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EARLY PERMIAN BRACHIOPODA AND MOLLUSCA FROM THE NORTHWEST HIMALAYA, INDIA

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Key-words: Early Permian, Brachiopoda, Mollusca, Himalaya, Palaeobiogeography.

Riassunto. È descritta ed illustrata una fauna del Permiano inferiore marino proveniente dal NW Himalaya (Lahul, India). I Brachiopodi sono predominanti come abbondanza e diversità e tra di essi sono descritte due specie nuove: *Tivertonia chumikensis* e *Neochonetes (Sommeriella) marpoensis.* I Brachiopodi e i Molluschi mostrano forti affinità Gondwaniane ed in particolare appartengono alla Provincia Cimmerica. Forti analogie si hanno con le faune coeve del Kashmir, Afghanistan e Pamir. Pure evidenti sono i rapporti con le equivalenti faune dell' Australia occidentale. La fauna è considerata di età Sakmariano superiore (Sterlitamakiano).

Abstract. The present paper describes and illustrates the Early Permian marine fauna collected from the northwest Himalaya (Lahul, India). Brachiopoda dominate the fauna in terms of abundance and include the two new species *Tivertonia chumikensis* and *Neochonetes (Sommeriella) marpoensis.* The Brachiopoda and Mollusca both exhibit strong Gondwanan relationships and the fauna belongs to the Cimmerian Province of Gondwana. Strong faunal links are shown with correlative faunas from Kashmir, Afghanistan and the Pamirs. Significant faunal relationships with correlative Western Australian faunas are also evident. The fauna is considered to be Late Sakmarian (Sterlitamakian) in age.

Introduction.

The Early Permian marine fauna described in this study comes from the northwest Himalaya and provides critical data for understanding peripheral Gondwanan faunal relationships.

Permian rocks crop out widely in the NW Himalaya of Zanskar and Lahul (India). Nevertheless more complete and less metamorphosed and tectonized sequences are found only in the area between Phugtal and the Upper Lingti Valley (Gaetani et al., 1990).

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The faunas described in the present study come from the Member A of the Chumik Formation.

Stratigraphy and localities.

Localities.

Fossiliferous localities are on the spur immediately east of the Chumik Marpo yak alpage on the right side of the Lingti Chu (Fig. 1). The fossiliferous localities within the Chumik Marpo section are indicated in figure 3 of Gaetani et al. (1990, p. 149). Samples ZB1-5 came from isolated blocks on the NE ridge, nearby the section. Sample ZG 45 was collected in the measured section and additional ZG samples were collected from scree below the ZG 45 bed. Instead, the sample LZ 43 was collected from scree on the opposite (NW) side of the spur by G. Lucchini and A. Zelioli in 1989.

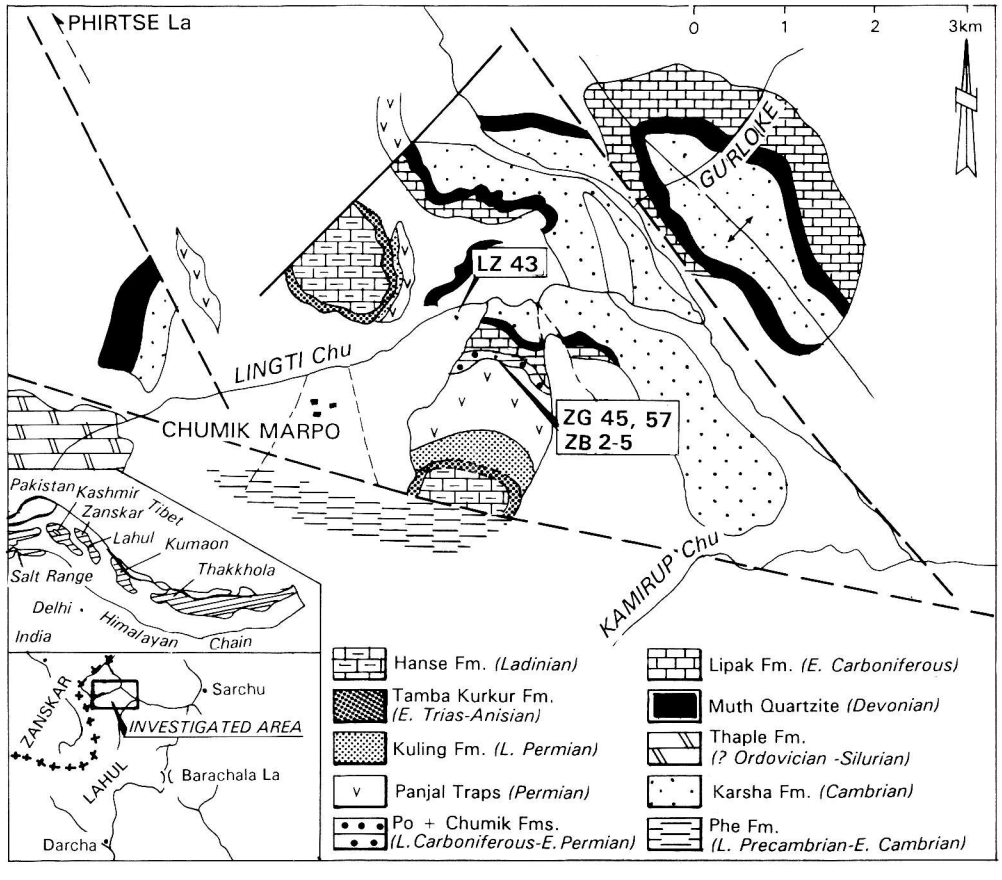

Fig. 1 - Geological sketch-map of the Chumik Marpo area, with position of the fossil localities.

All specimens are registered with and housed in the collections of Museo di Paleontologia dell'Università di Milano.

The fauna.

The Chumik Marpo fauna is treated by us as being a single entity for biostratigraphical purposes, coming as it does from a restricted stratigraphical range and associated scree material.

All brachiopod species are discussed below in terms of their relationships and new species are fully described. Representatives of the Mollusca are less well preserved in terms of critical details of the dentition and external ornament. Nevertheless, most specimens can be assigned to genera and hence they are illustrated to aid future comparisons of the present fauna with other Himalayan discoveries.

The Chumik Marpo fauna includes the following elements.

Brachiopoda

Tivertonia chumikensis sp. nov.
Neochonetes (Sommeriella) marpoensis sp. nov.
chonetid indet.
Reedoconcha kashmirica (Reed, 1932)
dictyoclostid indet.
Cyrtella nagmargensis (Bion, 1928)
Neospirifer kimsari (Bion, 1928)
Fusispirifer sp.
Trigonotreta sp.
Spirelytha ? sp.
Stenoscisma sp.
Hoskingia sp.

Mollusca

Megadesmus sp.
Parallelodon cf. *brenensis* Reed, 1932
Parallelodon ? sp.
Chaenomya ? sp.
Stutchburia sp.
Aviculopecten cf. *cunctatus* Reed, 1932
Astartila ? sp.
Pachymyonia sp.
Pseudoconocardium sp.

Conulata

Paraconularia sp.

Age and palaeogeographical relationships of the fauna.

The Chumik Marpo fauna exhibits strong generic and specific links with the fauna of the Pyroclastic Division (= Nagmarg Beds) of the Agglomeratic Slate of Kashmir. This classic fauna from Kashmir was chiefly described by Bion (1928) and Reed (1932) and was reviewed more recently by Dickins and Shah (1979) but is still in need of modern revision. Nevertheless several species from the Chumik Marpo fauna are directly related to the Kashmir fauna such as species of *Reedoconcha*, *Cyrtella*, *Neospirifer* and *Parallelodon.*

Other genera of brachiopods such as *Fusispirifer, Trigonotreta*, *Spirelytha* and *Hoskingia* indicate a wider Gondwanan relationship as do the genera *Cyrtella* and *Reedoconcha*. Further details of the palaeobiogeographical relationships of the brachiopods in the fauna are provided below under systematic palaeontology.

While the bivalves are not formally described in this study it is noted that several forms are comparable with Western Australian Early Permian species described by Dickins (1957, 1963). We would note in particular the following comparisons. Our *Stutchburia* sp. recalls both *Stutchburia variabilis* Dickins (1957) from the Tastubian top

of the Lyons Group and Sterlitamakian Callytharra Formation, Carnarvon Basin and *Stutchburia hoskingae* Dickins (1963) from the Sterlitamakian Fossils Cliff Formation, Perth Basin. Our *Pachymyonia* sp. appears allied to species from both Tastubian and Sterlitamakian units referred to both *Pachymyonia* and *Myonia*. *Parallelodon brenensis* Reed (1932) also invites comparison with *P. bimodoliratus* Dickins (1963) from Sterlitamakian units in Western Australia.

The overall faunal affinities of the Chumik Marpo fauna are clearly Sakmarian as indicated by Gaetani et al. (1990, p. 151). A few elements of the fauna suggest a comparison with Late Tastubian faunas of Western Australia but the overall relationships of the fauna suggest a Late Sakmarian (Sterlitamakian) age. This age is consistent with conclusions developed on the age of the Nagmarg Beds of the Agglomeratic Slate through earlier studies such as those by Fantini Sestini (1966), Waterhouse (1970, 1976), Dickins and Shah (1979) and Archbold and Gupta (1986).

Permian brachiopod faunas from the northern margin of Gondwana, including the Himalayan region, were grouped together by Archbold (1983) into the Cimmerian Province. Strong faunal relationships between the Chumik Marpo fauna described herein and correlative faunas of Kashmir, Afghanistan and the Pamirs suggest the potential for recognition of subprovinces within the Cimmerian Province, pending modern revision of classic faunas such as those from Kashmir.

Systematic Palaeontology

Phylum **Brachiopoda**

Order **Chonetida** Nalivkin, 1979

Suborder **Chonetidina** Muir-Wood, 1955

Superfamily *Chonetacea* Bronn, 1862

Family *Rugosochonetidae* Muir-Wood, 1962

Genus *Tivertonia* Archbold, 1983

Type species *Lissochonetes yarrolensis* Maxwell, 1964.

Discussion. *Tivertonia* was proposed by Archbold (1983) for smooth rugochonetids, traditionally assigned to *Lissochonetes* Dunbar & Condra, 1932, but separated from that genus because of differences in shell outline and shorter ventral hinge spines. *Tivertonia* is characterised by a semi-circular outline, with the maximum width of the shell being anterior of the hinge line, and the absence of clearly demarcated ears. The genus is also characterised by clearly developed smooth brachiophores developed anteriorly of the lateral septa at maturity and a pseudocapillate shell structure.

Tivertonia is known from the Early Permian of Eastern Australia (Archbold, 1983, 1986) and New Zealand (Begg & Ballard, 1991). Its presence in the Early Per-

mian of Argentina was indicated by Archbold (1983). Additional Argentinian species also include *Lissochonetes jachalensis* Amos (1961, see also Simanauskas, 1991) and *Lissochonetes breviseptum* Amos (1961, see also Pujana, 1989, pl. 1, fig. 6-9). *Tivertonia* is also known from the Sakmarian (Early Sterlitamakian Garu Formation of the Siang District, Eastern Himalaya) (Singh & Archbold, 1993). *Lissochonetes* cf. *geinitzianus* of Ching et al. (1977, pl. 1, fig. 5, 6; see also Ching, 1979, pl. 1, fig. 18,19) from the Sakmarian of Southern Tibet is also allied to *Tivertonia* although material is inadequate for precise generic assignment. The new species described herein is the first report of the genus described from the Northwestern Himalaya.

Tivertonia chumikensis sp. nov.

Pl.1, fig. 1-11; Pl.2, fig. 1-4, 6-8

Holotype. A natural mould of a dorsal valve interior, figured on Pl. 1, fig. 1, 2, from locality ZB 5. MPUM 6808.

Figured material. One ventral valve, one ventral valve internal mould, two dorsal valve internal moulds, four dorsal valve external moulds and one dorsal valve from locality ZB 5. One ventral valve internal mould, one ventral valve external mould, two dorsal valve internal moulds and two internal moulds of conjoined shells from locality ZG 57. MPUM 6809-6823.

Size ranges. Width of shell 16.0 - 23.0 mm; height of ventral valve 10.5 - 19.0 mm; height of dorsal valve 9.5 - 18.5 mm. (Note that tectonic deformation has resulted in distortion of measurements.)

Description. Gently concavo-convex shells, widest at about shell mid-length. Ventral valve evenly convex with gentle median flattening or incipient sulcus. Delthyrium small, pseudodeltidium poorly known. Ventral exterior smooth. Dorsal exterior smooth with growth lines; if valve exterior worn, growth lines become indistinct or totally removed and radiating pseudo-capillae become visible (reflecting the distribution of fine radiating taleolae, the long axis of which is parallel to, rather than normal to, the exterior surface of the valve). Immature dorsal valve flat, mature valve very gently concave.

Ventral exterior with short (at submaturity) to moderate lengthed median septum up to 0.6 valve length. Adductor scars small and feebly impressed. Diductor scars large, distinct, may be weakly striate, extend to anterior of median septum at maturity. Pair of low, parallel ridges may be developed adjacent to the anterior of the median septum at maturity. Anterior and lateral margins of valve interior finely pustulose. Teeth stout, strong. Ventral interarea low.

Dorsal interior with low, strong cardinal process and prominent alveolus. Median and lateral septa poorly developed at submaturity (numerous radiating pustulose rows are present at this stage of ontogeny). At maturity, median septum and short lateral septa are distinct. The short lateral septa extend anteriorly into prominent, smooth brachiophores with straight inner margins and curved outer margins. Brachial ridges are marked by raised pustulose areas to the anterior and lateral margins of the brachiophores at maturity. Socket plates stout with distinct sockets.

Discussion. *Tivertonia chumikensis* sp. nov. is a large species for the genus. It is distinguished from mature *T. yarrolensis* (Maxwell, 1964) by means of its distinctive brachiophores - those of *T. yarrolensis* possess a curved inner margin. *T. jachalensis* (Amos, see Simanauskas, 1991, pl. 1, fig. 13), from the Late Carboniferous - Early Permian of Argentina, lacks a ventral sulcus and possesses brachiophores with a curved inner margin. This species was originally described, extensively illustrated and named *Chonetes scitula* by Leanza (1945) and may be ancestral to *Tivertonia.*

Specimens figured as *Neochonetes* sp. A by Gaetani et al., 1990 (fig. 5.4 and 5.5) are typical representations of *Tivertonia chumikensis* sp. nov.

Genus *Neochonetes* Muir-Wood, 1962

Subgenus *Sommeriella* Archbold, 1982

Type species *Chonetes prattii* Davidson, 1859.

Discussion. The subgenus *Sommeriella* was originally proposed with the name *Sommeria* (Archbold, 1981) and renamed by Archbold (1982) for representatives of *Neochonetes* with the maximum width of mature shells usually anterior of the hinge and a distinct dorsal fold and ventral sulcus. The new species described below, although incompletely known, is tentatively referred to *N. (Sommeriella).* It represents the first reasonably well known species of *Neochonetes (Sommeriella)* known from the Early Permian of the Himalayan region.

Neochonetes (Sommeriella) marpoensis sp. nov.

Pl.2, fig.5; Pl.3, fig. 1-9

Holotype. An external mould of a conjoined shell from locality ZG 57 and figured on Pl. 3, fig. 2,6. MPUM 6826.

Figured material. One internal mould of a conjoined shell, two incomplete external moulds of conjoined shells, three external moulds of dorsal valves, two incomplete external moulds of ventral valves, all from locality ZG 57. MPUM 6827-6834.

Size ranges. Maximum shell width 13.5 - 19.5 mm; height of ventral valve 11.0 - 13.0 mm; height of dorsal valve 10.0 - 12.0 mm.

Description. Height of shell just over two-thirds of maximum width. Maximum width varies from anterior to posterior of shell mid-length; hinge width less than maximum width. Ventral valve evenly convex. Sulcus shallow, arises close to umbo, broadens anteriorly. Dorsal valve gently concave with low median fold, broadening anteriorly, moderately distinct. Chilidium unknown. Ornament of capillae distinct, increase by bifurcation and intercalation. Capillae fine, 6 to 7 per mm at 10 mm from umbo. Growth lines fine, more pronounced anteriorly.

External moulds of ventral valves show external ornament poorly or when worn appear to be smooth. External moulds of dorsal valves show capillae clearly unless

worn at which stage traces of pseudo-capillae are visible on the valve posterior. Ventral hinge spines are unknown.

Available internal moulds of the species are not direct counterparts to the available external moulds. The internal moulds that are referred by us to *N. (S.) marpoensis* are comparable to the internal moulds of submature *Tivertonia.* Nevertheless one internal mould is figured which may represent an interior of *Neochonetes (S.) marpoensis.* The ventral median septum is about half the valve length and the diductor scars are large and moderately impressed. The dorsal interior possesses a long, thin, blade-like median septum and fine lateral septa in addition to radiating rows of elongate papillae. The cardinal process is apparently small.

Discussion. *Neochonetes (Sommeriella)* is a widespread and abundant brachiopod found throughout the Tethyan - peripheral Gondwanan region as reviewed by Archbold (1983). The subgenus is particularly abundant in the Westralian Province. Although previous interpretation of Early Permian chonetids from the Himalayan region (Archbold, 1983, p. 69) indicated the presence of *N. (Sommeriella)* it is now clear that most of these reports are referable to *Tivertonia* as discussed by Singh & Archbold (1993). Species of *Neochonetes (Sommeriella)* described from the Early Permian successions of Western Australia (Archbold, 1981) are normally larger species than *N. (S.) marpoensis* and possess coarser capillae. The small species *N. (S.) hockingi* Archbold, 1991, from the Aktastinian of western Australia (Archbold, 1991a) is closer to *N. (S.) marpoensis* in general size but possesses coarser capillae and a more rounded outline than the new species.

Chonetid indet.

Pl. 2, fig. 9, 10

Comments. A single internal mould of a ventral valve, (approximately 13.5 mm wide), from locality ZG 57, (MPUM 6836), indicates the presence of a third chonetid in the Chumik Marpo fauna. The specimen possesses stout teeth, a broad delthyrium, a median septum about half the valve length and parallel vascular trunks developed anteriorly of the median septum. Traces of possible coarse external costellae are impressed on the interior of the valve anterior. The generic position of the specimen is unclear.

Order **Productida** Sarycheva & Sokolskaya, 1959

Suborder **Productidina** Waagen, 1883

Superfamily *Aulostegacea* Muir-Wood & Cooper, 1960

Family *Aulostegidae* Muir-Wood & Cooper, 1960

Subfamily *Aulosteginae* Muir-Wood & Cooper, 1960

Genus *Reedoconcha* Kotlyar, 1964

Type species *Productus (Taeniothaerus) permixtus* Reed, 1932.

Reedoconcha kashmirica (Reed, 1932)

Pl. 4, fig. 1, 2

Comments. Two specimens of ventral valves from locality LZ 43, scree material at Chumik Marpo, indicate the presence of *Reedoconcha* within the fauna. The smaller specimen (MPUM 6837) is that of a juvenile ventral valve with spines scattered over the valve and elongate spine ridges. A brush of finer spines are present on the one preserved ear of the valve, the spines are up to 16.0 mm long. The specimen recalls the ventral valve figured by Reed (1932, pl. 4, fig. 10) which possesses a shallow sulcus and distinct ear spines.

The second specimen from Chumik Marpo (MPUM 6838) is of a more mature ventral valve (length approximately 50 mm). Spines are worn off the valve but the distinctive coarse spine ridges (up to 2 mm wide and 16.0 mm in length) are prominent.

Reedoconcha kashmirica (Reed) may represent juvenile and submature specimens of two larger species named *Productus (Taeniotherus)* (sic) *permixtus* and *Productus (Taeniotherus)* (sic) *brenensis* by Reed (1932). However large collections are required to confirm any such relationship between the species.

Allied *Reedoconcha* specimens have been figured by Termier et al. (1974, pl. 11, fig. 1-8) from the Late Sakmarian of Wardak, Afghanistan. They are comparable in size to our material and probably represent the same species.

Fantini Sestini (1966, p. 23, pl. 2, fig. 1) described and figured a single ventral valve from the Sakmarian of Hamid Kuh (North Iran) as *Thaeniothaerus* cf. *permixtus*. However, as noted by Fantini Sestini, the ornament of her specimen is considerably finer than that of Reed's specimens from the Agglomeratic Slate of Kashmir.

Taeniothaerus rusticus of Grunt (in Grunt & Dmitriev, 1973) from the Late Sakmarian of the Pamir is also a species with relatively coarse, long spine bases that may be allied to *Reedoconcha* as is *Taeniothaerus aifamensis* Archbold (1991b) from the Late Sakmarian of Irian Jaya. Both these species possess finer ornament than the Chumik Marpo specimens but are nevertheless characterised by possessing relatively long ventral spine ridges.

Superfamily *Productacea* Gray, 1840

Family *Dictyoclostidae* Stehli, 1954

Dictyoclostid indet.

Pl. 4, fig. 3

Comments. A single incomplete external mould of a submature ventral valve from locality LZ 43 (MPUM 6839) indicates the presence of a dictyoclostid such as *Reticulatia* in the fauna. Characteristic reticulate ornament, scattered and numerous spine bases and demarcated ears each with a brush of spines are present. Material is inadequate for generic assignment.

Order **Spiriferida** Waagen, 1883
Suborder **Spiriferidina** Waagen, 1883
Superfamily *Syringothyridacea* Fredericks, 1926
Family *Syringothyrididae* Fredericks, 1926
Subfamily *Permosyrinxinae* Waterhouse, 1986
Genus *Cyrtella* Fredreicks, 1924

Type species *Cyrtia kulikiana* Fredericks, 1916.

Comments. The relationship of *Cyrtella* to other genera has been recently summarized by Archbold (1990, p. 7). The genus is treated by us as being a senior synonym of *Punctocyrtella* Plodowski (1968) but we note that detailed study of the shell structure of most Gondwana species is required to confirm accurate generic assignment of the various species.

Gondwanan Early Permian faunas are characterised by the presence of large *Cyrtella* - like spiriferids from Oman to Western Australia (see summary by Archbold, 1987) and probably Tasmania (described by Clarke, 1990 as *Pseudosyrinx*). The externally homeomorphic genus *Septosyringothyris* occurs in the Early Permian of Argentina (Lech, 1986).

Cyrtella nagmargensis (Bion, 1928)

Pl. 4, fig. 4-8; Pl. 5, fig. 1, 6

1928 *Spirifer nagmargensis* Bion, p. 27, pl. 2, fig. 2-5; pl. 4, fig. 15; pl. 5, fig. 1.
1932 *Syringothyris nagmargensis* - Reed, p. 25, pl. 6, fig. 1-4.
1974 *Cyrtella nagmargensis* - Termier et al., p. 81, pl. 6, fig. 3-5; text-fig. 8a-c.
1990 *Cyrtella nagmargensis* - Gaetani et al., p. 115, fig. 5.3.

Figured material. A complete mature shell from ZG 57 and a dorsal valve from locality ZB 4; an incomplete juvenile ventral valve external mould from ZG 57 and an incomplete juvenile dorsal valve external mould from ZB 5. MPUM 6840-6844.

Comments. The material from Chumik Marpo falls within the range of physical attributes of *Cyrtella nagmargensis* as described from the Agglomeratic Slate of Kashmir by Bion (1928) and Reed (1932). The large dorsal valves possess 10 to 11 costae on each valve flank and ventral valve costae are fine on the juvenile specimen and the posterior of the large ventral valve. The median groove on the dorsal fastigium is pronounced.

Specimens from the Agglomeratic Slate described by Bion (1928) and Reed (1932) lack any preservation of the shell and hence detail of the massive posterior thickening of the ventral valve is lacking in their descriptions. However, Termier et al. (1974, pl. 6, fig. 3) illustrate a specimen showing a massive ventral interarea, delthyrium and posterior thickening comparable to the large specimen figured herein.

Cyrtella australis Thomas (1971), from the Tastubian Lyons Group and Sterlitamakian Callytharra Formation of the Carnarvon Basin, Western Australia, is distin-

guished from *C. nagmargensis* by means of the sinuosity of the anterior commissure, shorter ventral adminicula and lower ventral interarea.

Cyrtella nagmargensis is distinguished from other Early Permian Gondwanan species of the genus by means of its number of costae and the presence of a distinct furrow on the fastigium. Other species possess finer, sharper costae or lack the dorsal furrow (Archbold, 1990).

Superfamily *Spiriferacea* King, 1846

Family *Spiriferidae* King, 1846

Subfamily *Neospiriferinae* Waterhouse, 1968

Genus *Neospirifer* Fredericks, 1924

Type species *Spirifer fasciger* von Keyserling, 1846.

Comments. The syntypic series of *Spirifer fasciger* von Keyserling, 1846 was reillustrated by Archbold & Thomas (1984a). New genera of neospiriferid brachiopods and the genera *Neospirifer* and *Fusispirifer* were reviewed in a series of articles by Archbold & Thomas (1985, 1986, 1987). The material described below is retained in *Neospirifer* for the present but we note that several morphological features are not typical of the genus. Costae are in fascicles of three (suggesting a relationship to the *Trigonotretinae*) while the transverse shell outline and the high fastigium and deep sulcus suggest a relationship with *Crassispirifer* Archbold & Thomas (1985). Large collections, in order to study the full ontogeny of the species, are required so that a more precise generic placement can be made (see discussion in Archbold & Thomas, 1986, p. 127).

Neospirifer kimsari (Bion, 1928)

Pl. 5, fig. 2-5; Pl. 7, fig. 1, 2, 4, 6, 7

1928 *Spirifer kimsari* Bion, p. 22, pl. 1, fig. 3,4; pl. 4, fig. 1-7.
1932 *Spirifer (Spiriferella) kimsari* - Reed, p. 31, pl. 5, fig. 2, 2a.
1990 *Neospirifer kimsari* - Gaetani et al., p. 151, fig. 5.6.

Figured material. One submature shell from ZB 5, one juvenile shell from ZG 57 and an incomplete juvenile ventral valve from ZG 57. MPUM 6845-6847.

Comments. The three illustrated specimens conform to the material of the species illustrated by Bion (1928). Distinctive features of the species include the high fastigium and deep sulcus, the transverse trigonal shell outline and the characteristic fascicles each of three costae on the flanks of both valves.

Related species appear to include *Spiriferina (Spiriferella) personata* Reed (1932, pl. 5, fig. 1) and *Spirifer (Neospirifer) fasciger* var. *paucicostulata* Reed (1932, pl. 5, fig. 3, 4) both from the Agglomeratic Slate of Kashmir, although both species are based on inadequate material. *Neospirifer fasciger paucicostulatus* of Fantini Sestini (1966, pl. 5,

fig. 2, 3) from the Late Sakmarian of Northern Iran is a related form with rounded extremities, costae in fascicles of three and a moderately low fastigium and shallow sulcus.

Neospirifer joharensis Diener as described by Grunt & Dmitriev (1973, p. 132, pl. 9, fig. 10-13; pl. 16, fig. 1) from the Late Sakmarian of the Pamirs is a species with a pronounced fastigium and sulcus and costae comparable with those of the present material. It is a less transverse species than *N. kimsari* but is allied to the Kashmir species. Diener's original account of *Spirifer joharensis* (Diener, 1897, pl. 4, fig. 3) indicates a rather different species with a shallow sulcus and low fastigium that may be a juvenile specimen of a larger neospiriferid species.

Several neospiriferid species from the Permian of northeastern Russia have also been referred to Bion's species. Likharev (1934, p. 54, pl. 1, fig. 3, 4, 6, 7, 9 and 10) referred a suite of specimens from the Kolyma Region to *Spirifer nitiensis* Diener var. *kimsari* Bion which appear to be more closely allied to *Fusispirifer* judging from the shallow sulcus and moderately transverse outline of the specimens. Yanishevskii (1938, p. 52, pl. 17, fig. 3-5) referred Likharev's specimens to a new species named *Spirifer nitiensiformis*, a robust, transverse species that appears to be allied to *Crassispirifer*. Kashirtsev (1959, p. 53, pl. 33, fig. 6) referred a ventral valve from the Late Permian Omolon Suite tentatively to Bion's species. However, the specimen, which possesses poorly developed fascicles of costae and a narrow sulcus, was referred to *Neospirifer kedonensis* Einor (in Kashirtsev, 1959) by Zavodovskii and Stepanov (1970, pl. 75, fig. 3). Einor's species (Kashirtsev, 1959, pl. 23, fig. 1-4) is a true *Fusispirifer* but we do not agree with Zarodovskii and Stepanov's assignment of the ventral valve to that species. Its generic position is not obvious but suffice to say it is not close to Bion's species.

Genus *Fusispirifer* Waterhouse, 1966

Type species *Spirifer nitiensis* Diener, 1897.

Fusispirifer sp.

Pl. 6, fig. 1

Comments. A single specimen of an internal mould of a ventral valve from locality ZB 4 (MPUM 6848) indicates the probable presence of *Fusispirifer*. The mould is relatively flat, with a shallow sulcus and distinct impressions of coarse branching costae on the lateral flanks reflecting the external ornament. The ventral muscle field extends posteriorly beyond the hinge line and is relatively small.

Fusispirifer legrandblainae Archbold & Thomas (1987) from the Early Permian of Afghanistan (figured by Legrand-Blain, 1968, pl. 3, fig. 5-10 as *Fusispirifer byroensis* ? Glauert) is a large species with the external costal pattern impressed on the ventral valve interior. However, the ventral muscle field of the Afghanistan species is large.

Fantini Sestini (1965, p. 141, pl. 20, fig. 1) recorded two ventral valves probably attributable to *Fusispirifer* from the Abgarch Valley, Western Karakorum as *Neospirifer*

fasciger nitiensis. This possible Early Permian occurrence may be related to the report herein.

Fusispirifer is well known from the Late Permian of the Himalaya as reviewed by Archbold & Thomas (1987, p. 177). However the Late Permian, Himalayan reports of the genus (Archbold & Thomas, 1987) do not indicate species closely related to the specimen in the present fauna. *Fusispirifer plicatus* Waterhouse (1966, figured by Bion, 1928, pl. 1, fig. 1, 2; pl. 4, fig. 8-13; pl. 5 fig. 9 as *Spirifer nitiensis*) is a small species with a high fastigium and relatively deep sulcus that may be allied to *Crassispirifer* rather than true *Fusispirifer*.

Australian Permian representatives of *Fusispirifer* (Archbold & Thomas, 1987; Clarke, 1987) show a range of morphological features but our present specimen does not belong to any described species.

Subfamily *Trigonotretinae* Schuchert, 1983

Genus *Trigonotreta* Koenig, 1825

Type species *Trigonotreta stokesii* Koenig, 1825.

Discussion. The type species of *Trigonotreta* and the generic concept of *Trigonotreta* and Australian species have received considerable attention and the reader is referred to discussions by Clarke (1979, 1990), Archbold & Thomas (1984a, 1986) and Waterhouse (1987).

Trigonotreta sp.

Pl. 7, fig. 3, 5, 8

Figured material. One submature ventral valve from locality ZB 5, one internal mould of a submature ventral valve from locality LZ 43 and one external mould of an incomplete mature ventral valve from locality ZG 45. MPUM 6849-6851.

Comments. The presence of true *Trigonotreta* within the Chumik Marpo fauna is well shown by the three ventral valves figured herein. The characteristic fascicles of three costae, the ontogenetic change from a trigonal to a more subquadrate shell outline and the development of a small ventral apical callus even at submaturity all indicate a species of *Trigonotreta*. Material is inadequate for detailed comparison with described species but we note that Bion (1928, pl. 5, fig. 6-8) had implied the presence of *Trigonotreta* in the Late Sakmarian fauna of the Agglomeratic Slate.

Superfamily *Reticulariacea* Waagen, 1883

Family *Elythidae* Fredericks, 1924

Subfamily *Elythinae* Fredericks, 1924

Genus *Spirelytha* Fredericks, 1924

Type species *Spirelytha pavlovae* Archbold & Thomas, 1984a (nom. nov. for *Spirifer scheii* Tschernyschew & Stepanov, 1916).

Spirelytha ? sp.

Pl. 6, fig. 8, 9

Figured material. An incomplete external mould of the posterior of a ventral valve from locality LZ 43. MPUM 6852.

Comments. The specimen represents an elythid because of the presence of double-barrelled spine bases. Internal features are unknown and hence the generic position of the specimen is speculative. However the presence of a ventral sulcus is consistent with an assignment to *Spirelytha* Fredericks (1924). The genus was redescribed by Archbold & Thomas (1984a) and shown to be of biostratigraphical value in the Early Permian of Western Australia and to occur elsewhere in the Early Permian of peripheral Gondwanan regions. The use of the genus has subsequently been confirmed by Klets (1987) and Abramov & Grigoryeva (1988) for eastern Siberia and Shi & Waterhouse (1991) for southeast Asia.

The large size of the incomplete specimen (37 mm in width) suggests comparison with *S. fredericksi* Archbold & Thomas (1984a) from the Late Sakmarian of Western Australia and *S. petaliformis* Pavlova (1973 in Grunt & Dmitriev, 1973) from the Late Sakmarian of the Pamirs.

Order **Rhynchonellida** Kuhn, 1949

Superfamily *Stenoscismatacea* Oehlert, 1887 (1883)

Family *Stenoscismatidae* Oehlert, 1887 (1883)

Subfamily *Stenoscismatinae* Oehlert, 1887 (1883)

Genus *Stenoscisma* Conrad, 1839

Type species *Terebratula schlotheimii* von Buch, 1835.

Stenoscisma sp.

Pl. 6, fig. 2-7

Figured specimen. A large internal mould of a conjoined shell and the posterior portion of the external mould of the same specimen from locality LZ 43. MPUM 6853-6854.

Comments. The single specimen (maximum width, 34 mm; length of ventral valve, 32 mm; length of dorsal valve, 29 mm) indicates a large, strongly costate stenoscismatinid. Three costae occur in the ventral sulcus with four on the dorsal fold. Lateral flanks of valves carry four costae on the ventral valve and three on the dorsal valve. The specimen indicates a distinctive species with no comparable specimens having been reported from adjacent geographical regions.

Order **Terebratulida** Waagen, 1883

Superfamily *Terebratulacea* Waagen, 1883

Family *Dielasmatidae* Schuchert, 1913
Subfamily *Dielasmatinae* Schuchert, 1913
Genus *Hoskingia* Campbell, 1965

Type species *Dielasma trigonopse* Hosking, 1933.

Hoskingia sp.

Pl. 7, fig. 9, 10

Figured material. A single, tectonically distorted, internal mould of a conjoined shell from locality ZG 57. MPUM 6855.

Comments. The single specimen represents a large species (dorsal valve length, 49 mm; ventral valve length, 58 mm) with a sub-triangular outline posteriorly and a gently sulciplicate anterior commissure. A low fold is present on the ventral valve and a gentle sulcus is present on the anterior half of the dorsal valve. Lack of the details of arrangement of the loop, hinge plate and punctae prevents confirmation of the generic position of the specimen. Nevertheless, comparison is indicated with the Western Australian Artinskian species *Hoskingia nobilis* (Etheridge, 1907, see also Campbell, 1965) and a new undescribed *Hoskingia* species from the Aktastinian (Early Artinskian) High Cliff Sandstone, Perth Basin, Western Australia.

This specimen was listed by Gaetani et al. (1990) as *Dielasma* cf. *lidarense* Diener (1915) but that species has been referred to *Beecheria* by Waterhouse & Gupta (1979) and is from the Fenestella Shales of possible Visean age. Diener's species has a straight commissure unlike the sulciplicate commissure of the present specimen.

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PLATE 1

Fig. 1,2 - *Tivertonia chumikensis* sp. nov. Holotype. Locality ZB 5, MPUM 6808. Dorsal valve internal mould and latex cast; x 2.4.

Fig. 3,4 - *Tivertonia chumikensis* sp. nov. Paratype. Locality ZB 5, MPUM 6809. Latex cast of dorsal valve internal mould and dorsal valve internal mould; x 1.8 and 2.5.

Fig. 5 - *Tivertonia chumikensis* sp. nov. Paratype. Locality ZG 57, MPUM 6810. Dorsal valve internal mould; x 2.8.

Fig. 6 - *Tivertonia chumikensis* sp. nov. Paratype. Locality ZG 57, MPUM 6811. Internal mould of shell in dorsal view; x 3.5.

Fig. 7 - *Tivertonia chumikensis* sp. nov. Paratype. Locality ZB 5, MPUM 6812. Decorticated ventral valve in ventral view; x 2.1.

Fig. 8 - *Tivertonia chumikensis* sp. nov. Paratype. Locality ZB 5, MPUM 6813. Dorsal valve internal view; x 2.2.

Fig. 9 - *Tivertonia chumikensis* sp. nov. Paratype. Locality ZG 57, MPUM 6814. Latex cast of ventral valve external mould; x 2.6.

Fig. 10 - *Tivertonia chumikensis* sp. nov. Paratype. Locality ZB 5, MPUM 6815. Latex cast of dorsal valve external mould; x 3.6.

Fig. 11 - *Tivertonia chumikensis* sp. nov. Paratype. Locality ZG 57, MPUM 6816. Latex cast of dorsal valve internal mould; x 2.8.

PLATE 2

Fig. 1 - *Tivertonia chumikensis* sp. nov. Paratype. Locality ZB 5, MPUM 6817. Ventral valve internal mould; x 2.5.

Fig. 2 - *Tivertonia chumikensis* sp. nov. Paratype. Locality ZG 57, MPUM 6818. Ventral valve internal mould; x 3.

Fig. 3 - *Tivertonia chumikensis* sp. nov. Paratype. Locality ZB 5, MPUM 6819. Dorsal valve external mould; x 1.6.

Fig. 4 - *Tivertonia chumikensis* sp. nov. Paratype. Locality ZG 57, MPUM 6820. Ventral valve internal mould; x 3.2.

Fig. 5 - *Neochonetes (Sommeriella) marpoensis* sp. nov. Paratype. Locality ZG 57, MPUM 6827. Ventral valve internal mould; x 3.2.

Fig. 6 - *Tivertonia chumikensis* sp. nov. Paratype. Locality ZG 57, MPUM 6821. Ventral valve internal mould; x 3.4.
Fig. 7 - *Tivertonia chumikensis* sp. nov. Paratype. Locality ZB 5, MPUM 6822. External mould of worn dorsal valve; x 2.1.
Fig. 8 - *Tivertonia chumikensis* sp. nov. Paratype. Locality ZB 5, MPUM 6823. External mould of worn dorsal valve; x 1.6.
Fig. 9,10 - Chonetid indet. Locality ZG 57, MPUM 6836. Latex cast of ventral valve internal mould and the internal mould; x 3.0.

PLATE 3

Fig. 1 - *Neochonetes (Sommeriella) marpoensis* sp. nov. Paratype. Locality ZG 57, MPUM 6828. External mould of worn dorsal valve; x 2.4.
Fig. 2,6 - *Neochonetes (Sommeriella) marpoensis* sp. nov. Holotype. Locality ZG 57, MPUM 6826. Latex cast of external mould of shell in dorsal and ventral views; x 2.6.
Fig. 3 - *Neochonetes (Sommeriella) marpoensis* sp. nov. Paratype. Locality ZG 57, MPUM 6829. Latex cast of worn ventral valve external mould; x 2.5.
Fig. 4 - *Neochonetes (Sommeriella) marpoensis* sp. nov. Paratype. Locality ZG 57, MPUM 6830. Latex cast of dorsal valve external mould; x 3.
Fig. 5 - *Neochonetes (Sommeriella) marpoensis* sp. nov. Paratype. Locality ZG 57, MPUM 6831. Latex cast of dorsal valve external mould; x 3.
Fig. 7 - *Neochonetes (Sommeriella) marpoensis* sp. nov. Paratype. Locality ZG 57, MPUM 6832. Dorsal valve internal mould; x 2.6.
Fig. 8 - *Neochonetes (Sommeriella) marpoensis* sp. nov. Paratype. Locality ZG 57, MPUM 6833. Incomplete ventral valve external mould; x 2.4.
Fig. 9 - *Neochonetes (Sommeriella) marpoensis* sp. nov. Paratype. Locality ZG 57, MPUM 6834. Latex cast of external mould of worn dorsal valve; x 3.2.

PLATE 4

Fig. 1 - *Reedoconcha kashmirica* (Reed). Locality LZ 43, MPUM 6837. Latex cast of ventral valve external mould; x 1.
Fig. 2 - *Reedoconcha kashmirica* (Reed). Locality LZ 43, MPUM 6838. Ventral valve in ventral view; x 1.
Fig. 3 - Dictyoclostid indet. Locality LZ 43, MPUM 6839. Latex cast of incomplete ventral valve external mould; x 1.
Fig. 4 - *Cyrtella nagmargensis* (Bion). Locality ZB 4, MPUM 6840. Dorsal valve; x 1.
Fig. 5 - *Cyrtella nagmargensis* (Bion). Locality ZG 57, MPUM 6841. Latex cast of incomplete juvenile ventral valve external mould; x 3.2.
Fig. 6,7 - *Cyrtella nagmargensis* (Bion). Locality ZG 57, MPUM 6842. Mature shell in posterior and anterior views; x 1.
Fig. 8 - *Cyrtella nagmargensis* (Bion). Locality ZB 5, MPUM 6843. Latex cast of external mould of juvenile dorsal valve; x 2.4.

PLATE 5

Fig. 1,6 - *Cyrtella nagmargensis* (Bion). Locality ZG 57, MPUM 6844. Mature shell in ventral and dorsal view; x 1.
Fig. 2-5 - *Neospirifer kimsari* (Bion). Locality ZG 57, MPUM 6845. Juvenile shell in dorsal, posterior, ventral and anterior views; x 1.2.

PLATE 6

Fig. 1 - *Fusispirifer* sp. Locality ZB 4, MPUM 6848. Ventral valve internal mould; x 1.
Fig. 2,4,7 - *Stenoscisma* sp. Locality LZ 43, MPUM 6853. Internal mould of shell in ventral, dorsal and anterior views; x 1.2.
Fig. 3,5,6 - *Stenoscisma* sp. Locality LZ 43, MPUM 6854. Latex cast from external mould in dorsal, posterior and ventral views; x 1.2.
Fig. 8,9 - *Spirelytha* ? sp. Locality LZ 43, MPUM 6852. Latex cast of external mould of incomplete ventral valve posterior; x 1.25 and x 4.

PLATE 7

Fig. 1,2,6,7 - *Neospirifer kimsari* (Bion). Locality ZB 5, MPUM 6846. Shell in dorsal, anterior, ventral and posterior views; x 1.2.
Fig. 3 - *Trigonotreta* sp. Locality ZB 5, MPUM 6849. Ventral valve in ventral view; x 1.2.
Fig. 4 - *Neospirifer kimsari* (Bion). Locality ZG 57, MPUM 6847. Ventral valve in ventral view; x 1.2.
Fig. 5 - *Trigonotreta* sp. Locality LZ 43, MPUM 6850. Internal mould of ventral valve in ventral view; x 1.2.
Fig. 8 - *Trigonotreta* sp. Locality ZG 45, MPUM 6851. Latex cast of ventral valve external mould; x 1.
Fig. 9,10 - *Hoskingia* sp. Locality ZG 57, MPUM 6855. Internal mould of distorted shell in dorsal and ventral views; x 1.

PLATE 8

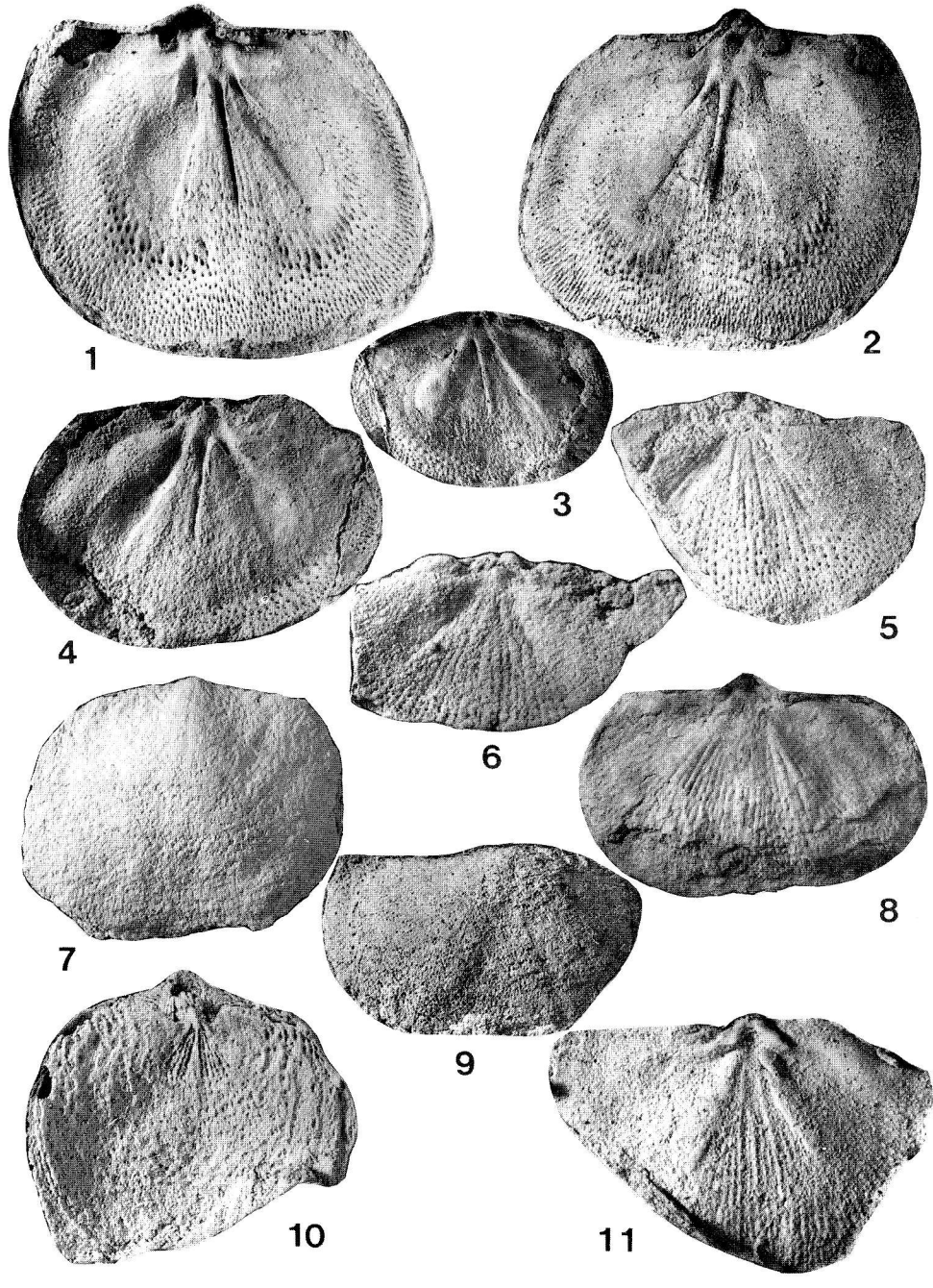
Fig. 1,2 - *Megadesmus* sp. Locality ZB 5, MPUM 6856. Left valves in side and front views; x 1.
Fig. 3-5 - *Megadesmus* sp. Locality ZB 3, MPUM 6857. Distorted shell in tilted left valve view, side view of left valve and dorsal view; x 1.

PLATE 9

Fig. 1 - *Parallelodon* cf. *brenensis* Reed. Locality ZB 5, MPUM 6858. Left valve in side view; x 2.2.
Fig. 2 - *Chaenomya* ? sp. Locality ZB 5, MPUM 6860. Left valve in side view; x 2.3.
Fig. 3 - *Parallelodon* ? sp. Locality ZG 45, MPUM 6861. Left valve internal mould; x 2.2.
Fig. 4 - *Stutchburia* sp. Locality ZB 5, MPUM 6862. Latex cast of left valve external mould; x 2.5.
Fig. 5-7 - *Parallelodon* ? sp. Locality ZB 5, MPUM 6862. Internal mould of juvenile shell showing left valve, right valve and dorsal view; x 2.5.
Fig. 8 - *Parallelodon* ? cf. *brenensis* Reed. Locality ZG 45, MPUM 6859. Dorsal view of specimen; x 2.
Fig. 9 - *Chaenomya* sp. Locality ZB 5, MPUM 6865. Left valve in side view; x 2.
Fig. 10 - *Aviculopecten* cf. *cunctatus* Reed. Locality ZG 45, MPUM 6867. Right valve ? in side view; x 1.2.
Fig. 11,12 - *Parallelodon* ? sp. Locality ZG 57, MPUM 6863. Internal mould of left valve in tilted anterior and side views; x 1.8.
Fig. 13 - Bivalve indet. Locality ZB 5, MPUM 6868. Internal mould of left valve in side view; x 2.
Fig. 14 - *Parallelodon* ? sp. Locality ZG 45, MPUM 6866. Right valve internal mould in side view; x 2.5.

PLATE 10

Fig. 1 - *Paraconularia* sp. Locality ZB 5, MPUM 6869; x 1.5.
Fig. 2,3 - *Astartila* ? sp. Locality ZB 5, MPUM 6870. Specimen in left side and posterior views; x 1.8.
Fig. 4,5,7, - *Pachymyonia* sp. Locality ZG 57, MPUM 6871. Specimen in dorsal, right and left view; x 1.5.
Fig. 6 - *Pseudoconocardium* ? sp. Locality ZB 2, MPUM 6872; x 1.5.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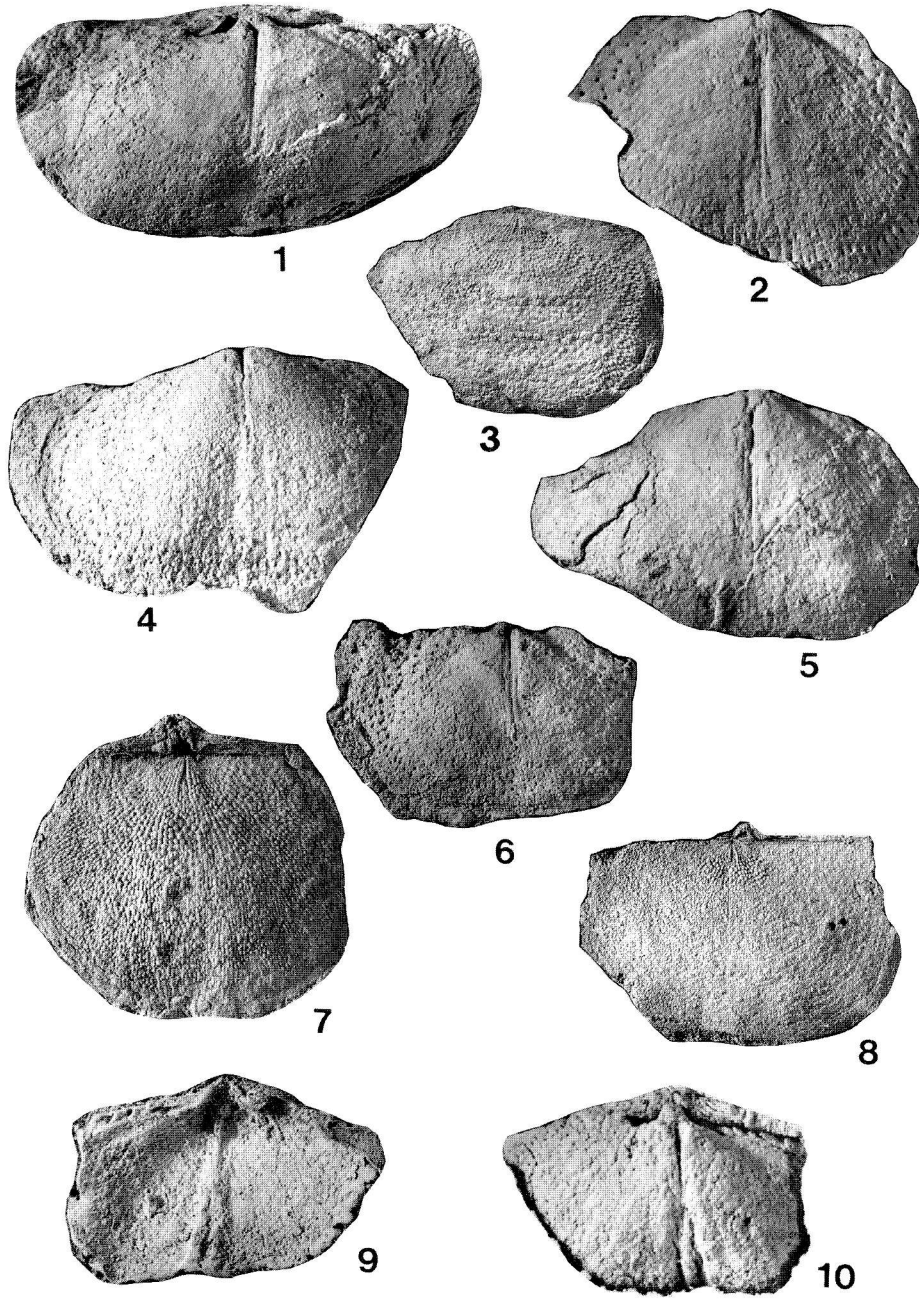
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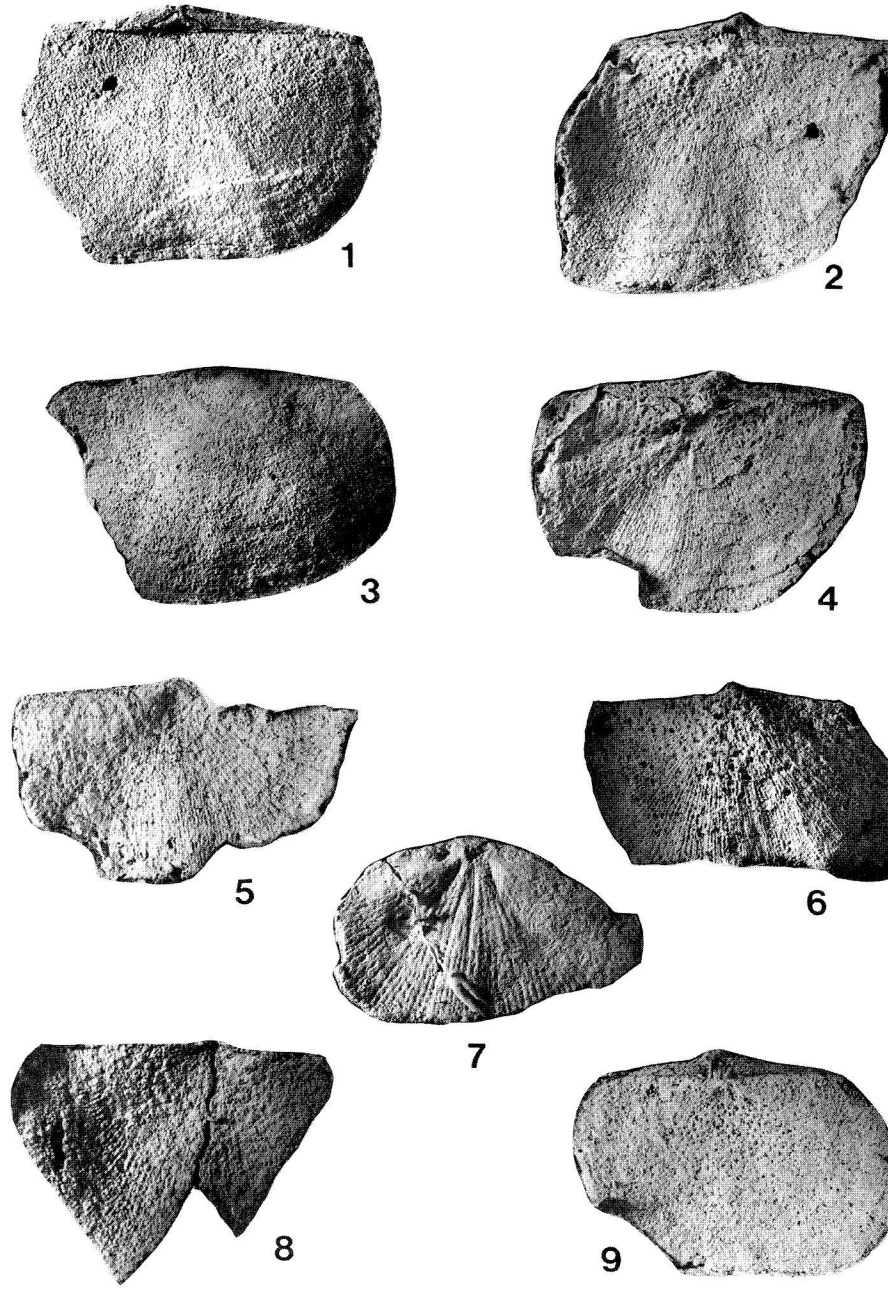
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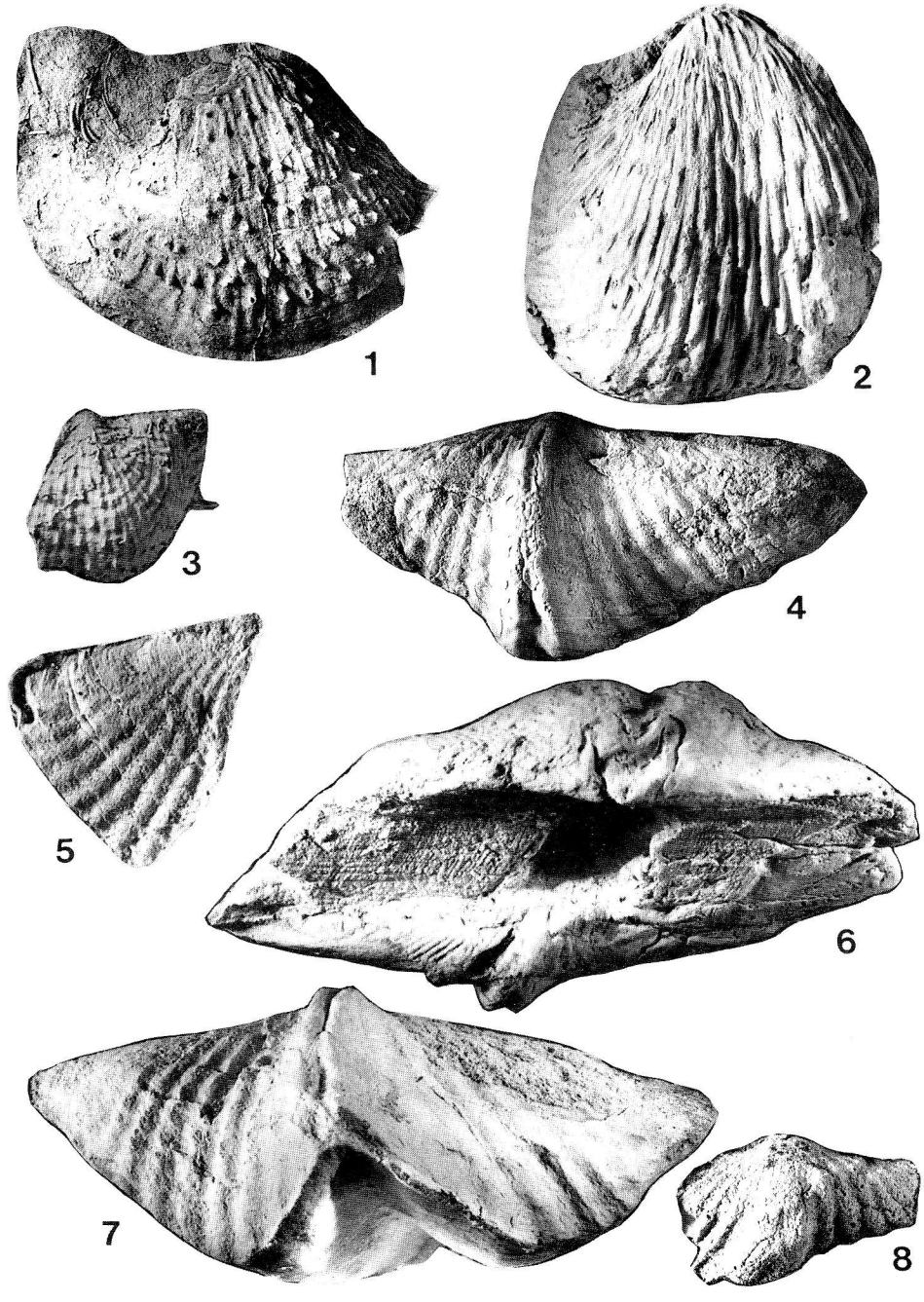
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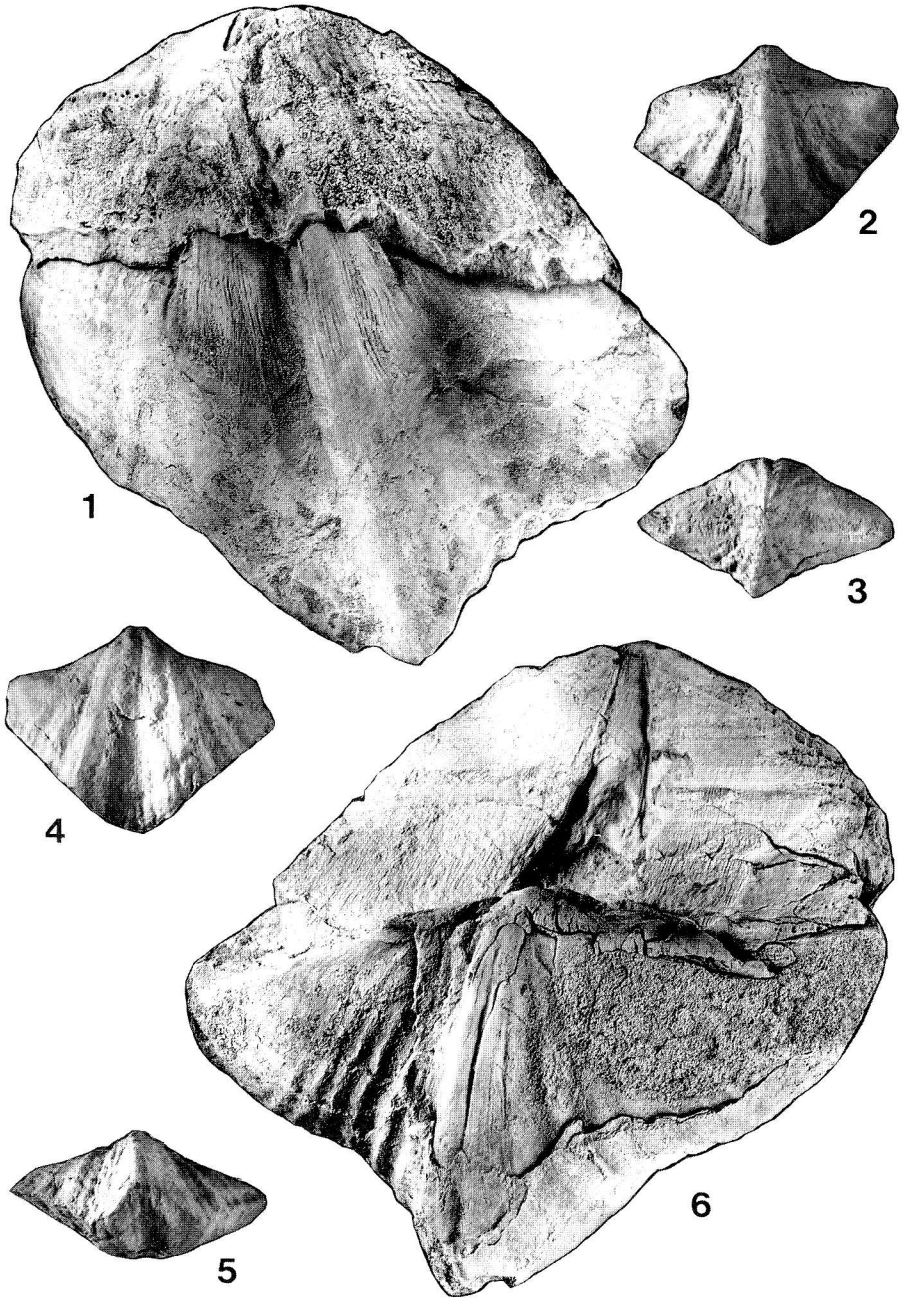
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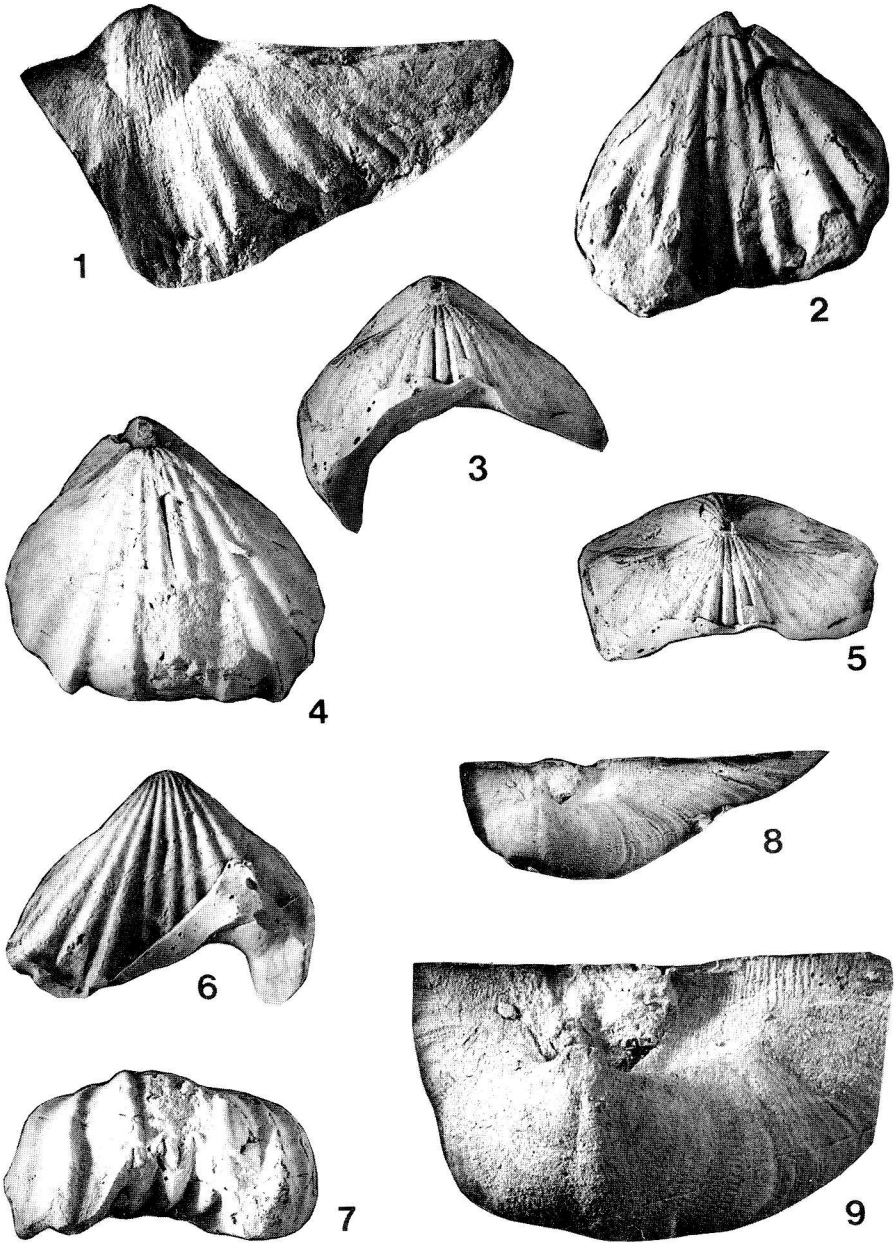
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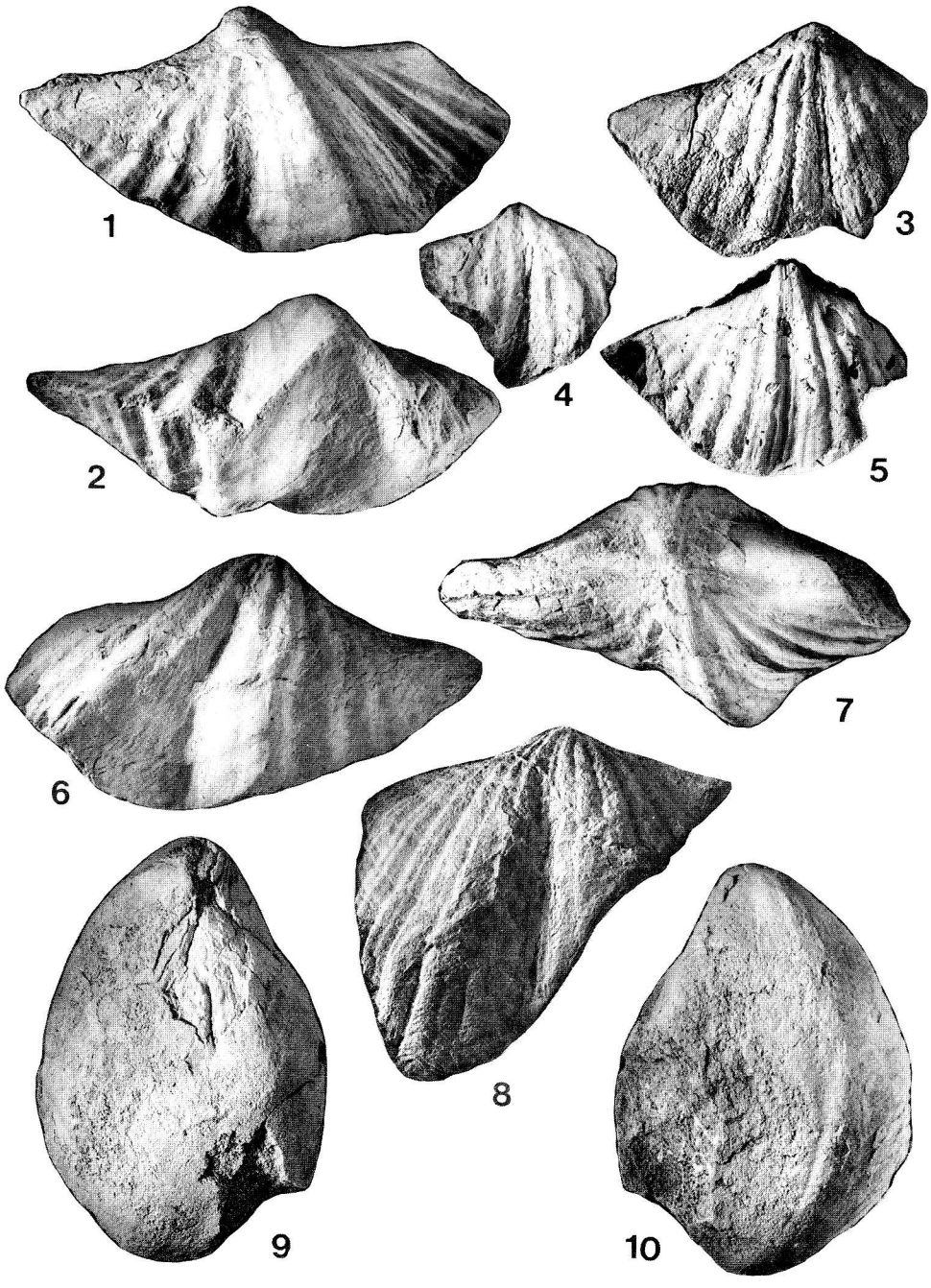
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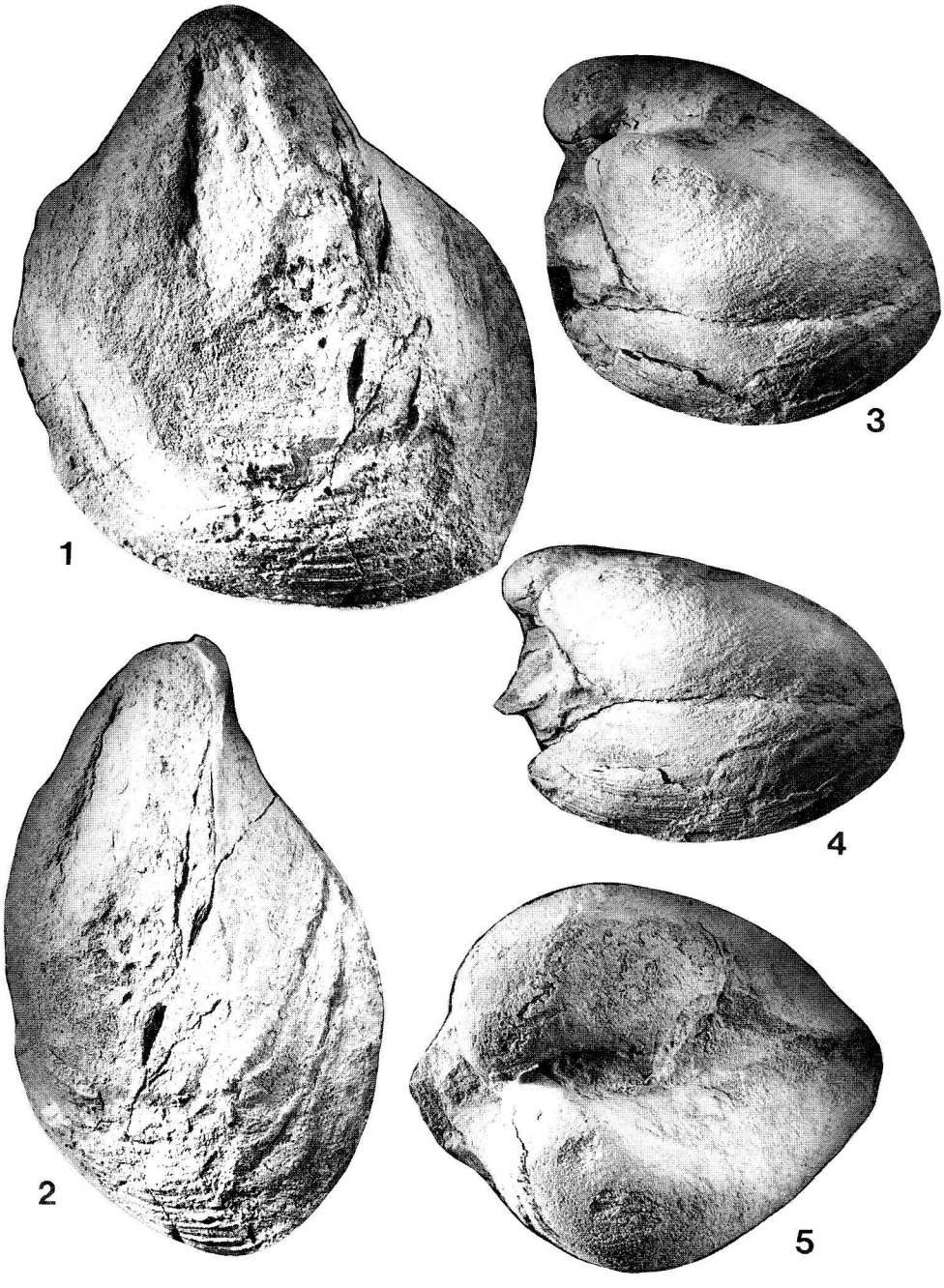
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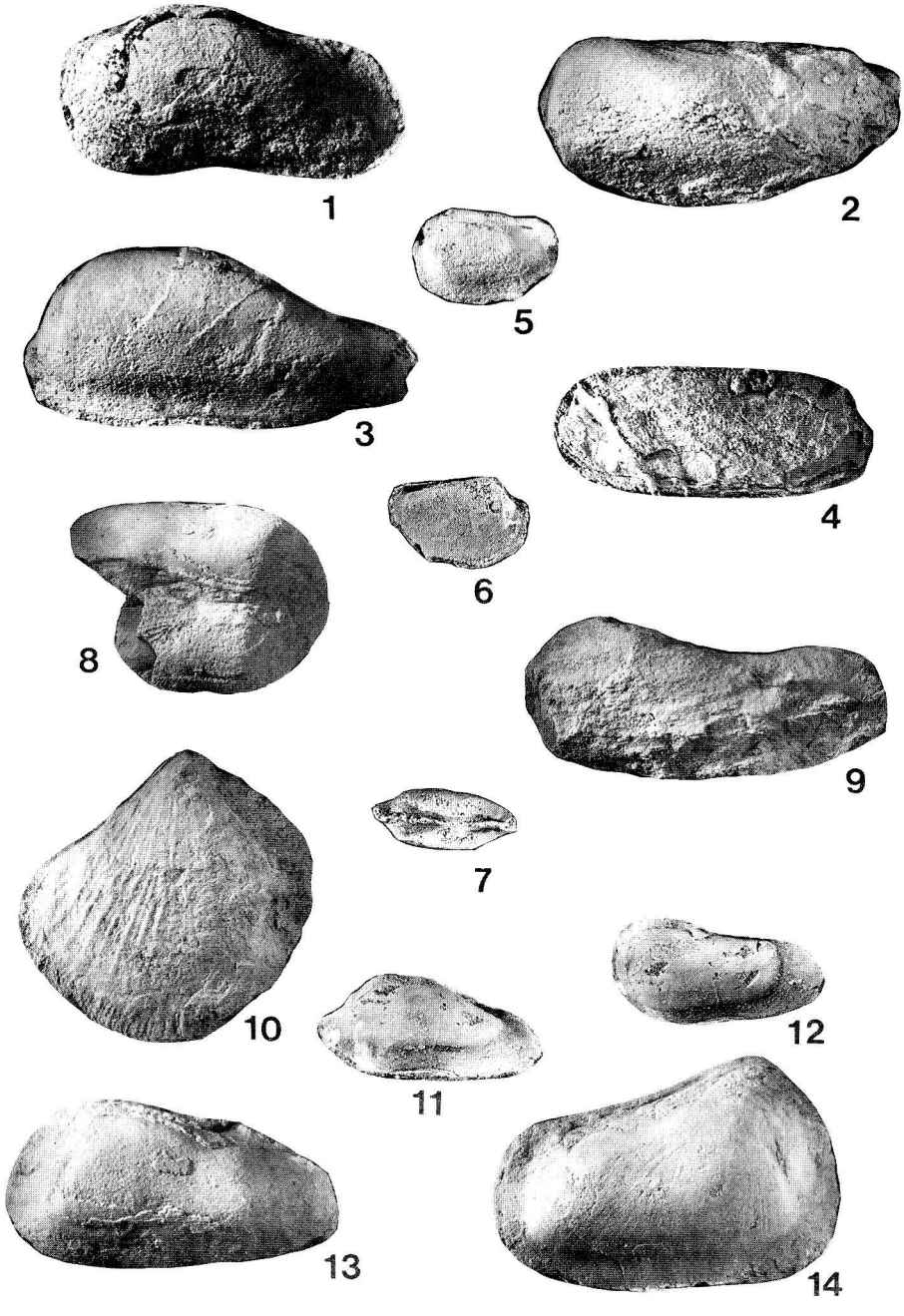
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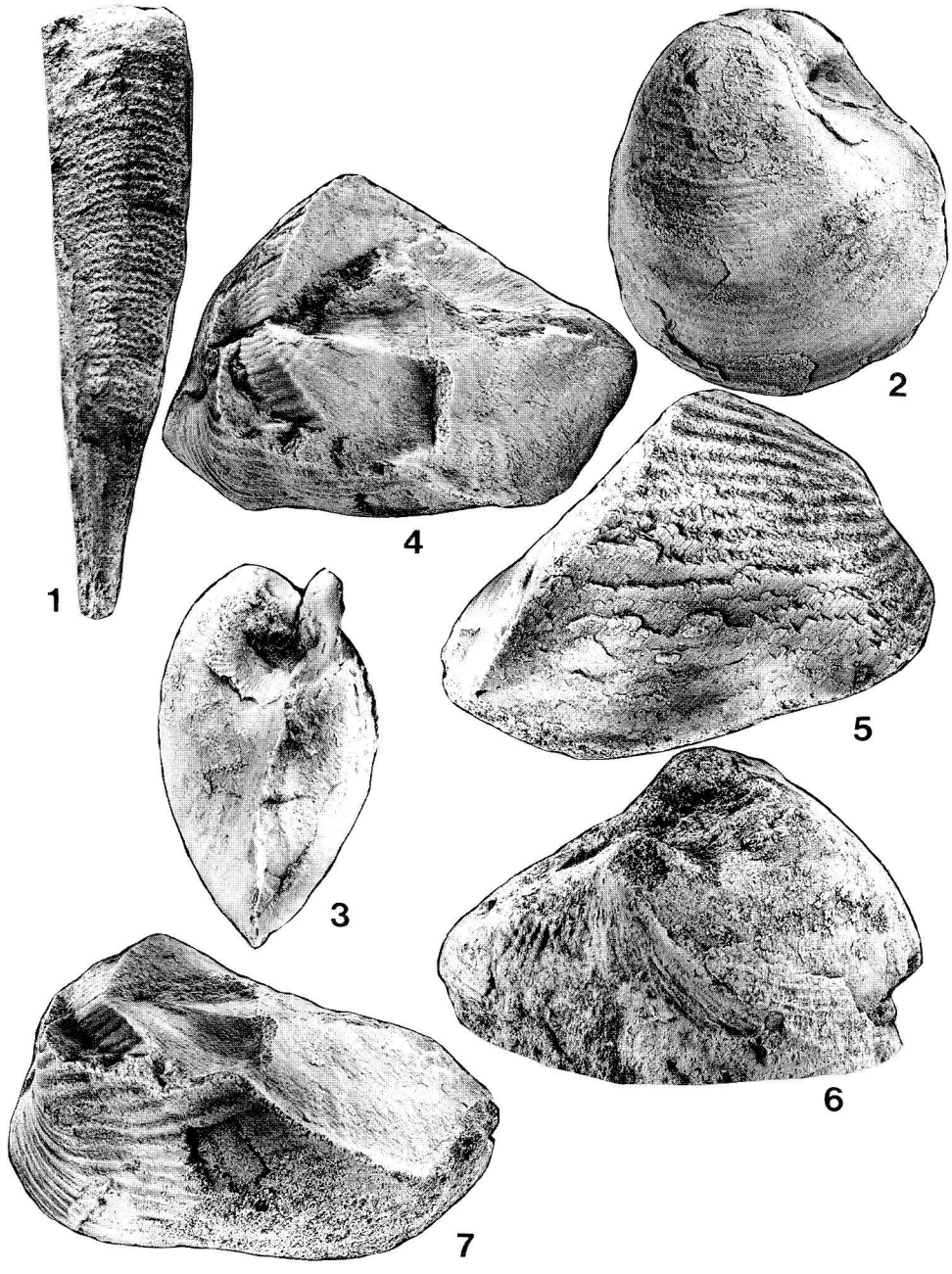
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