080-U) from the Tarbagatay Range do not occur in contemporaneous brachiopod faunas from adjacent areas. Thus *Kleithriatreta*, *Kostjubella*, *Neotreta* (?), and *Prototreta* (?) are not known from the Amgian of either Siberia (Pelman 1977, 1983; Pelman & Pereladov 1986) or the Malyi Karatau Range (Koneva 1986, 1990; *Prototreta* described by Koneva 1990 is a true member of this genus and clearly differs from *Prototreta* (?) from Tarbagatay). *Kleithriatreta lamellosa* Roberts, 1990 was described originally from the early Middle Cambrian (Ordian) of New South Wales, Australia (Roberts & Jell 1990). A new species of *Kleithriatreta* was discovered recently in the late Early Cambrian of Sarytuma, southern

Central Kazakhstan (Popov & Holmer, unpublished) and yet another undescribed new species of the same genus, occurs together with *Neotreta kargailensis* Popov, Berg-Madsen & Holmer, 1994 in the Middle Cambrian of the northern Tien-Shan Range (Popov *et al.* 1994).

The late Middle Cambrian (Mayan) sample (308-B) includes only *Acrothele* sp., *Anabolotreta* sp. and *Stilpnotreta galinae* sp. n. All these taxa belong to late Middle and early Late Cambrian cosmopolitan genera. In particular, *Anabolotreta* and *Stilpnotreta* are known from Antarctica (Rowell *et al.* 1984), Australia and New Zealand (Henderson & MacKinnon 1981), northern Siberia (Ushatinskaya 1994), and the Malyi Karatau Range in Kazakhstan (Koneva 1986). *Stilpnotreta* is also known from Antarctica (Rowell *et al.* 1984) and Baltoscandia (Puura & Holmer 1993). *Stilpnotreta galinae* sp. n. was described originally from the Middle Cambrian Kyzylkojandy Formation of northeastern Central Kazakhstan under the name *Neotreta pusilla* Ushatinskaya, 1986 (non *Neotreta pusilla* Koneva, 1986), where it occurs together with diverse late Middle Cambrian (Mayan) lingulate brachiopod and trilobite faunas (Esenov & Shlygin 1971; Ushatinskaya *et al.* 1986). *Anabolotreta* has also been reported from Greenland (Zell & Rowell 1988) and Novaja Zemlja (Popov 1985).

The large number of endemic Amgian taxa may suggest that the Tarbagatay Range was relatively isolated from the adjacent Baltic and Angaran (Siberian) plates during the early Middle Cambrian; however, the distribution of *Kleithriatreta* may indicate that there were some palaeogeographic connections between the faunas of the Tarbagatay Range and the Australian part of Gondwana, as well as with the south and central Kazakhstanian terranes during the early Middle Cambrian. In contrast, the Late Cambrian and Early Ordovician brachiopod faunas of northeastern Central Kazakhstan, probably originating from the northern prolongation of the same composite subduction complex between the northeastern and south-western segments of the Yermentau-Chingiz-Tarbagatay tectonofacies zone (Šengör *et al.* 1993), clearly demonstrate affinities with faunas of the Baltica region (Popov & Holmer 1994).

Systematic palaeontology

Abbreviations: L – sagittal length, W – maximum width, T – height, Il – length of pseudointerarea, Iw – width of pseudointerarea, Pw – width of dorsal median groove, Cl – length of dorsal cardinal muscle field, Cw – width of dorsal cardinal muscle field, Sa – length of median ridge or septum, Sm – distance from umbo to point of maximum height of median septum, X – mean, S – standard deviation from mean, N – number of specimens, min – minimum observed size, max – maximum observed size.

All figured and cited specimens are housed in the Palaeontological Museum, University of Uppsala (PMKz).

Class Lingulata Gorjansky & Popov, 1985
Order Lingulida Waagen, 1885
Superfamily Acrotheloidea Walcott & Schuchert, 1908
[*nom. correct.* Holmer *et al.* 1996 (*pro* Acrothelacea *nom. transl.* Ushatinskaya 1994: p. 41, *ex.* Acrothelinae Walcott & Schuchert, 1908)].

Discussion. — Ushatinskaya (1994, 1995), Holmer *et al.* (1996), and Holmer & Popov (in press) recently provided a discussion on the affinity of Acrotheloidea. They regarded Acrotheloidea as separate superfamily within the order Lingulida.

Family Acrothelidae Walcott & Schuchert, 1908
Subfamily Acrothelinae Walcott & Schuchert, 1908
Genus *Acrothele* Linnarsson, 1876

Acrothele sp.

Fig. 3M–N.

Remarks. — Two fragmentary ventral valves have an elongate oval foramen posterior to the umbo. Internally, the umbonal area is slightly thickened, but lacks an internal pedicle tube. A single juvenile dorsal valve has two long posterior spines on the larval shell and an anterior pair of tubercles. These features are diagnostic for *Acrothele* (see Rowell 1980), but the available specimens are poorly preserved and therefore left under open specific nomenclature.

Material. — Figured ventral valve: PMKz31; dorsal valve: PMKz32. Total of 2 ventral and 1 dorsal valves.

Occurrence. — Amgian (sample 1080-B); Mayan (sample 308-U); Mountain Kostjube, Tarbagatay Range, Kazakhstan.

Order Acrotretida Kuhn, 1949

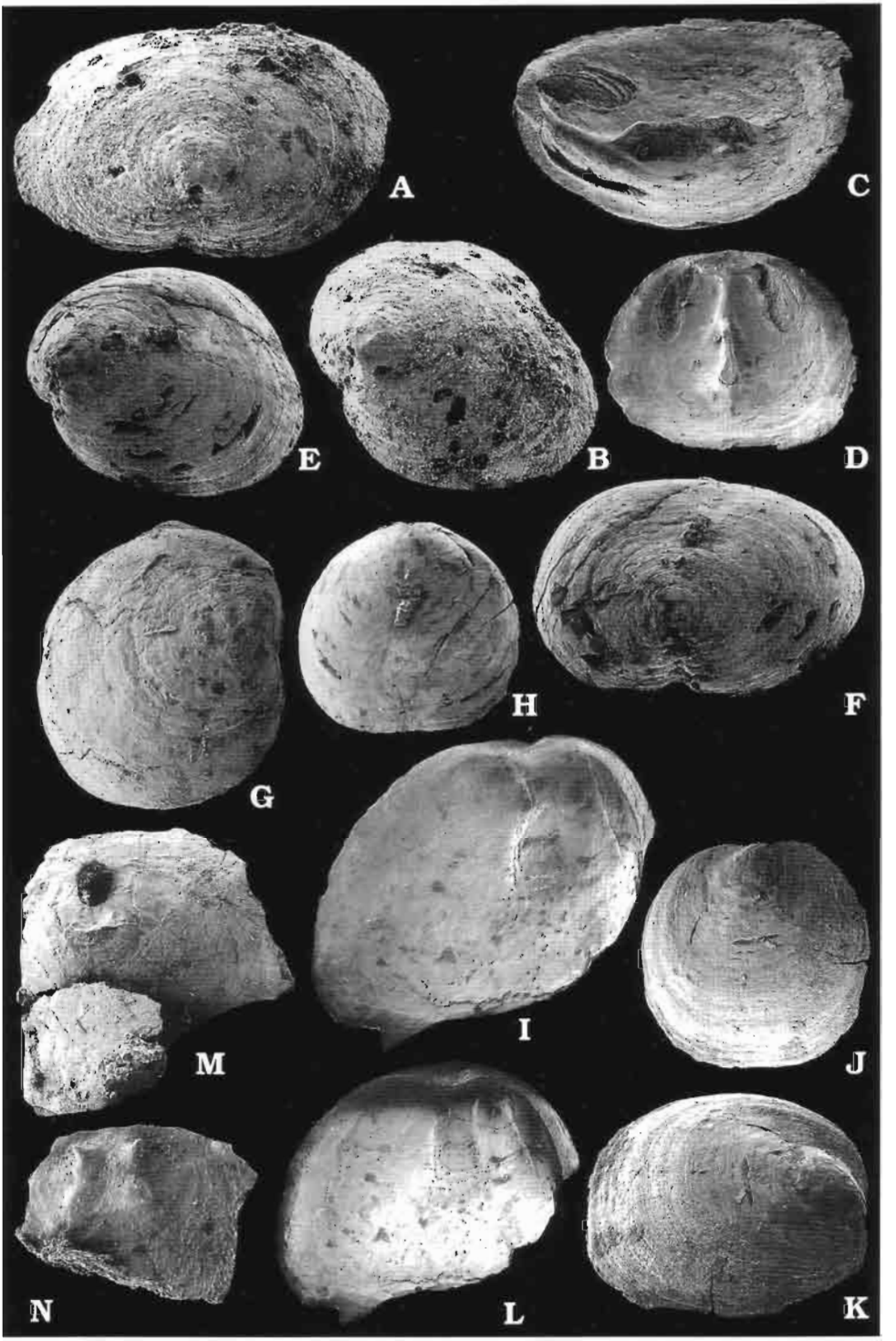
Remarks. — The order Acrotretida is here used in the restricted sense to include only the superfamily Acrotretoidea, as proposed by Holmer & Popov (1996).

Superfamily Acrotretoidea Schuchert, 1893
Family Acrotretidae Schuchert, 1893
Genus *Anabolotreta* Rowell & Henderson, 1978

Anabolotreta sp.

Fig. 7L, M.

Fig. 3. **A–L**. *Kostjubella relaxata* gen. et sp. n. **A, B**. Juvenile ventral valve PMKz60 in oblique posterior view (A, × 52.5) and oblique lateral view (B, × 46.5). **C, D**. Holotype PMKz61 in oblique lateral view of dorsal interior (C, × 40) and dorsal interior (D, × 25). **E, F, H**. Ventral valve PMKz62 in oblique lateral view (E, × 34), oblique posterior view (F, × 40) and exterior (H, × 26). **G**. Ventral valve PMKz63 in oblique lateral view; × 37. I. Ventral valve PMKz64, interior; × 45. **J, K**. Dorsal valve MKz65, exterior (J, × 25), oblique lateral view (K, × 31). **L**. Ventral valve PMKz91, interior; × 35. **M, N**. *Acrothele* sp. ventral valve PMKz66, exterior (M, × 19.5) and dorsal valve PMKz67 (N, × 40). All specimens from sample 1080-B (Amgian), northern slope of Mountain Kostjube, Tarbagatay Range, Kazakhstan.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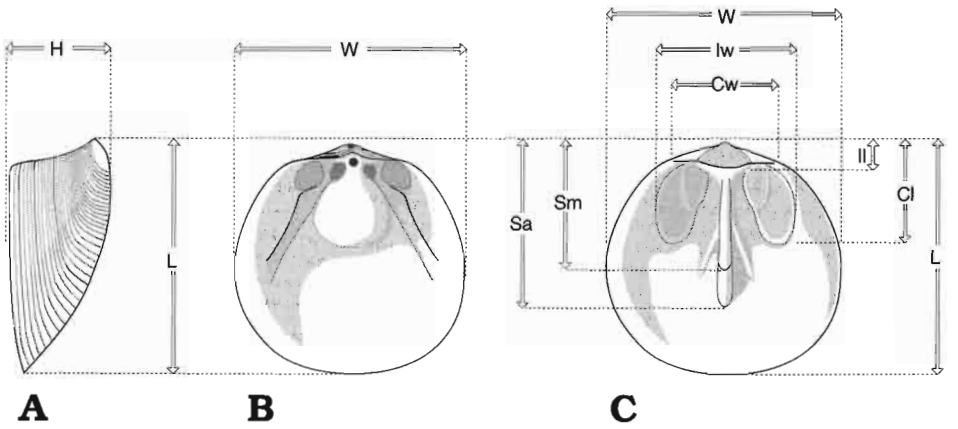


Fig. 4. *Kostjubella relaxata* gen. et sp. n., schematic drawings showing locations of measurements; ventral valve lateral view (**A**), ventral valve interior (**B**), dorsal valve interior (**C**).

Remarks. — The single ventral valve recovered is gently convex, transversely suboval in outline, and about 87% as long as wide and 26% as high as long. The pseudointerarea is relatively narrow, procline, and poorly differentiated from the lateral sides; it is divided by an intertrough. The pedicle foramen is small, subcircular, and not enclosed within the larval shell. The interior has a boss-like apical process directly anterior to the internal foramen. The shell is ornamented by numerous, regularly spaced growth lamellae and fine concentric fila. The valve cannot be assigned to any described species, but it is very similar to *A. tegula* Rowell & Henderson, 1978 in most characters.

Material. — Figured ventral valve: PMKz33 (L = 0.92, W = 10.6, T = 0.24).

Occurrence. — Mayan (sample 308-U); Mountain Kostjube, Tarbagatay Range, Kazakhstan.

Genus *Kostjubella* gen. n.

Type species: *Kostjubella relaxata* sp. n.

Derivation of name: After the Mountain Kostjube, near the type locality.

Diagnosis. — Shell ventribiconvex; ventral valve strongly convex in lateral profile with maximum height anterior to umbo; ventral pseudointerarea narrow, divided by deep intertrough; pedicle foramen small, elongate suboval, not enclosed within larval shell; dorsal valve gently convex with shallow sulcus; dorsal pseudointerarea low, with lens-like median groove; ventral interior with boss-like apical process, anterior to short internal pedicle tube; ventral mantle canals baculate; dorsal median ridge strong, subtriangular, buttressed posteriorly,

Discussion. — *Kostjubella* is similar to *Canthylotreta* Rowell, 1966 in most characters; however, *Kostjubella* differs in having a pedicle foramen that is not enclosed within the larval shell and a strong, subtriangular median ridge instead of a triangular median septum. *Hadrotreta* Rowell, 1966 also has a pedicle foramen that is not enclosed within the larval shell, as well

as a dorsal sulcus and median ridge, but can be distinguished from *Kostjubella* by the shape of the conical ventral valve, which has its maximum height at the umbo, and the apical process, which fills the entire apex; moreover, *Hadrotreta* lacks a subtriangular median ridge. The ventral valve of *Kostjubella* is similar to *Vandalotreta* (Mergl, 1988); however, it differs in having a dorsal sulcus and subtriangular median ridge.

Kostjubella relaxata gen. et sp. n.

Figs 3A–L, 4; Tables 1–2.

Holotype: PMKz61, dorsal valve (L = 1.26, W = 1.44, Il = 0.12, Iw = 0.64, Cl = 0.44, Cw = 0.84, Sa = 0.88).

Type locality: Mountain Kostjube, Tarbagatay Range, Kazakhstan.

Type horizon: Amgian (sample 1080-B).

Derivation of name: Latin *relaxatus* — loose, slack.

Table 1. *Kostjubella relaxata* sp. n., average dimensions of ventral valves.

	L	W	T	L/W	T/W
N	5	5	5	5	5
X	1.17	1.21	0.49	97%	42%
S	0.122	0.044	0.047	13.2	8.2
Min	1.02	1.16	0.42	92%	32%
Max	1.30	1.26	0.52	110%	51%

Table 2. *Kostjubella relaxata* sp. n., average dimensions of dorsal valves.

	L	W	Il	Iw	Pw	Sa	Sp	Cl	Cw
N	5	4	5	5	5	5	4	5	5
X	1.22	1.38	0.10	0.61	0.31	0.87	0.30	0.48	0.82
S	0.117	0.079	0.022	0.086	0.046	0.087	0.032	0.046	0.087
Min	1.02	1.16	0.08	0.46	0.24	0.72	0.26	0.42	0.72
Max	1.30	1.26	0.12	0.68	0.36	0.94	0.34	0.52	0.92

	L/W	Iw/W	Pw/W	Sa/L	Sp/L
N	5	4	5	5	5
X	88%	43%	51%	71%	35%
S	5.7	5.0	4.2	1.1	2.9
Min	81%	37%	47%	70%	32%
Max	93%	49%	58%	72%	39%

Material. — Figured ventral valves: PMKz60, PMKz62 (L = 1.12, W = 1.22, T = 0.52), PMKz63, PMKz64, PMKz91; dorsal valve PMKz65 (L = 1.30, W = 1.40, Ii = 0.08, Iw = 0.62, Cl = 0.48, Cw = 0.74, Sa = 0.94). Total 8 ventral and 6 dorsal valves.

Diagnosis. — As for genus.

Description. — Shell ventribiconvex, subcircular in outline. Ventral valve on average 97% as long as wide and 42% as high as long; moderately convex in transverse profile with maximum height somewhat anterior to umbo; ventral pseudointerarea narrow, catacline to slightly apsacline,

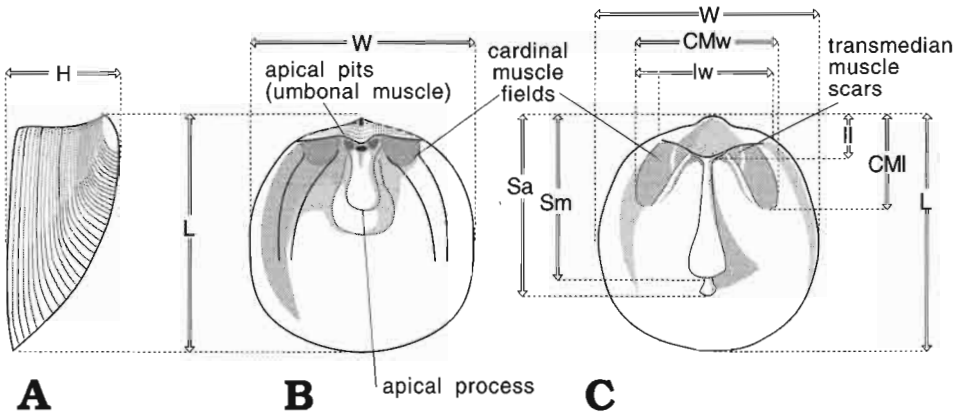


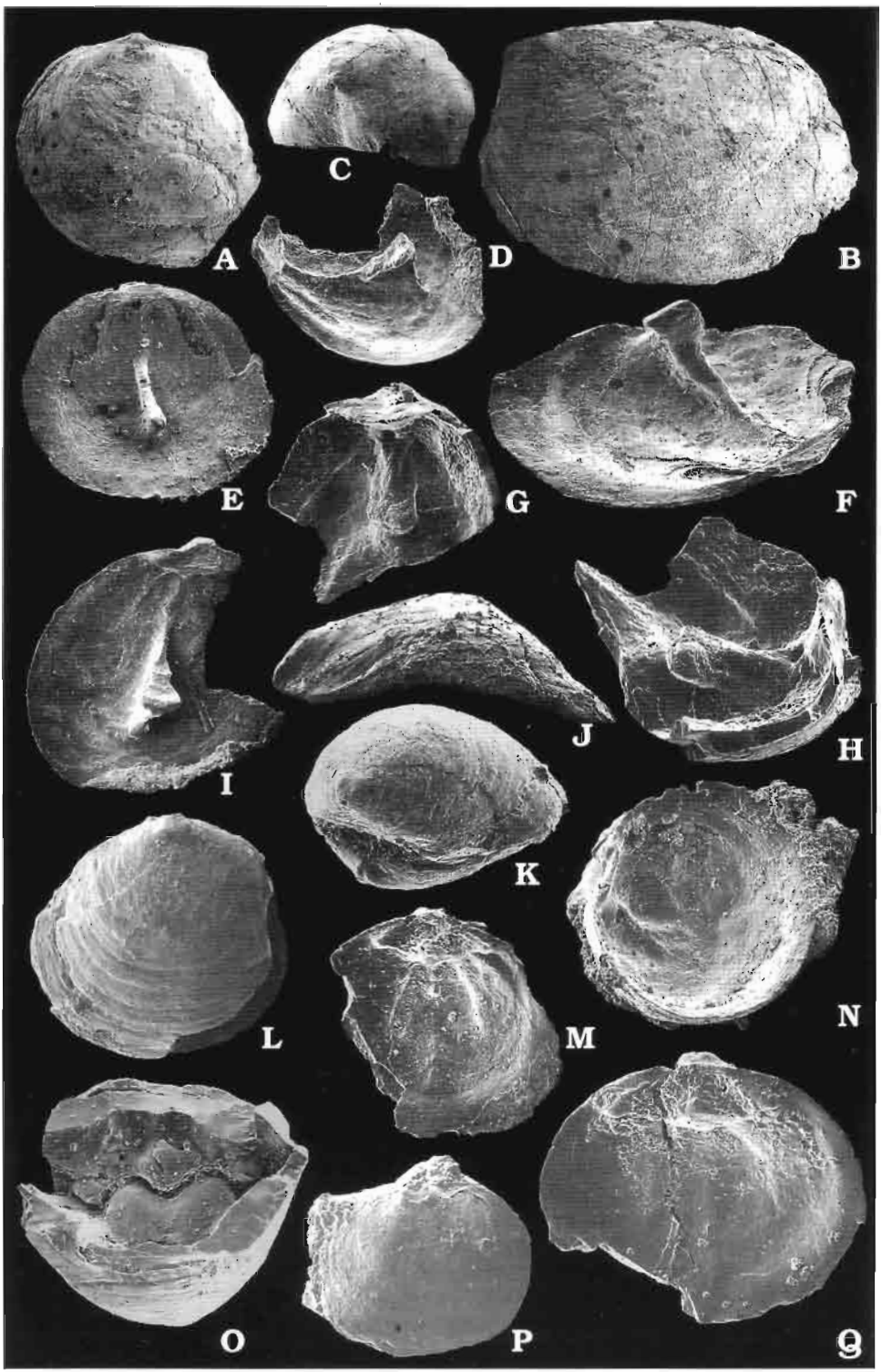
Fig. 5. *Prototreta* (?) *dolosa* sp. n., schematic drawings showing locations of measurements; ventral valve lateral view (**A**), ventral valve interior (**B**), dorsal valve interior (**C**).

with deep intertrough; pedicle foramen small, elongate suboval, not enclosed within larval shell. Dorsal valve gently convex, on average 88% as long as wide, weakly sulcate anteriorly; dorsal pseudointerarea low, somewhat anacline, occupying on average 43% of maximum valve width; median groove shallow, lens-like, occupying on average 51% as wide as pseudointerarea. Larval shell finely pitted, postlarval shell ornamented by fine fila and weak, regularly spaced growth lamellae.

Ventral interior with boss-like, subtriangular apical process, anterior to short internal pedicle tube; apical pits moderately deep, directly lateral to internal pedicle tube; mantle canals baculate. Dorsal median septum low, triangular, occupying on average 71% of valve length; dorsal cardinal muscle scars elongate suboval, excavated medially; scars bordered by elevated rim and extended forward about 2/5 of valve length.

Discussion. — *Kostjubella relaxata* sp. n. is somewhat similar in the morphology of its dorsal valve to some of the Early to Middle Cambrian acrotretids assigned by Pelman (1977) to *Homotreta* Bell, 1941 (e.g., *H. salankensis* and *H. gorjanskii*); however, *K. relaxata* differs markedly in the internal and external morphology of the ventral valve ventral and in the

Fig. 6. **A–J**. *Prototreta* (?) *dolosa* sp. n. **A, B**. Ventral valve PMKz76, exterior (A, × 26) and lateral view (B, × 39). **C**. Ventral valve PMKz77, oblique posterior view showing pseudointerarea and intertrough; × 23. **D**. Dorsal valve PMKz78, interior, oblique lateral view; × 39. **E**. Interior of juvenile dorsal valve PMKz79; × 18. **F**. Dorsal valve PMKz80, interior, oblique lateral view; × 45. **G, H**. Ventral valve PMKz81, interior (G, × 26) and oblique lateral view of ventral interior showing muscle platform on the apical process (H, × 34). **I**. Holotype PMKz82, dorsal valve interior; × 25. **J**. Dorsal valve PMKz83, exterior, lateral view; × 38. **K–Q**. *Stilpnotreta galinae* sp. n. **K, L**. Conjoined valves PMKz84 oblique posterior view (K, × 37), ventral view (L, × 37). **M**. Dorsal valve PMKz85, interior; × 34. **N**. Ventral valve PMKz86, interior, oblique lateral view; × 45. **O**. Interior of the posterior margin of conjoined valves PMKz87 showing 'articulation'; × 51. **P**. Dorsal valve PMKz88, exterior; × 37. **Q**. Dorsal valve PMKz90, interior; × 47.5. All specimens from sample 308-B (Mayan), northern slope of Mountain Kostjube, Tarbagatay Range, Kazakhstan.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development of the dorsal median septum. The generic assignment of the Siberian species remain uncertain; the type species of *Homotreta*, *H. interrupta*, is inadequately known (see further below), but according to Rowell (1965) it can be regarded as a junior synonym to *Prototreta* Bell, 1941.

Occurrence. — Type locality only.

Genus *Neotreta* Sobolev, 1976

Neotreta (?) sp.

Fig. 7A.

Material. — Figured dorsal valve: PMKz68.

Remarks. — This single dorsal valve is provisionally referred to *Neotreta* because it has a wide, straight posterior margin and a wide, high, but very rudimentary pseudointerarea. The shell is ornamented with very fine, closely spaced rugellae. It is somewhat similar to *Neotreta kargailensis* (Popov *et al.*, 1993) in the morphology of the dorsal pseudointerarea, but it cannot be compared in detail.

Occurrence. — Amgian (sample 1080-B); Mountain Kostjube, Tarbagatay Range, Kazakhstan.

Genus *Stilpnotreta* Henderson & MacKinnon, 1981

Type species: *Stilpnotreta magna* Henderson & MacKinnon, 1981.

Diagnosis. — See Henderson & MacKinnon (1981: p. 297).

Species assigned. — *S. magna* Henderson & MacKinnon, 1981 from the late Middle to early Late Cambrian of New South Wales, Australia and New Zealand; *S.* cf. *magna* Henderson & MacKinnon, 1981 (Rowell *et al.* 1984) from the Late Cambrian of West Antarctica; *S. tecta* Koneva, 1990 from the Amgian of Malyi Karatau Range, Kazakhstan; *S. inaequalis* Ushatinskaya, 1994 from the Late Cambrian (*Glyptagnostus stolidotus* Biozone) of north-central Siberia; *Stilpnotreta galinae* sp. n. [= *Neotreta* (?) *pusilla* Ushatinskaya (in Ushatinskaya *et al.* 1986)] from the Mayan of north-eastern Central Kazakhstan; *Stilpnotreta* ? sp. (Puura & Holmer 1993) from the Late Cambrian 'Obolus-beds' of Sweden.

Stilpnotreta galinae sp. n.

Fig. 6K–Q; Table 3.

Neotreta (?) *pusilla* sp. nov.; Ushatinskaya (in Ushatinskaya *et al.* 1986: p. 37, pl. 4: 1–10) non *Neotreta pusilla* sp. nov., Koneva, 1986: p. 202.

Holotype: PMKz84, complete shell (L = 1.06, Ld = 1.00, W = 1.08, T = 0.72).

Type locality: Mountain Kostjube, Tarbagatay Range, Kazakhstan.

Type horizon: Mayan (sample 308-U).

Derivation of name: In honor of Galina T. Ushatinskaya.

Material. — Figured complete shells: PMKz87, PMKz88 L = 0.76, Ld = 0.72, W = 0.90, T = 0.56); dorsal valves: PMKz85 (L = 0.96, Il = 0.22, Iw = 0.72, Cl = 0.52, Cw = 0.76, Sa = 0.76), PMKz89 (L = 0.76, W = 0.90, Il = 0.14, Iw = 0.50, Cl = 0.34, Cw = 0.62, Sa = 0.62); ventral valve: PMKz86. Total of 3 complete shells, 18 ventral and 3 dorsal valves.

Table 3. *Stilpnotreta galinae* sp. n., average dimensions of ventral valves.

	L	W	T	L/W	T/L
N	9	9	9	9	9
X	0.81	0.86	0.43	94%	51%
S	0.152	0.137	0.131	9.5	7.4
Min	0.60	0.58	0.28	77%	80%
Max	1.06	1.08	0.72	104%	93%

Diagnosis. — Shell ventribiconvex, subcircular; ventral valve strongly convex with maximum height anterior to umbo; pseudointerarea apsacline, with pair of tooth-like projections at center; dorsal valve moderately and evenly convex; dorsal pseudointerarea consisting mainly of concave median groove with prominent central tubercle; ventral interior with low, broadly triangular apical process almost occluding apex and extending anteriorly to internal foramen; dorsal interior with vestigial median ridge.

Description. — Shell thick, ventribiconvex, subcircular in outline; ventral valve strongly convex, on average 43% as high as long, with maximum height somewhat anterior to umbo; ventral pseudointerarea apsacline, provided with pair of prominent, tooth-like projections along posterior margin. Dorsal valve moderately and evenly convex; dorsal pseudointerarea occupying about 20% of total valve length and about 56% of valve width, with broad, concave median groove occupying about 64% of total width of pseudointerarea, and divided by high, thick median projection, fitting tightly into depressions between projections in ventral valve.

Ventral interior with low, broadly triangular apical process, almost occluding apex and extending to pedicle foramen; dorsal interior with small, rounded cardinal muscle fields; dorsal median ridge vestigial, extending anterior to mid-valve.

Discussion. — Our specimens are more or less identical in all main morphological characters with the types of *Neotreta pusilla* Ushatinskaya, 1986 from north-eastern Central Kazakhstan. The weak dorsal median ridge and the prominent projections from the pseudointerareas were not recorded by Ushatinskaya *et al.* (1986); however, the original description was based on a limited number of specimens and a dorsal valve illustrated by Ushatinskaya *et al.* (1986: pl. 4: 10) seems to show the median projection. *N. pusilla* differs from all other species of *Neotreta* (see Popov *et al.* 1994) in having a relatively short, rounded posterior margin and well-defined ventral pseudointerarea, which is divided by an intertrough. These features suggest that it is better referred to *Stilpnotreta*, which also shows the prominent projections from the pseudointerareas (Henderson & MacKinnon 1981: fig. 8). It is also important to note that *Neotreta pusilla* of Koneva 1986 is not congeneric with the species described by Ushatinskaya (1986) under the same name (Popov *et al.* 1994), and therefore the name of the species introduced by Ushatinskaya represent a primary senior homonym of *Neotreta pusilla* Koneva and needs to be replaced.

Thus, the new species *Stilpnotreta galinae* (= *Neotreta pusilla* Ushatinskaya) is proposed here, based on the much better preserved material from the Tarbagatay Range.

Stilpnotreta galinae differs from all other species of this genus in having a relatively large shell with more strongly thickened valves, with larger and thicker median projections from the pseudointerareas.

Occurrence. — Mayan (sample 308-U); Mountain Kostjube, Tarbagatay Range, Kazakhstan. Kyzylkojandy Formation, north-eastern Central Kazakhstan.

Genus *Prototreta* Bell, 1938

Type species: *Prototreta trapeza* Bell, 1938.

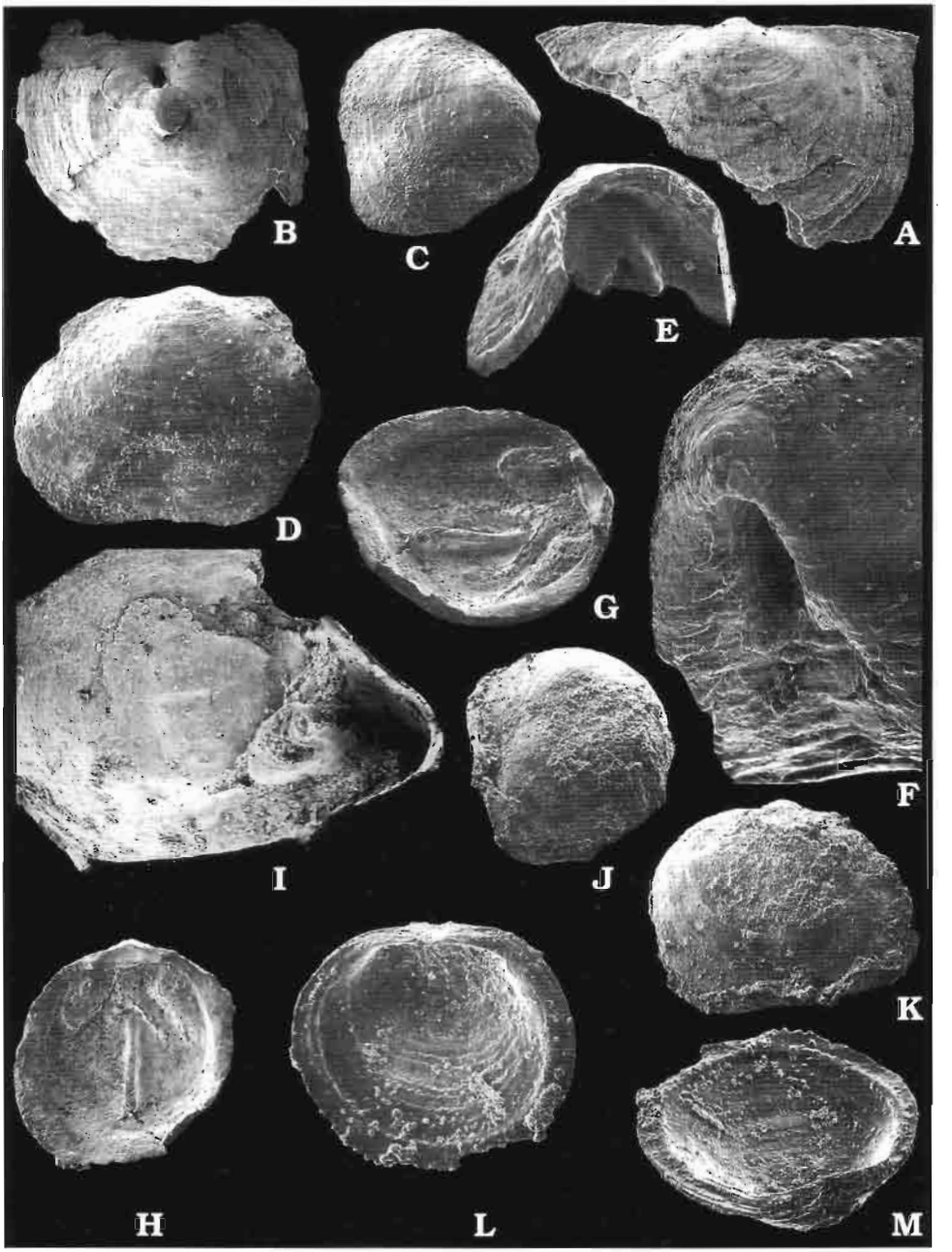
Emended diagnosis. — Shell subcircular to transversely oval with weakly convex posterior margin; ornament of fine rugae; ventral valve conical to highly conical; ventral pseudointerarea procline to apsacline with intertrough; foramen not enclosed within larval shell; dorsal valve weakly convex; dorsal pseudointerarea long, anacline with broad triangular median groove; apical process broad, ridge-like, penetrated by pedicle tube; apical pits postero-lateral to foramen; dorsal median septum triangular, sometimes digitate or with thickened rod or platform near top; median buttress narrow, elongate.

Discussion. — As understood here, *Prototreta* includes three groups of species with different types of median septum: (1) the first is characterized by having a digitate median septum and includes the type species *P. trapeza* Bell, 1938 and *P. flabellata* Bell, 1941 (both from the Middle Cambrian of Montana); (2) the second group has a blade-like, triangular median septum lacking a platform or with a septal rod and includes *P. interrupta* (Bell, 1941) (the type species of *Homotreta* Bell from the Middle Cambrian of Montana) and *Prototreta* sp. (Zell & Rowell, 1988) (from the Middle Cambrian of central North Greenland), *P. mimica* Bell, 1941 (from the Middle Cambrian of Montana), *P. nativa* Koneva, 1979 (from the Early Cambrian of Central Kazakhstan), and *P. venusta* Koneva, 1990 (from the Middle Cambrian of Malyi Karatau Range, Kazakhstan); (3) the third group is characterized by a high, conical ventral valve and has a flat, narrow, triangular surmounting plate on a high, triangular median septum, and includes *P. convexa* Aksarina (in Aksarina & Pelman 1978) (from the Mayan of Kuznetskij Alatau, southwestern Siberia) and *P. grybovensis* Popov, 1985 (from the Mayan of Novaja Zemlja).

Prototreta (?) *dolosa* sp. n.

Figs 5, 6A–J.

Fig. 7. **A**. *Neotreta* (?) sp. Dorsal valve PMKz68, exterior; × 32. Sample 1080-B (Amgian), northern slope of Mountain Kostjube, Tarbagatay Range, Kazakhstan. **B–K**. *Kleithriatreta* cf. *lamellosa* Roberts. **B**. Ventral valve PMKz69, exterior; × 28; **C, D**. Dorsal valve PMKz70, oblique posterior view (C, × 40) and exterior (D, × 45). **E, F**. Ventral valve PMKz71, lateral view of interior showing the muscle platform on the apical process (E, × 40) and posterior view of



the ventral pseudointerarea and pedicle foramen (F, × 32). **G, H**. Dorsal valve PMKz72, oblique lateral view of the interior (G, × 28) and interior (H, × 23). **I**. Ventral valve PMKz73, interior, oblique view; × 35. **J, K**. Dorsal valve PMKz74, oblique posterior view (J, × 26) and exterior (K, × 26). Sample 1080-B (Amgian), northern slope of Mountain Kostjube, Tarbagatay Range, Kazakhstan. **L, M**. *Anabolotreta* sp. Ventral valve PMKz75, interior (L, × 36.5) and oblique posterior view of the ventral pseudointerarea (M, × 36.5). Sample 308-B (Mayan), northern slope of Mountain Kostjube, Tarbagatay Range, Kazakhstan.

Holotype: PMKz82, dorsal valve (L = 1.12, Il = 0.16, Cl = 0.50, Sm = 0.82, Sa = 0.94).
Type locality: Northern slope of the Mountain Kostjube, Tarbagatay Range, Kazakhstan.
Type horizon: Amgian (sample 1080-B).
Derivation of name: Latin *dolosus*, crafty, deceitful.

Material. — Figured ventral valves: PMKz76 (L = 1.26, T = 0.56), PMKz77, PMKz81; dorsal valves: PMKz78, PMKz79 (L = 0.76, W = 0.90, Il = 0.06, Iw = 0.32, Cl = 0.36, Cw = 0.48, Sa = 0.56), PMKz80, PMKz83. Total of 12 ventral and 10 dorsal valves.

Diagnosis. — Shell ventribiconvex, subcircular in outline; ventral valve strongly convex in sagittal profile, with maximum height anterior to umbo; ventral pseudointerarea narrow, catacline, divided by deep intertrough; ventral interior with broad, ridge-like apical process bearing elevated muscle platform anterior to short internal pedicle tube; dorsal valve moderately to strongly convex with high, triangular median septum bearing flat, triangular surmounting plate; dorsal median buttress very short, broadly subtriangular in outline.

Description. — Shell ventribiconvex, subcircular in outline. Ventral valve strongly convex to obtusely conical, about 86% as long as wide and 48% as high as long, with maximum height slightly anterior to umbo; anterior slope of ventral valve strongly convex in cross section; ventral pseudointerarea narrow, triangular, catacline, divided by moderately deep intertrough; pedicle foramen small, elongate oval, not enclosed within larval shell. Dorsal valve moderately to strongly convex; pseudointerarea low, somewhat anacline, occupying about 40% of total valve width; median groove shallow, lens-like. Ornamentation becoming lamellose peripherally.

Internal pedicle tube along posterior slope of valve, supported anteriorly by ridge-like apical process, with widened median part strongly raised to form boss-like muscle platform. Dorsal median septum high, triangular, occupying about 74–84% of total valve length, with flat, narrow, triangular surmounting plate, inclined at 90 relative to valve floor; median buttress short, broadly subtriangular, strongly widened posteriorly; dorsal cardinal muscle fields large, elongate suboval in outline, occupying about 46% of total valve length, slightly excavated medially and bordered by low rim. Mantle canal system baculate with widely divergent *vascula lateralia*.

Discussion. — *Prototreta* (?) *dolosa* sp. n. has a septum like that of the third group of *Prototreta* (see above); however, it differs from other species of *Prototreta* in having the maximum height somewhat anterior to the ventral umbo, with a narrow and relatively low ventral pseudointerarea, and a strongly convex dorsal valve, as well as in having a very short, broadly triangular median buttress in the dorsal valve. Another diagnostic feature of *P.* (?) *dolosa* is the presence of an elevated muscle platform on the apical process. It is likely that *P.* (?) *dolosa* may prove to represent a separate genus; however, it is assigned provisionally to *Prototreta*, because a revision of this genus (including also the Siberian species assigned by Pelman 1977 to *Homotreta*) is outside the scope of this paper.

Occurrence. — As for holotype.

Family Ceratretidae Rowell, 1965
Genus *Kleithriatreta* Roberts, 1990

Kleithriatreta cf. *lamellosa* Roberts, 1990

Fig. 7B-K; Table 4.

cf. *Kleithriatreta lamellosa* gen. et sp. nov.; Roberts in Roberts & Jell 1990: p. 291, figs 25–27.

Table 4. *Kleithriatreta* cf. *lamellosa* Roberts average dimensions of ventral valves.

	L	W	Il	Iw	Sa	Sm	Cl	Cw
N	4	4	4	4	4	3	4	4
X	1.00	1.18	0.095	0.505	0.71	0.52	0.43	0.69
S	0.260	0.260	0.047	0.087	0.204	0.104	0.140	0.164
Min	0.72	0.90	0.06	0.38	0.94	0.40	0.26	0.52
Max	1.30	1.48	0.016	0.58	1.00	0.58	0.58	0.84

	L/W	Iw/W	Cl/L	Sa/L	Sm/L
N	4	4	4	4	3
X	85%	43%	42%	71%	58%
S	10.7	4.7	4.2	6.5	8.2
Min	76%	39%	36%	62.5%	52%
Max	100%	50%	50%	77%	67%

Material. — Figured ventral valves: PMKz69, PMKz71, PMKz73; dorsal valves: PMKz70 (L = 1.12, W = 1.48, Il = 0.10, Iw = 0.58, Cl = 0.50, Cw = 0.84, Sa = 0.70), PMKz72 (L = 1.30, W = 1.30, Il = 0.16, Iw = 0.54, Cl = 0.58, Cw = 0.82, Sa = 1.00), PMKz74 (L = 0.72, W = 0.90). Total of 7 ventral and 9 dorsal valves.

Description. — Shell strongly ventribiconvex, transversely subrectangular in outline. Ventral valve strongly convex to obtusely conical, about 62% as high as long, with maximum height at umbo; ventral pseudointerarea procline to slightly catacline, well defined laterally, with deep intertrough; lateral slopes of valve evenly convex in cross section; pedicle foramen elongate elliptical in outline, about 200 μm long, posterior to umbo. Dorsal valve moderately convex with maximum height somewhat anterior to umbo, weakly sulcate anteriorly; dorsal pseudointerarea low, somewhat anacline, occupying about 43% of maximum valve width; dorsal median groove deep, lens-like, occupying about 25% of width of pseudointerarea. Ornamentation with up to 6 growth lamellae.

Ventral apical process high, ridge-like, thickened anteriorly, penetrated posteriorly by internal pedicle tube, with spoonlike platform anterior to foramen; ventral cardinal muscle fields situated on low platform, posterolateral to apical process; mantle canal system baculate. Dorsal interior with moderately high triangular median septum, occupying about 71% of total valve length, buttressed posteriorly, with upper septal rod in gerontic specimens; dorsal cardinal muscle fields strongly thickened, elongate suboval in outline, occupying about 42% of total valve length.

Remarks. — The Kazakhstanian specimens are closely similar to *Kleithriatreta lamellosa* Roberts from the Middle Cambrian (Ordian) Coonigan Formation of New South Wales, Australia, but can be distinguished by their somewhat smaller size and by the strongly developed spoonlike muscle platform on the apical process in gerontic specimens.
Occurrence. — Amgian (sample 1080-B); Mayan (sample 308-U); Mountain Kostjube, Tarbagatay Range, Kazakhstan.

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