Rivista Italiana di Paleontologia e Stratigrafia	volume 107	numero 3	tavole 1-8	pagine 307- 344	Dicembre 2001

PERMIAN BRACHIOPODS FROM KARAKORUM (PAKISTAN) PT. 3.

LUCIA ANGIOLINI

Received August 2, 2001; accepted October 10, 2001

Key-words: Transitional biota. Brachiopods. Biostratigraphy. Correlation. Palaeobiogeography. Mass extinction. Guadalupian. Pakistan.

Riassunto. In questo lavoro viene descritta la fauna a brachiopodi proveniente dal Membro 2 della Formazione Panjshah in Karakorum (Pakistan settentrionale) sia dal punto di vista tassonomico, che per quanto concerne le implicazioni biostratigrafiche e paleobiogeografiche. Tale fauna è costituita da 29 generi, dei quali 3 incerti ed uno impossibile da identificare, appartenenti agli ordini Productida, Orthida, Rhynchonellida, Athyridida, Spiriferida e Terebratulida. Viene inoltre istituita la nuova sottofamiglia Hunzininae della famiglia Spiriferellidae, che include *Darbandia* n. gen., con specie-tipo *D. vagabunda* n. sp. e *Elivina chapursani* n. sp. Una terza nuova specie viene assegnata al genere *Anchorhynchia* della famiglia *Wellerellidae: A. cimmerica* n. sp. L'età della fauna in esame, calibrata dalle associazioni a fusulinidi e conodonti provenienti dai medesimi livelli, è attribuibile al Wordiano superiore (Guadalupiano), un intervallo di tempo caratterizzato da estremo provincialismo che rende molto problematiche le correlazioni intercontinentali.

L'analisi biostratigrafica quantitativa ha reso evidente che esistono due cambiamenti faunistici significativi all'interno della Zona di Associazione *Elivina chapursani- Chapursania tatianae*, cambiamenti che non sembrano controllati da fattori ecologici e che possono pertanto essere considerati marker biocronologici. Tale zona viene correlata con le associazioni faunistiche della Formazione Gnishik in Armenia e della base della Formazione Takhtabulak in SE Pamir. Gli elementi faunistici che la caratterizzano sono sia generi ad ampia distribuzione geografica, che generi aventi affinità Gondwaniana, Cimmerica (taxa endemici) e Tetidiana, questi ultimi particolarmente abbondanti. L'associazione a brachiopodi della Formazione Panjshah risulta pertanto una fauna transizionale, caratteristica che la rende estremamente utile per le correlazioni intercontinentali. Inoltre, essa testimonia la persistenza della Provincia Transhimalayana (Regione Cimmerica) nel Guadalupiano, provincia originatasi verso la fine del Cisuraliano nel settore compreso tra Armenia, Afghanistan centrale, Karakorum e SE Pamir. Infine, lo studio dell'evoluzione della biodiversità a brachiopodi nel Guadalupiano in Asia centrale testimonia che la crisi di massa che ne caratterizza la fine è un evento abbastanza rapido, probabilmente limitato alla fine del Capitaniano.

Abstract. Late Wordian (Guadalupian) brachiopods from Member 2 of the Panjshah Formation in the Karakorum (N Pakistan) are described. The brachiopod assemblage, dated by the associated fusulinids and conodonts, consists of 29 genera (3 of which are questionable and 1 unidentifiable) of the orders Productida, Orthida, Rhynchonellida, Athyridida, Spiriferida and Terebratulida. Hunzininae, a new subfamily of the Spiriferellidae is proposed; it includes *Darbandia* n. gen., with type species *D. vagabunda* n. sp. and *Elivina chapursani* n. sp. A third new species is assigned to the genus *Anchorhynchia* of the family *Wellerellidae: A. cimmerica* n. sp.

A quantitative biostratigraphic analysis demonstrates two major faunal changes in the *Elivina chapursani- Chapursania tatianae* Assemblage Zone of the upper part of Member 2, which are not strictly linked to lithological changes. This biozone is correlated with the brachiopod faunas of the Gnishik Formation of Armenia and those of the basal Takhtabulak Formation of SE Pamir.

The faunal elements of the *Elivina chapursani- Chapursania tatianae* Assemblage Zone are an admixture of wide-ranging, Tethyan (particularly abundant), Gondwanan and endemic (Cimmerian) genera, representing a transitional fauna and a biostratigraphic tool for intercontinental correlation, which are particularly problematic in this time interval. The Panjshah transitional fauna demonstrates the persistence of the Transhimalayan Province of the Cimmerian Region into the late Guadalupian, which originated at the end of the Cisuralian and occupied Armenia, Central Afghanistan, Karakorum and SE Pamir. It provides also some insights into the biodiversity pattern before the mass extinction at the end of the Guadalupian, and suggests that this event was as rapid as the end- Permian mass extinction, at least in Central Asia.

Introduction.

This paper describes late Wordian (Guadalupian) brachiopods from Karakorum, Northern Pakistan and represents one additional step in a series of papers describing the Carboniferous-Permian brachiopod faunas of these remote areas (Angiolini 1995; Gaetani et al. 1995; Angiolini 1996a; Angiolini 1996b; Angiolini et al. 1999) (Fig. 1).

The Guadalupian was characterised by a distinct provincialism, culminating with the end-Guadalupian mass extinction. The global biotic endemism of this epoch tends to hamper mid-Permian correlations among the different biogeographic realms and the existing time scales. However, as successfully defined by Shi (2000),

Dipartimento di Scienze della Terra, Università degli Studi di Milano, Via Mangiagalli 34, 20133 Milano - Italy
E-mail: lucia@e35.gp.terra.unimi.it

thermore, the generic association characterising the Cathaysian Province during middle-late Guadalupian (Shi & Archbold 1995 p. 135) is not recognisable either in Karakorum or in SE Pamir and Armenia. The Kachik and Iranian faunas in turn indicate the persistence of the transitional biota into the Capitanian. The Cimmerian Region should thus have lasted to the end of the Guadalupian and it was no longer recognisable in the Lopingian, as shown by Shen & Shi (2000).

Another important problem is the subdivision of the Cimmerian Region, as already pointed out by Shi & Archbold (1995). According to Angiolini (in press), during the Roadian-early Wordian, two provinces are clearly identified in the transitional Cimmerian Region: the Transhimalayan Province (Angiolini in press) embracing Afghanistan, Armenia, SE Pamir and Karakorum, and the Sibumasu Province (Fang 1991), emended to include Oman and Salt Range, located southward and south - eastward of the former. By the late Wordian-Capitanian, the Transhimalayan and Sibumasu Provinces still existed, but the Salt Range and N Oman belonged now to the incipient Himalayan Province, stretching along the southern margin of the Neotethys. This complex pattern supports the implication advanced by Shen & Shi (2000) that the mixed nature of the Himalayan Province was not caused by tectonic vicariance but by climatic evolution and ocean currents.

The review of the faunal succession of North Karakorum (Angiolini 1996b; Angiolini in press) demonstrates the dynamic nature of the provincial patterns during the Permian in Central Asia. The late Wordian brachiopod fauna from Karakorum represents the final recorded stage of a long-lasting evolution from the Asselian-Sakmarian faunas with Gondwanan affinity (Westralian Province), through the Kungurian-Roadian transitional assemblages, characterised by an admixture of wide-ranging Tethyan, Cimmerian and Gondwanan genera (with still a significant proportion of the latter) identifying the Transhimalayan Province in the Cimmerian Region. The ratio Gondwanan/Tethyan genera is markedly reduced in the late Wordian brachiopod assemblage, although still differentiated from the Cathaysian faunas, demonstrating the persistence of the Transhimalayan Province in the Guadalupian.

The significant and gradual change of marine provinciality recorded by the Karakorum brachiopod faunas during the Early-Middle Permian is related to the northward drift of the Mega Lhasa since the Early Permian, coupled with a global climatic warming and broadening of the palaeotropical belt, as suggested also by Shi & Archbold (1998) for SE Asia (Shan Thai and Baoshan Blocks).

In this context, the hypothesis that the disappearance of the Cimmerian Region may also have been enhanced by the concomitant end-Guadalupian mass-extinction is very intriguing. This link may be further elaborated considering the evolution of the brachiopod biodiversity in the Mega Lhasa. For instance, the biodiversity change in the Karakorum faunas demonstrates an increase in diversity from the Roadian assemblage, characterised by a Permian Ratio = 1.14, based on 17 genera (P.R. as emended by Shi & Archbold 1995), to the late Wordian assemblage, with more than 30 genera and a Permian Ratio = 2.42.

A consistent increase in biodiversity during the Wordian-Capitanian is recorded also by the brachiopod faunas from Iran, Central Afghanistan, SE Pamir, and Armenia. This positive trend was followed in turn by a clear extinction pattern at the end of the Capitanian with a major faunal turnover in the Wuchiapingian. This is best documented by the brachiopods of the Kachik and Akhura Formations of Armenia (Ruzhentsev & Sarycheva 1965) and strongly supported by the associated fusulinids, cephalopods, corals (Leven 1998) and by the Iranian faunas (Fantini Sestini 1965c; Fantini Sestini & Glaus 1966), indicating that the end-Guadalupian mass extinction also affected the Cimmerian Region, being particularly evident in the middle-high latitude regions of both hemispheres (Shi et al. 1999). By the beginning of the Wuchiapingian, the Cathaysian brachiopod elements were much less affected by the crisis, since the Tethyan Realm acted as a refuge area (Shi et al. 1999), and invaded the Mega Lhasa blocks, which were therefore incorporated into the Cathaysian Province.

Finally, the high diversity of the Wordian-Capitanian brachiopod assemblages from the Cimmerian Region and of Guadalupian brachiopods from the Baoshan Block (Shi & Archbold 1998) and Peninsular Malaysia (Sone et al., 2001) seems to support the suggestive hypothesis advanced by Erwin (1996) and by Shi et al. (1999) that the end-Permian mass extinction consisted of two discrete and unrelated events, one at the end of the Capitanian and another, more severe event at the end of the Changhsingian.

Furthermore, the patterns of brachiopod biodiversity seems to indicate that the crises did not start in the Wordian, at least not in the Cimmerian Region and Himalayan Province, where the brachiopods show significant diversification in the late Wordian and up to the Capitanian, so that the end-Guadalupian extinction was probably as rapid as that occurring in the Changhsingian. This is in contrast to the progressive decline of gastropods observed by Erwin (1996) since the Wordian.

Systematic descriptions.

All of the specimens described are housed in the Paleontological Museum of the University of Milan, Italy (collection numbers MPUM8463-8600). The systematic study follows the classification of Racheboeuf in Williams et al. (2000) for the chonetids, of Brunton et al.

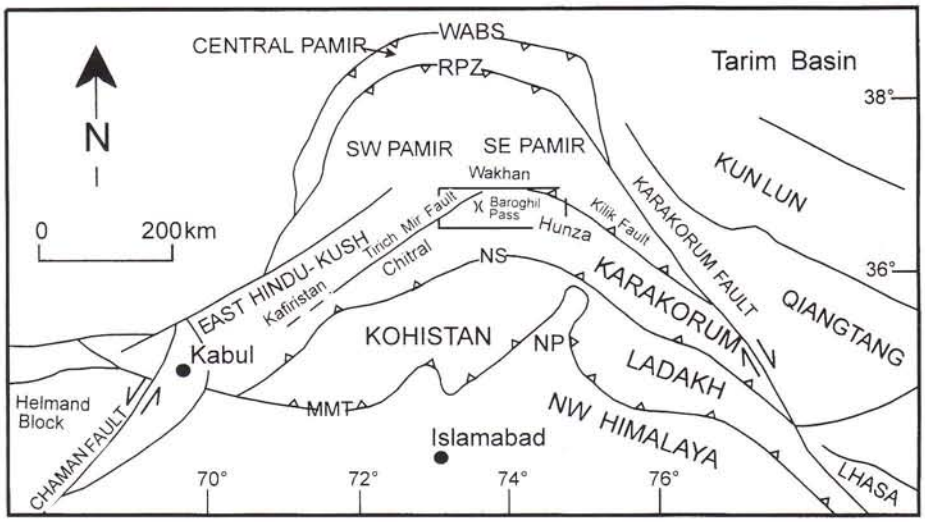


Fig. 1 - Tectonic sketch map showing the position of the Karakorum block in the Central Asia geo-collage. NP: Nanga-Parbat syntaxis; MMT: Main Mantle Thrust; NS northern suture; RPS: Rushan-Pshart suture; WABZ: Wanch-Ak Baital zone. The frame is for Fig. 2.

mixed transitional biota can serve as "biostratigraphic gateways", allowing correlation between adjacent realms, which in turn, may help correlate different Permian regional time-scales.

In this context, the mid-Guadalupian transitional brachiopod fauna from Karakorum is of particular interest. Located in the Mega Lhasa (Cimmerian blocks), which drifted away from the Gondwanan margin since the Early Permian (Garzanti et al. 1999; Angiolini in press), it provides a correlation between the neighbouring Gondwanan and Tethyan Realms. Furthermore, together with accompanying conodont and fusulinid assemblages (Gaetani et al. 1995), the mixed brachiopod faunas may provide a significant correlation between the Tethyan Scale and the standard Permian time scale of Jin et al. (1997).

Besides the stratigraphic and paleobiogeographic implications, this paper focuses on taxonomy. Some controversial genera of the family Spiriferellidae are analysed and the whole assemblage, including one new subfamily, one new genus and three new species, is described for the first time.

Previous papers on mid-Permian brachiopods from Karakorum Range are the monographs of Merla (1934), Renz (1939, 1940) and Fantini Sestini (1965b), describing allied faunas from its north-eastern side (Rimu Glacier and Shaksgam Valley). However, these studies, which are invaluable for taxonomy, described the Permian faunas in general, with no detailed stratigraphy or bed-by-bed sampling.

The brachiopod fauna: provenance and composition.

The brachiopod fauna under examination was collected from Member 2 of the Panjshah Formation (Gaetani et al. 1995) during two Italian expeditions (1986, 1991) to the Upper Hunza Valley, Karakorum, N Pakistan (Fig. 1, 2). Most of the specimens come from the type section of the Panjshah Formation (Fig. 2, asterisk; Fig. 3), located at Panjshah Shrine, near Darband in the Chapursan Valley and were collected by A. Tintori, M. Gaetani and L. Angiolini. A few other specimens were collected from the same member in the Abgarch Valley, at locality KL1 above Pariar at 4100 m above sea level by A. Zanchi, and in the Shikarjerab Valley at locality KT1 by A. Tintori (Fig. 2, triangle and star, respectively). From a stratigraphic point of view, the brachiopods collected are the youngest brachiopod fauna recovered from the Permian successions of the Upper Hunza and Karambar Valleys, and they were detected about 125 metres above the Roadian *Waagenoconcha (Gruntoconcha) macrotuberculata/Callytharrella sinensis* assemblage which characterises the first member of the Panjshah Formation (Angiolini 1996a).

The lithology of the brachiopod-bearing unit consists of marly bioclastic limestones, and the inferred depositional environment is a rather cool and deep muddy shelf with episodes of storm deposition reworking brachiopods, crinoids, foraminifers, solitary corals, bryozoans, and oncoids from shallower water settings (Gaetani et al. 1995).

The brachiopod fauna is diversified, albeit poorly represented numerically, with about 210 specimens representing 29 genera. The fauna comprises: *?Tethyochonetes* sp. ind., *?Spinomarginifera* sp. ind., *Retimarginifera* sp. ind., *R. gaetanii* Angiolini, 1995, *Pseudoantiquatonia* sp. ind., *Linoproductus* sp. ind., *Magniplicatina* sp. ind., *Compressoproductus* cf. *mongolicus* (Diener, 1897), *Leptodus* sp. ind., *Peltichia* sp. ind., *Orthotichia* cf. *avushensis* Sokol'skaya, 1965, *Stenoscisma* aff. *armenica* Sokol'skaya, 1965, *S.* cf. *purdoni* (Davidson, 1862), *Anchorhynchia cimmerica* n. sp., *Pontisia* sp. ind., *Lirellaria* sp. ind., *Terebratuloidea* sp. *A*, *T.* sp. B., *Spirigerella* sp. ind., *Hustedia* sp. ind., *Attenuatella* sp. ind., *Martinia* sp. ind., *M. subtriquetra* Merla, 1934, *Chapursania tatianae* Angiolini, 1995, *Tiramnia* aff. *tschernyschewi* (Grunt, 1973), *Martiniopsis* sp. ind., *Car-*

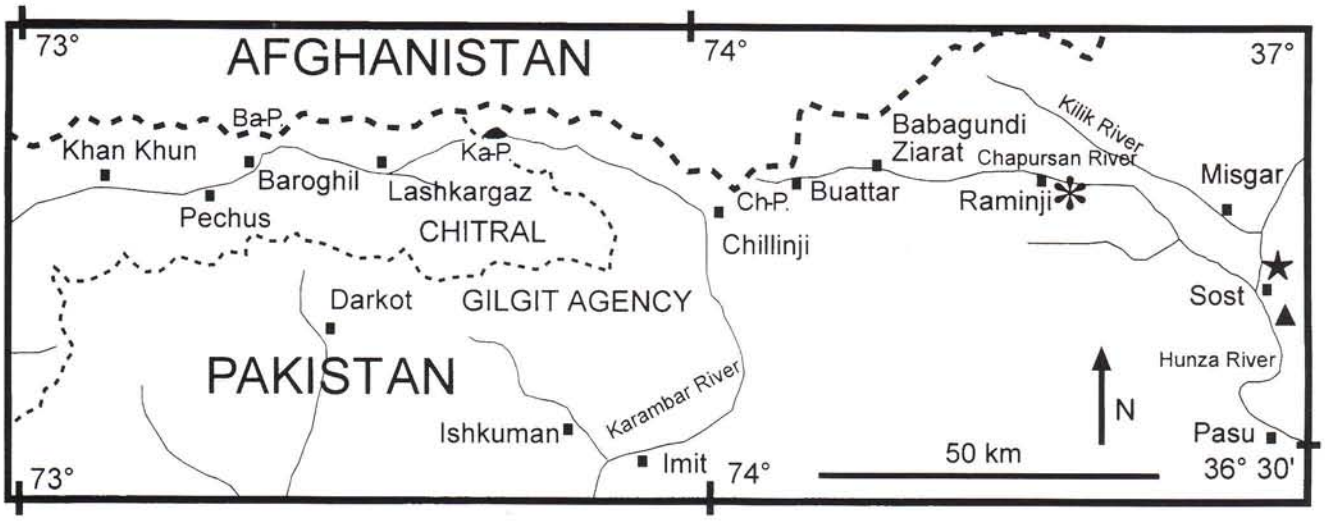


Fig. 2 - Geographic map of N Pakistan from the Yarkhun Valley to the Upper Hunza Valley. Symbols indicate the location of fossiliferous localities: asterisk, Panjshah section (Darband); star, locality KT1, Shikarjerab Valley; triangle, locality KL1, Abgarch Valley. Ba-P. is Baroghil Pass; Ka-P. is Karambar Pass; Ch-P. is Chillinji Pass.

torhium aff. *lunwalensis* (Reed, 1944), *Elivina chapursani* n. sp., *Darbandia vagabunda* n. gen. n. sp., *Tipispirifer* cf. *psittacus* (Merla, 1934), ?*Squamularia* sp. ind. a Spiriferinid fam. gen. et sp. ind. and *Rostranteris* sp. ind. The assemblage is numerically dominated by rhynchonellids and spiriferids.

A few very poorly preserved specimens, belonging to the genera *Ogbinia* and *Orthothetina*, also were collected from the type section, but are not described in the systematic section below.

Biostratigraphy.

The brachiopod succession of Member 2 of the Panjshah Formation obtained from bedrock-controlled samples was analysed using the Unitary Associations (UA) method of Guex (1991). A first run addressing only 9 species from Member 2 of the Panjshah Formation, had been processed previously using the BioGraph Program (Savary & Guex 1991) by Angiolini (1996b). A more comprehensive second run, based on 29 taxa distributed in 1 section (Panjshah section, Fig. 3), with high superpositional control, is presented here (Fig. 4). The reproducibility matrix is not reported, the data coming only from one section. Six Unitary Associations were detected. UAs 1 and 2 form a coherent group, differing only in the occurrence in UA 1of a few specimens of *Terebratuloidea* sp. B. The same holds true for UAs 4 and 5, which differ only in the short ranging species *Magniplicatina* sp. ind. and *Lirellaria* sp. ind. restricted to the latter. A first major change in composition occurs with UA 3, characterising bed KJ85, where *Terebratuloidea* sp. A, *Hustedia* sp. ind., ?*Squamularia* sp. ind., *Martinia subtriquetra, Stenoscisma* aff. *armenica* and *Anchorhynchia cimmerica* n. sp. first appear in the succession (Fig. 3, 4). However, the main change in composition occurs in UA 4 (beds KK78 to KT7-8), with the first occurrence of *Linoproductus* sp. ind., *Tiramnia* aff. *tschernyschewi, Tipispirifer* cf. *psittacus*, *Cartorhium* aff. *lunwalensis, Darbandia vagabunda* n. sp., *Retimarginifera* sp. ind., *Martiniopsis* sp. ind., *Compressoproductus* aff. *mongolicus*, the last five ranging up into UA5 (bed KK79). UA 6 has no meaning, being characterised only by ?*Spinomarginifera* sp. ind., probably due to insufficient documentation and very poor preservation. It is interesting to note that the composition of beds KK67 and KT7-8, both characterised by UA 4, shows no change even if they are separated by about 35 m of poorly fossiliferous marlstones and marly limestones. On the other hand, the two major faunal changes do not correspond to lithological changes and therefore are probably not ecologically controlled.

Chapursania tatianae, Elivina chapursani n. sp. and *Rostranteris* sp. ind. co-occur from bed 1 to bed 9, i.e. throughout an interval of significant thickness within the 10 bed succession. On this basis, the *Stenoscisma armenica-Chapursania tatianae* Assemblage Zone of Gaetani et al. (1995) and Angiolini (1996b) is emended to include also the beds KJ87 to KJ85 and is renamed *Elivina chapursani-Chapursania tatianae* Assemblage Zone, from the most characteristic species. The boundaries of this zone coincide with two barren intervals, and its thickness is about 52 metres.

Age.

In the present paper, ages are according to the Permian time scale approved by the Subcommission on Permian Stratigraphy of ICS and published by Jin et al. (1997), taking into account the correlation of the

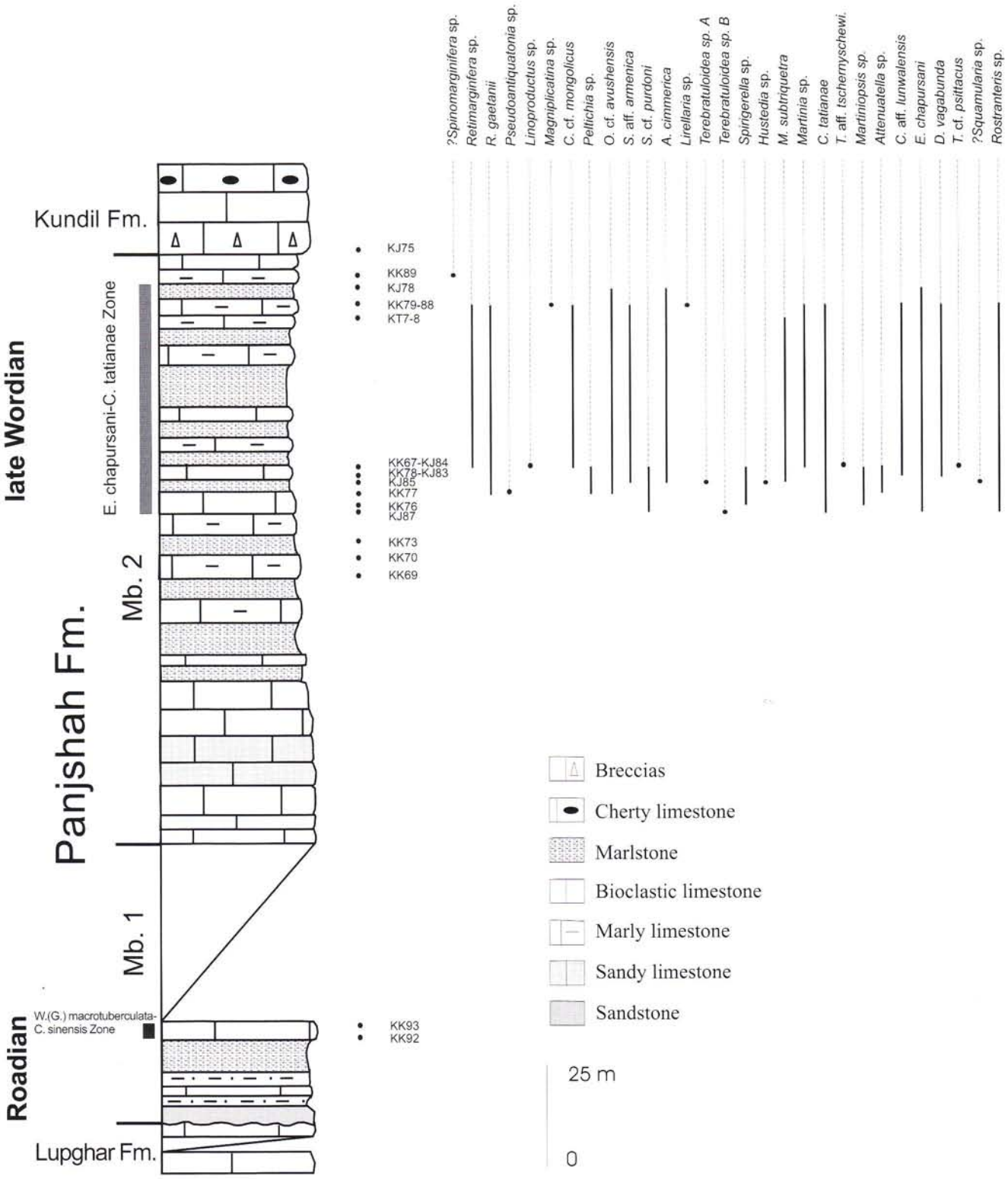


Fig. 3 - Panjshah type section, located near Darband in the Chapursan Valley with the stratigraphic range of the described brachiopods. For a detailed location of the section in Gaetani et al. (1995, fig. 11) Samples KK80, KT6, KK68, KT9 are not reported along the section because they have been collected in the scree, the former two above KT7-8, the latter below KJ83. Sample KJ75 yelded conodonts, whereas samples KK69-KK73 yelded foraminifers. The *Elivina chapursani-Chapursania tatianae* Biozone is late Wordian in age; the *Waagenoconcha (Gruntoconcha) macrotuberculata-Callytharrella sinensis* Biozone is Roadian.

Guadalupian with the Tethyan Scale (Leven 1980 emended by Kotlyar & Pronina 1995), as shown by Angiolini et al. (1998, tab. 1). This correlation, which shows the Kubergandian corresponding to the Roadian, the Murgabian (restricted to the *Neoshwagerina craticulifera* Zone) to part of the Wordian, and the Midian to the latest Wordian-Capitanian, is difficult to draw and some of the problems lie in the original definition of the Tethyan Scale.

The Murgabian was introduced by Miklukho-Maklai (1958) and its lectostratotype was defined by Leven (1967) in the Dzhamantal Mountains (SE Pamir). Leven (1967, 1981) emended the stage confining it to the "*Neoschwagerina* genozone", with its lower boundary drawn at the appearance of *Neoschwagerina* accompanied by *Verbeekina* and *Presumatrina*. Leven (1980) defined the overlying Midian stage by the appearance of *Yabeina* and *Lepidolina* and abundant aberrant fusulinids, suggesting to select the stratotype in the Armenian sections (*Chusenella abichi* Zone, Arpa Formation).

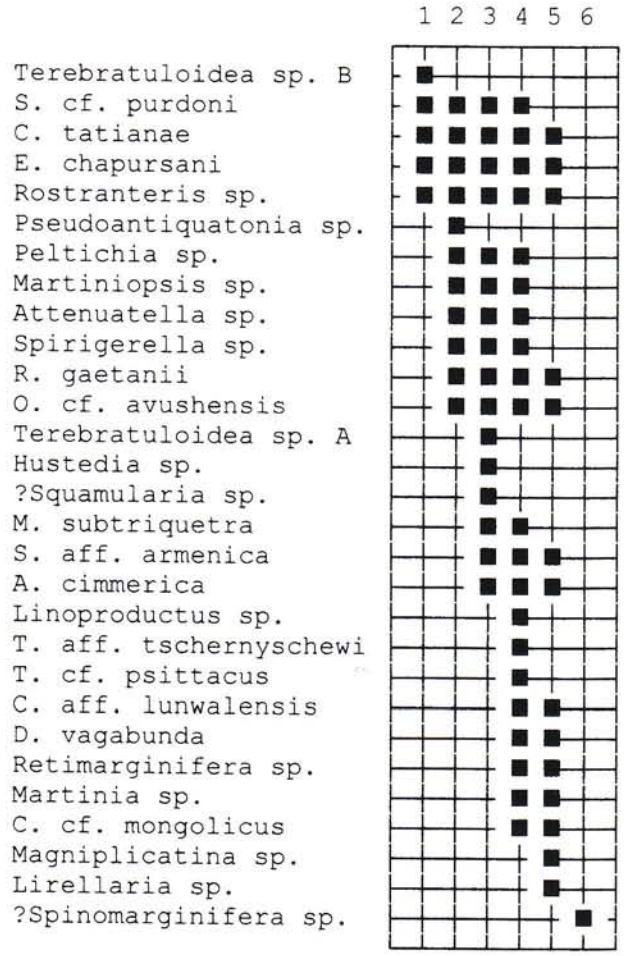
Kotlyar and Pronina (1995) revised these stages, showing that the Murgabian should be restricted to the *N. craticulifera* zone. In fact, the *N. simplex* Zone must be excluded from the Murgabian because its fusulinid assemblage was found in association with Kubergandian ammonoids (Bogoslovskaya 1994). The *N. margaritae* zone in turn shows the occurrence of the first *Yabeina* and *Lepidolina* (Davydov 1996), which should indicate the base of the Midian.

Regarding the correlation of the emended Murgabian (restricted to the *N. craticulifera* Zone) and Midian stages, the former equates to part of the Wordian, and the latter to the late Wordian-Capitanian, as suggested also by Kozur (1994) and Davydov (1996). In fact, the Illawarra reversal (which lies below the base of the Capitanian) was recognized in the uppermost part of the Makou Formation in S China by Heller et al. (1995) to correspond to the *N. margaritae* Zone (Jin et al. 1997). Furthermore, according to Kozur (1995), Wordian conodonts, and especially, Wordian ammonoids (*Waagenoceras*) occur together with early Midian small foraminifers in Sicily (Rupe del Passo di Burgio block). According to Davydov (1996) and Rui & Nassichuk (1996), Wordian ammonoids occur together with lower Midian fusulinids in the Cache Creek Terrane of British Columbia. Furthermore, according to Kotlyar & Pronina (1995), the Midian is characterised by two distinct ammonoid assemblages: a lower one, Wordian in age, occurring together with *Yabeina* and an upper one, Capitanian. These problems of correlation is reflected also in the difficulties encountered by Gaetani et al. (1995) in giving

BIOGRAPH v2.10
1990-95 by J.Savary & J.Guex

SORTED UNITARY ASSOCIATIONS

29 taxa
6 unitary associations



CORRELATION TABLE

10 horizons

Section PANJSHAH

```
KK89:   6 -   6
KJ78:   3 -   5
KK79:   5 -   5
KT7-8:  4 -   4
KK67:   4 -   4
KK78:   4 -   4
KJ85:   3 -   3
KK77:   2 -   2
KK76:   2 -   4
KJ87:   1 -   1
```

Fig. 4 - Output of the Biograph 2.10 Program showing the 6 Unitary Associations sorted from the distribution of brachiopods along the Panjshah section and their repartition along the section.

an age to the fauna of Member 2 of the Panjshah Formation. In fact, while fusulinids (chiefly recovered from beds KK69 to KK73) - represented by the genera *Minojapanella* and *Lantschichites* - suggest an early Midian age, conodont assemblages detected just above the brachiopod assemblage (from bed KJ75 upward) represent the cline from *M. phosphoriensis* (Youngquist, Hawley & Miller) to *M. bitteri* (Kozur). According to very recent conodont zonation (Mei & Henderson 2001), these conodonts indicate the Wordian and Capitanian stage, respectively. Therefore, an early Midian equating to the late Wordian age is indicated for the Panjshah brachiopod fauna (*Elivina chapursani-Chapursania tatianae* Assemblage Zone).

This late Wordian age is supported independently by the brachiopods. In fact, according to Grunt (1989) the genus *Spirigerella* spans the latest Roadian-Capitanian time interval, its lower occurrence being questionable. According to Cooper & Grant (1976), the Guadalupian spiriferids show a trend toward a narrow shape: more specifically the mid-late Guadalupian species of *Cartorhium*, *Eliva* and *Spiriferella* show a heart-shaped outline. *Pseudoantiquatonia* is known from the Wordian of Central Tibet and Western Yunnan (Shi & Shen 2001) and the Wordian of Yunnan (Shi 2000). *Anchorhynchia* occurs in the Guadalupian-Lopingian of North Gondwana, Mega Lhasa and China. *Spinomarginifera* occurs in the Guadalupian-Lopingian of China and Mega Lhasa. *Orthotichia avushensis*, *Stenoscisma purdoni* and *Cartorhium lunwalens* is are recorded typically from the late Wordian-Capitanian (Ruzhentsev & Sarycheva 1965; Waagen 1884; Reed 1944). The recorded species of *Stenoscisma* and *Compressoproductus* are close to Capitanian-Lopingian representatives of the genera. Finally, the genus *Tethyochonetes* has been reported so far from the Lopingian of S Tibet and S China (Chen et al. 2000).

However, although brachiopod assemblages seem to differ rather sharply from the early to the late Wordian, they do not help to discriminate clearly the late Wordian from the Capitanian, as outlined in the following paragraph.

Correlation.

The Panjshah fauna (*Elivina chapursani-Chapursania tatianae* assemblage) is mostly similar to that of the Gnishik Formation of Armenia (Ruzhentsev& Sarycheva 1965), the basal Takhtabulak Formation of SE Pamir (Grunt & Dmitriev 1973) and, to a lesser degree, to one assemblage of the Ruteh Limestone of the Alborz Mountains (Iran) (Fantini Sestini 1965c).

The Panjshah brachiopod fauna is a mixed transitional fauna sensu Shi et al. (1995), that shows links with both the mid-Permian Australian faunas and with the Guadalupian faunas of Texas. With the former the Panishah fauna shares the genera *Magniplicatina*, *Leptodus*, *Stenoscisma*, *Hustedia*, *Attenuatella*, *Martinia* and, through correlation by *Pseudoantiquatonia* in central Tibet (Shi 2000), also *Tomiopsis*. Correlation with the Wordian-Capitanian of West Texas are supported by the occurrence of *Stenoscisma*, *Lirellaria*, *Pontisia*, *Linoproductus*, *Magniplicatina*, *Cartorhium*, *Elivina* common to the Word Formation and Capitan Formation (Glass Mountains) and to the Capitanian Lamar Member of the Bell Canyon Formation (Guadalupe Mountains).

Correlation with Armenia. The Karakorum fauna fits well with the brachiopods described by Ruzhentsev & Sarycheva (1965) from the Gnishik Formation of Armenia, sharing species of *Orthotichia*, *Spinomarginifera*, *Anchorhynchia*, *Lirellaria*, *Rostranteris* and the genera *Linoproductus*, *Leptodus*, *Ogbinia*, *Orthothetina*, *Terebratuloidea*, and *Squamularia*.

The Gnishik fauna is overlain by the Arpa Formation, which contains the same fusulinid *Minojapanella* found in the Karakorum assemblage (beds KK69-73 in Fig. 3). This is in turn overlain by the late Midian Kachik Formation with a brachiopod fauna still rather similar to the Arpa, differing only in four species of the genera *Rhipidomella*, *Septospirigerella* and *Orthotethina*. According to Kotlyar et al. (1983, 1989) and Leven (1998), the fusulinids of the Gnishik represent the *Neoschwagerina margaritae* Zone, whereas those from the Kachik are typical of the *Lepidolina kumaensis* Zone, suggesting respectively a late Wordian and Capitanian age in the standard time scale and fitting well with the proposed correlation.

Correlation with SE Pamir. A strong similarity exists between the Karakorum and SE Pamir faunas, with seven out of eleven species described by Grunt & Dmitriev (1973) from the base of the Takhtabulak Formation represented in Member 2 of the Panjshah Formation. This assemblage was dated as early Dzhulfian by Grunt & Dmitriev (1973), but its striking similarity to both the Panjshah and the Gnishik faunas suggests an older, Guadalupian age. According to Grunt & Dmitriev (1973), underlying rocks (Gan Formation) contain only a few representatives of *Martinia triquetra*, whereas brachiopods from the middle-upper part of the Takhtabulak Formation are very diversified and strongly different from the lower ones, suggesting a younger Lopingian age. Leven (1998) outlined also the problematic position of the brachiopod assemblage recorded by Grunt & Dmitriev at the base of the Takhtabulak Formation. In fact, this formation is given a Changsingian age on the basis of fusulinids and conodonts (Kozur 1994; Leven 1998).

Correlation with Salt Range, Pakistan. The Panjshah brachiopod fauna shares only a few long ranging genera with the Amb Formation, considered Roadian to Wordian in age on the basis of conodonts (Wardlaw & Pogue

1995; Wardlaw & Mei 1998) but not younger than mid-Wordian, according to the brachiopod assemblage and Peri-Gondwanan correlations (Angiolini & Bucher 1999; Angiolini in press). This age assignment is further constrained by the occurrence of the Illawarra Reversal - which is allocated below the base of the Capitanian (Jin et al. 1997; Menning 2000) - in the basal part of the Wargal Formation (Haag & Heller 1991), and by the occurrence of the fusulinids *N.* aff. *margaritae* and *Chusenella* in its Unit 2 (Pakistani-Japanese Research Group 1985).

On the other hand, the Panjshah fauna shows more links with the Wargal Formation, sharing *Stenoscisma purdoni, Cartorhium lunwalensis*, and comparable species of the genera *Terebratuloidea, Spirigerella*, and *Hustedia*. The Wargal Formation lies disconformably above the Amb Formation and contains Capitanian to Wuchiapingian foraminifers and conodonts (Wardlaw & Pogue 1995, p. 218).

Correlation with Central Afghanistan and Iran. Moving westward, the correlations are less easy to draw mainly because this late Murgabian or early Midian interval is less represented. In fact, correlative levels from the *Neoschwagerina margaritae* Zone of Central Afghanistan (Termier et al. 1974) yield only *Marginifera typica* (which is neither illustrated nor preserved in the collection in Lyon) and *Selloproductus sellatus* Termier, Termier, Lapparent & Marin, 1974 which is a *Linoproductus* species.

In Central Iran, the fauna from the Abadeh Formation (Taraz et al. 1981) is different and is Capitanian in age according to Waterhouse & Gupta (1983) and Kotlyar (1994), as supported also by conodonts (Mei & Henderson 2001).

In the Alborz Mountains (N Iran), the Ruteh brachiopod fauna (Fantini Sestini 1965c) spans the Wordian interval with the lower assemblages (levels 1-2) being early Wordian and correlated to the Amb brachiopod fauna. Brachiopods from level 3, characterised by species of *Orthotichia, Orthotetina, Spinomarginifera, Linoproductus, Magniplicatina* besides *Crurithyris* and *Whitspakia*, are rather similar to the Panjshah fauna.

The overlying Nesen Formation is Lopingian based on brachiopods, corals, and fusulinids (Fantini Sestini & Glaus 1966).

Palaeobiogeographic implications.

The *E. chapursani - C. tatianae* brachiopod fauna is a transitional fauna (sensu Shi et al. 1995), and is characterised by an admixture of wide-ranging Tethyan, Gondwanan and endemic taxa. However, these different faunal elements are not distributed equally, the assemblage showing a significant Tethyan affinity.

In fact, if wide-ranging genera are a significant portion, represented by *Linoproductus, Orthotichia, Stenoscisma, Hustedia, Martinia, Martiniopsis*, only *Retimarginifera* (represented by two species) is a truly Gondwanan genus, whereas Tethyan taxa dominate with *Tethyochonetes, Spinomarginifera, Compressoproductus, Leptodus, Peltichia, Pontisia, Lirellaria, Anchorhynchia, Terebratuloidea, Spirigerella, Cartorhium, Squamularia*, and *Rostranteris*.

Magniplicatina and *Attenuatella* are antitropical bitemperate genera (sensu Shi & Grunt 2000). Endemic Cimmerian genera are *Tipispirifer, Pseudoantiquatonia, Elivina, Chapursania* and *Darbandia*, the latter restricted so far to Karakorum. The Boreal genus *Tiramnia* occurs also in the assemblage.

Worthy of note is the distribution of the genera *Elivina, Chapursania*, and *Anchorhynchia* which characterise the Peri-Gondwanan Himalayan Province, as emended by Shen & Shi (2000), and the Cimmerian Region of Grunt & Shi (1997). More specifically, the two former genera seem to be restricted to the two biogeographical units, whereas *Anchorhynchia* is recorded also from the Cathaysian Province.

The southward migration of these genera and of *Tiramnia* during the *Guadalupian* may be the result of both a "stepping stones" migration mechanism (as described by Shi & Grunt 2000) and a response to the climatic cooling and the related lowering of thermal gradients induced by the Kazanian (Wordian p.p.) Kolyma-Omolon glaciation in the northern hemisphere (Mikhaylov et al. 1970). Furthermore, the pattern of surface and deep water currents (Archbold 1998) during the Guadalupian may also have favoured the migration of these faunal elements. A north to south intercontinental migration during the Wordian was already demonstrated for the bipolar brachiopod genera *Terrakea* and *Tomiopsis* by Shi & Grunt (2000).

The transitional character of the late Wordian Panjshah fauna from Karakorum has great significance to the dynamic evolution of the Permian provinciality. In fact, the existence of the Gondwanan, Tethyan and Boreal Realms, whose boundaries are complicated by the waxing and waning of different transitional provinces, has been demonstrated and defined already by Archbold and co-authors (Archbold 1983; Archbold & Shi 1995; Shi et al. 1995; Shi & Archbold 1998, etc.). However, the exact time span and subdivision of the transitional provinces in general, and of the Cimmerian Region in particular, have not yet been assessed. According to Shi & Archbold (1998), the Cimmerian Region should vanish by the beginning of the Wuchiapingian, becoming incorporated in the Cathaysian biogeographical unit. The Karakorum fauna with its peculiar admixture of faunal elements and rather high level of endemic taxa (Endemicity = 0.25 calculated according to Shi & Archbold 1995), and genera in common with the Peri-Gondwanan Himalayan Province, indicates that the Cimmerian Region still existed during the late Wordian. Fur-

in Williams et al. (2000) for the productids, of Williams & Harper in Williams et al. (2000) for the orthids, of Savage (1996) for the rhynchonellids, of Alvarez et al. (1998) for the athyridids, of Carter et al. (1994) for the spiriferids and of Stehli in Williams et al. (1965) for the terebratulids.

The systematic study relies on personal examination of the collections of Alborz, Iran (Fantini Sestini 1965c, d) and of Shaksgam (Fantini Sestini 1965b) housed in Milan (Italy); of NE Karakorum (Merla 1934) housed in Florence (Italy); of Central Afghanistan (Termier et al. 1974) housed in Lyon (France); of SE Pamir (Grunt & Dmitriev 1973) housed in Moscow; of topotype specimens from Chitichum and of the Chernyshev (1902) collection in St.-Petersburg (Chernyshev Museum housed in VSEGEI).

Some of the described taxa are represented by a very small collection of specimens but one should take into account both the remote region from which they are recovered and the structural framework of the Karakorum chain, which suffered from several orogenic events. Most of the specimens are seriously recrystallized so that they do not show a preserved ultrastructure when sectioned. For instance Lower Triassic conodonts recovered from a nearby section (Wirokhun section) show a CAI index of 4.5-5.5 (Gaetani personal communication), which also indicates strong recrystallization.

Class **Strophomenata** Williams, Carlson, Brunton, Holmer & Popov, 1996

Order Productida Sarycheva & Sokol'skaya, 1959

Suborder Chonetidina Muir-Wood, 1955

Superfamily Chonetoidea Bronn, 1862

Family Rugosochonetidae Muir-Wood, 1962

Subfamily Rugosochonetinae Muir-Wood, 1962

Genus *Tethyochonetes* Chen, Shi, Shen & Archbold, 2000

Type-species: *Waagenites soochowensis quadrata* Zhan, 1979

? Tethyochonetes sp. ind.

Pl. 1, fig. 8

Material. A dorsal valve: MPUM8463 (KK68-22).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, loose sample KK68, Panjshah section. Late Wordian.

Remarks. A fragment of a slightly concave dorsal valve which should have been about 14 mm wide suggests the possible occurrence of *Tethyochonetes*. In fact, it is ornamented by bifurcating, rounded, coarse costellae, numbering 9 per 5 mm at mid-valve. The interspaces between costellae are wide, deep and rounded as those characterising the genus.

According to Chen et al. (2000) *Tethyochonetes* occurs in the Lopingian of China from Nyalam County to the Zhejiang Province and in northwest Vietnam.

Suborder Productidina Waagen, 1883

Superfamily Productoidea Gray, 1840

Family Productellidae Schuchert, 1929

Subfamily Margiferinae Stehli, 1954

Tribe Margiferini Stehli, 1954

Genus *Spinomarginifera* Huang, 1932

Type species: *Spinomarginifera kueichowensis* Huang, 1932

?Spinomarginifera sp. ind.

Pl. 1, fig. 9

Material. 2 dorsal valves: MPUM8464 (KK68-20); MPUM 8465 (KK89-1).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, bed KK89, loose sample KK68, Panjshah section. Late Wordian.

Remarks. Two, poorly preserved and deformed specimens probably suggest the occurrence of the genus *Spinomarginifera*. In fact, the dorsal valve - 24.6 mm wide - is geniculated and ornamented by narrow and irregular rugae and fine, elongate spine bases. Long spines seem to arise anteriorly from the dorsal trail. It may be close to *S. labaensis* (Likharev, 1936) from the Gnishik Formation of Armenia for their large size and ornamentation.

The genus *Spinomarginifera* occurs in the Guadalupian-Lopingian of South China (Huang, 1932), Thailand, Elbuz Mountains (Iran) (Fantini Sestini 1965c), Armenia (Ruzhentsev & Sarycheva 1965), Central Tibet (Shi & Shen 2001), Baoshan Block (Shi & Archbold 1998), Peninsular Malaysia (Sone et al. 2001), Indochina (Shi & Shen 1998), and Japan (Yanagida 1973).

Tribe Paucispiniferini Muir-Wood & Cooper, 1960

Genus *Retimarginifera* Waterhouse 1970

Type-species: *Retimarginifera perforata* Waterhouse, 1970

Retimarginifera gaetanii Angiolini 1995

Pl. 1, figs. 1-3

1995 *Retimarginifera gaetanii* Angiolini, p. 204, fig. 16.3.
1995 *Retimarginifera gaetanii* - Gaetani et al., pl. 10, fig. 6-7.

Material. 2 conjoined shells: MPUM8466 (KK68-19); MPUM8472 (KK79-31); 5 ventral valves: MPUM8467 (KK67-8); MPUM8468 (KK79-27); MPUM8469 (KK88-9,-11); MPUM8470 (KK88-10); 1 dorsal valve MPUM8471 (KK77-25).

Occurrence and age. Central Karakorum, Chapursan Valley,

Panjshah Formation, Mb. 2, beds KK67, KK77, KK79, KK88, loose sample KK68, Panjshah section. Late Wordian.

Remarks. *R. gaetanii* is characterised by its weakly transverse shape, its deep sulcus, ornamentation of fine and numerous ribs, and a strongly reticulate visceral disc.

It is similar to *Retimarginifera lapparenti* (Termier et al., 1974) from the Guadalupian of Central Afghanistan, from which it differs by its narrower and deeper sulcus.

Lamnimargus himalayensis (Diener, 1899) from the late Guadalupian-Lopingian of the Tethys Himalaya is characterised by its coarser costae, less reticulate disc and by the occurrence of multiple trails in the dorsal valve.

Retimarginifera sp. ind.

Pl. 1, fig. 4

1995 *Retimarginifera* sp. ind. - Gaetani et al., pl. 10, fig. 5.

Material. 1 conjoined shell: MPUM8473 (KK79-4); 3 ventral valves: MPUM8474 (KK79-5); MPUM8475 (KK67-5); MPUM8476 (KK68-16); 2 dorsal valves: MPUM8477 (KK68-2,-18).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KK67, KK79, loose sample KK68, Panjshah section. Late Wordian.

Description. Concavo-convex, geniculate shell with sub-rectangular outline; maximum width at the hinge. Specimen KK79-4 has a maximum width of 14.4 mm and a length of 10.7 mm. Ventral valve with narrow and shallow median sulcus beginning 5 mm anterior to the umbo. Dorsal valve with low and rounded fold appearing distinctly only anterior to the visceral disc.

Ornamentation of ribs and fine rugae producing a reticulate pattern on the disc. The ribs increase by intercalation up to 10 for each flank at the anterior margin and broaden anteriorly up to 0.6-0.7 mm at the anterior margin. The ventral sulcus is ornamented by two converging, fine ribs. Rarely cicatrix of attachment of spines have been detected.

Dorsal valve interior with raised pear-shaped adductor scars.

Discussion. This species of *Retimarginifera* is characterised by its narrow and shallow ventral sulcus and coarse ribs. *Retimarginifera* sp. ind. differs from *R. praelecta* (Reed, 1925) by its shallower sulcus and more numerous ribs; from *R. gaetanii* because of its narrower and shallower ventral sulcus and the fewer and coarser ribs; from *R. rimuensis* (Merla, 1934) by its finer and more numerous costae, the deeper ventral sulcus and a less enrolled ventral valve.

Family Productidae Gray, 1840

Subfamily Leioproductinae Muir-Wood & Cooper, 1960

PLATE 1

All x 1 except when specified

Fig. 1-3 - *Retimarginifera gaetanii* Angiolini - 1: ventral view of specimen MPUM8472 (KK79-31); 2-3: ventral valves, specimens MPUM8468 (KK79-27) and MPUM8470 (KK88-10).

Fig. 4 - *Retimarginifera* sp. ind. - Ventral view of a conjoined specimen, MPUM8473 (KK79-4).

Fig. 5 - *Magniplicatina* sp. ind. - Ventral valve, specimen MPUM8482 (KK79-6).

Fig. 6-7 - *Compressoproductus* cf. *mongolicus* (Diener) - 6,7: ventral valves, specimens MPUM8483 (KK88-8) and MPUM8484 (KK67-34).

Fig. 8 . - *?Tethyochonetes* sp. ind. - Dorsal valve, specimen MPUM8463 (KK68-22).

Fig. 9 - *?Spinomarginifera* sp. ind. - Dorsal valve external mould, specimen MPUM8464 (KK68-20).

Fig. 10 - *Leptodus* sp. ind. - Ventral valve interior, specimen MPUM8486 (KL1-1).

Fig. 11 - *Pseudoantiquatonia* sp. ind. - Dorsal valve interior and external mould, specimen MPUM8478 (KK68-4).

Fig. 12 - *Peltichia* sp. ind. - Oblique-dorsal view of a conjoined specimen MPUM8487 (KK67-16).

Fig. 13-15, 17-23 - *Stenoscisma* aff. *armenica* Sokol'skaya - 13: ventral view of a conjoined specimen MPUM8494 (KK67-29); 14-15: ventral and dorsal views of a conjoined specimen MPUM8496 (KJ84-5); 17-18: ventral and dorsal views of a conjoined specimen MPUM8497 (KT9-1); 19-20: dorsal (2,5 x) and ventral view of a ventral valve showing spondylium, specimen MPUM8498 (KJ84-8); 21-22: ventral (2,5 x) and dorsal views of a dorsal valve showing camarophorium with intercamarophorial plate, specimen MPUM8499 (KJ84-7); 23: ventral view of a conjoined specimen MPUM8495 (KJ84-3).

Fig. 16 - *Linoproductus* sp. ind. - Ventral valve, specimen MPUM8481 (KK68-28).

Fig. 24-28 - *Stenoscisma* cf. *purdoni* Davidson - 24: dorsal view of a conjoined specimen MPUM8508 (KJ84-16); 25-26: ventral and dorsal views of a conjoined specimen MPUM8510 (KJ87-2); 27-28: ventral and dorsal views of a conjoined specimen MPUM8509 (KJ85-8).

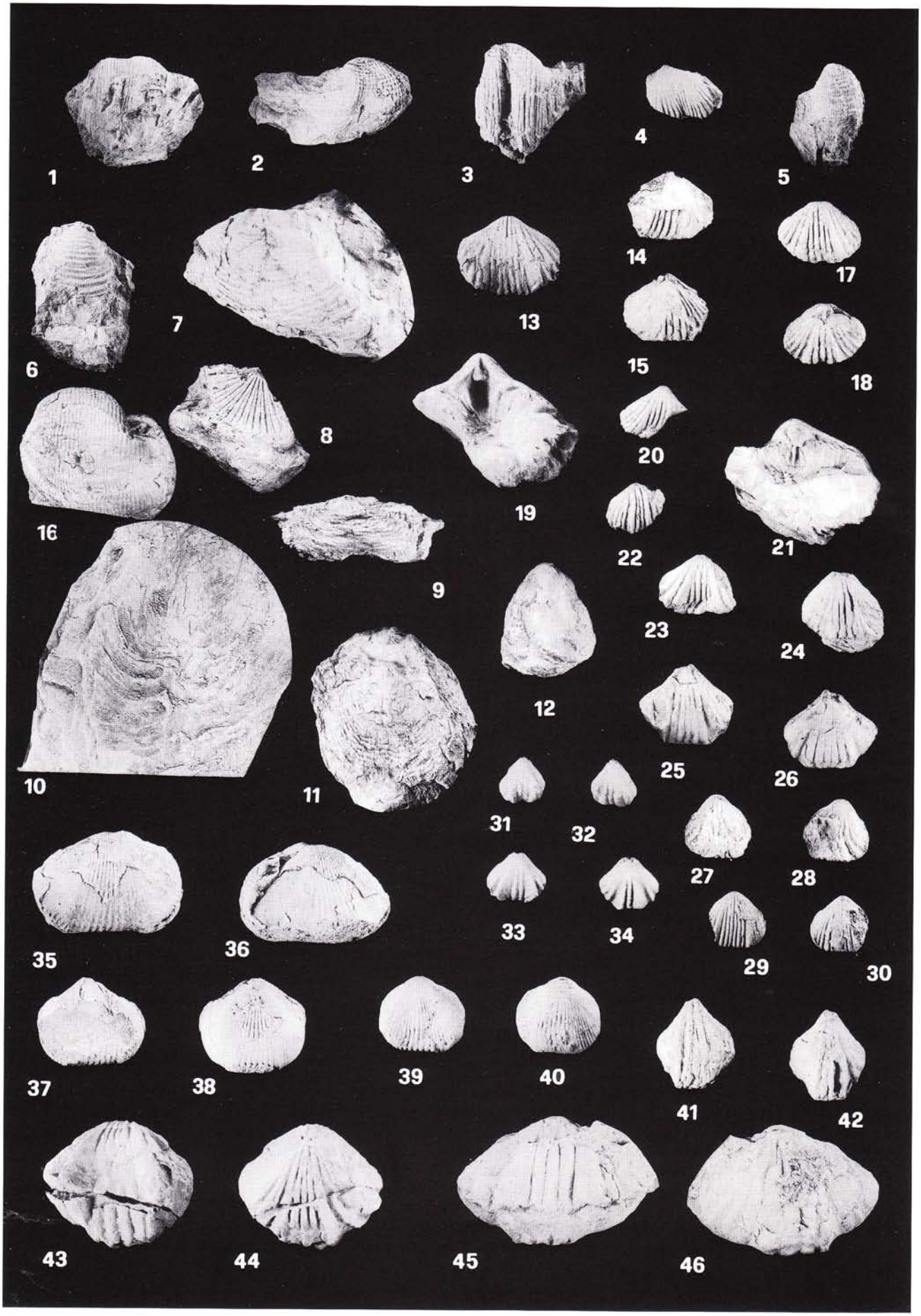
Fig. 29-30 - *Lirellaria* sp. ind. - Ventral and dorsal views of a conjoined specimen MPUM8527 (KK79-22).

Fig. 31-34 - *Pontisia* sp. ind. - 31-32: ventral and dorsal views of a conjoined specimen MPUM8524 (KT1-1); 33-34: ventral and dorsal views of a conjoined specimen MPUM8525 (KT1-2).

Fig. 35-40 - *Anchorhynchia cimmerica* n. sp. - 35-36: ventral and dorsal view of a conjoined specimen MPUM8515 (KT9-3), holotype; 37-38: ventral and dorsal views of a conjoined specimen MPUM8516 (KJ85-14); 39-40: ventral and dorsal views of a conjoined specimen MPUM8517 (KJ78-1).

Fig. 41-42 - *Terebratuloidea* sp. A - Ventral and dorsal views of a conjoined specimen MPUM8528 (KJ85-16).

Fig. 43-46 - *Terebratuloidea* sp. B - 43-44: ventral and dorsal views of a conjoined specimen MPUM8529 (KJ87-16); ventral and dorsal views of a conjoined specimen MPUM8530 (KJ87-17).


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46

Tribe Tyloplectini Termier & Termier, 1970

Genus *Pseudoantiquatonia* Zhan & Wu, 1982

Type species: *Pseudoantiquatonia mutabilis* Zhan & Wu, 1982

Pseudoantiquatonia sp. ind.

Pl.1, fig. 11

Material. 2 ventral valves: MPUM8479 (KK77-22,-23); 1 dorsal valve: MPUM8478 (KK68-4).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, bed KK77, loose sample KK68, Panjshah section. Late Wordian.

Remarks. Three poorly preserved specimens suggest the occurrence of a Tyloplectini, probably *Pseudoantiquatonia* as the ribbing is fine. They are characterised by planoconvex shells with trails. The ventral valve is sulcate, with rugae on the visceral disc and elongate spine bases producing ribs anteriorly. The dorsal valve is flat, with visceral disc about 27 mm wide and 20.4 mm long, ornamented by rugae, striae and dimples. Dorsal interior with faint trace of a myophragm.

Pseudoantiquatonia occurs in the Wordian Xiala Formation of Xainza, Lhasa Block (Tibet) (Zhan & Wu, 1982) and in the Wordian Shazipo Formation of Western Yunnan (Shi, 2000; Shi & Shen, 2001).

Superfamily Linoproductoidea Stehli, 1954

Family Linoproductidae Stehli, 1954

Subfamily Linoproductinae Stehli, 1954

Genus *Linoproductus* Chao, 1927

Type species: *Productus cora* d'Orbigny, 1842

Linoproductus sp. ind.

Material. 2 ventral valves: MPUM8480 (KK67-11); MPUM8481 (KK68-28).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, bed KK67, loose sample KK68, Panjshah section. Late Wordian.

Remarks. Two poorly preserved specimens belonging to the genus *Linoproductus* have been recognised. They are characterised by deep, strongly enrolled ventral valves - suggesting a deep corpus cavity - about 29 mm wide and 33 mm long, ornamented by costellae, very low and irregular rugae and spines. Costellae are rather coarse, widely spaced and number about six per 5 mm at 15 mm from the umbo. They are slightly sinuous and deflected around rather large spine bases.

Family Monticuliferidae Muir-Wood & Cooper, 1960

Subfamily Auriculispinae Waterhouse, 1986

Genus *Magniplicatina* Waterhouse, 1983

Type species: *Cancrinella magniplica* Campbell, 1953

Magniplicatina sp. ind.

Pl. 1, fig. 5

1925 *Productus cancriniformis* - Reed, p. 24, pl. 5, fig. 7-8.
1965a *Cancrinella cancriniformis* - Fantini Sestini, p. 57, pl. 5, fig. 11.
1995 *Magniplicatina* sp. ind. - Gaetani et al., pl. 10, fig. 10.

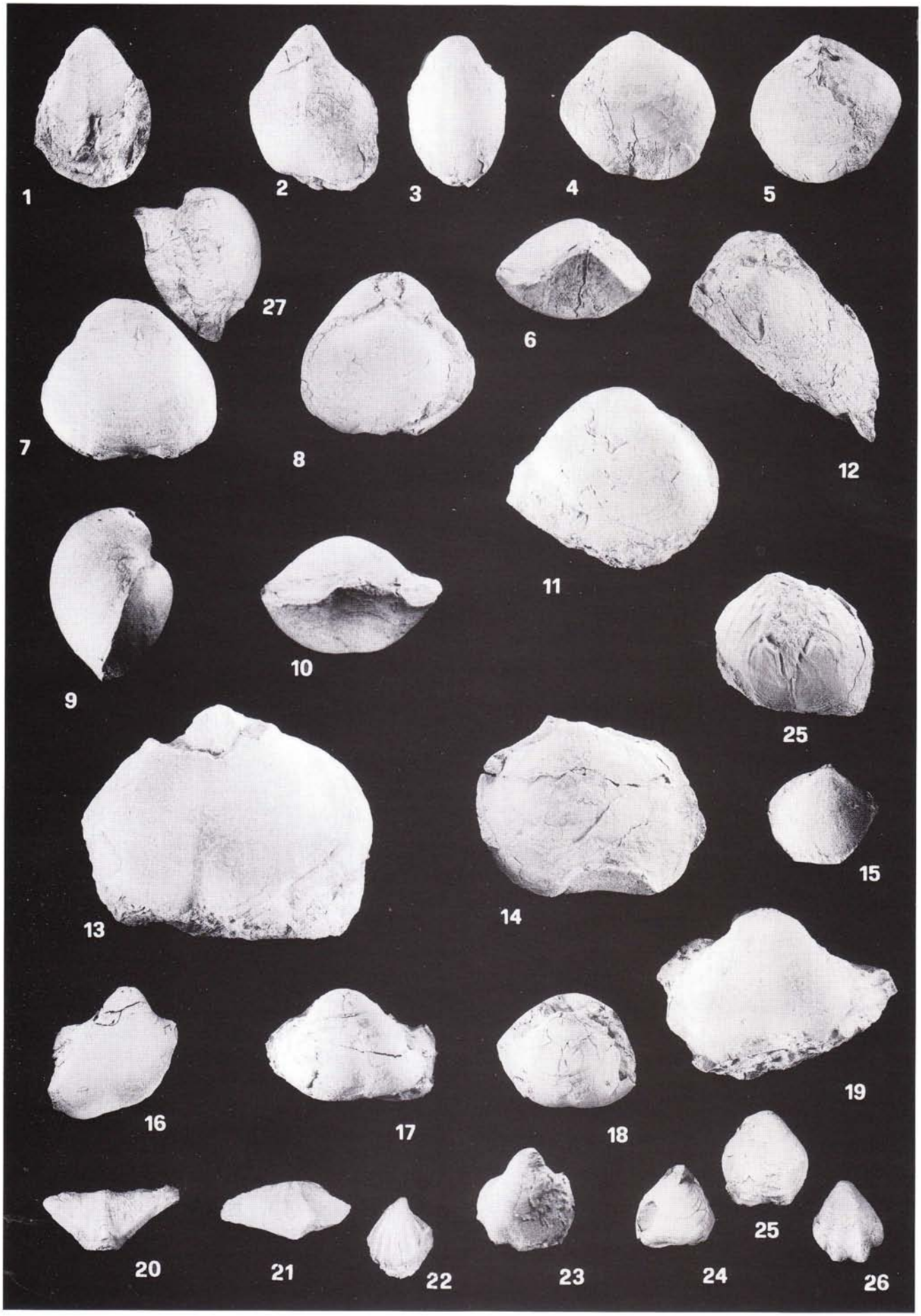
Material. 1 ventral valve: MPUM8482 (KK79-6).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, bed KK79, Panjshah section. Late Wordian.

Description. Ventral valve convex with pointed, swollen and strongly incurved umbo and with subcircular outline. Maximum width of 10.4 mm anterior to the hinge; corresponding length of 13.3 mm. Ears small and flat.

PLATE 2
All x 1

Fig. 1 - *Spirigerella* sp. ind. - Ventral valve, specimen MPUM8532 (KK67-35).
Fig. 2-3, 27 - *Attenuatella* sp. ind. - 2-3: ventral valves, specimens MPUM8537 (KK80-1); MPUM8538 (KK67-40); 27: lateral view of a ventral valve, specimen MPUM8539 (KK67-21).
Fig. 4-10 - *Martinia subtriquetra* Merla - 4-6: ventral, dorsal and anterior view of a conjoined specimen MPUM8541 (KT6-1); 7-10: ventral, dorsal, lateral and anterior view of a conjoined specimen MPUM8543 (KJ85-2).
Fig. 11-12 - *Martinia* sp. ind. - 11: ventral valve, specimen KT8-1; 12: dorsal views of a conjoined specimen MPUM8544 (KK79-28).
Fig. 13-14, 25 - *Chapursania tatianae* Angiolini - 13: ventral valve, specimen MPUM8548 (KJ87-1); 14: dorsal view of a conjoined valve MPUM8549 (KK67-63); 25: ventral view of an internal mould of a conjoined specimen MPUM8550 (KK67-19).
Fig. 15 - *Orthotichia* cf. *avushensis* Sokol'skaya in Ruzhentsev & Sarycheva - Dorsal valve, specimen MPUM8493 (KJ78-7).
Fig. 16 - *Martiniopsis* sp. ind. - Ventral valve, specimen MPUM8565 (KK68-14).
Fig. 17-19 - *Tiramnia* aff. *tschernyschewi* Grunt - 17-18: ventral and postero-ventral views of ventral valve, specimen MPUM8561 (KK67-57); 19: ventral valve, specimen MPUM8563 (KK67-3).
Fig. 20-21 - *Tipispirifer* sp. ind. - Dorsal and ventral views of a conjoined specimen MPUM8588 (KK67-40).
Fig. 22 - *Hustedia* sp. - Ventral valve, specimen MPUM8535 (KJ85-28).
Fig. 23 - ?*Squamularia* sp. ind. - Ventral valve, specimen MPUM8589 (KJ85-3).
Fig. 24-25 - *Rostranteris* sp. ind. - 24: dorsal view of a conjoined specimen MPUM8595 (KK68-A); 25: ventral view of conjoined specimen MPUM8592 (KK67-31); 24: ventral view of a conjoined specimen MPUM8598 (KJ87-23).


1
2
3
4
5
27
6
7
8
12
11
9
10
25
15
13
14
19
16
17
18
20
21
22
23
24
25
26

Ornamentation of rugae, costellae and spines. The rugae, which are prominent (0.6-0.9 mm in length) and irregular, are distributed over the entire valve. The costellae are fine, broaden anteriorly and increase by bifurcation, numbering 13 per 5 mm at 10 mm from the umbo. The spine bases are elongate and distributed over ventral corpus and ears.

Discussion. This specimen of *Magniplicatina* is characterised by its strong convexity, its incurved umbo and by the ornamentation of fine costellae and prominent rugae crossing the venter. The specimens from NE Karakorum described by Merla (1934) as *P. cancriniformis* (1934, p. 261, pl. 25, figs. 24-26) resemble the studied specimen in their ornamentation but show a less compressed shape.

Subfamily Compressoproductinae Jin & Hu, 1978

Genus *Compressoproductus* Sarycheva, 1960

Type-species: *Productus compressus* Waagen 1884, non Say 1823

Remarks. According to Waterhouse & Piyasin (1970), the genus *Compressoproductus* is based on *P. compressus* Waagen, 1884 from the Wargal Formation of Salt Range, which is a junior homonym of *P. compressus* Say, 1823 (Branson 1948). Waterhouse & Piyasin (1970) suggested to rename Waagen species as *P. morhapressus*, designating the specimen figured by Waagen (1884, Pl. 81, fig. 1a-d) as the lectotype.

The genus *Compressoproductus* differs from *Striatifera* Chao, 1927 by its ornamentation of pronounced rugae and the internal characters; from *Permundaria* Nakamura, Kato & Choi, 1970 by its narrower hinge and the convex ventral corpus.

The specimens from the Guadalupian of Wardak described and figured by Termier et al. (1974, pl. 27, figs. 1-3) as *Permundaria sisophonensis* Nakamura, Kato & Choi, 1970 seem to belong to the genus *Compressoproductus*, differing from the material under study by more irregularly arranged rugae.

Compressoproductus cf. **mongolicus** (Diener, 1897)

Pl. 1, figs. 6-7

1934 *Productus mongolicus* - Merla, p. 265.

Material. ventral valves: MPUM8483 (KK88-8) ; MPUM8484 (KK88-12); MPUM8485 (KK67-34).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KK67 and KK88, Panjshah section. Late Wordian.

Description. Ventral valve convex with subtriangular outline. Umbo pointed; hinge narrow. Ears small and flat.

Ornamentation of ribs and rugae. The ribs are very fine and number 17-18 per 5 mm at the anterior margin. The rugae are regularly spaced and number 5-6 per 5 mm in the umbonal region; anteriorly they are coarser and higher and number 3-4 per 5 mm.

Dimensions (in mm):

	W	L
KK88-8	14.6	15.9
KK88-12	6.8	7.9

Discussion. The Karakorum specimens resemble *C. mongolicus* from Chitichun in their fine ornamentation, but show anteriorly more pronounced rugae. The specimens from NE Karakorum described by Merla (1934) as *C. mongolicus* are very similar to the studied material. The same holds true for the Pamirian specimens described as *C. mongolicus* by Grunt & Dmitriev (1973) which show pronounced rugae.

Other occurrences. *C. mongolicus* was originally described by Diener (1897) from the Capitanian Chitichun Limestone of S Tibet. *C. mongolicus* occurs in the Permian of NE Karakorum (Merla 1934), at the base of the Takhtabulak Formation of SE Pamir (Grunt & Dmitriev 1973) and in the Capitanian-Lopingian of South China (Huang 1932).

Suborder Lyttoniidina Williams, Harper & Grant, 1997

Superfamily Lyttonioidea Waagen, 1883

Family Lyttoniidae Waagen, 1883

Subfamily Lyttoniine Waagen, 1883

Genus *Leptodus* Kayser, 1883

Type-species: *L. richthofeni* Kayser, 1883

Leptodus sp. ind.

Pl. 1, fig. 10

Material. 1 ventral valve: MPUM8486 (KL1-1); 1 fragment of dorsal valve interior: KK68-9.

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, loose sample KK68, Panjshah section; Abgarch Valley, at 4100 m a.s.l. above Pariar, Panjshah Formation, Mb. 2, sample KL1 Late Wordian.

Remarks. Two specimens suggest the occurrence of the genus *Leptodus* in the Panjshah fauna. The ventral valve interior shows a sharp, arcuate septum and part of the attachment flap. The dorsal valve interior shows a symmetrical septal apparatus with 6 blunt septa.

Class **Rhynchonellata** Williams, Carlson, Brunton, Holmer & Popov, 1996

Order Orthida Schuchert & Cooper, 1932

Suborder Dalmanellidina Moore, 1952

Superfamily Enteletoidea Waagen, 1884

Family Enteletidae Waagen, 1884

Genus *Peltichia* Jin & Liao in Jin & Sun, 1981

Type species: *Paraenteletes sinensis* mut. *zigzag* Huang, 1933

Remarks. The genus *Peltichia* has been revised by Shen et al. (1999) to include several enteletids from Armenia, Pamir, Vietnam, South China, Japan previously placed in *Paraenteletes* King, 1931 and *Enteletina* Schuchert & Cooper, 1931. It differs from allied enteletids by its large, weakly plicate, dorsally sulcate shell, internally characterised by a thickened, raised dorsal adductor platform.

The genus ranges from the late Cisuralian to the late Lopingian in the Tethyan Realm.

Peltichia sp. ind.

Pl. 1, fig. 12

1973 *Paraenteletes ruzhencevi* Sokol'skaya - Grunt & Dimitriev, p. 80, pl. 1, fig. 8.

Material. 1 conjoined shell: MPUM8487 (KK67-16); 1 ventral valve: MPUM8488 (KK77-20); 1 dorsal valve: MPUM8489 (KJ84b-1).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KK67, KK77, KJ84, Panjshah section. Late Wordian.

Description. Subequally biconvex, globose shell with subtriangular outline. Maximum width anterior to mid-length. Sulcate anterior commissure followed by zig-zag plications. Ventral valve with a narrow, subangular median plica flanked by at least one plication on each side. Dorsal valve with swollen, high and incurved umbo. Dorsal sulcus narrow, starting from the umbo and widening anteriorly, flanked by at least two plications for each side originating at mid-valve. Both valves display the typical tubular costellate ornamentation.

Ventral valve interior with long, subparallel dental plates and median septum.

Dorsal valve interior with raised adductor platform.

Dimensions (in mm):

	W	L	Th
KK67-16	17.5	21.2	18.2

Discussion. The Karakorum specimens are mostly similar to the Pamirian ones described as *Paraenteletes ruzhencevi* (Sokol'skaya in Ruzhentsev & Sarycheva, 1965) by Grunt & Dimitriev (1973). Both differ from the Armenian Lopingian *P. ruzhencevi* - already included in the genus *Peltichia* by Shen et al. (2000) - by a less wide and less transverse outline, narrower dorsal sulcus and narrower, more angular plicae. This suggest that these specimens may belong to a different species.

Family Schizophoriidae Schuchert & Le Vene, 1929

Genus *Orthotichia* Hall & Clarke, 1892

Type species: *Orthis? morganiana* Derby, 1874.

Remarks. The genus *Orthotichia* differs from *Acosarina* Cooper & Grant, 1969 in having a non sulcate dorsal valve, longer dental plates and a lower but longer ventral septum; *Kotlaia* Grant, 1993 is a small, biconvex schizophoriid genus characterised by a weakly sulcate commissure and a very long, low ventral median septum.

Orthotichia cf. **avushensis** Sokol'skaya in Ruzhentsev & Sarycheva, 1965

Pl. 2, fig. 15

Material. 1 conjoined shell: MPUM8490 (KK67-15); 2 ventral valves: MPUM8491 (KK67-38; KK77-13); 2 dorsal valves: MPUM8492 (KJ85-5); MPUM8493 (KJ78-7).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KK67, KK77; KJ85; KJ78, Panjshah section. Late Wordian.

Description. Medium sized, biconvex shell with tear-drop shaped outline and maximum width anterior to mid-valve. Anterior commissure rectimarginate. Ventral valve with high umbo, flattening anteriorly. Dorsal valve more convex than ventral one.

Ornamentation of costellae arising by intercalation, numbering about 15-18 per 5 mm at the anterior margin, and growth lamellae.

Interior of ventral valve with long dental plates and a low median septum.

Dimensions (in mm):

	W	L	Th
KK67-15	28,5	28,2	13.6
KJ85-5	18,2	17.3	
KJ78-7	17,8	17,1	

Discussion. The Karakorum specimens, although not well preserved, are very similar to *Orthotichia avushensis* from Armenia (Ruzhentsev & Sarycheva 1965) and SE Pamir (Grunt & Dmitriev 1973) by their particular outline, convexity and ornamentation.

Other occurrences. *O. avushensis* occurs in the Guadalupian Gnishik Formation of Armenia (Ruzhentsev & Sarycheva 1965) and at the base of the Takhtabulak Formation of SE Pamir (Grunt & Dmitriev 1973).

Order Rhynchonellida Kuhn, 1949

Superfamily Stenoscismatoidea Oehlert, 1887

Family Stenoscismatidae Oehlert, 1887

Subfamily Stenoscismatinae Oehlert, 1887

Genus *Stenoscisma* Conrad, 1839

Type-species: *Terebratula schlotheimi* von Buch, 1835

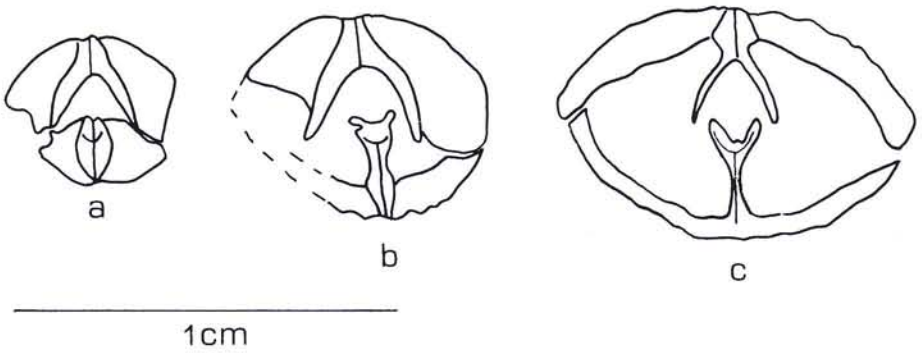


Fig. 5 - *Stenoscisma* aff. *armenica* Sokol'skaya - Specimen MPUM8531 (KJ85-7). a-c: sections respectively at 2.45 mm, 3.0 mm, 4.9 mm from the umbo.

Stenoscisma aff. **armenica** Sokol'skaya, 1965

Pl. 1, figs. 13-15, 17-23; Pl. 6, figs. 1-6, fig. 5

1965b *Stenoscisma pinguis* (Waagen, 1883) - Fantini Sestini, p. 195, pl. 23, fig. 8-11.
1973 *Stenoscisma armenica* Sokol's kaya, 1965 - Grunt & Dmitriev, p. 128-129, pl. 8, fig. 13-14; pl. 14, fig. 8.
1995 *Stenoscisma armenica* - Gaetani et al., pl. 10, fig. 9.

Material. 10 conjoined specimens: MPUM8494 (KK67-29); MPUM8495 (KJ84-3); MPUM8496 (KJ84-5); MPUM8497 (KT9-1); MPUM8500 (KJ84-1,-2,-4); MPUM8501 (KJ85-6, -9); MPUM8531 (KJ85-7); 14 ventral valves: MPUM8498 (KJ84-8); MPUM8502 (KK67-4); MPUM8503 (KK79-5); MPUM8504 (KJ84-6,-9,-10,-11,-12,-13,-14,-15); MPUM8505 (KJ85-10,-11,-12); 4 dorsal valves: MPUM8499 (KJ84-7); MPUM8506 (KK67-5 KJ84-9); MPUM8593 (KT9-2).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KK67, KK79, KJ84, KJ85, loose sample KT9, Panjshah section. Late Wordian.

Description. Medium-sized, biconvex shell with subpentagonal to transverse outline. Maximum width at mid-length. Zig-zag, uniplicate anterior commissure with trapezoidal fold. Ventral valve with sulcus beginning 4-6 mm anterior to the umbo, widening and deepening anteriorly. Dorsal valve more convex than the ventral one with flat fold, widening and standing distinctly above flanks only anteriorly.

Ornamentation of sharply crested costae, increasing by bifurcation and intercalation up to 4-5 median ribs and 4-6 ribs on each flank at the anterior margin.

Interior of ventral valve with deep spondylium, sessile at the umbo and anteriorly raised on a low median septum. Interior of dorsal valve with cardinal plate and long and curved camarophorium with intercamarophorial plate, elevated on high median septum.

Dimensions (in mm):

	W	L	Th	a
KK67-29	19.6	15	11.9	115°
KK67-4	18.1	10		105°
KT9-1	15.8	11.9	8.4	
KJ84-1	14.8	11.3	9.2	
KJ84-5	16.3	13	9.6	
KJ85-6	17.7	13	11.1	
KJ85-7	17.9	15.1	8.5	

Discussion. *Stenoscisma armenica* has been erected by Sokol'skaya (in Ruzhentsev & Sarycheva 1965) for the Wuchiapingian of Armenia. According to Sokol'skaya, *S. armenica* differs from *S. purdoni* (Davidson, 1862) by its small size, fewer costae and lower uniplicature; from *S. venusta* (Girty, 1909) by its ventral sulcus beginning anterior to the umbo. In fact, *S. purdoni* from the Wargal Formation of Salt Range has a very variable number of costae (from 10 to 18 on the entire valve) and a less transverse, subtriangular outline, with greater length. The specimens from Karakorum and those from SE Pamir (Grunt & Dimitriev 1973) slightly differ from the Armenian *S. armenica* in having a more convex ventral valve, an higher and pointed ventral umbo and finer costae.

Among the Stenoscimatacean specimens from NE Karakorum studied by Merla (1934) there are some unpublished specimens assigned by the author to *Camarophoria humbletonensis* (Howse, 1848) which probably belong to *S.* aff. *armenica*; others, described as *C. mutabilis* Chernyshev, 1902 in Merla (1934), belong to a different species of *Stenoscisma*, being characterised by fewer (3 on the sulcus, 4 on the fold and 2-3 on each flank) and wider (1.5-1.7 mm in width) costae.

The specimens described as *S. pinguis* (Waagen, 1883) from Shaksgam by Fantini Sestini (1965b) are closely related to the specimens under examination.

Other occurrences. *S.* aff. *armenica* occurs in the Permian of NE Karakorum (Rimu Glacier) (Merla 1934), Shaksgam (Fantini Sestini 1965b) and in the basal Takhtabulak Formation SE Pamir (Grunt & Dmitriev 1973).

Stenoscisma cf. **purdoni** (Davidson, 1862)

Pl. 1, figs. 24-28

Material. 11 conjoined shells: MPUM8507 (KK67-85); MPUM8508 (KJ84-16); MPUM8509 (KJ85-8); MPUM8510 (KJ87-2); MPUM8511 (KJ85-13); MPUM8512 (KJ87-3,-4,-5,-6,-7,-8); 2 ventral valves: MPUM8513 (KJ87-9,-10); 5 dorsal valves: MPUM8514 (KJ87-11,-12,-13,-14,-15).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KK67, KJ84, KJ85, KJ87, Panjshah section. Late Wordian.

Description. Medium-sized, biconvex shell with subtriangular outline. Maximum width anterior to mid-length. Zig-zag, uniplicate anterior commissure with high, sub-rectangular fold. Ventral valve with sulcus beginning anterior to the umbo, deepening and widening

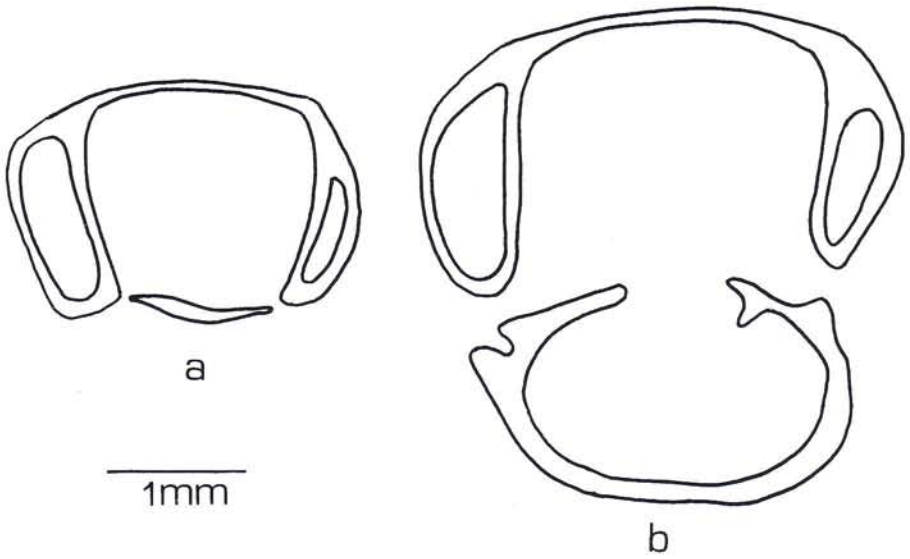


Fig. 6 - *Anchorhynchia cimmerica* n. sp. - Specimen MPUM8517 (KJ78-1). a-b: sections respectively at 0.5 mm, 0.8mm from the umbo.

anteriorly. Anteriorly, the sulcus is well delimited from the flanks of the valve by steep and smooth slopes. Dorsal valve with rather distinct fold widening anteriorly.

Ornamentation of prominent, generally rounded crested costae very variable in number, numbering 3-6 on the sulcus and fold and 4-7 on each flank at the anterior margin. Growth lines are also present.

Interior of ventral valve with deep spondylium.

Dimensions (in mm):

	W	L	Th
KJ84-16	16.3	13.3	12.2
KJ85-8	12.7	12	7.2
KJ87-2	18.2	14	11.2
KJ87-5	12.7		6.8
KJ87-13	12.1	10	8.4

Discussion. These specimens are characterised by their high uniplicature, their sub-triangular outline and the highly variable number of costae, thus resembling *Stenoscisma purdoni* from the Wargal Formation of Salt Range. However, the Karakorum specimens show a deeper sulcus and a more elongate outline than the Salt Range species.

Other occurrences. *S. purdoni* occurs in the Wargal Formation of Salt Range (Waagen, 1884), in Shaksgam, in the Chitichun Limestone (S Tibet), and in Timor (Broili, 1996).

Superfamily Wellerelloidea Likharev in Rzhonsnitskaya, 1956

Family Wellerellidae Likharev in Rzhonsnitskaya, 1956

Subfamily Uncinunellininae Savage, 1996

Genus *Anchorhynchia* Ching & Ye in Jin et al., 1979

Type-species: *Anchorhynchia madoensis* Ching & Ye in Jin et al., 1979

Remarks. The genus *Anchorhynchia* Ching & Ye was proposed to include those *Uncinunellina*-like species which are costate from the beak.

The problem of the semicostation of *Uncinunellina* Grabau, 1932 was raised by Grant (1976), who examined topotype specimens of its type-species *U. theobaldi* (Waagen, 1884) from the Wargal Formation of the Salt Range, describing in detail the internal characters (short dental plates and divided hinge plate) and the features of the marginal spines and the anterior commissure (geniculation of the valve margins producing a flat anterior surface). In fact, if the Salt Range [*U. theobaldi* and *U. jabiensis* (Waagen, 1884)] and Thai species (*U. mitigata* Grant, 1976) are semicostate, Grabau's concept of the genus included also species costate to the umbo, such as some of the specimens from Basleo (Timor) described as *U. timorensis* (Beyrich, 1865) by Broili (1916) and *U. wangenheimi* (Moeller, 1862) from China. According to Grant (1976) only the species with costae beginning far forward from the umbo can be surely ascribed to *Uncinunellina*: so among the specimens from Timor only that figured by Broili (1916) in pl. 13, fig. 1 is an *Uncinunellina*. However, the costate specimens of *Uncinunellina?* figured by Grant (1976, pl. 48, figs. 18-31) do not show an uncinuloid shape and geniculate margins, but they have a convex ventral valve and a commissure as in normal Rhynchonelloids and should therefore be excluded both from *Uncinunellina* and *Anchorhynchia*.

According to Savage (1996) the diagnosis of the subfamily Uncinunellininae includes Wellerellidae with anteriorly flattened costae and marginal spines developed from intertroughs, thus enhancing the importance of the uncinuloid shape. This means that uncinuloid semicostate species should belong to *Uncinunellina*, whereas uncinuloid fully costate species should be included in *Anchorhynchia*.

Different Asian specimens - previously placed in *Uncinunellina* -, such as those figured by Diener (1897) from Chitichun, by Broili (1916 in pl. 12, fig. 12, pl. 13, fig. 2) from Timor, by Renz (1940) from NE Karakorum, by Fantini Sestini (1965b) from Shaksgam, by

Grunt & Dmitriev (1973) from SE Pamir, by Ruzhentsev & Saricheva (1965) from Armenia, show a transverse, uncinuloid shape (geniculate valve margins and flattened costae meeting in a plane), a flat ventral valve, and a fully costate ornamentation. Therefore, they should be included in the genus *Anchorhynchia*. The same holds true for the specimens from Pietra di Salomone described by Gemellaro (1898) as *Uncinulus velifer* Gemellaro, 1898.

The distribution of the genus *Anchorhynchia* - overlapping in part with that of *Uncinunellina* - is significant, the genus occurring in the Guadalupian-Lopingian of the northern Gondwana margin, Mega Lhasa, Northwestern China (Jin et al. 1979) and South China (Shen et al 1992), from north of the paleoequator to south of the southern paleotropic in the Tethyan realm, Cimmerian Region and Himalayan Province.

Anchorhynchia cimmerica n. sp.

Pl. 1, figs. 35-40; Pl. 6, figs. 14-15, fig. 6

Holotype. A conjoined shell: MPUM8515 (KT9-3).

Derivatio nominis. Cimmerica from the Cimmerian Province.

Material. 5 conjoined specimens: MPUM8515 (KT9-3); MPUM8516 (KJ85-14); MPUM8517 (KJ78-1); MPUM8518 (KT8-2; KJ78-2); 3 ventral valves: MPUM8519 (KK67-23,-30); MPUM8520 (KT9-4); 2 dorsal valves: MPUM8521 (KK67-6); MPUM8522 (KJ85-17); fragments: MPUM8523 (KJ78-7,-8; KJ85-15).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KK67, KJ85, KJ78, KT8, loose sample KT9, Panjshah section. Late Wordian.

Description. Medium to large sized for the genus, strongly biconvex shell with transverse sub-elliptical outline and wedge-shaped profile. Maximum width slightly anterior to mid-length. Both valves geniculate anteriorly with anterior commissure strongly uniplicate. Ventral valve with shallow median sulcus beginning about mid-length, widening anteriorly. Dorsal valve much more convex than the ventral one with low and flat median fold.

Ornamentation of fine, round-crested costae beginning few mm anterior to the umbo. The costae broaden and flatten anteriorly and increase in number by bifurcation and intercalation up to 9-10 median ribs and about 13-16 ribs on each flank at the anterior margin in adults. Near the anterior margin the ribs show a median groove. The intercostal troughs are narrow and extended to interlock across the margin of the valves.

Interior of ventral valve with thin and straight dental plates, close to the valve walls, but not fused to them. Interior of dorsal valve with divided hinge plate (fig. 6).

Dimensions (in mm):

	W	L	Th
KT9-3	28.8	19.4	17.7
KJ85-14	20.5	17.2	15.8
KT8-2	12.1	10.6	8.1
KJ78-1	16.5	14.5	12

Discussion. The studied specimens are placed in the genus *Anchorhynchia* because of their uncinuloid shape and fully costate surface.

A. cimmerica n. sp. differs from *A. madoensis* Ching & Ye in Jin et al., 1979 from the Guadalupian of Mado County (Qinghai Province, NW China) by its finer costae and the orientation of the dental plates which are not fused to the lateral walls as in the type-species of the genus.

The Karakorum material resembles the fully costate specimen figured by Broili (1916, in pl. 12, fig. 12) as *U. timorensis* (Beyrich, 1865) from Bitauni (Timor) in shape and ornamentation. The Shaksgam specimens described as *U. timorensis* by Renz (1940) and Fantini Sestini (1965b) are very similar to the studied material, differing only by a slightly more transverse outline. The same holds true for those described as *U. timorensis* from the basal Takhtabulak Formation of SE Pamir (Grunt & Dmitriev 1973), which besides being more transverse, shows a deeper sulcus. However, these Pamirian specimens show straight and parallel dental plates not fused to the valve walls (Grunt & Dmitriev 1973, fig. 25, p. 113) as are those of *A. cimmerica* n. sp.

The specimens from the Gnishik Formation of Armenia figured as *U. timorensis* by Ruzhentsev & Sarycheva (1965) are very similar to the Karakorum material, except for slightly wider costae.

The specimens from Chitichun (Tibet) described as *U. timorensis* by Diener (1897) have a more variable number of median costae and a comparatively wider fold.

Family Pontisiidae Cooper & Grant, 1976

Subfamily Pontisiinae Cooper & Grant, 1976

Genus *Pontisia* Cooper & Grant, 1969

Type-species: *Pontisia stehlii* Cooper & Grant, 1969

Pontisia sp. ind.

Pl. 1, figs. 31-34; Pl. 6, figs. 11-13; fig. 7

Material. 3 conjoined specimens: MPUM8524 (KT1-1); MPUM8525 (KT1-2); MPUM8526 (KT1-3).

Occurrence and age. Central Karakorum, Shikarjerab Valley, locality KT1, Panjshah Formation, Mb. 2. Late Wordian.

Description. Biconvex, globose shell with tear-drop shaped outline. Maximum width anterior to mid-length. Anterior commissure uniplicate with high fold. Ventral valve with sulcus absent or occurring only at the anterior margin. Dorsal valve with low fold.

Ornamentation of sharp costae numbering 2 in the sulcus, 3 on the fold and 2-3 on each flank. The median costa on the fold is slightly depressed.

Interior of ventral valve with short dental plates close to the valve walls. Interior of dorsal valve with probably undivided hinge plate.

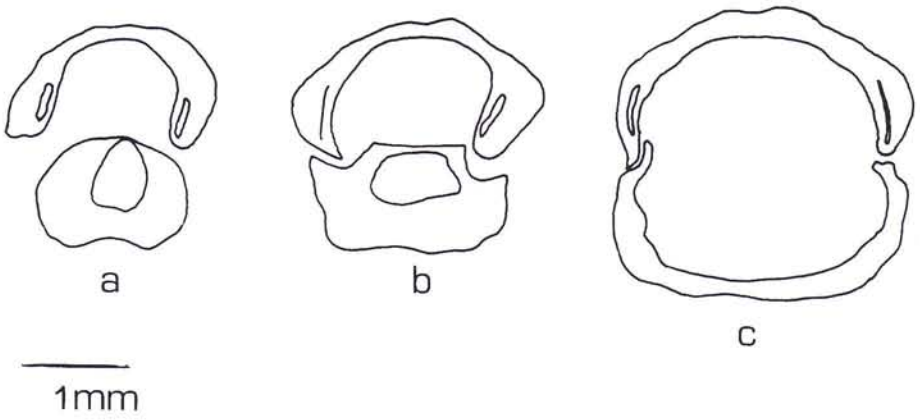


Fig. 7 - *Pontisia* sp. ind. - Specimen MPUM8524 (KT1-1). a-c: sections respectively at 1.2 mm, 1.35 mm, 2.5 mm from the umbo.

Discussion. These specimens of *Pontisia* differs from *P. exoria* Grant, 1976 from the Guadalupian of Thailand by their smaller dimensions and fewer costae; from *P. stehlii* Cooper & Grant (1976) from the Guadalupian of Texas by a less transverse outline and fewer and shorter costae.

Genus *Lirellaria* Cooper & Grant, 1976

Type-species: *Lirellaria costellata* Cooper & Grant, 1976

Remarks. *Lirellaria* differs from *Pontisia* Cooper & Grant by its costellate ornamentation; from *Wellerella* Dunbar & Condra, 1932 by the absence of a dorsal median septum supporting the hinge plate.

Lirellaria sp. ind.

Pl. 1, figs. 29-30

1995 *Lirellaria* sp. ind. - Gaetani et al., pl. 10, fig. 6-7.

Material. 1 conjoined shell: MPUM8527 (KK79-23).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, bed KK79, Panjshah section. Late Wordian.

Description. Biconvex, globose shell with subpentagonal outline. Maximum width of 10 mm anterior to mid-length; length 9.5 mm. Anterior commissure uniplicate with wide and rounded fold. Ventral valve with a very shallow sulcus occurring only at the anterior margin. Dorsal valve without fold.

Ornamentation semicostate. Costae number 6 in the sulcus, 7 on the fold and 5 on each flank.

Interior of ventral valve with dental plates. Interior of dorsal valve with undivided hinge plate and a very low median ridge.

Discussion. This is the first identification of a species of *Lirellaria* from Asia. However, this specimen differs from the Texas species of *Lirellaria* by its finer ornamentation and different external shape. The Armenian specimens figured as *Wellerella arthaberi* (Chernyshev) by Ruzhentsev & Sarycheva (1965) are very similar to the Karakorum material and seem to lack the median septum.

Family Allorhynchidae Cooper & Grant, 1976

Genus *Terebratuloidea* Waagen, 1883

Type-species: *Terebratuloidea davidsoni* Waagen, 1883

Terebratuloidea sp. A

Pl. 1, figs. 41-42

Material. 1 conjoined shell: MPUM8528 (KJ85-16).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, bed KJ85, Panjshah section. Late Wordian.

Description. Medium, biconvex shell with subpentagonal outline; foramen subcircular. Maximum width of 15 mm, corresponding length of 17.6 mm and thickness of 9.9 mm. Ventral valve flat, with high and pointed umbo and shallow sulcus. Dorsal valve with high fold.

Ornamentation of 3 angular costae in the sulcus, 4 on the fold and 3 on each flank.

Discussion. This specimen resembles *T. depressa* Waagen, 1883 in its general shape and in the number of costae, differing by its more elongate outline.

Terebratuloidea sp. B

Pl. 1, figs. 43-46; Pl. 6, figs. 7-10

Material. 2 conjoined shells: MPUM8529 (KJ87-16); MPUM8530 (KJ87-17).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, bed KJ87, Panjshah section. Late Wordian.

Description. Large, strongly biconvex shell with transverse outline. Anterior commissure uniplicate with high fold. Ventral valve with incurved umbo and subcircular foramen. Median sulcus starting anterior to the umbo, widening and deepening anteriorly. Dorsal valve more convex than ventral valve with low and flat fold.

Ornamentation of round-crested costae, broaden-

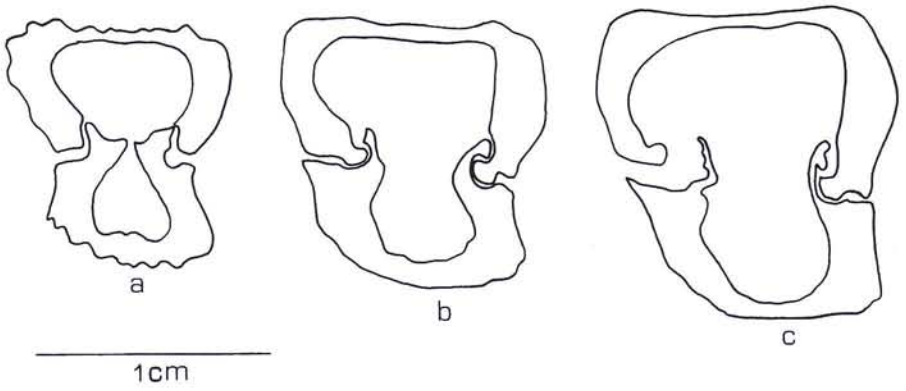


Fig. 8 - *Terebratuloidea* sp. B - Specimen MPUM8530 (KJ87-17). a-c: section respectively at 2.9mm, 4.7 mm, 5.05 mm from the umbo.

ing anteriorly and numbering 3-4 on the sulcus, 4-5 on the fold and 3-4 on each flank. Costae rarely bifurcate anteriorly.

Interior of ventral valve with strong, elongate teeth, not supported by dental plates. Interior of dorsal valve with divided, concave hinge plate. A low myophragm seems to be present (fig. 8).

Discussion. The distinctive features of these specimens are their large size, strong swelling and comparatively few costae. This combination of characters does not fit into any recognised *Terebratuloidea* species.

Terebratuloidea trochus Merla, 1934 from NE Karakorum is also inflated but has much smaller dimensions and fewer costae. *Terebratuloidea davidsoni* Waagen, 1883 is globose but has smaller dimensions and sharper costae.

Order Athyridida Boucot, Johnson & Staton, 1964
Suborder Athyrididina Boucot, Johnson & Staton, 1964
Superfamily Athyridoidea Davidson, 1881
Family Athyrididae Davidson, 1881
Subfamily *Spirigerellinae* Grunt, 1986
Genus *Spirigerella* Waagen, 1883

Type-species: *Spirigerella derbyi* Waagen, 1883

Spirigerella sp. ind.

Pl. 2, fig. 1

1995 *Martiniopsis* sp. ind. - Gaetani et al., pl. 10, fig. 11.

Material. 3 ventral valves: MPUM8532 (KK67-35); MPUM8533 (KK67-49); MPUM8534 (KK76-3).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KK67, KK76, Panjshah section. Late Wordian.

Remarks. A few specimens of *Spirigerella* have been detected in the Karakorum fauna. They show a convex ventral valve with elongate oval outline; maximum width of 18.2 mm, corresponding length 26.5 mm and thickness 10 mm. The umbo is slender, incurved and pointed. The median sulcus is deep and narrow, starting at 1/3 the length of the valve. Among the *Spirigerella* species they are closest to *Spirigerella media*, Waagen 1883 from the Wargal Formation, by their shape and depth of the sulcus.

Suborder Retziidina Boucot, Johnson & Staton, 1964
Superfamily Retzioidea Waagen, 1883
Family Neoretziidae Dagis, 1972
Subfamily Hustediinae Grunt, 1986
Genus *Hustedia* Hall & Clarke, 1893

Type species: *Terebratula mormoni* Marcou, 1858

Hustedia sp. ind.

Pl. 2, fig. 22

Material. 2 ventral valves: MPUM8535 (KJ85-18); MPUM8536 (KT9-6).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KJ85, loose sample KT9, Panjshah section. Late Wordian.

Remarks. Two small ventral valves, 7.7 mm wide and 9 mm long, are referable to *Hustedia*. They have a high and slender umbo with large foramen and are ornamented by four sharp costae on each flank. The width of the costae is 0.5 mm at the anterior margin.

They are rather similar to the Karakorum specimens described by Merla (1934) as *Hustedia* cf. *indica* Waagen, 1883. However, both differ from the original Salt Range species by the shape of the umbo.

Order Spiriferida Waagen, 1883
Suborder Spiriferidina Waagen, 1883
Superfamily Ambocoelioidea George, 1931
Family Ambocoeliidae George, 1931
Subfamily Ambocoeliinae George, 1931
Genus *Attenuatella* Stehli, 1954

Type-species: *Attenuatella texana Stehli*, 1954

Remarks. *Attenuatella* is an elongate genus with

long, attenuated and incurved umbo, characterised internally by a very long and prominent median myophragm which is indicated by a groove externally in decorticated specimens. Its micrornamentation consists of very fine spine bases.

According to Cooper & Grant (1976) it has been described, besides Texas, from the Permian of New Zealand, Australia, Mexico, Siberia, Urals, Novaya Zemlya. It also occurs in the Lopingian of Japan (Tazawa 1987) and northwest Thailand (Waterhouse 1983).

Attenuatella sp. ind.

Pl. 2, figs. 2-3, 27

Material. 5 ventral valves: MPUM8537 (KK80-1); MPUM8538 (KK67-40); MPUM8539 (KK67-21); MPUM8540 (KK67-59; KK77-18).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KK67, KK77, loose sample KK80, Panjshah section. Late Wordian.

Description. Ventral valve convex with subpentagonal to subovate outline. Maximum width around mid-valve. Umbo long, attenuated and incurved. A shallow median depression occurs anteriorly making the anterior commissure probably emarginate.

Ornamentation of sinuous growth lamellae at the anterior margin.

Interior of ventral valve with long median myophragm bisecting more than mid-valve.

Dimensions (in mm):

	W	L	Th
KK67-21	17.3	25.4	13.3
KK67-40	18	28	14.6

Discussion. These specimens are large for the genus *Attenuatella*, which is generally characterised by a small size and no details on the micrornamentation is available. However, the umbonal attenuation and the internal characters of the Karakorum specimens suggest assignement to *Attenuatella*.

Superfamily Martinioidea Waagen, 1883

Family Martiniidae Waagen, 1883

Subfamily Martiniinae Waagen, 1883

Genus *Martinia* McCoy, 1844

Type-species: *Spirifer glaber* Sowerby, 1820

Remarks. *Martinia* differs from *Tiramnia* Grunt, 1977 by its straight and simple vascular channels; from *Martiniopsis* Waagen, 1883 by the absence of dental plates.

Martinia subtriquetra Merla, 1934

Pl. 2, figs. 4-10

1934 *Martinia subtriquetra* Merla, p. 236, pl. 21, fig. 1.

1965b *Martinia subtriquetra* - Fantini Sestini, p. 204, pl. 23, fig. 17.

Material. 3 conjoined shells: MPUM8541 (KT6-1); MPUM85 (KT7-5); MPUM8543 (KJ85-2).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KT7, KJ85, loose sample KT6, Panjshah section. Late Wordian.

Description. Medium sized, biconvex shell with subpentagonal to subrhomboidal outline. Hinge narrow; maximum width at mid-length. Lateral commissures straight and anterior commissure slightly uniplicate.

Ventral valve more convex than the dorsal valve. Ventral umbo incurved with umbonal slopes regularly tapering to the cardinal extremities. Median sulcus shallow. Dorsal valve regularly convex, with subcircular to transversally subelliptical outline.

Ornamentation of sinuous growth lamellae.

Dimensions (in mm):

	W	L	Th
KT6-1	29.1	27.8	19.1
KT7-5	17.8	17.4	12.3
KJ85-2	33.3	31.9	22.9

Discussion. Specific characters of *Martinia subtriquetra* are its subpentagonal to subrhomboidal outline, wide umbonal region, straight lateral commissures and shallow ventral sulcus.

The specimens from the Murgabian (possibly Roadian-early Wordian) of SE Pamir described as *M. triquetra* Gemellaro, 1899 by Grunt & Dmitriev (1973) are rather similar to *M. subtriquetra*, differing by a deeper ventral sulcus.

Other occurrences. *M. subtriquetra* occurs in the Permian of NE Karakorum (Rimu Glacier) and of Shaksgam (Fantini Sestini 1965b).

Martinia sp. ind.

Pl. 2, figs. 11-12; Pl. 5, figs. 3-4

Material. 1 conjoined shell: MPUM8544 (KK79-28); 5 ventral valves: MPUM8545 (KK67-25,-32); MPUM8546 (KK68-17); MPUM8547 (KT8-1); MPUM8560 (KK67-51).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KK67, KK79, KT8, loose sample KK68, Panjshah section. Late Wordian.

Description. Medium to large sized, biconvex shell with oval outline. Hinge narrow; maximum width always inferior to the length.

Ventral valve strongly convex, longitudinally very incurved. Interarea not well distinct from the flanks. Median sulcus very shallow, occurring only anteriorly to mid-length and protruding dorsally as a tongue.

Dorsal valve with pointed umbo and swollen apical region.

Ornamentation of faint growth lamellae.

Interior of ventral valve with thin, straight and radially arranged vascular channels.

Dimensions (in mm):

	W	L	Th
KK67-25	26	46.5	16.5
KK67-51	18.5	30.3	13.4
KK68-17	22	31.3	18
KT8-1	35.7	35.1	

Discussion. These specimens are characterised by their longitudinally oval outline, their strongly convex and incurved ventral valve.

They differ from *M. nucula* Rothpletz, 1892 and *M. elegans* Diener, 1897 by their elongate outline; furthermore *M. elegans* shows a ventral interarea well separated from the flanks.

Genus *Chapursania* Angiolini, 1995

Type-species: *Chapursania tatianae* Angiolini, 1995

Remarks. The genus *Chapursania* has been erected by Angiolini (1995) to include species similar to *Martinia*, but possessing a much thicker shell substance, a larger and deeper muscle field and coarse, sinuous, branching vascular channels connected by transverse ones. Furthermore, the width of the hinge is greater than that of the genus *Martinia*, which is typically very short relatively to shell width. As pointed out by Cooper & Grant (1976), the genus *Martinia* possesses an evident longitudinal line of weakness in the middle of the ventral valve which does not occur in *Chapursania*.

SEM analysis of a few specimens belonging to the two genera (Pl. 5, fig. 1-4) has revealed differences in the thickness of the secondary and tertiary layers. In fact, *Martinia* sp. is characterised by a 70-80 μm-thick secondary layer and a 130 μm thick tertiary layer of coarse, irregular to prismatic calcite crystals, whereas *Chapursania tatianae* exhibits a more than 400 μm thick tertiary layer consisting of vertically stacked crystals up to 30-40 μm wide and a comparatively much thinner secondary layer. Furthermore the fabric of the tertiary layer of *C. tatianae* shows a distinct, regular transverse depositional banding with periodicity of 1-2 μm.

Another closely allied genus is *Spinomartina* Waterhouse, 1968 with type species *S. spinosa* Waterhouse, 1968. However, *Spinomartina*, besides being characterised by fine surface spinules, shows a different pattern of vascular channels (fine, simple, radiating from the muscle field) and a smaller muscle field. Furthermore, according to Waterhouse (1968) its ultrastructure is made of flexuous fibres nearly normal to the shell surface.

The genus *Chapursania* has been recently found also in the Wuchiapingian of the Himalayas (Angiolini et al. in progress).

Chapursania tatianae Angiolini, 1995

Pl. 2, figs. 13, 14, 25; Pl. 5, figs. 1-2

1995 *Chapursania tatianae* Angiolini, p. 210, fig. 16.10.
1995 *Chapursania tatianae* - Gaetani et al., pl. 10, fig. 12-14.

Material. 6 conjoined shells: MPUM8549 (KK67-63); MPUM8550 (KK67-19); MPUM8551 (KK67-20,-48); MPUM8552 (KK78-4); MPUM8555 (KK79-13,-25); 12 ventral valves: MPUM8548 (KJ87-1); MPUM8553 (KK67-1,-28,-39,-46,-61); MPUM8554 (KK68-8); MPUM8556 (KK77-12); MPUM8557 (KK79-29; KK88-3; KJ85-1); MPUM8558 (KK88-6); 1 dorsal valve: MPUM8559 (KK68-1).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KK67, KK76, KK78, KK79, KK88, KJ85, KJ87, loose sample KK68, Panjshah section. Late Wordian.

Remarks. As pointed out by Angiolini (1995), this species externally resembles *Martinia nucula* Rothpletz, 1892 from Timor in its transversally elliptical outline and occurrence of a sulcal tongue. However, the pattern of the vascular channels of Rothpletz species is unknown, preventing a direct comparison.

The species *C. tatianae* is characterised by its linear, narrow, well defined ventral sulcus which broadens anteriorly to 2/3 the length of the valve and its ornamentation of marked growth lines and lamellae, which are usually irregularly spaced.

Genus *Tiramnia* Grunt, 1977

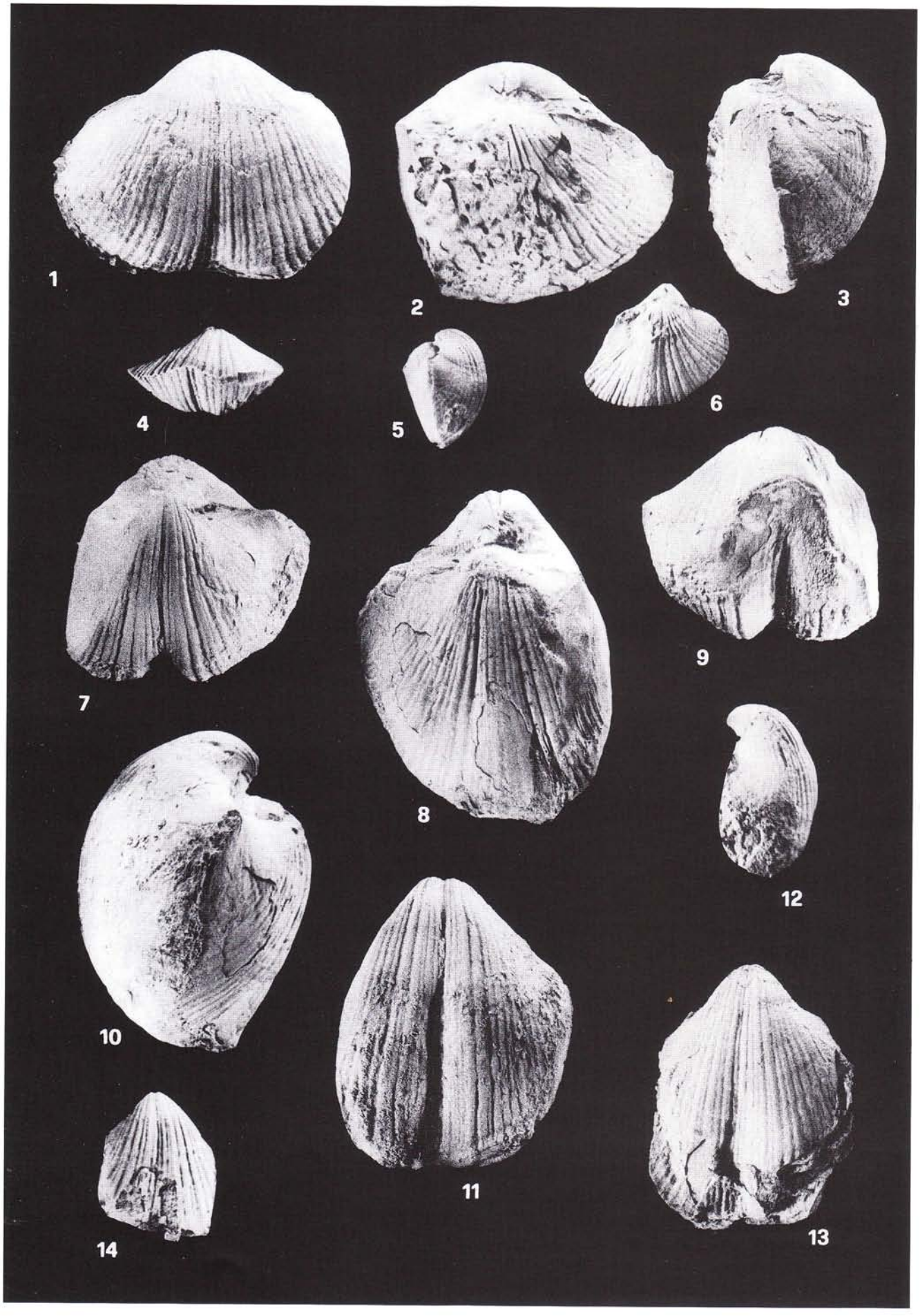
Type-species: *Martinia uralica* Chernyshev, 1902

Remarks. The genus *Tiramnia* has been erected by Grunt (1977) to include species externally similar to *Martinia*, but possessing simple, coarse and incurved vascular channels and a long median furrow dividing the muscle field. *Tiramnia* differs from *Chapursania* by its arcuate vascular channels, its smaller and narrower muscle field which is bisected by a long median groove. SEM analysis (Angiolini 1993) of a specimen belonging to *Tiramnia tscheryschewi* (Grunt in Grunt & Dmitriev,

PLATE 3
All x 1

Fig. 1-6 - *Cartorhium* aff. *lunwalensis* (Reed) - 1-3: ventral, dorsal and lateral views of a conjoined specimen MPUM8570 (KT7-2); 4-6: anterior, lateral and dorsal views of a conjoined specimen MPUM8571 (KT7-3).

Fig. 7-14 - *Elivina chapursani* n. sp. - 7-11: posterior, dorsal, anterior, lateral and ventral views of a conjoined specimen MPUM8576 (KT7-6); 12-13: lateral and ventral views of a conjoined specimen MPUM8577 (KJ78-4), holotype; 14 ventral view of specimen MPUM 8581 (KT6-2).


1
2
3
4
5
6
7
8
9
10
11
12
13
14

1973) reveals that its ultrastructure is similar to that of the genus *Chapursania* in the thickness and fabric of the tertiary layer, characterised by a marked transverse depositional banding.

According to Grunt (1977) the species *Martinia tschakobaika* Grunt, in Grunt & Dmitriev 1973, *M. tschernyschewi* Grunt, in Grunt & Dmitriev 1973, *M. semiglobosa* Chernyshev, 1902 and *M. greenlandica* Dunbar, 1955 belong to the genus *Tiramnia*. The same holds true for *Tiramnia canadica* Shi & Waterhouse, 1996 from the Early Permian of Northern Yukon (Canada).

Tiramnia aff. **tscheryschewi**

(Grunt in Grunt & Dmitriev 1973)

Pl. 2, figs. 17-19

1993 *Martinia tschernyschewi* - Angiolini, p. 294, pl.6, fig. 3-5.
1995 *Tiramnia tschernyschewi* - Gaetani et al., pl. 10, fig. 15.

Material. ventral valves: MPUM8561 (KK67-57); MPUM8562 (KK67-52,-58,-60); MPUM8563 (KK67-3); MPUM6931 (KK67-61); MPUM8564 (KK68-12).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, bed KK67, loose sample KK68, Panjshah section. Late Wordian.

Description. Medium to large sized for the genus. Ventral valve longitudinally strongly incurved, with sub-triangular to subpentagonal outline. Ventral umbo large, swollen and incurved; ventral interarea not distinct from the lateral flanks. Median sulcus shallow, occurring only anteriorly to mid-length. Anterior commissure slightly uniplicate. Ornamentation of growth lamellae.

Interior of ventral valve with narrow and elongate muscle field.

Dimensions (in mm):

	W	L	W/L	Th
KK67-3	36.1	30	1.2	17
KK67-52	25.5	22.2	1.15	15
KK67-57	30	21.3	1.4	17.8

Discussion. *T. tschernyschewi* (Grunt in Grunt & Dmitriev, 1973, p. 144, pl. 11, figs. 6-9) is characterised by its sub-triangular to sub-pentagonal outline, its swollen and wide ventral umbo and its shallow ventral sulcus.

The Shaksgam specimen described as *M. uralica* by Fantini Sestini (1965b) is similar to *T.* aff. *tscheryschewi*, but it shows a deeper sulcus and very thick growth lamellae.

Other occurrences. *T. tschernyschewi* occurs in the Darvasian (roughly corresponding to the Kungurian-Roadian) of the SE Pamir (Grunt & Dmitriev 1973).

Family Martiniopsiidae Kotlyar & Popeko, 1967

Genus *Martiniopsis* Waagen, 1883

Type-species: *Martiniopsis inflata* Waagen, 1883

Martiniopsis sp. ind.

Pl. 2, fig. 16

Material. 6 ventral valves: MPUM8565 (KK68-14); MPUM8566 (KK68-10); MPUM8567 (KK67-14,-47); MPUM8568 (KK76-5; KK77-9).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KK67, 68, KK76, KK77 Panjshah section. Late Wordian.

Remarks. A few poorly preserved Martiniopsiid ventral valves have been detected. They have been placed in *Martiniopsis* due to the occurrence of dental lamellae. In terms of their general shape and long and slender umbo they are close to the specimens from NE Karakorum described as *M. laticollis* Merla, 1934.

Superfamily Spiriferoidea King, 1846

Family Trigonotretidae Schuchert, 1893

Subfamily Neospiriferinae Waterhouse, 1968

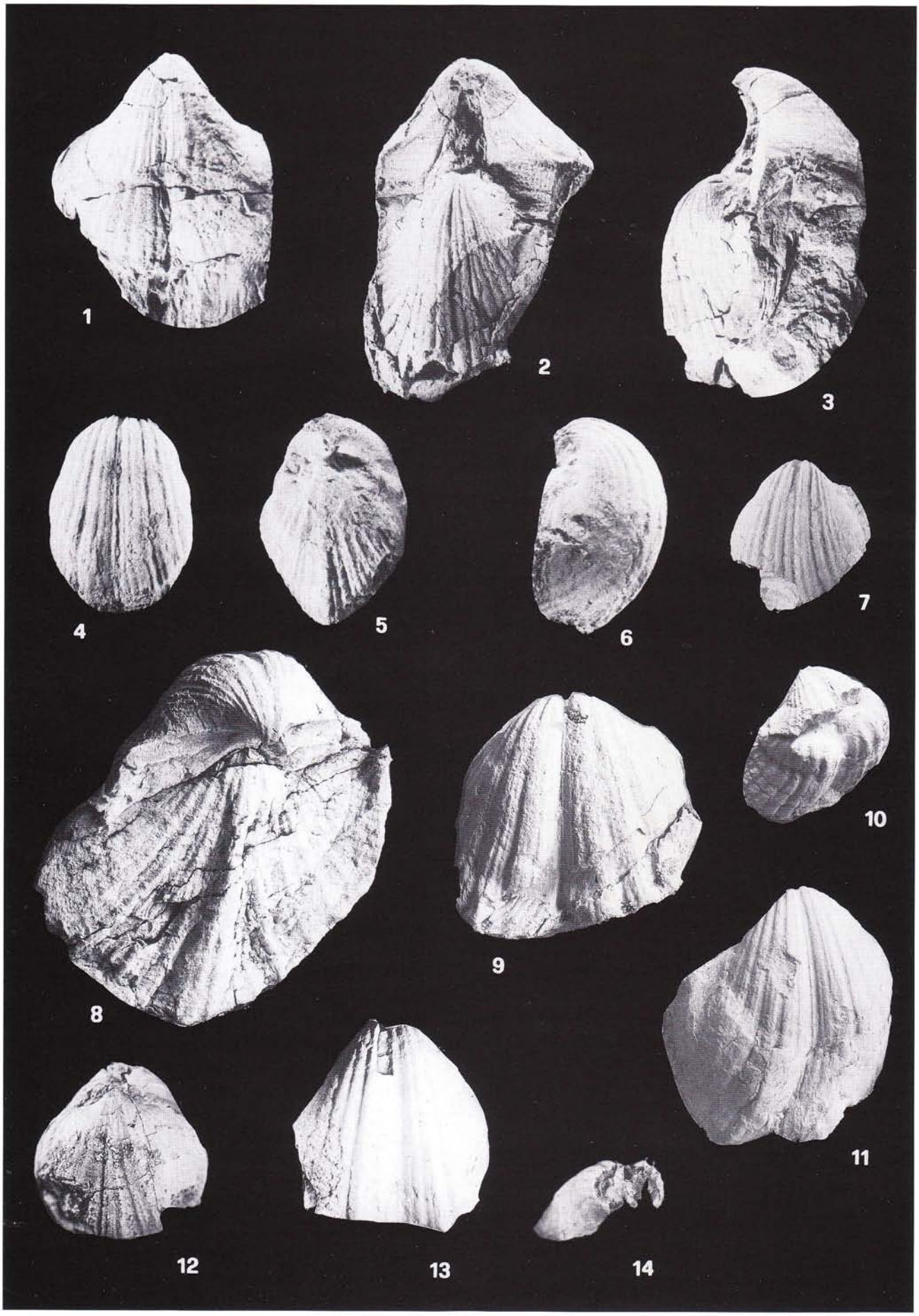
Genus *Cartorhium* Cooper & Grant, 1976

Type-species: *Cartorhium retusum* Cooper & Grant, 1976

Remarks. *Cartorhium* Cooper & Grant, 1976 is characterised by its narrow hinge, low fold, shallow sulcus and asymmetrically fasiculate coarse costae. It differs from *Choristites* Fisher de Waldheim, 1825 by its higher and fasciculate costae and less thickened, separat-

PLATE 4
All x 1

Fig. 1-3 - *Darbandia vagabunda* n. gen. n. sp. - 1-3: ventral, dorsal and lateral views of a conjoined specimen MPUM8585 (KJ84-17), holotype.
Fig. 4-6 - *Hunzina electa* Angiolini - 4-5: ventral and dorsal views of a conjoined specimen KT12; lateral view of a conjoined specimen KT13. All from the Lupghar Formation, Mb. 1, Chapursan Valley, N Pakistan.
Fig. 7 - *Hunzina tenuisulcata* (Merla) - Ventral valve, specimen MPUM7455 (KL19-30). From the Lupghar Formation, Mb. 1, Shimshal Valley, N Pakistan.
Fig. 8-11 - *Tintoriella rajah* (Salter) - 8: dorsal views of a conjoined specimen MS4-1; 9-11: ventral views of specimens MS31-1, MS31-3, 1034-1. All from the Gungri Formation, Spiti, India.
Fig. 12-14 - *Elivina tibetana* (Diener) - Dorsal, ventral and posterior view of a conjoined specimen (4/640) from Chitichun, presented from Diener to Chernyshev and housed at V.S.E.G.E.I. in St.-Petersburg.


1
2
3
4
5
6
7
8
9
10
11
12
13
14

ed and divergent dental plates; from *Neospirifer* Fredericks, 1924 chiefly by its rounded, not transverse outline and its triangular interarea.

According to Cooper & Grant (1976, p. 2192) the genus *Cartorhium* includes also the Salt Range species that have been assigned by Reed (1944) to the subgenus *Purdonella*, occurring in the Wargal and Chidru Formations. As also pointed out by Shi & Waterhouse (1996), the type species of *Purdonella*, *P. nikitini* (Chernyshew, 1902), shows parallel dental plates and a different ornamentation.

In W Texas *Cartorhium* ranges from the Cisuralian to the Capitanian.

Cartorhium aff. **lunwalensis** (Reed, 1944)

Pl. 3, figs. 1-6

Material. 3 conjoined shells: MPUM8569 (KT7-1); MPUM8570 (KT7-2); MPUM8571 (KT7-3); 5 ventral valves: MPUM8572 (KT7-4); MPUM8573 (KJ83-1); MPUM8574 (KK67-9); MPUM8575 (KK88-4); MPUM8594 (KK79-26).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KT7, KJ83, KK67, KK79, KK88, Panjshah section. Late Wordian.

Description. Biconvex shell with subpentagonal to transversally subelliptical outline. Hinge narrow. Maximum width at about mid-length. Anterior commissure uniplicate. Posterolateral margins rounded.

Ventral valve strongly convex with pointed and incurved umbo on a wide and concave interarea. Median sulcus rather wide, shallow, and "V" shaped, extending anteriorly as a short tongue. Dorsal valve with sub-elliptical outline and a low median fold.

Ornamentation of rounded ribs forming low, anteriorly indistinct fascicles of 2-3 asymmetrically bifurcating ribs. The ribs widen anteriorly up to 2 mm at the anterior margin of the mature specimens and become flatter and lower toward the anterior margin. Growth lamellae irregularly occur, denser near the anterior margin.

Interior of ventral valve with high and long dental plates, diverging towards the valve floor.

Dimensions (in mm):

	W	L	Th
KT7-1	47.5	43.2	34.4
KT7-2	>50	44.1	33.8
KT7-3	27.9	23.2	15.7

Ontogenetic variations. The mature specimens are comparatively thicker and more strongly biconvex and show a relatively shallower median sulcus and less distinct fascicles of ribs.

Discussion. This species is charaterised by poorly defined fascicles of ribs which become indistinct anteriorly. It is similar to *Cartorhium lunwalensis* from the Wargal Formation in the shape and ornamentation, differing only by its more incurved ventral umbo and less distinct fascicles of costae. According to Reed (1944) diagnostic features of the species *C. lunwalensis* are its rounded outline and a distinct median groove in the sulcus. However, the latter character seems to be most evident only in the juveniles.

The Karakorum specimens differ from *Cartorhium multiradiatus* (Reed, 1944) by their narrower hinge and more rounded outline.

Cartorhium alisangensis (Termier et al., 1974) from Wardak (Afghanistan) differs by its much larger size, flatter valves and coarser ornamentation.

The Iranian specimens identified by Fantini Sestini (1965d) from the Dorud Formation as *Purdonella lunwalensis*, belong to the genus *Cartorhium* but to a different species, being characterised by less convex valves, thinner and less incurved umbo, narrower sulcus and relatively coarser ornamentation.

Other occurrences. *Cartorhium lunwalensis* occurs in the Wargal and Chhidru Formations of Salt Range, Pakistan and it has been described from the Murgabian (= Wordian) of Wardak, Afghanistan (Termier et al. 1974).

Family Spiriferellidae Waterhouse, 1968

Subfamily Hunzininae n. subfam.

Diagnosis. Spiriferellidae characterised by delthyrium open or possibly occupied by stegidial plates, narrow hinge, micrornament nonpustolose, generally with strong lamellae; lateral slopes non plicate, ornamented by fasciculate ribs.

Genera included. *Hunzina* Angiolini, 1995; *Elivina* Fredericks, 1924; *Darbandia* n. gen.

Discussion. Carter et al. (1994, p. 346) elevated the subfamily Spiriferellinae Waterhouse, 1968 to familial rank and stated that most of the genera of this family are: ". a close-knit group characterised by thick ventral umbones and a pustulose micro-ornament.".

Spiriferella has a pustulose micrornamentation, but its ventral umbonal region is slightly thickened and its delthyrium closed. More specifically, the paratypes of *Spiriferella saranae* (de Verneuil, 1845) of the Chernyshev Collection housed at the V.S.E.G.E.I. of St.-Petersburg show a slight apical callus and a delthyrium occluded by a convex solid plate, like a pseudodeltidium.

After having analysed different Karakorum and Himalayan genera belonging to this family and compared them to *Spiriferella*, I am inclined to distinguish two subfamilies:

- the Spiriferellinae, characterised by a wide hinge relatively to shell width, strongly plicate and coarsely costate to fasciculate lateral slopes, a pustulose micrornamentation - including the genus *Tintoriella* Angiolini 1996 and the genera listed by Carter et al., 1994, except for *Elivina* and *Tipispirifer* Grant, 1976. *Tintoriella* is clearly separated from *Spiriferella* by its open delthyri-

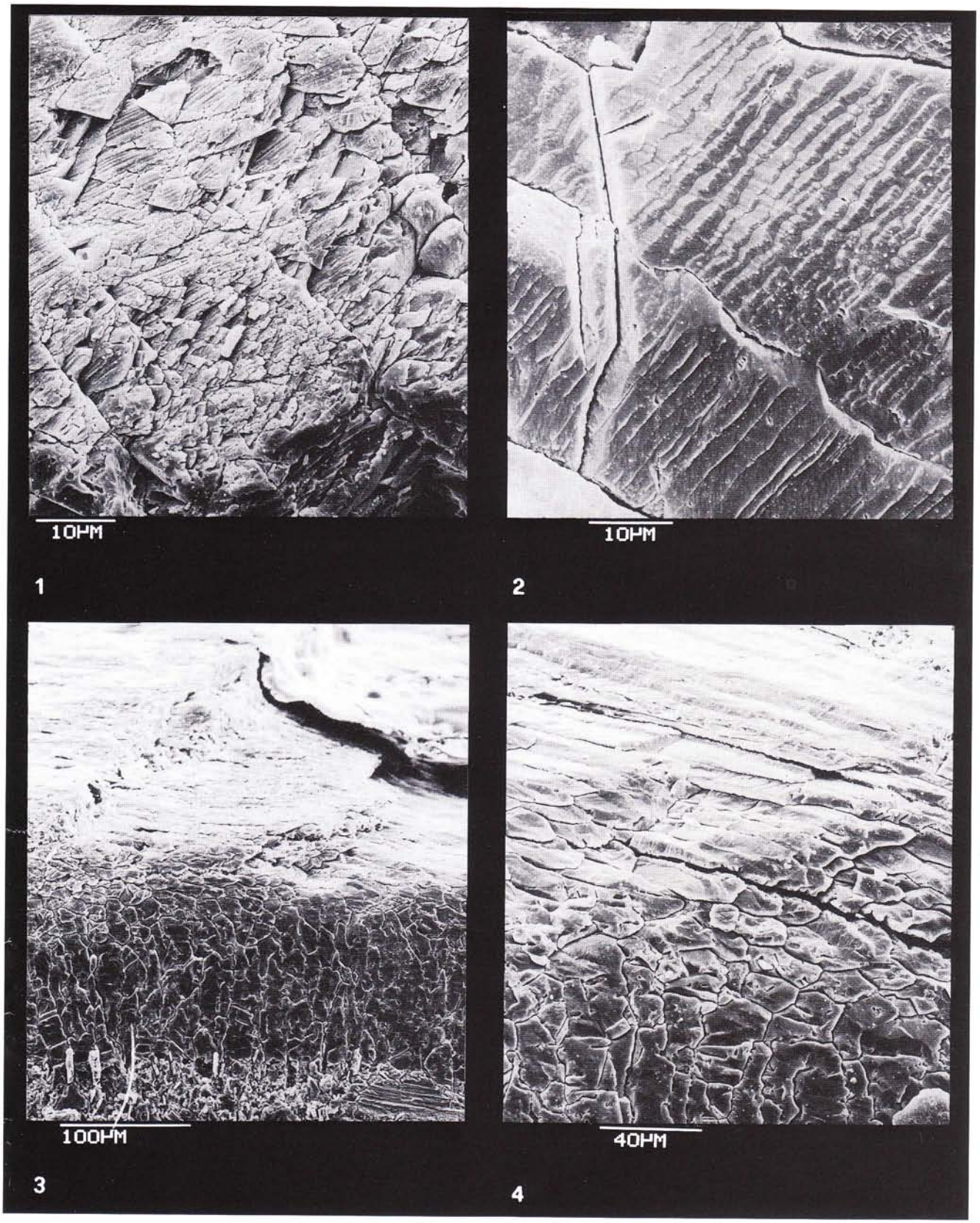


PLATE 5

Fig. 1-2 - *Chapursania tatianae* Angiolini - 1: section of specimen MPUM8554 (KK68-8) showing a thick tertiary layer consisting of vertically stacked crystals up to 30-40 µm wide; 2: section of specimen MPUM8558 (KK88-6) showing fabric of the tertiary layer with a distinct, regular transverse depositional banding with periodicity of 1-2 µm.

Fig. 3-4 - *Martinia* sp. ind. - Section of specimen MPUM8560 (KK67-51) showing secondary layer and 130 µm thick tertiary layer of coarse, irregular to prismatic calcite crystals.

um, strongly fasciculate ornamentation and its bulbous ventral myophragm (*T. rajah* (Salter), Pl. 4, figs. 8-11; Pl. 8, figs. 7-11).

- the Hunzininae, characterised by a narrow hinge with respect to shell width, a bulbous shape, non plicate lateral slopes which are ornamented by bifurcating costae and costellae which rarely form fascicles, a micrornamentation of predominantly concentric lamellae - including *Hunzina* Angiolini, 1996, *Elivina*, and *Darbandia* n. gen.

Both the subfamilies are characterised by the occurrence of short to long ventral adminicula and variably developed apical callus. The variability in the length of the dental plates has been discussed also by Cooper & Grant (1976, p. 2242), who considered it unreliable as a taxonomic character. Hence, the differences between the subfamilies chiefly rely on the width of the hinge, the presence versus absence of plications on the lateral slopes and the pustulose versus lamellose micrornamentation.

Genus *Elivina* Fredericks, 1924

Type-species: *Spirifer tibetanus* Diener, 1897

Diagnosis. Medium to large sized, elongate oval, biconvex Hunzininae. Hinge narrow. Delthyrium open. Ventral sulcus "V" shaped. Ventral lateral slopes ornamented by rounded, bifurcating costae, producing elegant and flat fascicles. Dorsal fastigium low but distinct. Dorsal lateral slopes ornamented by bifurcating costae, rarely fasciculate. Micrornamentation of prominent and irregular growth lamellae. Ventral interior with apical callosity; dental plates divergent towards the valve floor.

Composition of the genus. *Elivina tibetana* from Chitichun Lmst. (South Tibet); *Elivina chapursani* n. sp. from the late Wordian of Karakorum; *Elivina detecta* Cooper & Grant, 1976, *Elivina compacta* (Girty, 1909), *Elivina inflata* (Cooper & Grant, 1976), *Elivina shumardi* (Cooper & Grant, 1976) from the Capitanian of W Texas.

Discussion. The above diagnosis relies on personal analysis of two topotype specimens (labelled 4/640) of *Elivina tibetana* (Diener, 1897) from Chitichun, housed at the V.S.E.G.E.I., St.-Petersburg (Pl. 4, figs. 12-14) and on Diener' s (1897, pl. 6, figs. 1-6) description and illustrations of the type-species. The above diagnosis differs from the description of the genus *Elivina* given by Cooper & Grant (1976, p. 2241) chiefly about the size of the genus and the nature of its costation. In fact, in the diagnosis of the genus, Cooper & Grant (1976, p. 2241) stated: " Small, ...costae...most not bifurcating, few splitting asymmetrically, ... not producing fascicles or strong plications of side,...". However, the analysis of the topotype specimens of *E. tibetana* and the description by Diener himself (Diener, 1897, p. 45) clearly show that the type-species can attain a large size (more than 60 mm in length), its slopes are not plicate and its ornamentation consists of invariably bifurcating costae which form flat fascicles. In any case, the fasciculate ornamentation has also been pointed out by Cooper & Grant (1976, p. 2245) in the discussion of their new species *Elivina detecta*, where they commented: "*Elivina detecta* differs from the type-species, *E. tibetanus* from the Himalaya mountains, in its finer and more numerous ribs that... do not form such definite fascicles". On the other hand, the above-emended diagnosis is more in agreement with that of Waterhouse & Waddington (1982, p. 33), except for the plications of the lateral flanks which do not occur in *Elivina*.

The genus *Elivina* differs from *Hunzina* by its larger size, its more regularly fasciculate ventral lateral slopes, its more numerous, finer and rounded costae, a distinct dorsal fastigium which is usually multiribbed, a deeper sulcus and its much longer dental plates; from the Spiriferellinae *Spiriferella* and *Tintoriella*, *Elivina* is distinguished by its narrower hinge, its non plicate ventral slopes, a less or non-fasciculate dorsal valve, its shorter adminicula, and the absence of pustules. In general, as already remarked by Diener (1897, p. 46) for his *S. tibetanus*, the ornamentation of *Elivina* is very elegant, besides being prominent, making the allied genera much more roughly sculpured, when compared.

The external and internal characters of the above mentioned genera have been reported for *Hunzina electa* Angiolini, 1996 (Pl. 4, figs. 4-6), *Hunzina tenuisulcata* (Merla, 1934) (Pl. 4, fig. 7; Pl. 7, Figs. 8-12), *Tintoriella rajah* (Pl. 4, Figs. 8-11; Pl. 8, Figs. 7-11); *Elivina tibetana* (Pl.4, Figs. 12-14) for comparison.

Concerning previous attributions to genus *Elivina*, the accurate descriptions and illustrations of Cooper & Grant (1976), suggest that their new species *Elivina? annectens* - being plicate and pustulose - belongs to *Spiriferella*, whereas the Capitanian *Elivina detecta* and *Elivina compacta* are small to medium representatives of *Elivina*. The same holds true for *Eliva inflata* and *Eliva shumardi* which show the external and internal charac-

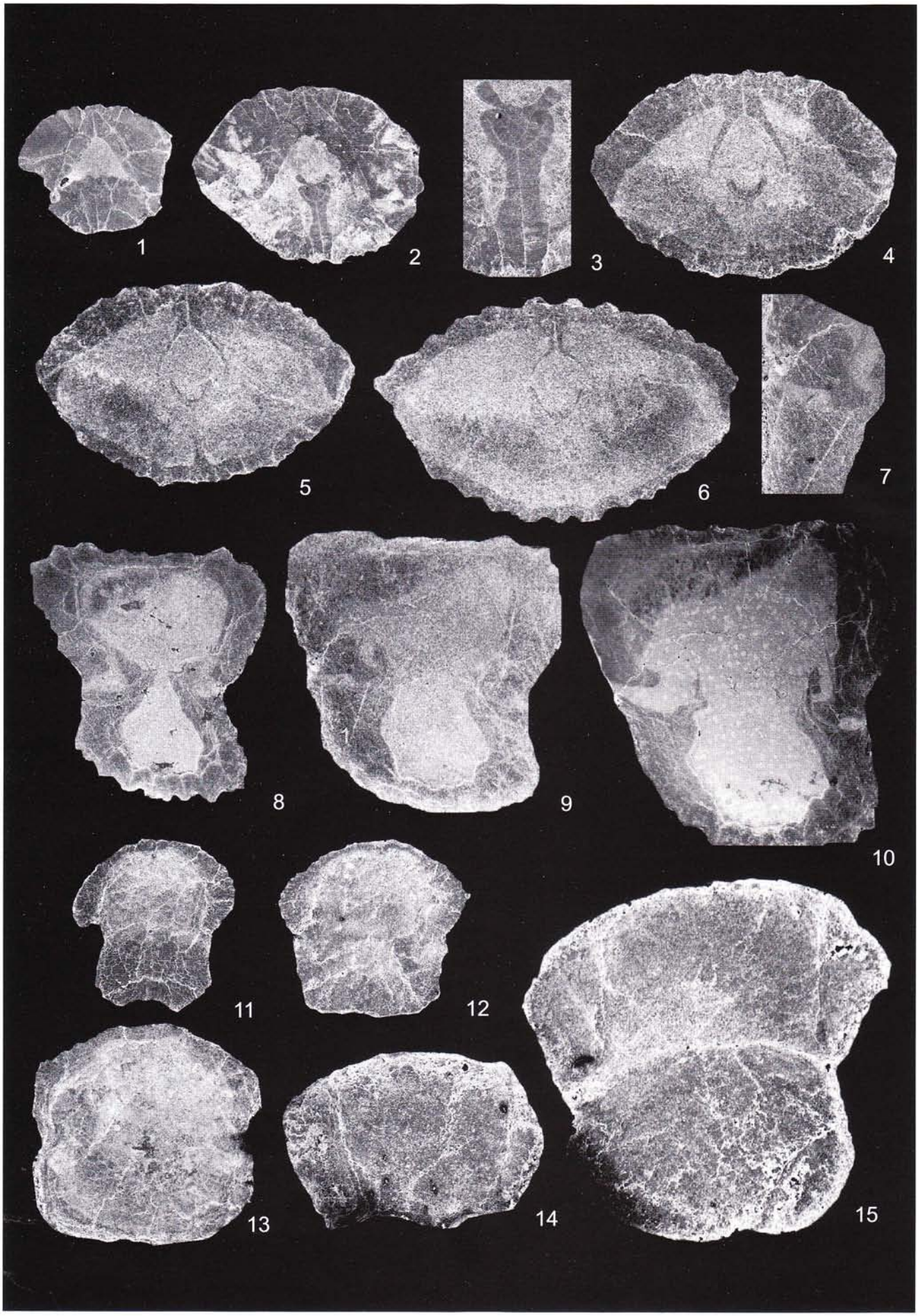
PLATE 6

Fig. 1-6 - *Stenoscisma* aff. *armenica* Sokol'skaya - Specimen MPUM8531 (KJ85-7). 1-2, 4-6: sections respectively at 2.45 mm, 3.0 mm, 3.8 mm, 4.15mm, 4.9 mm from the umbo, x 7 ; 3 enlargment of fig. 2, showing camarophorium.

Fig. 7-10 - *Terebratuloidea* sp. B - Specimen MPUM8530 (KJ87-17). 7: enlargment of fig. 9; 8-10: section respectively at 2.9mm, 4.7 mm, 5.05 mm from the umbo, x 5.

Fig. 11-13 - *Pontisia* sp. ind. - Specimen MPUM8524 (KT1-1), sections respectively at 1.2 mm, 1.35 mm, 2.5 mm from the umbo, x 17.

Fig. 14-15 - *Anchorbynchia cimmerica* n. sp. - Specimen MPUM8517 (KJ78-1), sections respectively at 0.5 mm, 0.8mm from the umbo, x 20.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

ters of *Elivina*.

The Sakmarian species of *Elivina hoskingae* Archbold & Thomas, 1985 (from Western Australia) probably belong to the genus *Hunzina*, being characterised by an ornamentation of simple costae, branching far anteriorly and producing weak and variable fascicles, a poorly distinct dorsal fold with median groove and by the dental plates deeply embedded in umbonal thickening. The same holds true for *Elivina yunnanensis* Shi, Fang & Archbold, 1996 from the Baoshan Block (Shen et al. 2000).

E. tschernyschewi Waterhouse & Waddington, 1982 probably belongs to *Spiriferella*, having plicate lateral slopes. The same probably holds true for *E. cordiformis* Waterhouse & Waddington, 1982 from Canada.

The species of *Spiriferella* from Central Afghanistan (Termier et al. 1974) and that from Thailand (Grant 1976) probably belong to *Tintoriella*, being plicate and fasciculate and having a median myophragm.

The evolutionary changes from the Cisuralian *Hunzina* to the Guadalupian *Elivina* may have involved an increasing size, increasing number of costae, bifurcation starting more and more posteriorly, increasing length of dental plates. More or less the same basic potential of change has been observed by Waterhouse at al. (1978) inside the *Spiriferella* stocks.

Elivina chapursani n. sp.

Pl. 3, figs. 7-13; Pl. 7, figs. 1-7

Holotype. A conjoined shells: MPUM8577 (KJ78-4).

Derivatio nominis. From the Chapursan Valley, Karakorum, N Pakistan.

Material. 3 conjoined shells: MPUM8576 (KT6-7); MPUM8577 (KJ78-4); MPUM8578 (KJ78-6); 10 ventral valves: MPUM8579 (KK68-7,-29); MPUM8580 (KK79-12) MPUM 8580 (KK79-12; KT 8-4-5); MPUM8581 (KT6-2); MPUM8582 (KJ78-3,-5, KJ87-18); 2 dorsal valves: MPUM8583 (KK79-11,-15).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KK79, KT8, KJ78, KJ87, loose samples KK68, KT6, Panjshah section. Late Wordian.

Description. Large-sized, strongly biconvex shell, with heart-shaped profile. Hinge narrower than maximum width. Anterior commissure strongly uniplicate.

Ventral valve with a strongly incurved umbo over the interarea, which is denticulate and wider than high. Ventral sulcus "V" shaped, wide and deep, protruding anteriorly as a tongue. The sulcus is ornamented by bundles of costae derived from successive bifurcations of the primary costae delimiting it and by a fine median costa. The lateral slopes of the ventral valve are plicate, ornamented by fine, rounded, bifurcating costae which form four to five flat fascicles of 3-4 ribs each. The width of the costae is 0.3-0.6 mm at 10 mm from the umbo. The radial ornamentation becomes much less prominent towards the lateral margins. Microrornamentation of irregularly arranged growth lamellae.

Dorsal valve with low but distinct fastigium, separated from the lateral slopes by two deep furrows. It is ornamented by three bifurcating costae, giving rise to six costae at a short distance from the umbo. Dorsal lateral slopes ornamented by bifurcating costae, forming two poorly defined fascicles on each side of the fastigium.

Ventral interior with apical callosity up to 2.2 mm from the umbo, dental plates high, straight, extending anteriorly up to 7.9 mm from the umbo and slightly divergent toward the valve floor. The dental plates are close to the shell walls up to 5.7 mm from the umbo, leaving a narrow and high umbonal cavity; then they detach from the walls giving way to two semicircular lateral cavities.

Dimensions (in mm):

	W	L	Th
KT7-6	>52	61.2	42.9
KT8-4	37.6	49.9	
KJ78-4	36.8	47.5	
KJ78-6	20.9	32	13

Discussion. *Elivina chapursani* n. sp. differs from *E. tibetana* (Diener, 1897) by its heart-shaped profile, longer hinge, finer and more numerous costae, deeper and anteriorly protruding sulcus, higher fastigium ornamented by more numerous ribs.

Darbandia n. gen.

Type-species: *Darbandia vagabunda* n. sp.

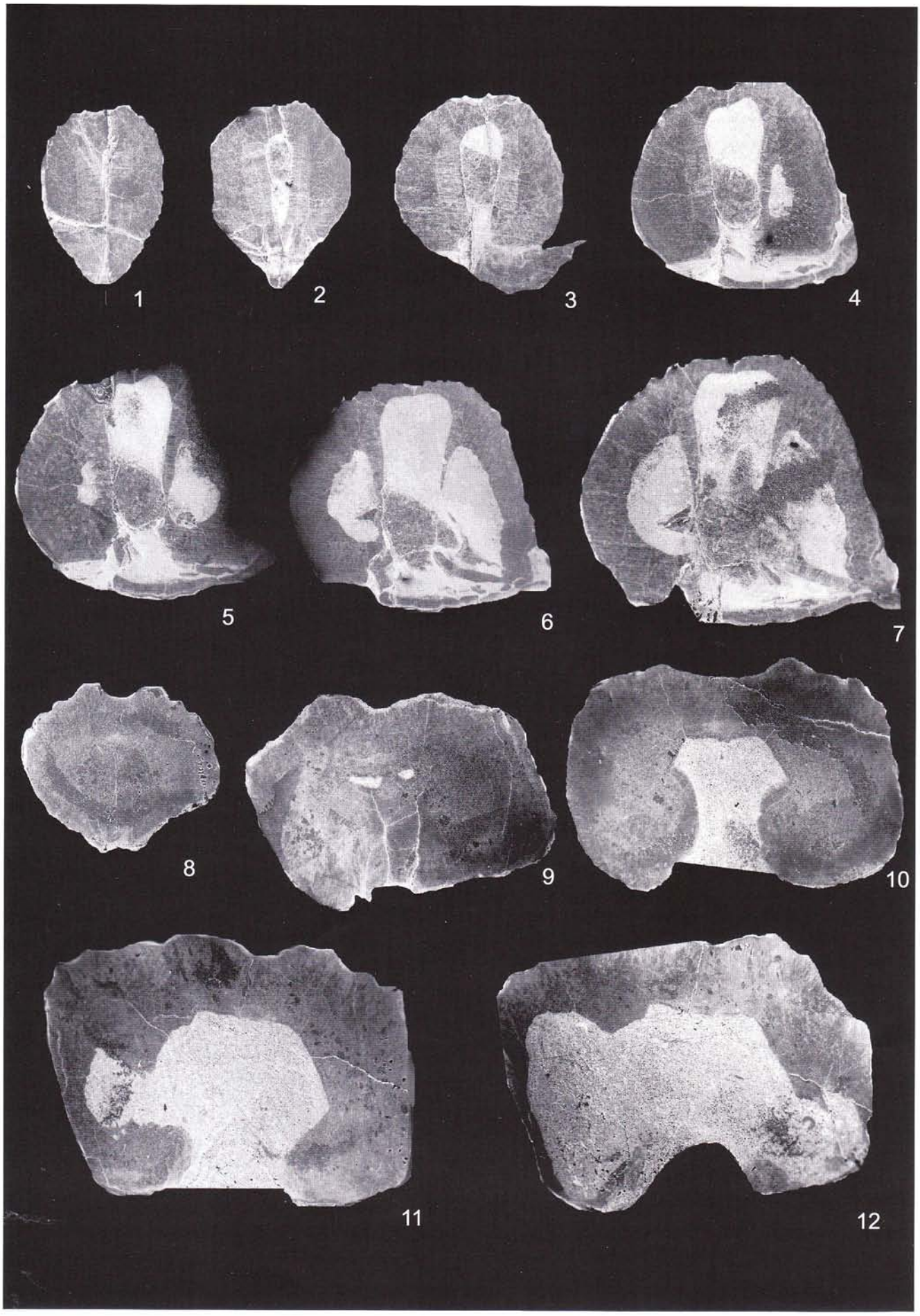
Derivatio nominis. From the locality of Darband, where the Panjshah type-section is located.

Diagnosis. Medium to large sized Hunzininae with very high, weakly apsacline to nearly orthocline, ventral interarea. Hinge narrow. Ornamentation of bifurcating costae, producing ill defined fascicles which dye out anteriorly. Microrornamentation of growth lamellae only. Ventral interior with apical callosity; dental plates divergent towards

PLATE 7

Fig. 1-7 - *Elivina chapursani* n. sp. - Specimen MPUM8578 (KJ78-6), sections respectively at 2.2 mm, 3.3 mm, 4.4mm, 5.9 mm, 6.3 mm, 7.0 mm, 7.3 mm from the umbo , x 4.

Fig. 8-12 - *Hunzina tenuisulcata* (Merla) - Specimen MPUM7452 (KL17-7) (Lupghar Formation, Mb. 1, Shimshal Valley), sections respectively at 2.9 mm, 7.6 mm, 9.9 mm, 13.9 mm, 15.5 mm from the umbo, x 4.


1
2
3
4
5
6
7
8
9
10
11
12

the valve floor.

Discussion. The new genus has been erected for this peculiar form characterised by an ornamentation similar to *Elivina* and by a very high interarea. This particular shape justifies the erection of a new genus even if the material is rather fragmentary.

Darbandia vagabunda n. sp.

Pl. 4, figs. 1-3, Pl. 8, figs. 1-6

Holotype. A conjoined shell: MPUM8585 (KJ84-17).

Derivatio nominis. Latin adjective *vagabundus-a-um*, due to its rare and sparse occurrence.

Material. 2 conjoined shells: MPUM8584 (KJ83-2); MPUM8585 (KJ84-17); 2 ventral valves: MPUM8586 (KK79-30); MPUM8587 (KK79-35)

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KK79, KJ83, KJ84, Panjshah section. Late Wordian.

Description. Biconvex shell, with flabellate outline. Hinge narrow. Maximum width anterior to mid-valve; anterior commissure uniplicate.

Ventral valve with high and slender umbo, and flaring outline. Interarea weakly apsacline to nearly orthocline, very high, flat, denticulate, with apparently opened delthyrium flanked by two furrows. Median sulcus narrow and shallow, slightly widening and deepening anteriorly, ornamented by a median costa and by ribs deriving by bifurcation of the costae flanking the sulcus.

Dorsal valve with sub-rhomboidal outline, rather prominent median fastigium ornamented by 3 costae each bifurcating at about 6 mm from the umbo, so that the fold is ornamented by 6 ribs for more than mid-length.

Ornamentation of costae bifurcating at a short distance from the umbo and giving way to poorly defined bundles of 3-4 ribs, which die out anteriorly. The ribs rapidly increase in width from 0.4-0.5 mm at 10 mm from the umbo to 1.4 mm at the anterior margin.

Ventral interior with apical callosity up to 3 mm from the umbo, dental plates strong, high, extending anteriorly up to 9 mm from the umbo and divergent towards the valve floor. The dental plates are close to the valve walls up to 6 mm from the umbo; the umbonal cavity shows a flared section and it is larger than the lateral cavities.

Dimensions (in mm):

	W	L	Th	H
KJ84-17	>39	70.5	35.6	25.1
KJ83-2	55	59.8	25	>15
KK79-30	34	28.1		

Dimensions. *Darbandia vagabunda* n. sp. is based on only four specimens. However, the holotype is not atypical of the species, the paratypes being closely similar and characterised by a very high, apsacline to orthocline interarea and by a weakly fasciculate ornamentation.

Superfamily Paeckelmanelloidea Ivanova, 1972
Family Strophopleuridae Carter, 1974
Genus *Tipispirifer* Grant, 1976

Type species: *Tipispirifer oppilatus* Grant, 1976

Remarks. As outlined by Carter et al. (1994) *Tipispirifer* is an enigmatic genus due to its growth form and ornamentation associated to stegidial plates covering the delthyrium and to dental plates converging into a spondylium, thus making its suprageneric position problematic. Erecting the genus, Grant (1976) placed it in the Cyrtospiriferidae Termier & Termier, 1949, but he was not completely satisfied. Carter et al. (1994) included - again with some uncertainty - *Tipispirifer* in the Spiriferellidae Waterhouse, 1968 on the basis of its papillose microrornamentation and stegidial covering of delthyrium.

However, the spiriferellids have usually completely different shape, macrornament and arrangement of dental plates.

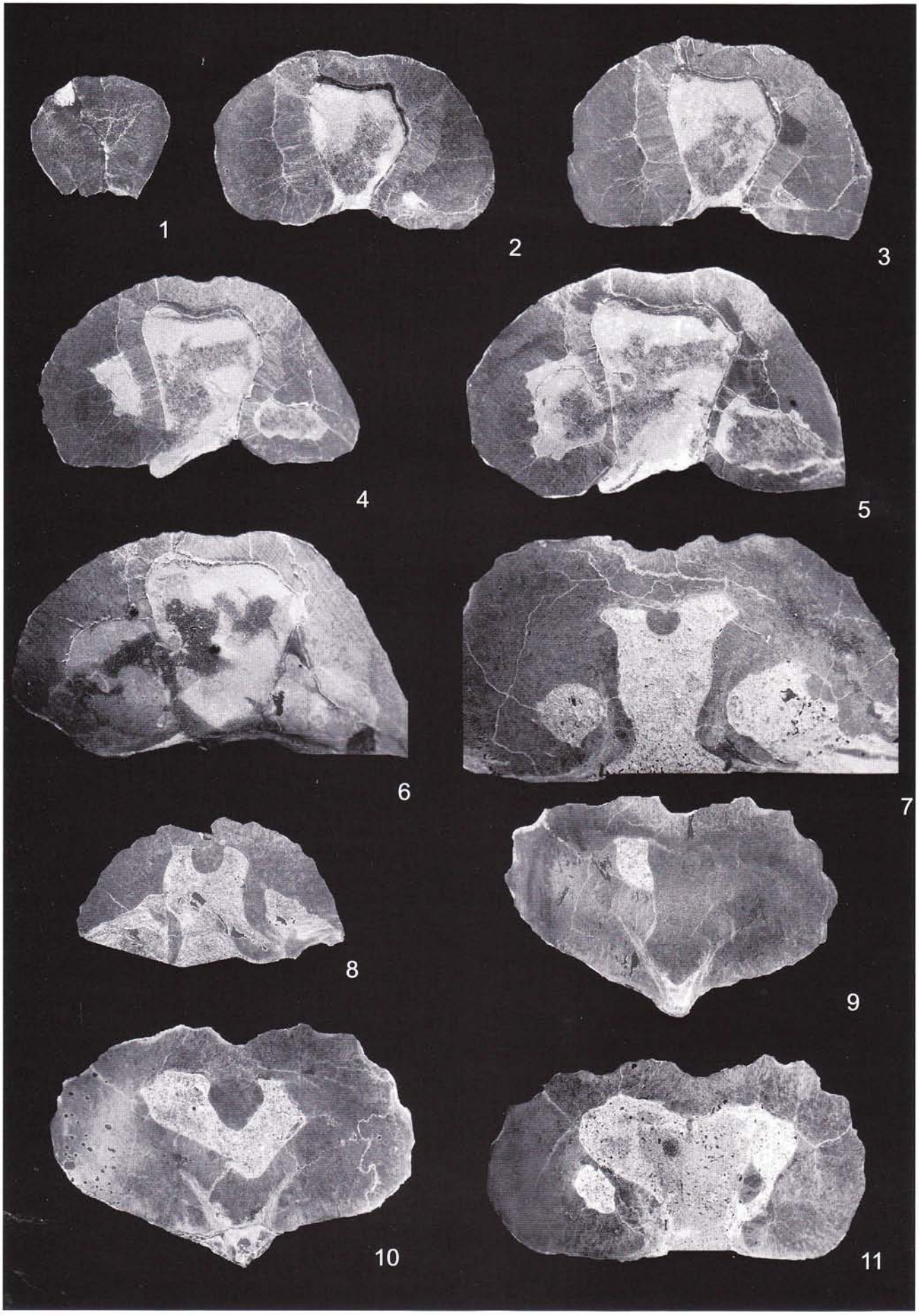
Another close group may be represented by the Strophopleuridae which, besides having a transverse shape and multicostate ornamentation, shows an high and weakly apsacline (or catacline) ventral interarea, a denticulate hinge and may have close-set dental plates.

The papillose microrornament of *Tipispirifer* is different from that typical of the latter family, but as outlined by Grant (1976, p. 213) it is not a persistent feature and may be the result of erosion and preservation (Gourvennec 1987). Furthermore, as stegidial plates in the spiriferids may be variable and characteristics of many different stocks (Grant 1976; Carter et al. 1994; Williams et al 1997), growth-shape, height and orientation of the interarea, ornamentation and internal characters are also reliable for classification purposes.

PLATE 8

Fig. 1-6 - *Darbandia vagabunda* n. gen. n. sp. - Specimen MPUM8586 (KK79-30), sections respectively at 1.6 mm, 5.9 mm, 6.3 mm, 7.1 mm, 7.7 mm, 8.7 mm from the umbo, x 4.

Fig. 7-11 - *Tintoriella rajah* (Salter) - 7: specimen MPUM7913 (Gungri Formation, Spiti), section at 6.1 mm from the umbo, x 4; 8: specimen MS16-1 (Gungri Fm, Spiti), section at 4.8 mm from the umbo, x 4; 9-11: specimen 1041-10 (Gungri Formation, Spiti), sections respectively at 3.4 mm, 3.8 mm, 5.2 mm from the umbo, x 4.


1
2
3
4
5
6
7
8
9
10
11

Inside the family, *Tipispirifer* may be placed in the Pterospiriferinae Waterhouse, 1975 or, better, in a new subfamily.

Tipispirifer cf. **psittacus** (Merla, 1934)

Pl. 2, fig. 20

Material. 1 conjoined shell: MPUM8588 (KK67-40).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KK67, Panjshah section. Late Wordian.

Description. Biconvex shell with very transverse outline and pointed, alate cardinal extremities. Maximum width at the hinge. Anterior commissure paraplicate. Shell substance inpunctate.

Ventral valve conical with high, slightly concave, weakly apsacline interarea with curved back beak. Median sulcus "V" shaped, starting at the umbo, widening anteriorly and flanked by two distinct plicae.

Dorsal valve with top-rounded median fold, ornamented by ribs.

Ornamentation of fine ribs, numbering 9 per 5 mm at mid-valve, and covering all the shell. Growth lamellae denser at the anterior margin.

Interior of ventral valve with dental plates converging to form a spondylium with adminicula diverging at the apex.

Dimensions (in mm):

	W	L	Th
KK67-40	25.4	>11.4	11.5

Discussion. This specimen clearly belongs to the genus *Tipispirifer* on the basis of profile, ornamentation and internal characters of the ventral valve.

Among the *Tipispirifer* species, it is very close to *T. psittacus* (Merla, 1934, pl. 21, figs. 18-19, 23-24, 26-29.) from NE Karakorum, which however is very poorly represented and badly preserved in the collection. The same holds true for the fragment of ventral valve described as *S.*? cf. *psittacus* Merla by Fantini Sestini (1965b).

Suborder Delthyridina Ivanova, 1972

Superfamily Reticularioidea Waagen, 1883

Family Reticulariidae Waagen 1883

Subfamily Reticulariinae Waagen, 1883

Genus *Squamularia* Gemellaro, 1899

Type species: *Squamularia rotundata* Gemellaro, 1899

Remarks. *Squamularia* is a strongly debated genus and its position remained unclear until Grant (1993) clarified its validity. An interesting discussion on its relationships with allied genera, such as *Permophricodothyris* Pavlova, 1965 was already performed by Cooper & Grant (1976). However, the revision of the material of Gemellaro from Sosio (Sicily) would add further knowledge on these genera. For instance, some of the *Reticularia* species from Sosio (i.e. *R. caroli* Gemellaro, 1899), besides lacking internal plates, have postero-laterally pointing spiralia and uniramous spines, thus differing from both *Squamularia* and *Permophricodothyris*. On the other hand, some of the *Reticularia* species from Sosio have been included in *Permophricodothyris* by Grant (1993), on the basis of the direction and number of volutions of the spiralia.

Squamularia is in fact characterised by its ornamentation of growth lamellae, which may be wavy, irregular and fringed, bearing uniramous spines and by its laterally pointing spiralia.

? **Squamularia** sp. ind.

Pl. 2, fig. 23

Material. 2 ventral valves: MPUM8589 (KJ85-3); MPUM8590 (KJ85-4).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KJ85, Panjshah section. Late Wordian.

Description. Ventral valve convex with subtriangular outline. Umbo long, slender and acute. Maximum width anterior to mid-length. A shallow median depression occurs anteriorly.

Ornamentation of irregular growth lamellae, numbering about 3 per mm, bearing traces of probably uniramous spines.

Dimensions (in mm):

	W	L
KJ85-3	19.2	19.4
KJ85-4	22.6	20

Discussion. As the direction of the spiralia is unknown the generic determination may be not sure. However, the maximum width placed at mid-length could indicate laterally directed spiralia, as suggested by Cooper & Grant (1976, p. 2248). Furthermore, the spines seem to be uniramous as are those characterising the genus *Squamularia*.

Order Spiriferinida Ivanova, 1972

Suborder Spiriferinidina Ivanova, 1972

Superfamily Pennospiriferinoidea Dagys, 1972

Family, genus and species undetermined

Material. 1 ventral valve: MPUM8591 (KK79-17).

Remarks. A single, punctate ventral valve with wide hinge and ornamented by 3 sharp, flat topped costae at each side of the sulcus suggests the occurrence of a genus of the families Punctospiriferidae or

Crenispiriferidae. However the micrornamentation is not well preserved, preventing a certain identification.

Order Terebratulida Waagen, 1883

Suborder Terebratulidina Waagen, 1883

Superfamily Dielasmatoidea Schuchert, 1913

Family Notothyrididae Likharev, 1960

Genus *Rostranteris* Gemellaro, 1898

Type species: *Dielasma adrianense* Gemellaro, 1894

Remarks. *Rostranteris* Gemellaro differs from *Notothyris* Waagen, 1883 by its plicate or intraplicate anterior commissure and a lower number of anterior plicae. According to Grant (1976) they do not have any other difference, based on study of topotype material.

Rostranteris sp. ind.

Pl. 2, figs. 24-26

Material. 17 conjoined shells: MPUM8592 (KK67-31); MPUM8595 (KK68-A); MPUM8596 (KK79-14; KJ84-18-19); MPUM8597 (KJ85-19-,-20,-21); MPUM8598 (KJ87-23); MPUM8599 (KJ87-20,-21,-22,-24,-25-26); 2 ventral valves: MPUM8600 (KJ87-27,-28).

Occurrence and age. Central Karakorum, Chapursan Valley, Panjshah Formation, Mb. 2, beds KK67, KK79, KJ87, KJ84, loose sample KK68, Panjshah section. Late Wordian.

Description. Biconvex shell with subovate to subpentagonal outline. Anterior commissure folded by 3 plications. Shell substance finely and regularly punctate.

Ventral valve convex, with strongly incurved umbo with epithyrid foramen. Two short and sharp plicae occur anteriorly to mid-valve. Dorsal valve with three rounded plicae, starting anterior to mid-valve, with the median one larger and slightly higher than the lateral ones.

Ornamentation of growth lamellae, denser near the anterior margin.

Interior of ventral valve with pedicle collar and without dental plates.

Dimensions (in mm):

	W	L	Th
KJ84-19	13.9	18.2	10.3
KJ85-20	13.4	17.6	11.8
KJ85-21	15.6	19.7	
KJ87-21	14.1	15.2	8.5
KJ87-23	13.2	15.8	9.9
KJ87-26	13	14.7	9.7

Discussion. The Karakorum specimens are very similar to those determined as *Notothyris nucleolus* (Kutorga, 1842) from the Gnishik Formation of Armenia (Ruzhentsev & Sarycheva 1965). They are included in the genus *Rostranteris* due to the low number of anterior plicae.

Acknowledgements.

Maurizio Gaetani is warmly thanked for field assistence and a first revision of the manuscript. Andrea Tintori and Andrea Zanchi are deeply thanked for collecting part of the specimens. John Carter, Paul Sartenaer, and Guang Shi revised the manuscript, giving precious suggestions. Giovanni Chiodi and Agostino Rizzi are thanked for technical assistance. Research supported by the EU contract CI*CT90.0852 (project leader: Maurizio Gaetani) and the Italian MURST 60% to Maurizio Gaetani.

REFERENCES

Alvarez F., Rong J. & Boucot A.J. (1998) - The classification of athyridid brachiopods. *J. Paleont.*, 72: 827-855, Lawrence.

Angiolini L. (1993) - Ultrastructure of some Permian and Triassic Spiriferida and Athyridida (Brachiopoda). *Riv. It. Paleont. Strat.*, 99: 283-306, Milano.

Angiolini L. (1995) - Permian brachiopods from Karakorum (Pakistan). Pt. 1 (with appendix). *Riv. It. Paleont. Strat.*, 101: 165-214, Milano.

Angiolini L. (1996a) - Permian brachiopods from Karakorum (Pakistan). Pt. 2. *Riv. It. Paleont. Strat.*, 102: 3-26, Milano.

Angiolini L. (1996b) - Permian brachiopods from Karakorum (Pakistan). In Copper P. & Jin J. (Eds.) - Brachiopods, Proceedings of the Third International Brachiopod Congress, Sudbury, Canada, 2-5 September 1995, pp. 13-18, Balkema Press, Rotterdam.

Angiolini L. (in press) - Middle Permian brachiopods from Oman and Perigondwanan correlations. The Systematic Association Volumes Special Series, London.

Angiolini L. & Bucher H. (1999) - Guadalupian brachiopods from the Khuff Formation, southeastern Oman. *Geobios*, 32: 665-699, Lyon.

Angiolini L., Brunton H., & Zanchi A. (1999) - Late Carboniferous brachiopods from Karakorum, Pakistan. *Riv. It. Paleont. Strat.*, 105: 3-22, Milano.

Angiolini L., Nicora A., Bucher H., Vachard D., Pillevuit A., Platel J.P., Roger J., Baud A., Broutin J., Marcoux J. & Al Hashmi H. (1998) - Evidence of a Guadalupian age for the Khuff Formation of southeastern Oman: preliminary report. *Riv. It. Paleont. Strat.*, 104: 329-340, Milano.

Archbold N.W. (1983) - Permian marine invertebrate provinces of the Gondwanan Realm. *Alcheringa*, 7: 59-73, Sydney.

Archbold N.W. (1998) - Correlation of the Western Australian Permian and Permian ocean circulation patterns. *Proc. R. Soc. Victoria*, 110: 85-106, Melbourne.

Archbold N.W. & Shi G.R. (1995) - Permian brachiopod faunas of Western Australia: Gondwanan-Asian relationships and Permian climate. *Journ. SE Asian Earth Sci.*, 11: 207-215, London.

Bogoslovskaya M.F. (1994) - Ammonoidea. Main features of stratigraphy of Permian System. *Nedra*, 248-257, Leningrad.

Branson C.C. (1948) - Literature on Permian Invertebrate Palaeontology. Bibliographic Index of Permian Invertebrates. *Geol. Soc. Amer. Mem.*, 26, 1049 pp., Boulder.

Broili F. (1916) - Die permischen Brachiopoden von Timor. In Wanner J. (ed.) - Palaeontologie von Timor, 7, 104 pp., Stuttgart.

Carter J., Johnson J.G., Gourvennec R. & Hong-Fei H. (1994) - A revised classification of the spiriferid brachiopods. *Annals of Carnegie Museum*, 63: 327-374, Pittsburgh.

Chernyshev T.N. (1902) - Die obercarbonische Brachiopoden des Ural und des Timan. *Trudy Geol. Kom.*, 16, 749 pp., St.-Petersburg.

Cooper G.A. & Grant R.E. (1976) - Permian Brachiopods of West Texas, IV. *Smithsonian Contributions to Paleobiology*, 21: 1923-2285, Washington.

Chen Z.Q., Shi G.R., Shen S. & Archbold N.W. (2000). *Tethyochonetes* gen. nov. (Chonetida, Brachiopoda) from the Lopingian (Late Permian) of China. *Proc. R. Soc. Victoria*, 112: 1-15, Melbourne.

Davydov V.I. (1996) - Fusulinid biostratigraphy and the correlation of Moscovian-Guadalupian North American, Tethyan and Boreal (Russian Platform/Uralian) standards. *Permophiles*, 29: 47-52.

Diener C. (1897) - The Permocarboniferous Fauna of Chitichun No. 1. *Paleont. Indica*, ser. 15, 1, 105 pp., Calcutta.

Erwin D.H. (1996) - Understanding biotic recovery: extinction, survival and preservation during the end-Permian mass extinction. In Jablonski D., Erwin D.H. & Lipps J.H. (eds.) - Evolutionary Paleobiology, University of Chicago press, 399-418, Chicago.

Fang Z.J. (1991) - Sibumasu biotic province and its position in Palaeotethys. *Acta Paleont. Sin.*, 30: 511-532.

Fantini Sestini N. (1965a) - Permian fossils of the Upper Hunza Valley. In A. Desio (ed.) - Italian expeditions to the Karakorum (K2) and Hindu Kush. IV Paleontology, Zoology, Botany, 1: 134-148, 385.

Fantini Sestini N. (1965b) - Permian fossils of the Shaksgam Valley. In A. Desio (ed.) - Italian expeditions to the Karakorum (K2) and Hindu Kush. IV Paleontology, Zoology, Botany, 1: 149-215, 386-393.

Fantini Sestini N. (1965c) - The geology of the Upper Djadjerud and Lar Valleys (North Iran). II. Palaeontology. Bryozoans, brachiopods and molluscs from the Ruteh Limestone (Permian). *Riv. It. Paleont Strat.*, 71: 13-109, Milano.

Fantini Sestini N. (1965d) - The geology of the Upper Djadjerud and Lar Valleys (North Iran). II. Palaeontology. Brachiopods from Dorud Formation (Permian). *Riv. It. Paleont Strat.*, 71: 773-789, Milano.

Fantini Sestini N. & Glaus M. (1966) - Brachiopods from the Upper Permian Nesen Formation (North Iran). *Riv. It. Paleont Strat.*, 72: 887-932, Milano.

Gaetani M., L. Angiolini, E. Garzanti, F. Jadoul, E. Ya. Leven, A. Nicora & D. Sciunnach. (1995) - Permian stratigraphy in the northern Karakorum, Pakistan. *Riv. It. Paleont. Strat.*, 101: 107-152, Milano

Garzanti E., Le Fort P. & Sciunnach D. (1999) - First report of Lower Permian basalts in South Tibet: tholeiitic magmatism during break-up and incipient opening of Neotethys. *Journ. Asian Earth Sci.*, 17: 533-546, London.

Gemellaro G.G. (1898-1899) - La fauna dei calcari con fusulina della Valle del fiume Sosio. *Giornale di Scienze Naturali ed economiche di Palermo*, 24: 231-338, Palermo.

Gourvennec R. (1987) - Morphologie des épines chez les brachiopodes Delthyrididae. *Lethaia*, 20: 21-31, Oslo.

Grant R.E. (1976) - Permian brachiopods from southern Thailand. *Journ. Paleont.*, 50, supplement to 3, *Paleont. Soc. Mem.*, 9, 254 pp., Lawrence.

Grant R.E. (1993) - Permian brachiopods from Khios Island, Greece. *Journ. Paleont.*, 67, supplement to 4, Paleont. Soc. Mem., 33, 21 pp., Lawrence.

Grunt T.A. (1977) - Upper Paleozoic brachiopods from Siberia and Arctic. *Trudy Paleont. Inst.*, 162, 118 pp., Moscow.

Grunt T.A. (1989) - Order Athyridida (evolutionary morphology and phylogeny). *Trudy Paleont. Inst.*, 238, 139 pp., Moscow.

Grunt T.A. & Dmitriev V.Ju. (1973) - Permian Brachiopoda of the Pamir. Akad. Nauk SSSR *Trudy Paleont. Inst.*, 136, 209 pp., Moscow.

Grunt T.A. & Shi G.R. (1997) - A hierarchical framework of Permian global marine biogeography. In: Jin Y.G., Dineley D. (Eds.) - Palaeontology and Historical Geology, ProcEedings of the 30th IGC, v. 12. VSP International Science Publishers, Utrecht, 2-17.

Guex J. (1991) - Biochronological Correlations. *Springer-Verlag*, 250 pp., Berlin.

Haag M. & Heller F. (1991) - Late Permian to early Triassic magnetostratigraphy. *Earth Planet. Sci. Lett.*, 107: 42-54, Amsterdam.

Heller F., Chen H.H., Dobson J. & Haag M. (1995) - Permian and Triassic magnetostratigraphy - new results from South China. *Phys. Earth Planet. Int.*, 89: 281-295.

Huang T.K. (1932) - Late Permian Brachiopoda of southwestern China. Part I. *Paleont. Sin.*, ser. B, 9: 1-138, Beijing.

Jin Y., Wardlaw B.R., Glenister B.F. & Kotlyar G.V. (1997) - Permian chronostratigraphic subdivisions. *Episodes*, 20: 10-15, Beijing.

Jin Yugan, Ye Songlin, Xu Hankui & Sun Dongli (1979) - Brachiopoda. In: Nanjing Institute of Geology and Palaeontology & Geological Institute of Qinghai Province (Eds.) - Paleontological atlas of northwest China. Qinghai Volume 1, 60-217. Geological Publishing House, Beijing.

Kotlyar G.V. (1994) - The *Lepidolina kumaensis* Zone and its position in the Tethyan Stratigraphic Scale. *Permophiles*, 24: 26-28. A Newsletter of SCPS, Ottawa.

Kotlyar G.V. & Pronina G.P. (1995) - Murgabian and Midian Stages of the Tethyan realm. *Permophiles*, 27: 23-26. A Newsletter of SCPS, Ottawa.

Kotlyar G.V., Zakharov Yu.D., Kropatcheva G.S., Pronina G.P., Chedija I.O., and Burago V.I. (1989) - Evolution of the latest Permian Biota. Midian regional stages in the USSR. *Izd. "Nauka"*, 184 pp., Leningrad.

Kotlyar G.V., Zakharov Yu.D., Koczyrkevicz B.V., Kropatcheva G.S., Rostovtsev K.O., Chedija I.O., Vuks G.P. & Guseva E.A. (1983) - Evolution of the latest Permian Biota. Dzhulfian and Dorashamian regional stages in the USSR. *Izd. "Nauka"*, 200 pp., Leningrad.

Kozur H. (1994) - Preliminary report on the Permian conodont fauna of Darvas and SE Pamir and its importance for the Permian Time Scale. *Permophiles*, 24: 13-15. A Newsletter of SCPS, Ottawa.

Kozur H. (1995) - The importance of the Permian pelagic sequences of the Sosio Valley (Sicily, Italy) for the elaboration of an international Permian Scale. *Permophiles*, 29: 26-27. A Newsletter of SCPS, Ottawa.

Leven E. Ya. (1967) - Stratigraphy and fusulinids of the Permian deposits of the Pamirs. *Trudy Geol. Inst. Akad. Nauk SSSR*, 167: 1-215.

Leven E. Ya. (1980) - Explanatory notes to the stratigraphic scale of Permian deposits of the Tethys area. *Izdat. VSEGEI*: 1-15, St.-Petersburg.

Leven E. Ya. (1981) - Permian Tethys Stage Scale and correlation os sections of the Mediterranean-Alpine folded belt. In Karamata S. & Sassi F.P. (eds.) - IGCP *No. 5, Newsletter*, 3: 100-112, Padova.

Leven E.Ya. (1998) - Permian fusulinid assemblages and stratigraphy of the Transcaucasia. *Riv. It. Paleont Strat.*, 104: 299-328, Milano.

Mei S. & Henderson C.M. (2001) - Evolution of Permian conodont provincialism and its significance in global correlation and paleoclimate implication. *Palaeogeogr., Palaeoclim., Palaeoecol.*, 170: 237-260, Amsterdam.

Menning M. (2000) - Magnetostratigraphic results from the Middle Permian type section, Guadalupe Mountains, West Texas. *Permophiles*, 37: 16. A Newsletter of SCPS, Ottawa.

Merla G. (1934) - Fossili antracolitici del Caracorum. Spedizione Italiana de Filippi nell'Himalaya, Caracorum e Turchestan cinese, II, 5: 99-319, Bologna.

Mikhaylov Yu.A., Ustritskiy V.I., Chernyak G.Ye. & Yavshits G.P. (1970) - Upper Permian glacio-marine sediments of the northeastern USSR. *Dokl. Akad. Nauk SSSR*, 190: 100-102.

Miklukho-Maklai A.D. (1958) - On stage subdivision of marine deposits of the USSR southern regions. *Dokl. Akad. Nauk SSSR*, 120: 157-178.

Pakistani-Japanese Research Group (1985) - Permian and Triassic Systems in the Salt Range and Sughar Range, Pakistan. In Nakazawa K. & Dickins J.M. (eds.) - The Tethys. Her paleogeography and paleobiogeography from Paleozoic to Mesozoic. *Tockai University Press*, 221-312.

Reed F.R.C. (1944) - Brachiopods and Mollusca from the Productus Limestone of the Salt Range. *Palaeont. Indica* N.S., 23, 2: 1-678, Calcutta.

Renz H. (1939) - Die Paleontologischen Ergebnisse der Expedition 1929/30. In Visser & Visser (eds.) - Karakorum und die angrenzenden Gebiete in den Jahren 1922, 1925, 1929, 1930, 1935, 3: 1-88, Leiden.

Renz H. (1940) - Die Paleontologischen Ergebnisse der Expedition 1935. In Visser & Visser (eds.) - Karakorum und die angrenzenden Gebiete in den Jahren 1922, 1925, 1929, 1930, 1935, 3: 119-268, Leiden.

Rui L. & Nassichuk W.W. (1996) - Upper Permian (Wordian) fusulinaceans from the Cache Creek Terrane, Northern British Columbia. *Canad. Journ. Earth Sci.*, 33: 1022-1036.

Ruzhentsev V.E. & Sarycheva T.G. (1965) - Evolution and succession of marine organisms at the Permo-Triassic boundary. *Akad Nauk SSSR, Trudy Paleont. Inst.*, 108, 430 pp., Moscow.

Savage J. (1996) - Classification of Palaeozoic rhynchonellid brachiopods. In Copper P. & Jin J. (Eds.) - Brachiopods. Proceedings of the Third International Brachiopod Congress, Sudbury, Canada, 2-5 September 1995, 13-18, Balkema Press, Rotterdam.

Savary J. & Guex J. (1991) - Biograph: un nouveau programme de construction des corrélations biochronologiques basées sur les associations unitaires. *Bulletin de la Societé Vaudoise des Sciences Naturelles*, 80: 317-340.

Shen S. & Shi G.R. (2000) - Wuchiapingian (early Lopingian, Permian) global brachiopod palaeobiogeography: a quantitative approach. *Palaeogeogr., Palaeoclim., Palaeoecol.*, 162: 299-318, Amsterdam.

Shen S., He X. and Zhu M. (1992) - Changhsingian brachiopods from Zhongliang Hill of Chongqing, Sichuan, South China. In Gu Dao-Youan et al. (Eds.) - The symposium on stratigraphy and paleontology of oil and gas bearing areas in China (3), 171-196. The Petroleum Industry Press, Beijing.

Shen S., Shi G.R. & Kuiyu Zhu (2000) - Early Permian brachiopods of Gondwana affinity from the Dingjazhai Formation of the Baoshan Block, Western Yunnan, China. *Riv. It. Paleont. Strat.*, 106: 263-282. Milano.

Shen S., Tazawa J.I. & Shi G.R. (1999) - Peltichia Jin & Liao, 1981 (Enteletidae, Brachiopoda) from Asia: Taxonomy, biostratigraphy, and paleobiogeography. *Journ. Paleont.* 73: 49-62, Lawrence.

Shi G.R. (2000) - Breaking the barrier between Provincialism and Global Correlation: Permian marine transitional faunas as gateways for global correlation. *Permophiles*, 37: 17-18. A Newsletter of SCPS, Ottawa.

Shi. G.R. & Archbold N.W. (1995) - Palaeobiogeography of Kazanian-Midian (Late Permian) Western Pacific brachiopod faunas. *Journ. SE Asian Earth Sci.*, 12: 129-141, London.

Shi. G.R. & Archbold N.W. (1998) - Permian marine biogeography of SE Asia. In Hall R. and Holloway J.D. (Eds.) - Biogeography and geological evolution of SE Asia, 57-72, Leiden.

Shi G.R. & Grunt. T.A. (2000) - Permian Gondwana-Boreal antitropicality with special reference to brachiopod faunas. *Palaeogeogr., Palaeoclim., Palaeoecol.*, 155: 239-263, Amsterdam.

Shi G.R. & Shen S. (1998) - A Changsingian (Late Permian) brachiopod fauna from Son La, northwest Vietnam. *Journ. Asian Earth Sci.*, 16: 501-511, London.

Shi G.R. & Shen S. (2001) - A biogeographically mixed, Middle Permian Brachiopod fauna from the Baoshan Block, Western Yunnan, China. *Palaeontology*, 44: 237-258, London.

Shi G.R. & Waterhouse J.B. (1996) - Lower Permian bra-

chiopods and molluscs from the upper Jungle Creek Formation, Northern Yukon Territory, Canada. *Geol. Surv. Canada Bull.*, 424, 241 pp., Ottawa.

Shi G.R., Archbold N.W. & Zhan L.P. (1995) - Distribution and characteristics of mixed (transitional) mid-Permian (Late Artinskian-Ufimian) marine faunas in Asia and their palaeogeographical implications. *Palaeogeogr., Palaeoclim., Palaeoecol.*, 114: 241-271, Amsterdam.

Shi G.R., Shen S. & Tong J. (1999) - Two discrete, possibly unconnected, Permian marine mass extinctions. In Yin H. & Tong J. (Eds.) - Proceedings of the International Conference on Pangea and the Paleozoic-Mesozoic Transition. March 9-11, 1999, China University of Geosciences, Wuhan, Hubei, China, 148-150.

Sone M., Leman M.S. & Shi G.R. (2001) - Middle Permian brachiopods from central Peninsular Malaysia - faunal affinities between Malaysia and west Cambodia. *Journ. Asian Earth Sci.*, 19: 177-194.

Taraz H., Golshani F., Nakazawa K., Shimizu P., Bando Y., Ishii K., Murata M., Okimura Y., Sakagami S., Nakamura K. & Tokuoka T. (1981) - The Permian and Lower Triassic System in the Abadeh region, Central Iran. *Mem. Fac. Sci. Kyoto Univ. Ser. Geol. Mineral.*, 47: 61-133.

Tazawa J. (1987) - *Attenuatella* (Brachiopoda) from the Upper Permian of northeast Japan and its bipolar distribution. *Trans. Proc. Palaeont. Soc. Japan*, N.S., 148: 276-284

Termier G., Termier H., de Lapparent A.K. & Marin P. (1974) - Monographie du Permo-Carbonifère de Wardak (Afghanistan Central). *Doc. Lab. Fac. Sci. Lyon*, 2, 168 pp., Lyon.

Waagen W.H. (1882-1885) - Salt Range fossils. Part 4 Brachiopoda. *Palaeont. Indica*, 13, 1, 1-5: 329-770, Calcutta.

Wardlaw J.B. & Mei S. (1998) - Conodont biostratigraphy of the Middle and Upper Permian of the Salt Range, Pakistan. Ecos VII, Seventh International conodont symposium held in Europe. Bologna-Modena, June 18-22, 1998, Abstracts, 117-118, Bologna.

Wardlaw B.R. & Pogue K.R. (1995) - The Permian of Pakistan. In Scholle P.A., Peryt T.M., Ulmer-Scholle D.S (Eds.). The Permian of Northern Pangea. *Springer Verlag*, 215-224, Berlin.

Waterhouse J.B. (1968) - The classification and descriptions of Permian Spiriferida (Brachiopoda) from New Zealand. *Palaeontographica*, A, 129, 94 pp., Stuttgart.

Waterhouse J.B. (1983) - A late Permian Lyttoniid fauna from northwest Thailand. *Pap. Dept. Geol.* Qd., 10: 111-153, Brisbane.

Waterhouse J.B. & Gupta V.J. (1983) - An early Djulfian (Permian) brachiopod faunule from Upper Shyok Valley (Karakorum Range) and the implications for dating of allied faunas from Iran and Pakistan. *Contributions to Himalayan Geology*, 2: 189-233, Delhi.

Waterhouse J.B. & Piyasin S. (1970) - Mid-Permian brachiopods from Khao-Phrik, Thailand. *Palaeontographica* A, 135: 83-197, Stuttgart.

Waterhouse J.B. & Waddington J. (1982) - Systematic descriptions, paleoecology and correlations of the Late Paleozoic subfamily Spiriferellinae (Brachiopoda) from the Yukon Territory and the Canadian Arctic Archipelago. *Geol. Surv. Canada Bull.*, 289: 1-73, Ottawa.

Waterhouse J.B., Waddington J. & Archbold N. (1978) - The evolution of the Middle Carboniferous to Late Permian brachiopod subfamily Spiriferellinae Waterhouse. In Stelck C.R. & Chatterton B.D.E. (Eds.) - Western and Arctic Canadian biostratigraphy. *Geol. Ass. Canada Spec. Pap.*, 18: 416-442, Ottawa.

Williams A., Carlson S.J., Brunton C.H.C., Holmer L.E. & Popov L. (1996) - A supra-ordinal classification of the Brachiopoda. *Phil. Trans. R. Soc. Lond.* B, 351: 1171-1193, London.

Williams A., Rowell A.J., Muir-Wood H-M., Pitrat C.W., Schmidt H., Stehli F.G., Ager D.V., Wright A.D., Elliott G.F., Amsden T.W., Rudwick M.J.S., Hatai K., Biernat G., McLaren D.J., Boucot A.J., Johnson J.G., Staton R.D., Grant R.E. & Jope H.M (1965) - In Moore R.C. (Ed.) - Treatise on Invertebrate Paleontology. Part H: Brachiopoda, *Geological Society America & University of Kansas Press*, 927 pp., Boulder & Lawrence.

Williams A., Brunton C.H.C. & Carlson S.J. et 43 al. (1997) - In R.L. Kaesler (Ed.) - Treatise on Invertebrate Paleontology. Part H: Brachiopoda (revised). Vol. 1, *Geological Society America & University of Kansas Press*, Boulder & Lawrence, 539 pp.

Williams A., Brunton C.H.C. & Carlson S.J. et 43 al. (2000) - In R.L. Kaesler (Ed.) - Treatise on Invertebrate Paleontology. Part H: Brachiopoda (revised). Vol. 2-3, *Geological Society America & University of Kansas Press*, 919 pp., Boulder & Lawrence.

Yanagida J. (1973) - Late Permian brachiopods from Yamamba Limestone in Sakawa Basin, Shikoku, Japan. Tohoku Univ. Sci. Rep. 2nd ser. (Geol.), Special Volume, 6, 353-369, Sendai.

Zhan L. & Wu R. (1982) - Early Permian brachiopods from Xainza District, Xizang (Tibet). Contribution to the Geology of the Qinghai-Xizang (Tibet) Plateau, 7, 86-109.