

## PERMIAN BRACHIOPODS FROM KARAKORUM (PAKISTAN). Pt. 2

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**Key-words:** Brachiopods, Biostratigraphy, Bolorian, Kubergandian, Karakorum, Pakistan.

**Riassunto.** Cinque associazioni a Brachiopodi sono state riconosciute nelle successioni permiane del Karakorum settentrionale (Pakistan) dall'Asseliano-Sakmariano al Murgabiano-Midiano. Nel presente lavoro si illustrano le due associazioni del Boloriano e del Kubergandiano. L'associazione a *Orthothena convergens-Aldina exilis* è stata campionata a tetto del Mb. 2 della Fm. Lashkargaz, lungo la sezione di Lashkargaz, in Karakorum occidentale. L'associazione più recente, denominata associazione a *Waagenoconcha (Gruntoconcha) macrotuberculata-Callytharrella sinensis*, è presente nel Mb. 4 della Fm. Lashkargaz, lungo le sezioni di Lashkargaz e Baroghil Est e nella località lungo il Fiume Yarkhun a 2 km da Lashkargaz. Inoltre questa associazione è stata campionata anche nel settore centrale del Karakorum, nel Mb. 1 della Fm. Panjshah, lungo la sezione di Panjshah (Valle Hunza). La prima delle due associazioni, piuttosto povera di forme, risulta dominata dalle specie *Aldina exilis* e *Marginifera andreae*; la seconda presenta invece un'altissima diversità tassonomica, con la dominanza dell'ordine Productida.

**Abstract.** Five brachiopod associations were collected in the Permian successions of N Karakorum (Pakistan) from the Asselian-Sakmarian to the Murgabian-Midian. The aim of this work is to describe the Bolorian and the Kubergandian faunas. The *Orthothena convergens-Aldina exilis* assemblage occurs at the top of the Mb. 2 of Lashkargaz Fm. at Lashkargaz, in Western Karakorum. The higher assemblage has been named *Waagenoconcha (Gruntoconcha) macrotuberculata-Callytharrella sinensis* assemblage and it has been recognized in the Mb. 4 of Lashkargaz Fm. of Lashkargaz and Baroghil area and in the Mb. 1 of Panjshah Fm. of Upper Hunza valley, in Central Karakorum. This assemblage is characterized by very high taxonomic diversity and biomass and it is dominated by the productids, whereas the lower assemblage is less diversified and dominated by *Aldina exilis* and *Marginifera andreae*.

### Introduction.

Large collections of Permian brachiopods were assembled during four Italian expeditions (1986, 1991, 1992a, 1992b) on the Pakistan side of Karakorum along the Upper Hunza valley and its laterals (Chapursan valley, Abgarch valley and Shimshal valley) and in the Chitral-Baroghil sector (W Karakorum) (Fig. 1).

Permian brachiopods from western Karakorum (Baroghil Ailak) were described by Reed (1925), whereas

brachiopods from Central Karakorum (Upper Hunza valley) were described by Fantini Sestini (1965a). At least five brachiopod assemblages have been recognized so far, from the Asselian-Sakmarian to the Murgabian-Midian of Karakorum (Angiolini, 1994). The first two assemblages have been described by Angiolini (1995) together with the description of new taxa collected in the higher assemblages. For the original diagnosis of some of the taxa here described refer to Angiolini (1995).

The aim of this paper is to describe the third and fourth brachiopod assemblages from Karakorum, which are respectively Bolorian and Kubergandian in age.

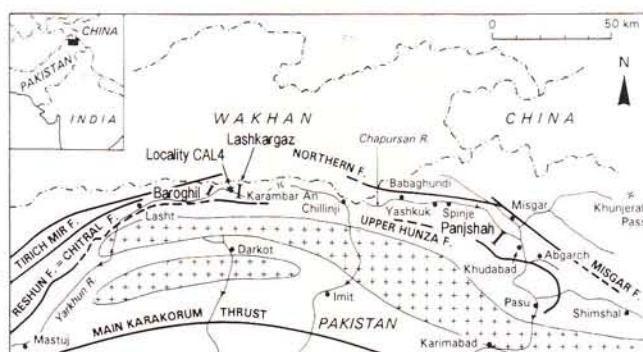


Fig. 1 - Geographic sketch map of the Pakistan side of N Karakorum.

### Stratigraphy.

The Permian stratigraphy of Karakorum (Pakistan) has been extensively described by Gaetani et al. (1995), to which reference is made for age assignments and description of stratigraphic sections. In the western extremities of Karakorum (Baroghil sector) the Lashkargaz Fm. overlays the Gircha Fm. and consists of 4 members spanning the Sakmarian-Kubergandian time interval. Member 2 of the Lashkargaz Fm. consists of fusulinid limestones, passing upward to marly limestones and bioclastic limestones. The age of this mem-

|     | Baroghil     | Chillinji            | Chapursan                     | Shimshal      |
|-----|--------------|----------------------|-------------------------------|---------------|
| 251 |              |                      |                               |               |
| 255 | Dorashamian  |                      |                               | ?             |
|     | Dzhulfian    | Ailak Fm.            | Wirokhun Fm.                  |               |
| 259 | Midian       |                      | Kundil Fm.                    | Kundil Fm.    |
| 264 |              |                      |                               |               |
|     | Murgabian    | Gharil Fm.           |                               |               |
| 269 |              |                      |                               |               |
|     | Kubergandian | Fm. Mb 4 *<br>Mb 3 * | Panjshah Fm. Mb 2 ▲<br>Mb 1 * | Panjshah Fm.  |
| 273 |              |                      |                               |               |
| 275 | Bolorian     |                      |                               | ?             |
|     | Artinskian   | Lashkargaz Mb. 2     |                               |               |
| 283 |              |                      | Lupghar Fm. Mb. 2             | Lupghar Fm. * |
| 287 | Sakmarian    | Lashkargaz Mb. 1 C * | Mb. 1 *                       |               |
|     | Asselian     | Gircha Fm.           | Gircha Fm. *                  | Gircha Fm.    |
| 295 |              |                      |                               |               |

Fig. 2 - Chronostratigraphic scheme of the Permian successions of Karakorum. The stars indicate the position of the brachiopods described in Angiolini (1995), the asterisks the position of the assemblages described in this paper, the triangles the association which will be described in a next paper (from Gaetani et al., 1995).

ber is Sakmarian to Bolorian on the basis of fusulinids and brachiopods (Gaetani et al., 1995). The Mb. 3 of the Lashkargaz Fm. consists of fine sandstones and siltites, whereas the Mb. 4 contains bioclastic cherty limestones at the base and dolostones, marls and marly limestones upward. The age of Mb. 3 and 4 is Kubergandian; the top of Mb. 4 may enter the Murgabian (Gaetani et al., 1995).

In the Upper Hunza valley and its laterals, the Lower Permian Gircha Fm. and Lupghar Fm. are topped by an erosional surface with sandstones, siltites and limestones of Mb. 1 of the Panjshah Fm. of Kubergandian age. The Mb. 2 of the Panjshah Fm. is represented by marls, marly and bioclastic limestones and is Murgabian-?Midian in age.

The two brachiopod assemblages under examination were collected as follow: the lower from the Mb. 2 of Lashkargaz Fm. (Upper Yarkhun valley); the higher association from the Mb. 1 of Panjshah Fm. (Chapursan valley, Upper Hunza) and in the Mb. 4 of Lashkargaz Fm. (Baroghil-Lashkargaz area) (Fig. 2).

### Composition of the assemblages.

The lower assemblage described in this paper has been found in two levels of marly limestones at the top of Mb. 2 of Lashkargaz Fm. in the Lashkargaz section (Fig. 3). It is characterized by the occurrence of *Orthothetina convergens* Merla, *Orthotichia* sp. ind., *Neochone-*

*tes (Neochonetes) costellata* Angiolini, *Neochonetes (Sommeriella) baroghilensis* (Reed), *Paramesolobus* aff. *sinuosus* (Schellwien), *Marginifera andreaei* Angiolini, *Retimarginifera praelecta* (Reed), *Magniplicatina inassueta* (Reed), *Compressoproductus* sp. ind., *Aldina exilis* Angiolini. The species which dominate are the productid *M. andreaei* (53% of the assemblage) and the rhynchonellid *A. exilis* (27% of the assemblage). However *M. andreaei* occurs as a significant cluster only in the lowest level (sample CK315), whereas *A. exilis* is subordinate in CK315, but continues upward for about 45 metres to the second fossiliferous level (sample CK319), where it shows an high biomass. The chonetids occur only in the uppermost level (CK319), where they represent 11% of the association, *N. (S.) baroghilensis* being dominant. This assemblage is characterized by low biomass and low diversity suggesting a near-shore environment; furthermore most of the specimens are disarticulated (except for *A. exilis* which has a strong articulation), indicating a rather high energy environment. According to Gaetani et al. (1995) the composition of the total fauna (brachiopods, Tabulata, crinoids, bryozoans, fusulinids, oncoids) and the lithofacies indicate deposition on a mobile carbonate ramp environment periodically polluted by clay during warm climate conditions.

The higher assemblage was collected in bioclastic limestones with black cherty nodules at the base of the Mb. 4 of Lashkargaz Fm. in the Lashkargaz section, in marly limestones and in bioclastic limestones with black cherty nodules at the base of the Mb. 4 of Lashkargaz Fm. in the Baroghil E section and in bioclastic limestones with quartz 18 m above the base of the Mb. 1 of Panjshah Fm. in the Panjshah section (Fig. 3). This assemblage is characterized by *Enteletes* sp. ind., *Derbyia grandis* Waagen, *Orthothetina convergens* Merla, *Neochonetes (N.) costellata* Angiolini, *N. (Sommeriella) baroghilensis* (Reed), *N. (S.) vialis* (Reed), *Paramesolobus* aff. *sinuosus* (Schellwien), *Retimarginifera praelecta* (Reed), *Transennatia reedi* Angiolini, *Echinoconchus* sp. ind., *Waagenoconcha (Waagenoconcha)* sp. ind., *W. (Gruntoconcha) macrotuberculata* Angiolini, *Chaoiella* sp. ind., *Callytharrella sinensis* (Sun), *Costiferina* sp. ind., *Reticulatia chitralis* Angiolini, *Magniplicatina johannis* Angiolini, *M. vindicata* (Reed), *Permophricodothyris* sp. ind. The order Productida numerically dominates the assemblage, representing 66.7% of the total fauna: in particular the big dictyoclostids *Reticulatia* and *Callytharrella* are 30% of the total assemblage. The chonetids are also abundant, representing 20% of the assemblage, whereas the spiriferids are very subordinate, being only represented by a single specimen of *Permophricodothyris*. Rhynchonellids are totally lacking. The productid *T. reedi* occurs in a single level (sample CK324) at the top of the assemblage, forming a characteristic cluster. This association shows a very high taxonomic diversity together with a

BAROGHIL EAST SECTION

LASHKARGAZ SECTION

PANJSHAH SECTION

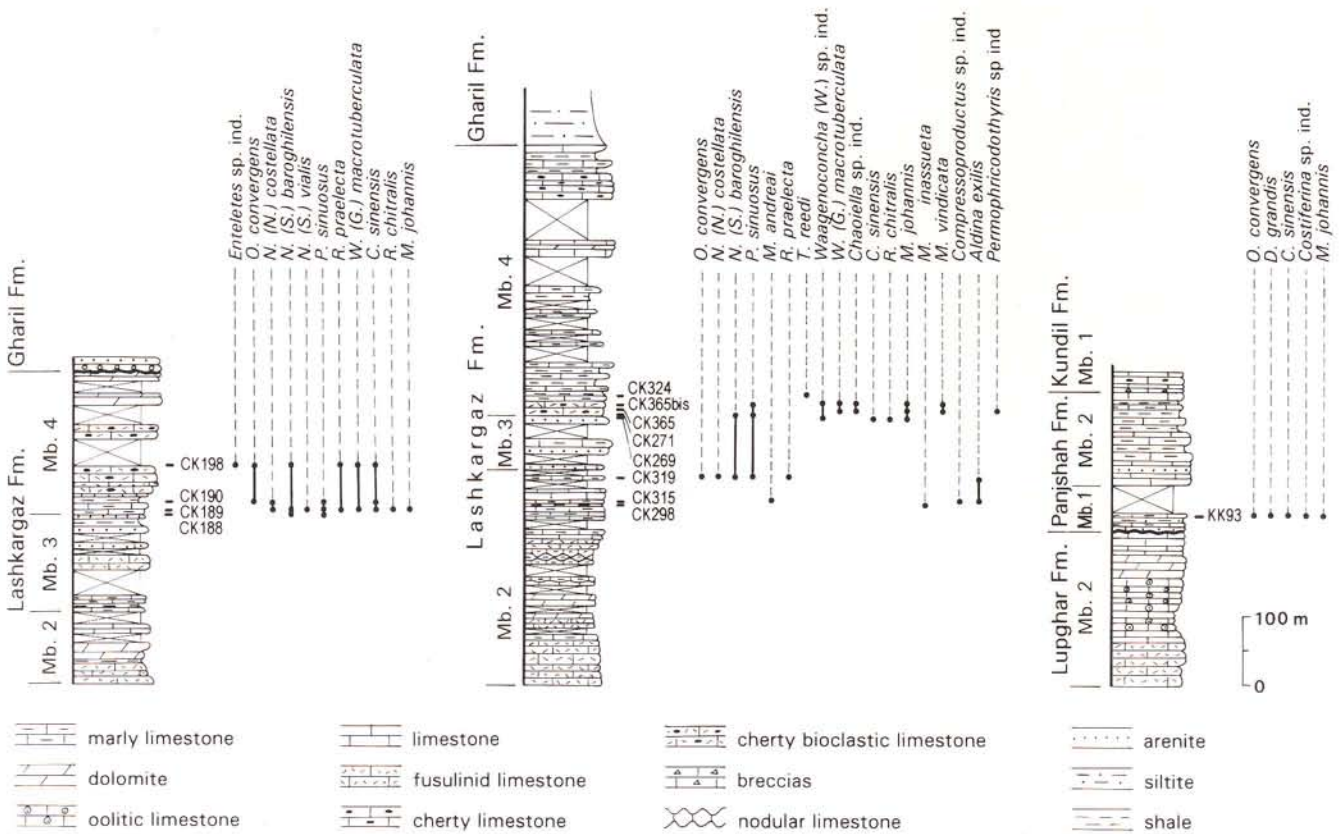


Fig. 3 - Correlations between the sections Baroghil E, Lashkargaz and Panjshah.

high biomass suggesting a mid-shelf environment in warm climatic conditions. The disarticulation and fragmentation of most of the specimens indicate a high energy environment. Gaetani et al. (1995) suggest deposition on a carbonate platform during tropical-equatorial climate conditions on the basis of the very high taxonomic diversity of the fauna and the increasing mineralogical stability of detritus.

**Biostratigraphy.**

The biostratigraphic study of these faunas led to the recognition of two assemblage zones. Furthermore the application of the Unitary Association Method of Guex (1991) carried out a more detailed subdivision based on 7 unitary associations and on 2 biochronozones [the numeration of the unitary associations follows that published in Angiolini (1995)]. The ages of the two assemblages here described are referred to the Tethyan stages which are based on fusulinids. No correlation to deposits characterized by ammonoids and conodonts is here provided.

The lower assemblage described in this paper has been interpreted as an assemblage zone, named *Orthothetina convergens-Aldina exilis* assemblage zone. It is 45 m-

thick and occurs at the top of the Mb. 2 of Lashkargaz Fm. in the Lashkargaz section. The lower boundary is represented by the lowermost occurrence of *Magniplicatina inassueta*, whereas the upper boundary corresponds to the highest occurrence of *A. exilis* and *O. convergens*. Inside this assemblage zone, two unitary associations have been recognized by applying the Biograph 2.02 program (Savary & Guex, 1991) (Fig. 4, 5). The first unitary association (U.A. 6) is characterized by the species *Marginifera andreae* and *Compressoproductus* sp. ind., which occur exclusively in the U.A. under consideration; the second (U.A. 7) is characterized by the pair *A. exilis* and *O. convergens*, which coexist only in this interval. These two U.A.'s have very low reproducibility, because they have been found only in the Lashkargaz section. The age of the *O. convergens-A. exilis* assemblage zone is Bolorian, as testified by the presence of the fusulinids *Pseudofusulina norikurensis krafftiformis* and *Darvasites* cf. *zulumartensis* (Gaetani et al., 1995).

The second association described in this paper has also been interpreted as an assemblage zone, named *Wagenoconcha (Gruntoconcha) macrotuberculata-Callytharrella sinensis* assemblage zone (in the sense of Salvador, 1994) by the two most prominent species. It has been recognized in the Mb. 4 of Lashkargaz Fm. of Lashkar-

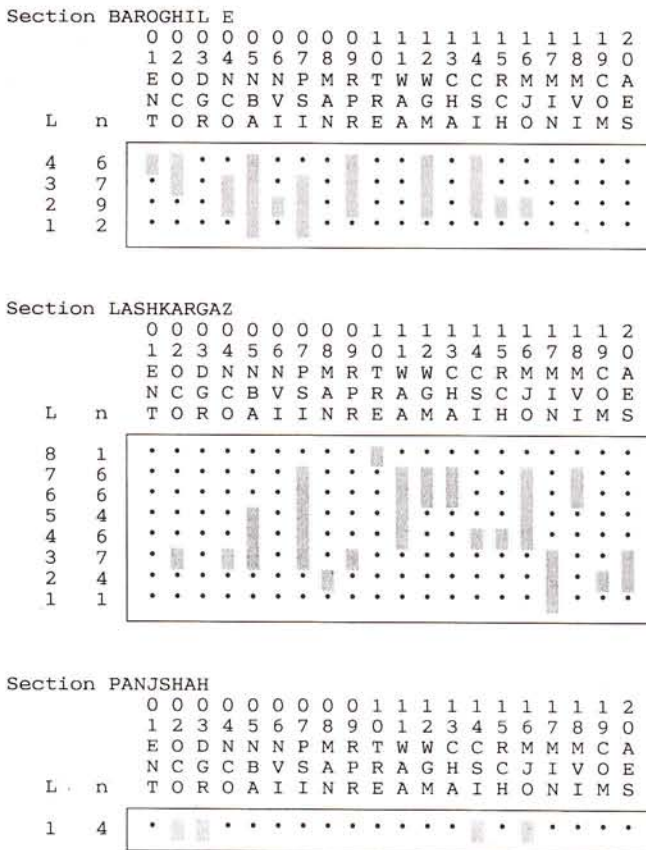


Fig. 4 - Local range charts. Output of the Biograph 2.02 program (Savary & Guex, 1991). Legend: L represents the number of levels in each stratigraphic section (see also Fig. 3); n is the number of species for each level, whereas the number followed by 3 letters indicates the name of the species: 01ENT = *Enteleles* sp.; 02OCO = *O. convergens*; 03DGR0 = *D. grandis*; 04NCO = *N. (N.) costellata*; 05NBA = *N. (S.) baroghilensis*; 06NVI = *N. (S.) vialis*; 07PSI = *P. aff. sinuosus*; 08MAN = *M. andreaei*; 09RPR = *R. praelecta*; 10TRE = *T. reedi*; 11WAA = *Waagenoconcha* sp.; 12WGM = *W. (G.) macrotuberculata*; 13CHA = *Chaoiella* sp.; 14CSI = *C. sinensis*; 15RCH = *R. chitralis*; 16MJO = *M. johannis*; 17MIN = *M. cf. inassueta*; 18MVI = *M. vindicata*; 19COM = *Compressoproductus* sp.; 20AES = *A. exilis*.

gaz and Baroghil E sections and in the Mb. 1 of Panjshah Fm. of Panjshah section (Fig. 3). The maximum thickness of this assemblage zone is 67 m. The lower boundary corresponds to the lowermost occurrence of *C. sinensis*, *Reticulatia chitralis*, *Magniplicatina johannis*; the upper boundary is placed at the highest occurrence of *Transennatia reedi*. Applying the Unitary Association Method of Guex (1991) with the Biograph 2.02 program (Savary & Guex, 1991) (Fig. 4, 5), five unitary associations have been recognized. The lowest unitary association (U.A. 8) is characterized by the existence interval of *Neochonetes (Sommeriella) vialis*; the second one, U.A. 9, is characterized by the existence interval of *Derbyia grandis*; the third one, U.A. 10 is characterized by the coexistence of *R. chitralis* and *Waagenoconcha (W.)* sp.; the following U.A. 11 is characterized by *Enteleles* sp.; the U.A. 12 is characterized by *Chaoiella*

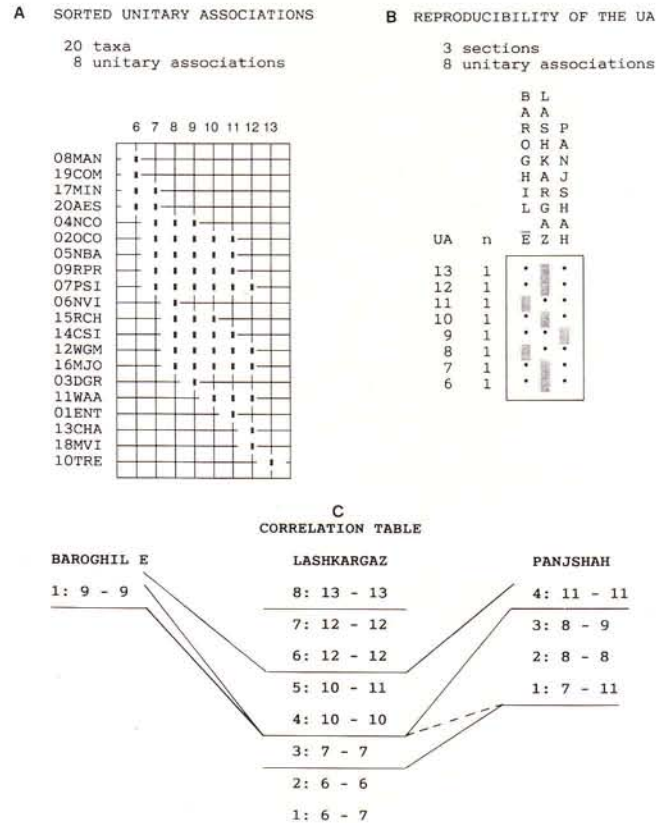


Fig. 5 - Output of the Biograph 2.02 program (Savary & Guex, 1991). A) Sorted Unitary Associations (U.A. 6-U.A. 12), key-letters for the species as in legend of Fig. 4; B) reproducibility matrix, where n is the coefficient of reproducibility for each U.A.; C) correlation table, where the levels of the stratigraphic sections are correlated using the Unitary Associations (U.A. 6-U.A. 12).

sp. and *Magniplicatina vindicata*; finally U.A. 13 is characterized by *T. reedi*, *M. johannis* and *W. (G.) macrotuberculata* occur throughout the unitary associations U.A. 8-12, whereas *C. sinensis* is present throughout U.A. 8-11 and *R. chitralis* occurs in U.A. 8-10. Finally *O. convergens*, *Neochonetes (Sommeriella) baroghilensis* and *Retimarginifera praelecta* coexist throughout U.A. 7-11 and *Paramesolobus aff. sinuosus* occurs from U.A. 7 to U.A. 12, having no biochronologic value. Considering now the reproducibility of the U.A.'s (Fig. 5B), they are present only in one section, thus being unreliable. To increase their reproducibility, without losing any useful information it is possible to merge the U.A.'s. The union of U.A. 8, U.A. 9 which have a similar faunal content, is identified in the Panjshah section, whereas the union of U.A. 10 and U.A. 11 is strictly identified in the Lashkargaz section; merging these U.A.'s, increases the reproducibility (coefficient of reproducibility = 2).

It is thus possible to extract two biochronozones, the first characterized by the pair of species *N. (S.) vialis* and *D. grandis* and the second by the pair of species *Waagenoconcha (W.)* sp. and *Enteleles* sp. The faunal con-

tent of U.A. 12 and U.A. 13 is rather peculiar; furthermore their union does not increase the reproducibility. So we retain them as separate U.A.'s, even if they have not a chronologic value. In conclusion the Unitary Association Method of Guex (1991) led to the recognition of 6 U.A.'s inside the *W. (G.) macrotuberculata-C. sinensis* assemblage zone; among these U.A. four can be merged to obtain respectively two biochronozones, whereas the others are not chronologically significant.

The age of the *W. (G.) macrotuberculata-C. sinensis* assemblage zone is Kubergandian, as testified by the occurrence of *C. sinensis* in the Kubergandian Tunlonggongba Fm. of NW Tibet (Sun, 1983), by the associated fusulinid (*Parafusulina (Parafusulina)* and *Parafusulina (Skinnerella)* spp.) and conodonts (Gaetani et al., 1995). The *W. (G.) macrotuberculata-C. sinensis* assemblage zone has a good reproducibility, occurring in three sections 200 km away. Furthermore the lithological control on this assemblage is poor, for it has been collected both in cherty bioclastic limestones and in marly limestones in the two sectors of Karakorum.

#### Collections and localities.

All specimens are housed at the Museo di Paleontologia (MPUM) del Dipartimento di Scienze della Terra dell'Università degli Studi di Milano (Italy). Specimens were found both in levels of measured sections and in isolated localities (for details refer to Gaetani et al., 1995) (Fig. 1, 2, 3).

#### Western Karakorum.

CK188, CK190, CK189, CK198 - Lashkargaz Fm., Mb. 4, Baroghil E section, Baroghil pass.

CK269, CK271, CK365, CK365bis, CK324 - Lashkargaz Fm., Mb. 4, Lashkargaz section, Lashkargaz.

CK298, CK315, CK319 - Lashkargaz Fm., Mb. 2, Lashkargaz section, Lashkargaz.

CAL4 - Yarkhun river, Hot Spring, 2 km W of Lashkargaz.

#### Central Karakorum.

KK93 - Panjshah Fm., Mb. 1, Panjshah section, Chapursan valley.

### Systematic descriptions

Classification according to the Treatise on Invertebrate Paleontology, Part H (Williams et al., 1965) and Archbold (1981).

Order Orthida Schuchert & Cooper, 1932

Suborder Orthidina Schuchert & Cooper, 1932

Superfamily *Enteletacea* Waagen, 1884

Family *Enteletidae* Waagen, 1884

Genus *Enteletes* Fischer de Waldheim, 1825

Type-species: *Enteletes glabra* Fischer de Waldheim, 1830

#### *Enteletes* sp. ind.

Pl. 1, fig. 1, 2

Material. 5 Ventral valves: MPUM7761 (CK198-17); MPUM7762 (CK198-1,-15,-40,-43).

2 Dorsal valves: MPUM7763 (CK198-18); MPUM 7764 (CK198-44).

Description. Medium-sized, biconvex shell, with globose shape and sub-circular outline. Hinge line straight, shorter than maximum width, which lies at mid-length. Anterior commissure strongly uniplicate.

Ventral valve convex, with sub-circular outline. Ventral umbo straight, high and pointed; interarea concave with open delthyrium. Ventral sulcus sub-angular starting at mid-length, widening and deepening anteriorly. At each side of the sulcus three large, sub-angular folds occur, decreasing in strength laterally. Dorsal valve more convex than the ventral valve. Dorsal umbo large and recurved. Dorsal fastigium sub-rounded, starting at mid-length. At each side three sub-angular folds are present, the last one being very low. Ornamentation of thin costellae.

Interior of ventral valve with long, straight and subparallel dental plates; median septum very long and high, dorsally thickened. Interior of dorsal valve with coarse and divergent brachiophore bases and a long and thin median septum.

#### Dimensions (in mm):

|          | Width | Length | Thickness | Hinge |
|----------|-------|--------|-----------|-------|
| CK198-1  | 22.3  | >18.4  | 10        |       |
| CK198-17 | 27    | >20    |           | 15    |
| CK198-18 | 23    | 19.6   | 9.7       | 16    |

Discussion. Typical characters of the material to hand are the globose shape with sub-circular outline, straight umbo, angular lateral costae, numbering three for each side.

*Enteletes* sp. ind. is very similar to *Enteletes waageni* Gemmellaro, 1892 differing from it by its sub-circular outline, lower dorsal umbo, fewer costae, more rounded ventral sulcus and dorsal fold. *Enteletes obesus* Grabau, 1931 has a more globose shape and shows a greater number of lateral costae; *Enteletes conjunctus* Reed, 1944, described by Termier et al. (1974) for the Early Murgabian of Afghanistan is distinguished by equidimensional costae and absence of distinct ventral sulcus and dorsal fold.

Geographic and stratigraphic distribution. *Enteletes* sp. ind occurs in the Kubergandian Mb. 4 of Lashkargaz Fm. of Baroghil Pass, Western Karakorum.

Subfamily *Schizophoriinae* Schuchert in  
Schuchert & Le Vene, 1929

Genus *Orthotichia* Hall & Clarke, 1892

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

***Orthotichia* sp.**

Material. 1 Ventral valve: MPUM7765 (KK315-126).

Description. Ventral valve with elliptical outline, moderately inflated. Ventral sulcus very low. Ornamentation finely multicostellate.

Geographic and stratigraphic distribution. *Orthotichia* sp. ind occurs in the Bolorian Mb. 2 of Lashkargaz Fm. of Lashkargaz, Western Karakorum.

Order Strophomenida Opik, 1934

Superfamily *Orthotetacea* Waagen, 1884

Family *Meekellidae* Stehli, 1954

Subfamily *Meekellinae* Stehli, 1954

Genus *Orthothenina* Schellwien, 1900

Type-species: *Orthotetes persicus* Schellwien, 1900

***Orthothenina convergens* Merla, 1934**

Pl. 1, fig. 3-6

1925 *Orthothenina* aff. *bashkirica* Reed, p. 77, pl. 7, fig. 12.

1934 *Orthothenina convergens* Merla, p. 282, fig. 18.

1934 *Orthothenina flabellum* Merla, p. 283, fig. 19.

1934 *Orthothenina flabellum* var. *protracta* Merla, p. 284, fig. 20.

Material. 30 Ventral valves: MPUM7766 (KK93-23); MPUM7767 (KK93-24); MPUM7768 (KK93-28, 33, 35, 36-38, 40, 40bis, 42, 43, 44, 50, 51, 59, 60, 78, 80, 83, 85, 86, 87); MPUM7769 (CK 190-5; CK198-22, 102, 116, 126, 139, 141; CK319-14).

10 Dorsal valves: MPUM7770 (KK93-34, 77, 79); MPUM7771 (CK189-124); MPUM7772 (CK190-1); MPUM7773 (CK198-2, 6, 11, 16, 124).

Lectotype. Ventral valve, sample IGF17069, here selected. Repository Museo di Paleontologia, Università di Firenze.

Type-locality. Left side of Rimu Glacier, NE Karakorum.

Description. Biconvex shell with subtriangular outline. Straight hinge line, narrower than maximum width, which lies anteriorly. Cardinal extremities rounded.

Ventral valve conical, convex posteriorly and flat toward the anterior margin, assuming a flabellate shape. Ventral umbo straight; interarea triangular with high and narrow delthyrium which is closed by a convex pseudodeltidium, transversally striated and bearing a median ridge. Dorsal valve more convex than the ventral one, with subcircular outline. Dorsal sulcus shallow, starting at a distance of 10-15 mm from the umbo, dee-

pening and widening anteriorly. Ornamentation of thin, rounded and spaced costae and costellae increasing in number anteriorly by intercalation and bifurcation in three cycles; the last cycle is near the anterior margin. The number of the ribs is 10-12 per 5 mm at a distance of 15 mm from the umbo. Interior of the ventral valve with thin and long dental plates, converging toward the floor of the valve and extending subparallel or slightly divergent up to 1/3 the length of the valve. Ventral muscle field raised with elongated oval outline. Interior of dorsal valve with long and divergent socket plates.

Dimensions (in mm):

|          | Width | Length | H.I. | W.I. |
|----------|-------|--------|------|------|
| KK93-23  | 20.5  | 22     | 7.2  | 12   |
| KK93-24  | 22.5  | >22    | 8    | 13.6 |
| KK93-42  | 26.7  | >15    |      |      |
| KK93-44  | 24.8  | 29     |      |      |
| KK93-59  | 13.8  | 12     |      |      |
| KK93-77  | 24    | 17     |      |      |
| CK198-22 | 26    | >24    | 7    | 10.5 |
| CK198-2  | >25.1 | >24.5  |      |      |

H.I.: Height of interarea

W.I.: Width of interarea

Ontogenetic variation. The dorsal sulcus is well defined only in the anterior part of mature specimens; it is very low or absent in the juveniles.

Discussion. The specimens under examination are placed in the species *Orthothenina convergens* Merla, 1934 because of the convergent dental plates. However, their external characters (i.e. the flabellate shape) fit well with the description of *O. flabellum* Merla, 1934. After the study of the material of Merla (1934) from Rimu Glacier (NE Karakorum), housed at the Museum of Paleontology of the University of Firenze, the present author decided to merge *O. convergens* and *O. flabellum* and its variety *protracta* in the same species. Both are characterized by flabellate shape and by convergent dental plates. In particular the degree of convergence of the dental plates seems to be variable, but always present. The specimen IGF17069 of Merla (1934), collected along the left side of Rimu Glacier and housed at Museum of Paleontology of the University of Firenze, has been chosen as lectotype.

The Baroghil specimens described by Reed (1925) as *Orthothenina* aff. *bashkirica* (Tschernyschew) belong to *O. convergens* being characterized by flabellate shape and convergent dental plates.

Geographic and stratigraphic distribution. *O. convergens* occurs in the Permian of NE Karakorum (Merla, 1934). In Western and Central Karakorum it is present in the Bolorian Mb. 2 of Lashkargaz Fm. of Lashkargaz, in the Kubergandian Mb. 4 of Lashkargaz Fm. of Baroghil Pass and in the Kubergandian Mb. 1 of Panjshah Fm. of Panjshah.

Family *Derbyiidae* Stehli, 1954  
 Subfamily *Derbyiinae* Stehli, 1954

Genus *Derbyia* Waagen, 1884  
 Type-species: *Derbyia regularis* Waagen, 1884

Comments. The author agrees with Grant (1993) in considering *Wardakia* Termier, Termier, de Lapparent & Marin (1974, p. 94, pl. 9, fig. 2-5; pl. 10, fig. 1-3) a junior synonym of the genus *Derbyia*.

***Derbyia grandis* Waagen, 1884**

Pl. 1, fig. 7-9

1884 *Derbyia grandis* Waagen, p. 597, pl. 51, fig. 1; pl. 52, fig. 1-3; pl. 53, fig. 3-5.  
 1916 *Derbyia grandis* - Broili, p. 7, pl. 115, fig. 9.  
 1974 *Wardakia grandis* - Termier et al., p. 94, pl. 9, fig. 2-5; pl. 10, fig. 1-3.  
 non 1973 *Derbyia grandis* - Grunt & Dmitriev, p. 84, pl. 3, fig. 1-4.

Material. 2 Ventral valves: MPUM7774 (KK93-65); MPUM7775 (KK93-81).

4 Dorsal valves: MPUM7776 (KK93-27); MPUM7777 (KK93-29,-46,-82).

Description. Large sized shell with irregular to semicircular outline. Hinge line straight and wide. Cardinal extremities rounded. Ventral valve convex, with irregular outline. Ventral umbo large, deformed by a cicatrix of attachment to the substratum. Dorsal valve uniformly convex in longitudinal and transverse directions, with semicircular outline. The valve is flattened towards the hinge line. Dorsal umbo small and recurved.

Ornamentation of irregular rugae, costae and costellae. The rugae are coarse and high on the ventral valve, whereas are less developed dorsally. The number of costellae increases anteriorly by intercalation and bifurcation: they number 16 per 10 mm at the anterior margin. The intercostal spaces are as wide as the costellae. Growth lamellae may occur.

Interior of ventral valve with thick median septum extending to 1/3-1/2 of the length of the valve. From its anterior extremity two low ridges recurve posteriorly delimiting the large muscle field. The anterior margin of the muscle scars is multilobate.

Interior of dorsal valve with thick and divergent socket plates. Cardinal process large, dorsally furrowed by a large and deep sulcus and fused to the socket plates.

Dimensions (in mm):

|         | Length | Width |
|---------|--------|-------|
| KK93-65 | 42.5   | 53    |
| KK93-27 | 40.7   | > 27  |
| KK93-82 | 31.4   | > 20  |

Discussion. The specimens fit well with the description given by Waagen (1884) in introducing *Derbyia grandis*. The study of topotypes of *D. grandis* from Salt Range, housed at the V.S.E.G.E.I. of S. Petersburg, confirmed the specific determination. The specimens from the Sakmarian of SE Pamir described as *D. grandis* by Grunt & Dmitriev (1973, p. 84, pl. 3, fig. 1-4) do not belong to the species *grandis*, being characterized by a shorter ventral septum, smaller muscle field and absence of strong rugae in the ventral valve.

Geographic and stratigraphic distribution. *D. grandis* occurs in the Middle and Upper Productus Limestone of Salt Range (Waagen, 1884), in the Permian of Timor (Broili, 1916) and in the Late Sakmarian of Wardak (Termier et al., 1974).

In Central Karakorum it is present in the Kubergandian Mb. 1 of Panjshah Fm. of Panjshah.

Order Chonetida Nalivkin, 1979

Suborder Chonetidina Muir-Wood, 1965

Family *Rugusochonetidae* Muir-Wood, 1962

Subfamily *Rugusochonetinae* Muir-Wood, 1962

Genus *Neochonetes* Muir-Wood, 1962

Type-species: *Chonetes dominus* King, 1938

Comments. The relationship of *Neochonetes* to allied genera and its junior synonym *Quadranetes* Sadlick, 1963 has been discussed in detail by Archbold (1981, 1982).

The subgenus *Neochonetes* (*Sommeriella*) was by Archbold (1981, 1982) with type-species *Chonetes prattii* Davidson, 1859 for those species characterized by medium-large size, maximum width anterior to the hinge, cardinal spines at moderate angle (40-45°) and distinct ventral sulcus. Archbold (1983) included in the subgenus *Sommeriella* the species *C. variolata* (d'Orbigny) as described by Diener (1911), Meyer (1922), Renz (1940), Fantini Sestini (1965b), Termier et al. (1974) and *Chonetes vialis* Reed described by Reed (1944) and Termier et al. (1974).

Subgenus *Neochonetes* (*Neochonetes*) Muir-Wood, 1962

***Neochonetes* (*Neochonetes*) *costellata* Angiolini, 1995**

Pl. 1, fig. 10, 11

1925 *Chonetes costata* Stuckenbergr var. Reed, p. 38, pl. 3, fig. 6.

1995 *Neochonetes* (*Neochonetes*) *costellata* Angiolini, p. 203, fig. 16.1.

Material. 5 Ventral valves: MPUM7778 (CK190-3); MPUM7779 (CK189-1); MPUM7780 (CK319-3); MPUM7783 (CAL4-11,-75).

2 Dorsal valves: MPUM7781 (CK198-107); MPUM7782 (CK319-10bis).

Comments. *N. (N.) costellata* was introduced by Angiolini (1995) for specimens with wide hinge line, flat ventral valve, very low ventral sulcus and ornamentation of costae and costellae which are coarse for the genus.

Geographic and stratigraphic distribution. *N. (N.) costellata* Angiolini occurs in the Bolorian Mb. 2 of Lashkargaz Fm. of Lashkargaz and in the Kubergandian Mb. 4 of Lashkargaz of Yarkhun river (2 km W of Lashkargaz) and of Baroghil Pass.

Subgenus *Neochonetes (Sommeriella)* Archbold, 1982

(= *Sommeria* Archbold, 1981)

Type-species: *Chonetes prattii* Davidson, 1859

**Neochonetes (Sommeriella) baroghilensis** (Reed, 1925)

Pl. 1, fig. 12-17; Text-fig. 6

1925 *Chonetes variolata* var. nov. *baroghilensis* Reed, p. 40, pl. 3, fig. 1-4.

1934 *Chonetes glabellipunctatus* Merla, p. 271, pl. 25, fig. 3-5.

Material. 12 Ventral valves: MPUM7784 (CK189-11,-19,-23,-29,-31,-34,-35,-36,-43,-47); MPUM7785 (CK198-105; CK319-16).

19 Partially decorticated ventral valves: MPUM7786 (CK189-26); MPUM7787 (CK189-9); MPUM7788 (CK198-136); MPUM7789 (CK189-2,-3,-4,-7,-10,-48,-101,-103,-108,-109,-132,-136,-156); MPUM 7790 (CK198-48,-136; CAL4-70).

6 Internal moulds of ventral valves: MPUM7791 (CK189-6); MPUM7792 (CK189-46); MPUM7793 (CK189-5,-14,-32); MPUM7794 (CK319-10).

9 Dorsal valves: MPUM7795 (CK189-23,-28,-30,-37,-52; CK198-30); MPUM7796 (CK319-9); MPUM7797 (CK319-5,-11).

Description. Medium-large sized, concavo-convex shell with semicircular to sub-rectangular outline. Maximum width anterior to the hinge line. Cardinal extremities rectangular or obtuse. Ventral valve moderately convex, with pointed and recurved umbo. Umbonal slopes diverging at 90°-100° and flattening toward the hinge line. Median sulcus narrow and deep posteriorly, widening and flattening anteriorly. Dorsal valve concave with very small umbo. Median fold low, widening anteriorly.

Ornamentation of fine capillae, bifurcating anteriorly. The number of capillae is 5 per 1 mm at a distance of 5 mm from the umbo. Growth lamellae occur anteriorly. Rare spines occur at the cardinal margin, inclined at 40° to the margin.

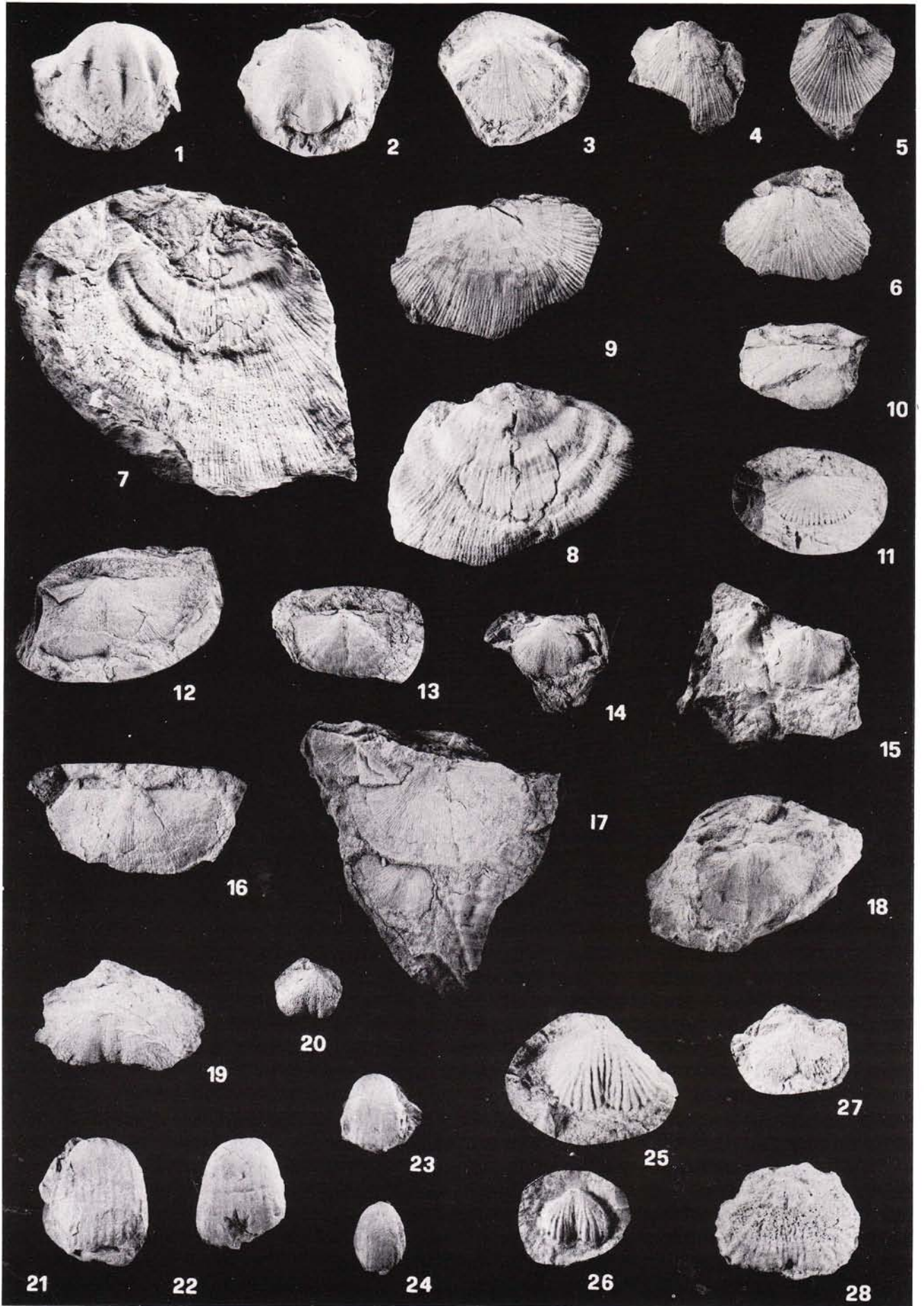
Interior of ventral valve with a low median septum extending to 1/3-1/2 the length of the valve. Interior of dorsal valve with long median septum, lateral ridges and sockets. Pseudopunctae are radially aligned and are very coarse in the postero-lateral regions, where they appear as coarse endospines.

PLATE 1

(All x 1, except when specified)

- Fig. 1 - *Enteletes* sp. ind. Ventral valve. Specimen MPUM7761 (CK198-17).  
 Fig. 2 - *Enteletes* sp. ind. Dorsal valve. Specimen MPUM7763 (CK198-18).  
 Fig. 3 - *Orthothetina convergens* Merla. Dorsal valve. Specimen MPUM7772 (CK190-1).  
 Fig. 4 - *Orthothetina convergens* Merla. Ventral valve. Specimen MPUM7766 (KK93-23).  
 Fig. 5 - *Orthothetina convergens* Merla. Ventral valve. Specimen MPUM7767 (KK93-24).  
 Fig. 6 - *Orthothetina convergens* Merla. Dorsal valve. Specimen MPUM7771 (CK189-124); 1.5 x.  
 Fig. 7 - *Derbyia grandis* Waagen. Interior of ventral valve. Specimen MPUM7774 (KK93-65).  
 Fig. 8 - *Derbyia grandis* Waagen. Internal mould of ventral valve. Specimen MPUM7774 (KK93-65).  
 Fig. 9 - *Derbyia grandis* Waagen. Dorsal valve. Specimen MPUM7776 (KK93-27).  
 Fig. 10 - *Neochonetes (Neochonetes) costellata* Angiolini. Ventral valve. Specimen MPUM7780 (CK319-3).  
 Fig. 11 - *Neochonetes (Neochonetes) costellata* Angiolini. Dorsal valve. Specimen MPUM7781 (CK198-107); x 1.5.  
 Fig. 12 - *Neochonetes (Sommeriella) baroghilensis* (Reed). Partially decorticated ventral valve. Specimen MPUM7786 (CK189-26); x 1.5.  
 Fig. 13 - *Neochonetes (Sommeriella) baroghilensis* (Reed). Internal mould of ventral valve. Specimen MPUM7792 (CK189-46).  
 Fig. 14 - *Neochonetes (Sommeriella) baroghilensis* (Reed). Internal mould of ventral valve. Specimen MPUM7791 (CK189-6).  
 Fig. 15 - *Neochonetes (Sommeriella) baroghilensis* (Reed). Partially decorticated ventral valve. Specimen MPUM7788 (CK198-136).  
 Fig. 16 - *Neochonetes (Sommeriella) baroghilensis* (Reed). Partially decorticated ventral valve. Specimen MPUM7787 (CK189-9); x 1.5.  
 Fig. 17 - *Neochonetes (Sommeriella) baroghilensis* (Reed). Dorsal valve. Specimen MPUM7796 (CK319-9); x 1.5.  
 Fig. 18 - *Neochonetes (Sommeriella) vialis* (Reed). Internal mould of ventral valve. Specimen MPUM7798 (CK189-121).  
 Fig. 19 - *Paramesolobus* aff. *sinuosus* (Schellwien). Partially decorticated ventral valve. Specimen MPUM7803 (CK365bis-18); x 1.5.  
 Fig. 20 - *Paramesolobus* aff. *sinuosus* (Schellwien). Partially decorticated ventral valve. Specimen MPUM7800 (CK189-54).  
 Fig. 21 - *Marginifera andreae* Angiolini. Ventral valve. Specimen MPUM7808 (CK315-117); x 1.5.  
 Fig. 22 - *Marginifera andreae* Angiolini. Ventral valve. Specimen MPUM7806 (CK315-79); x 1.5.  
 Fig. 23 - *Marginifera andreae* Angiolini. Ventral valve. Specimen MPUM7807 (CK315-108).  
 Fig. 24 - *Marginifera andreae* Angiolini. Ventral valve. Specimen MPUM7805 (CK315-67).  
 Fig. 25 - *Retimarginifera praelecta* (Reed). Ventral valve. Specimen MPUM7814 (CK198-31); x 1.5.  
 Fig. 26 - *Retimarginifera praelecta* (Reed). Ventral valve. Specimen MPUM7812 (CK319-14).  
 Fig. 27 - *Transennatia reedi* Angiolini. Dorsal valve. Specimen MPUM7821 (CK324-43).  
 Fig. 28 - *Transennatia reedi* Angiolini. Dorsal valve. Specimen MPUM7822 (CK324-53); x 1.5.





## Dimensions (in mm):

|           | Width | Length | Hinge width |
|-----------|-------|--------|-------------|
| CK189-5   | 16.2  | 9.3    |             |
| CK189-9   | 20.6  |        | 18.7        |
| CK189-11  | 27    | 17     |             |
| CK189-23  | 16.2  | 10     | 14.2        |
| CK189-26  | 18.6  | 11.4   | 17          |
| CK189-31  | 16.4  | 10.2   | 14.4        |
| CK189-34  | 15    | 10.3   |             |
| CK189-36  | 14    | 8.4    | 12          |
| CK189-43  | 19.2  | 11.9   | 18          |
| CK189-46  | 20    | 12.6   | 13          |
| CK189-101 | 27.6  | 14.2   |             |
| CK189-108 | 19.1  | 11.1   | 17.9        |
| CK189-156 | 16.4  | 11.6   | 13.7        |
| CK189-32  | 15.5  | 10.8   | 13.2        |
| CK198-105 | 11.5  | 7      | 11.1        |
| CK198-136 | 15    | 12.8   | 13.7        |
| CK189-30  | 15.2  | 9      | 12.8        |
| CK198-30  | 15.7  | 10     |             |
| CK319-9   | 21.9  | 13.2   |             |

Ontogenetic variations. The juveniles are more convex and less transverse than the adult specimens.

Discussion. *N. (S.) baroghilensis* (Reed) was described by Reed (1925) from the Permian of Baroghil Pass as a new variety of *Chonetes variolata* (d'Orbigny). However *N. (S.) baroghilensis* possesses sufficient diagnostic characters to be considered a different species. In fact it differs from *C. variolata* (d'Orbigny) by its larger dimensions, lower convexity of the ventral valve, deep and narrow sulcus widening anteriorly and very coarse postero-lateral endospines.

The specimens described as *N. variolata* by Termier et al. (1974, p. 95, pl. 11, fig. 9) may belong to *N. (S.) baroghilensis*. The specimens of *Chonetes glabellipunctatus* Merla (1934), housed at the "Museo di Paleontologia, Università di Firenze", have the same external characters and the very coarse postero-lateral endospines of *N. (S.) baroghilensis*: *Chonetes glabellipunctatus* is thus considered a junior synonym of the species *baroghilensis*.

Geographic and stratigraphic distribution. *N. (S.) baroghilensis* is present at Baroghil Ailak (horizon D of Reed, 1925) and near the Rimu Glacier, NE Karakorum (Merla, 1934). In Western Karakorum it occurs in the Bolorian Mb. 2 of Lashkargaz Fm. of Lashkargaz and in the Kubergandian Mb. 4 of Lashkargaz Fm. of Yarkhun river (2 km W of Lashkargaz) and of Baroghil Pass.

### *Neochonetes (Sommeriella) vialis* (Reed, 1944)

Pl. 1, fig. 18

1944 *Chonetes carbonifera* Keyserling var. *vialis* Reed, p. 116, pl. 20, fig. 1.

1974 *Neochonetes vialis* - Termier et al., p. 121, pl. 21, fig. 3.

Material. 4 Ventral valves: MPUM7798 (CK189-121); MPUM7799 (CK189-127,-147,-151).

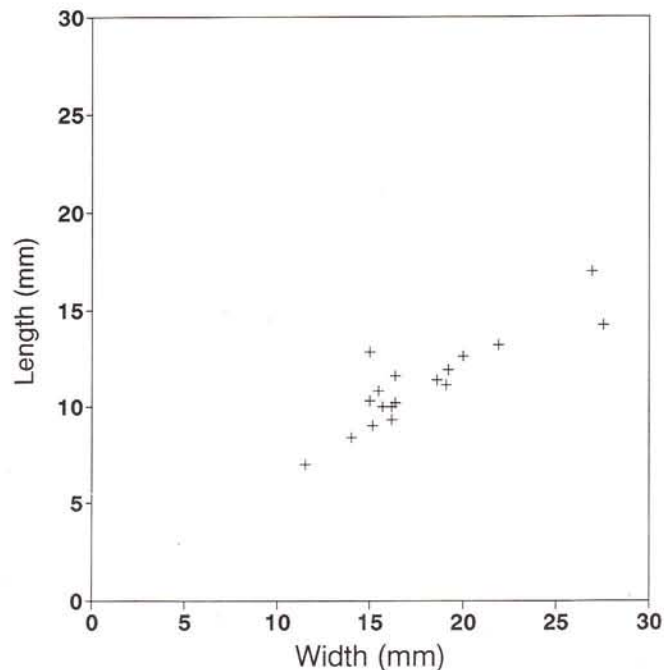


Fig. 6 - Width versus length diagram of *N. (S.) baroghilensis*, showing the increase in width during the growth of the shell and the less transverse outline of the juveniles.

Description. Large and convex ventral valve with maximum width anterior to the hinge line. Cardinal extremities subrectangular to obtuse. Ears flat and well differentiated. Ventral sulcus large and deep with "V" shaped section, starting from the umbo. Ornamentation of capillae. Interior of ventral valve with endospines.

## Dimensions (in mm):

|           | Width | Length | Hinge |
|-----------|-------|--------|-------|
| CK189-121 | 22.1  | 15.1   | 19.7  |
| CK189-127 | 20    | 13.8   |       |
| CK189-151 | 15    | 9.7    | 13.2  |

Discussion. *Neochonetes (Sommeriella) vialis* (Reed) differs from *N. (S.) baroghilensis* by its larger size, larger and deeper ventral sulcus with "V" shaped section.

Geographic and stratigraphic distribution. *N. (S.) vialis* is present in the Lower Productus Limestone of Salt Range (Reed, 1944) and in the Murgabian of Central Afghanistan (Termier et al., 1974).

In Western Karakorum it occurs in the Kubergandian Mb. 4 of Lashkargaz Fm. of Baroghil Pass.

### Genus *Paramesolobus* Afanaseva, 1975

Type-species: *Paramesolobus ivanovae* Afanaseva, 1975

Comments. *Paramesolobus* was described by Afanaseva (1975) for those species similar to *Mesolobus* Dunbar & Condra, 1932 but with ornamentation of capillae.

Archbold (1983) included in this genus both *Chonetes sinuosa* Schellwien and *Chonetes* cf. *latesinuata* Schellwien described by Renz (1939, 1940) for the Late Artinskian of Shaksgam.

Pecar (1986a, 1986b) described the genus *Capillomesolobus* Pecar of the family Rugosochonetidae from the Carboniferous and Permian of the Karavanke Mountains (Slovenia) and the Late Carboniferous of the Carnian Alps (Italy). *Capillomesolobus* is very similar to *Paramesolobus* differing from it by its smaller size and finer capillae (about 50-70 capillae per 10 mm at the anterior margin).

**Paramesolobus aff. sinuosus** (Schellwien, 1900)

Pl. 1, fig. 19, 20

1925 *Chonetes sinuosa* - Reed, p. 39, pl. 7, fig. 16-16a.

**Material.** 18 Partially decorticated ventral valves: MPUM7800 (CK189-54); MPUM7801 (CK189-6,-129,-131,-133,-138,-143,-145,-148,-149,-150,-160); MPUM7802 (CK190-2; CK319-4,-20,-20bis); MPUM7803 (CK365bis-18); MPUM7804 (CAL4-48).

**Description.** Moderately convex ventral valve, with semicircular outline. Maximum width anterior to the hinge line. Cardinal extremities rectangular to obtuse. Ventral sulcus widening and deepening anteriorly, with a median rounded fold. Ornamentation capillate. Interior of ventral valve with a low and long median septum extending to mid-length. Pseudopunctae are radially aligned.

Dimensions (in mm):

|             | Width | Length | Apical angle |
|-------------|-------|--------|--------------|
| CK189-6     | 13    | 9.2    | 37°          |
| CK189-54    | 17    | 11     | 44°          |
| CK189-131   | 19.6  | 13.6   |              |
| CK319-20    | 21.7  | 13     | 45°          |
| CK190-2     | 14.7  | 9      | 35°          |
| CK365bis-18 | 21.3  | 11.1   | 40°          |

**Discussion.** These specimens are similar to *Paramesolobus sinuosus* Schellwien, 1900 of their large sulcus, with a median fold extending for all its length, and the obtuse cardinal extremities. *P. latesinuatus* (Schellwien, 1892) shows a larger sulcus with a lower fold. However, as stated by Pecar (1986b, p. 38), the width of the ventral sulcus and the presence or absence of ventral median lobe show a significant intraspecific variability.

The specimens of *Chonetes sinuosa* described by Renz (1940, p. 141, pl. 2, fig. 5) from the Late Artinskian of Shaksgam are very similar to those from Karakorum.

**Geographic and stratigraphic distribution.** *P. aff. sinuosus* is present in the Trogkofel Limestone of Carnian Alps (Schellwien, 1900).

In Western Karakorum *P. aff. sinuosus* occurs in the Bolorian Mb. 2 of Lashkargaz Fm. of Lashkargaz and in the Kubergandian Mb. 4 of Lashkargaz Fm. of Yarkhun river (2 km W of Lashkargaz) and of Baroghil Pass. Reed (1925) collected it from the horizon E of Hayden (1915) section at Baroghil Ailak.

Order Productida Sarycheva & Sokolskaya, 1959

Suborder Productidina Waagen, 1883

Superfamily *Productacea* Gray, 1840

Family *Marginiferidae* Stehli, 1954

Genus *Marginifera* Waagen, 1884

Type-species: *Marginifera typica* Waagen, 1884

**Marginifera andreai** Angiolini, 1995

Pl. 1, fig. 21-24

1995 *Marginifera andreai* Angiolini, p. 203, fig. 16.2.

**Material.** 37 Ventral valves: MPUM7805 (CK315-67); MPUM7806 (CK315-79); MPUM7807 (CK315-108); MPUM7808 (CK315-117); MPUM7809 (CK315-A,-6,-10,-14,-16,-21,-22,-25,-27,-30,-35,-36,-39,-40,-42,-44,-72,-84,-85,-86,-92,-103,-112,-116,-130,-131,-132,-134,-136,-137,-139,-140,-141).

5 Dorsal valves: MPUM7810 (CK315-23,-34,-107,-120,-132bis).

**Comments.** *Marginifera andreai* is characterized by its small dimensions, long trail, absence of ventral sulcus, ill defined costae, low rugae and coarse spines. It differs from *Marginifera spinosocostata* (Abich, 1878) by means of the less pointed umbo, longer trail and for the dimensions and the arrangement of the spines. In fact *M. spinosocostata* has high and pointed spines bases, densely arranged on the visceral disc and coarser along the sulci delimiting the ears.

**Geographic and stratigraphic distribution.** *M. andreai* occurs in the Bolorian Mb. 2 of Lashkargaz Fm. of Lashkargaz, Western Karakorum.

Genus *Retimarginifera* Waterhouse, 1970

Type-species: *Retimarginifera perforata* Waterhouse, 1970

**Comments.** The genus *Retimarginifera* Waterhouse, 1970 has been discussed by Waterhouse (1970), Grant (1976), Waterhouse (1981) and in detail by Archbold (1984).

**Retimarginifera praelecta** (Reed, 1925)

Pl. 1, fig. 25, 26

1925 *Productus (Marginifera) praelectus* Reed, p. 106, pl. 5, fig. 4.

1934 *Productus* cf. *praelectus* Merla, p. 218, pl. 20, fig. 6.

1934 *Productus altimontanus* Merla, p. 223, pl. 20, fig. 27-32, 36-41.

Material. 1 Complete specimen: MPUM7811 (CK189-24).

9 Ventral valves: MPUM7812 (CK319-14); MPUM7813 (CK189-118,-135,-139,-140); MPUM7814 (CK198-31); MPUM7815 (CK198-110,-113,-117).

Description. Concavo-convex shell, with sub-quadrate transverse outline. Maximum width at the hinge line.

Ventral valve strongly convex, geniculated, with short trail. Ventral umbo pointed and recurved. Ears well defined from the lateral slopes. Ventral sulcus deep and narrow, starting 5 mm from the umbo and widening and deepening anteriorly. Dorsal valve concave with low and rounded fold.

Ornamentation of costae, costellae, rugae and spines. The costae are quite rounded with narrower intercostal troughs; inside the sulcus the costae are simple, slightly converging and numbering 2; along the flanks of the ventral valve costellae arise by bifurcation and intercalation up to 8-9 for each side at the anterior margin. The width of the costae and costellae is 0.8-1 mm anteriorly.

Dimensions (in mm):

|           | Width | Length |
|-----------|-------|--------|
| CK189-24  | 18.3  | 12.7   |
| CK189-140 | 13.4  | 9.4    |
| CK198-31  | 14.4  | 10.5   |
| CK198-110 | 15.7  | 10.3   |
| CK319-14  | 13.6  | 10.4   |

Discussion. The specimens to hand fit well with the original description of Reed (1925). The specimens of *Productus altimontanus* Merla, 1934, housed in the Museo di Paleontologia, Università di Firenze, belong to *Retimarginifera praelecta*. Merla distinguished the species *altimontanus* by means of the lower number of ribs (6 for each flank). In fact the preserved population of *P. altimontanus* shows a greater number of specimens with 8 ribs for each flank than specimens with only 6 ribs; furthermore the width of the ribs is always comprised between 0.8 and 1.2 mm. These small variations can be considered intraspecific.

*Retimarginifera rimuensis* (Merla, 1934) differs by more numerous and finer ribs and by a less deep and wider sulcus. The specimens described as *Probolionia himalayensis* (Diener, 1899) by Grunt & Dmitriev (1973) from the SE Pamir and housed at the Museum of Paleontology of Moscow, belong to the genus *Retimarginifera* (as suggested by Archbold, 1984) but to a distinct species, being characterized by fine ribs.

*R. praelecta* differs from the Australian *R. perforata* Waterhouse, 1970 by its finer ribs, larger intercostal troughs, less deep sulcus; from the Thai *R. celetaria* Grant, 1976 by the arrangement and number of ribs and from the Afghan species *R. lapparenti* Termier, Ter-

mier, de Lapparent & Marin, 1974 by less numerous and coarser ribs.

Geographic and stratigraphic distribution. *R. praelecta* was described from the Permian of Baroghil Pass (Reed, 1925); it is also present at Rimu, NE Karakorum (Merla, 1934).

In Western Karakorum it occurs in the Bolorian Mb. 2 of Lashkargaz Fm. of Lashkargaz and in the Kubergandian Mb. 4 of Lashkargaz Fm. of Baroghil Pass.

Genus *Transennatia* Waterhouse, 1975

Type-species: *Productus gratosus* Waagen, 1884

***Transennatia reedi* Angiolini, 1995**

Pl. 1, fig. 27, 28; Pl. 2, fig. 1-4

1925 *Productus* aff. *tartaricus* Reed, p. 31, pl. 3, fig. 9.  
1995 *Transennatia reedi* Angiolini, p. 205, fig. 16.4.

Material. 41 Ventral valves: MPUM7816 (CK324-3); MPUM7817 (CK324-18); MPUM7818 (CK324-23); MPUM7819 (CK324-34); MPUM7820 (CK324-1,-2,-4,-5,-6,-7,-8,-9,-10,-11,-12,-13,-14,-15,-16,-17,-19,-20,-21,-22,-24,-25,-26,-27,-28,-29,-30,-31,-32,-33,-35,-36,-37,-38,-39,-40,-41).

17 Dorsal valves: MPUM7821 (CK324-43); MPUM7822 (CK324-53); MPUM7823 (CK324-42,-44,-45,-46,-47,-48,-49,-50,-51,-52,-54,-55,-56,-57,-58).

Comments. Diagnostic characters of the species are the coarse ribs, not converging into the sulcus, and the deep and uniformly wide ventral sulcus. Relationships with other species have been discussed in Angiolini (1995).

Geographic and stratigraphic distribution. *T. reedi* occurs in the Kubergandian Mb. 4 of Lashkargaz Fm. of Lashkargaz.

Family *Echinoconchidae* Stehli, 1954

Subfamily *Echinoconchinae* Stehli, 1954

Genus *Echinoconchus* Stehli, 1954

Type-species: *Productus punctatus* Sowerby, 1822

***Echinoconchus* sp. ind.**

Pl. 2, fig. 11

Material. 1 Ventral valve: MPUM7824 (CAL4-64).

Description. Ventral valve moderately convex with sub-circular outline; umbo large and slightly recurved. Maximum width anterior to mid-length. Median sulcus quite deep, widening anteriorly. Ornamentation of raised bands separated by narrow and smooth grooves. The bands are absent in the umbonal region and are narrow on the lateral flanks: their width varies between 2 mm

and 2.9 mm. Rarely small spine bases can be distinguished on the bands.

Dimensions (in mm):

|         | Width | Length | Thickness |
|---------|-------|--------|-----------|
| CAL4-64 | 44.4  | 37.3   | 16.5      |

Discussion. The available specimen is similar to *E. punctatus* (Sowerby, 1822) as described by Fantini Sestini (1965b, p. 183, pl. 22, fig. 11, 12) for the Permian of Shaksgam. Both are in fact characterized by low convexity of the ventral valve and by ornamentation of bands with narrow grooves.

Geographic and stratigraphic distribution. *Echinoconchus* sp. ind. is present in the Kubergandian Mb. 4 of Lashkargaz Fm. of Yarkhun river (2 km W of Lashkargaz).

Family *Waagenoconchidae*

Muir-Wood & Cooper, 1960

Genus *Waagenoconcha* Chao, 1927

Type-species: *Productus humboldtii* d'Orbigny, 1842

Comments. The genus *Waagenoconcha* Chao, 1927 and its splitting in two subgenera (*Waagenoconcha* and *Wimanoconcha*) have been fully discussed by Archbold (1993). Angiolini (1995) introduced the new subgenus *Waagenoconcha (Gruntoconcha)* with type-species *Waagenoconcha (Gruntoconcha) macrotuberculata* Angiolini, 1995 for those forms characterized by a short trail and coarse, elongate spine bases. This subgenus differs from *W. (Waagenoconcha)* Chao, 1927 by means of its coarser and less elongate spine bases; from *W. (Wimanoconcha)* Waterhouse, 1983 by its smaller dimensions, shorter trail and absence of radial crenulations on the ventral trail.

The erection of the new subgenus is supported by the fact that the Uralian and Texas species [*W. humboldtii* d'Orbigny, 1842, *W. irginae* Stuckenbergh, 1898, *W. montpelierensis* (Girty, 1910)] are characterized by thin, elongated, regularly arranged spine bases, whereas some of the Tethyan ones (*W. abichi* Waagen, 1884, *W. macrotuberculata* Angiolini, 1995) possess very coarse spine bases. In any case *W. (Gruntoconcha)* share the same external shape, internal characters and the fact that the spine bases decrease in size anteriorly as *W. (Waagenoconcha)* (see the discussion in Grant, 1966). The specimens (mostly internal moulds) of *Waagenoconcha abichi* (Waagen, 1884) described by Termier et al. (1974) from the Early Murgabian of Central Afghanistan seem to be characterized by fine tubercles and thus probably belong to the subgenus *Waagenoconcha (Waagenoconcha)*.

***Waagenoconcha (Waagenoconcha)* sp. ind.**

Pl. 2, fig. 5

Material. 2 Ventral valves: MPUM7825 (CK269-9); MPUM7826 (CK365bis-28).

Description. Ventral valve uniformly convex, with sub-circular outline. Hinge narrow; maximum width anterior to mid-length. Umbo pointed and recurved. Lateral flanks steep. Ventral sulcus large and shallow. Ornamentation of thin and densely arranged spine bases. Flat rugae are also present, passing to growth lamellae at the anterior margin.

Dimensions (in mm):

|         | Width | Length |
|---------|-------|--------|
| CK269-9 | 21.2  | 19.6   |

Discussion. These few and badly preserved specimens have been placed in the subgenus *Waagenoconcha (Waagenoconcha)* because of their thin spine bases.

Geographic and stratigraphic distribution. *Waagenoconcha (W.)* sp. ind. is present in the Kubergandian Lashkargaz Fm., Mb. 4 of Lashkargaz, W Karakorum.

***Waagenoconcha (Gruntoconcha) macrotuberculata***

Angiolini, 1995

Pl. 2, fig. 6-10

1934 *Productus abichi* - Merla, p. 263.

1940 *Productus (Waagenoconcha) abichi* - Renz, p. 161, pl.4, fig. 6.

1995 *Waagenoconcha (Gruntoconcha) macrotuberculata* Angiolini, p. 206, fig. 16.6.

Material. 1 Complete specimen: MPUM7827 (CK365-6).

20 Ventral valves: MPUM7828 (CK189-18); MPUM7829 (CK198-3); MPUM7830 (CK198-111,-112); MPUM7831 (CK365-19); MPUM7832 (CK365-1,-11,-16,-22); MPUM7833 (CK365bis-12); MPUM7834 (CK365bis-17); MPUM7835 (CAL4-33,-34,-74,-88,-89,-93,-97,-98); MPUM7836 (CAL4-83).

8 Dorsal valves: MPUM7837 (CK189-20); MPUM7838 (CK198-28,-36,-107,-109); MPUM7839 (CK365-2); MPUM7840 (CK365-17; CAL4-87).

Discussion. This species has been discussed by Angiolini (1995). Diagnostic characters of *W. (G.) macrotuberculata* are the very steep lateral flanks; weak ventral sulcus; coarse, oval spine bases and low growth rugae.

Geographic and stratigraphic distribution. *W. (G.) macrotuberculata* occurs in the Permian of NE Karakorum (Merla, 1934) and in Shaksgam (Renz, 1940).

In Western Karakorum it is present in the Kubergandian Lashkargaz Fm., Mb. 4 of Baroghil, Yarkhun river (2 km W of Lashkargaz) and Lashkargaz.

Family *Dictyoclostidae* Stehli, 1954

Subfamily *Dictyoclostinae* Stehli, 1954

Genus *Callytharrella* Archbold, 1985Type-species: *Dictyoclostus callytharrensensis* Prendergast, 1943

Comments. *Callytharrella* was introduced by Archbold (1985) for species characterized by their large ears, convex ventral visceral disc, strongly geniculated dorsal valve and fasciculation of costae anteriorly to the spines. *Callytharrella* Archbold, 1985 differs from *Chaoiella* Fredericks, 1933 by its stronger costae which do not become lamellose anteriorly and the shape of the cardinal process; from *Reticulatia* Muir-Wood & Cooper, 1960 by means of the presence of costae on the ears, fasciculation of costae and costellae on the trail, absence of a marginal ridge in the dorsal valve and trilobed cardinal process.

Archbold (1985) included in *Callytharrella* also the species: *Costiferina sinensis* Sun, 1983 from the Bolorian-Kubergandian of NW Tibet, *Productus semireticulatus* Martin, 1881 in Broili (1916, pl. 2, fig. 14) from the Bolorian of Timor, *Productus spiralis* Waagen, 1884 as described by Broili (1915, pl. 21, fig. 7-9) for the Letti fauna and *Productus spiralis* Waagen (1884) from the Amb Fm., Salt Range. The specimen of *P. spiralis* from Rimu Glacier described by Merla (1934) and housed in the Museo di Paleontologia, Università di Firenze, should be included in the genus *Callytharrella*. Finally, the specimens of *Costiferina redacta* (Reed, 1944) described by Termier et al. (1974) from the Early Murgabian of Central Afghanistan belong to the genus *Callytharrella*, but to a different species characterized by fine ribs, occurrence of dense growth rugae and growth lines and shallow, wide ventral sulcus.

***Callytharrella sinensis* (Sun, 1983)**

Pl. 2, fig. 12-17

1925 *Productus gruenevaldti* - Reed, p. 78, pl. 4, fig. 5-7.1983 *Costiferina sinensis* Sun, p. 125, pl. 16, fig. 8-10.

Material. 22 Ventral valves: MPUM7841 (KK93-2,-3,-16,-17,-39,-55,-56,-73); MPUM7842 (CK189-114); MPUM7843 (CK190-11); MPUM7844 (CK198-4,-13,-137); MPUM7845 (CK269-18); MPUM7846 (CAL4-22,-52,-54,-58,-62,-75,-82).

22 Dorsal valves: MPUM7847 (KK93-9); MPUM7848 (KK93-4,-5,-7,-10,-57,-61,-62,-68,-69,-99); MPUM7849 (CK189-162); MPUM7850 (CK190-9); MPUM7851 (CK190-4,-6,-7,-10); MPUM7852 (CK198-14,-27; CK269-19); MPUM7853 (CAL4-32); MPUM7854 (CAL4-31).

Fragments: MPUM7855 (KK93-11,-12,-15,-18,-45; CK189-22; CK190-9,-12).

Description. Large sized, concavo-convex shell. Maximum width at the hinge line. Shell substance thick, pseudopunctate.

Ventral valve spirally enroled. Visceral disc convex and trail long and enroled. Umbo swollen, recurved; ears large and inflated. Ventral sulcus starting on the visceral disc, deepening on the trail. Dorsal valve concave, strongly geniculated, with long trail. Dorsal fold low, starting on the visceral disc.

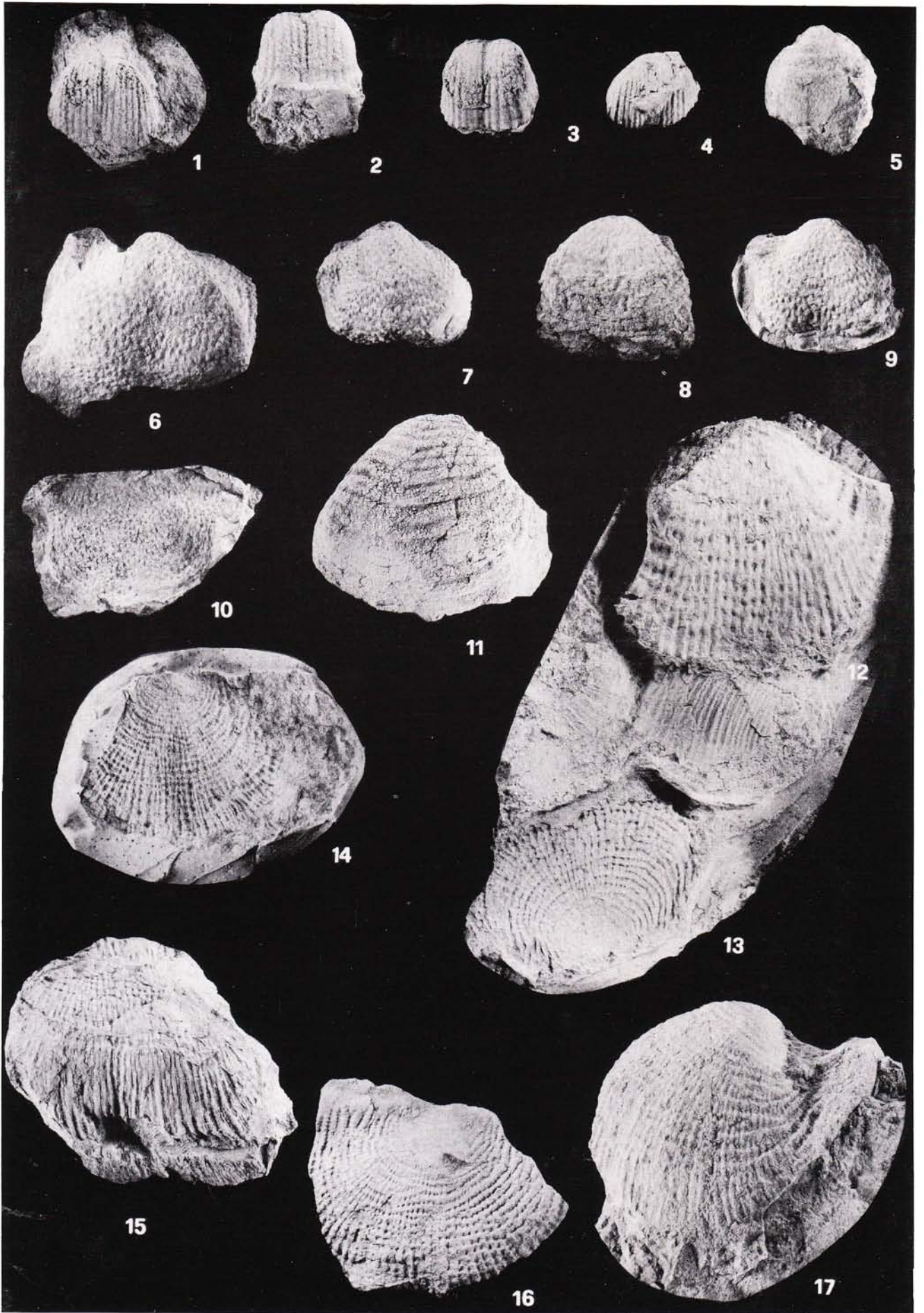
Ornamentation of ventral valve with thin and dense rugae (1-1.3 mm thick) widespread on the visceral disc and on the ears. Fine costae cross the rugae on the visceral disc forming a reticulate pattern. The costae bifurcate anteriorly forming fascicles of 2-3 costae and costellae, converging into the sulcus. The width of the costae and costellae is 1-1.5 mm on the trail. Spines are scattered on the visceral disc, on the trail and in groups of 4-5 on the ears.

Ornamentation of dorsal valve similar but finer and without spines. Small pits are present on the visceral disc and less numerous on the trail. The costae of the dorsal valve start to fasciculate on the visceral disc, where they form fascicles of 4 fine costae and costellae. Well defined growth lines are also present.

## PLATE 2

(All x 1, except when specified)

- Fig. 1 - *Transennatia reedi* Angiolini. Ventral valve. Specimen MPUM7816 (CK324-3).  
 Fig. 2 - *Transennatia reedi* Angiolini. Ventral valve. Specimen MPUM7819 (CK324-34).  
 Fig. 3 - *Transennatia reedi* Angiolini. Ventral valve. Specimen MPUM7818 (CK324-23).  
 Fig. 4 - *Transennatia reedi* Angiolini. Ventral valve. Specimen MPUM7817 (CK324-18).  
 Fig. 5 - *Waagenoconcha (Waagenoconcha)* sp. ind. Ventral valve. Specimen MPUM7825 (CK269-9).  
 Fig. 6 - *Waagenoconcha (Gruntoconcha) macrotuberculata* Angiolini. Ventral valve. Specimen MPUM7836 (CAL4-83).  
 Fig. 7 - *Waagenoconcha (Gruntoconcha) macrotuberculata* Angiolini. Ventral valve. Specimen MPUM7829 (CK198-3).  
 Fig. 8 - *Waagenoconcha (Gruntoconcha) macrotuberculata* Angiolini. Ventral valve. Specimen MPUM7831 (CK365-19).  
 Fig. 9 - *Waagenoconcha (Gruntoconcha) macrotuberculata* Angiolini. Ventral valve. Specimen MPUM7833 (CK365bis-12).  
 Fig. 10 - *Waagenoconcha (Gruntoconcha) macrotuberculata* Angiolini. Dorsal valve. Specimen MPUM7839 (CK365-2).  
 Fig. 11 - *Echinoconchus* sp. ind. Ventral valve. Specimen MPUM7824 (CAL4-64).  
 Fig. 12 - *Callytharrella sinensis* (Sun). Ventral valve. Specimen MPUM7843 (CK190-11).  
 Fig. 13 - *Callytharrella sinensis* (Sun). External mould of dorsal valve. Specimen MPUM7850 (CK190-9).  
 Fig. 14 - *Callytharrella sinensis* (Sun). Plastic replica of the external mould of dorsal valve. Specimen MPUM7850 (CK190-9).  
 Fig. 15 - *Callytharrella sinensis* (Sun). External mould of dorsal valve. Specimen MPUM7847 (KK93-9).  
 Fig. 16 - *Callytharrella sinensis* (Sun). External mould of dorsal valve. Specimen MPUM7853 (CAL4-32).  
 Fig. 17 - *Callytharrella sinensis* (Sun). Ventral valve. Specimen MPUM7845 (CK269-18).



Interior of ventral valve with dendritic adductor scars with oval outline surrounded by large, striated adductor scars. Interior of dorsal valve with sessile, posteriorly trifid cardinal process, with the median lobe dorsally recurved; lophidium present. The cardinal process is supported by a low median septum extending to the end of the visceral disc; lateral ridge thick and short. At each side of the median septum dendritic adductor scars are present.

## Dimensions (in mm):

|           | Width | Lv.d. | Lt. | Length |
|-----------|-------|-------|-----|--------|
| KK93-2    | 48    |       |     | 59     |
| KK93-16   | 48    | 34    |     |        |
| KK93-17   | 58    | 29    |     |        |
| KK93-56   | 40    |       |     | 45     |
| CAL4-54   | 57    | 30.4  |     | 54.5   |
| KK93-4    | 63    | 33    |     |        |
| KK93-7    | >62   | 38    |     |        |
| KK93-9    | 52    | 20    | 31  |        |
| KK93-10   | 43    | 30    |     |        |
| KK93-62   | 61    | 43    |     |        |
| KK93-69   | 59    | 36    |     |        |
| CK189-162 | 46    | 27    |     |        |
| CK190-6   | 45    | 28    |     |        |
| CK190-7   | 58.6  | 22    | >23 |        |
| CK190-9   | >50   | 21    | 26  |        |
| CK198-27  | >36   | 31    |     |        |
| CAL4-32   | 47.4  | 32    |     |        |

Lv.d.: Length of visceral disc

Lt.: Length of trail

Discussion. The specimens from Karakorum fit well with the description of *Callytharrella sinensis* (Sun) given by Sun (1983) for the Bolorian-Kubergandian of NW Tibet. Diagnostic characters of this species are the extensive reticulate ornamentation, the fasciculation of thin costae on the visceral disc and the long trail. *C. sinensis* differs from *C. callytharrensensis* (Prendergast, 1943) from the Callytharra Fm. of W Australia by means of its shallower ventral sulcus, finer ribs, more extensive reticulation, larger median lobe of the cardinal process and longer dorsal septum.

Geographic and stratigraphic distribution. *C. sinensis* occurs in the Bolorian-Kubergandian Tunlonggongba Fm. of NW Tibet (Rutog-Duoma) (Sun, 1983).

In Western and Central Karakorum it is present in the Kubergandian Mb. 4 of Lashkargaz Fm. of Baroghil, Yarkhun river (2 km W of Lashkargaz) and Lashkargaz and in the Kubergandian Mb. 1 of Panjshah Fm. of Panjshah.

Genus *Chaoiella* Fredericks, 1933Type-species: *Productus gruenewaldti* Krotov, 1888**Chaoiella** sp. ind.

Material. 2 Ventral valves: MPUM7856 (CK365-8,-18).

2 Dorsal valves: MPUM7857 (CK365bis-1,-2).

Description. Concavo-convex shell with sub-quadrate outline. Maximum width at the hinge line.

Ventral valve with convex visceral disc and long and sulcate trail. Ventral umbo strongly recurved. Median sulcus narrow and shallow. Dorsal valve strongly geniculated, with flat visceral disc. Ears triangular and well defined. A shallow median fold occurs on the anterior part of visceral disc and on the trail.

Ornamentation of the ventral valve with fine costae, bifurcating on the flanks. The costae and costellae number 5-6 per 5 mm at the anterior margin. Weak rugae occur on the visceral disc. Scars of spines are small and rare; growth lamellae are present anteriorly. Ornamentation of dorsal valve finer with pits on the ears.

## Dimensions (in mm):

|            | Width | Length | Thickness |
|------------|-------|--------|-----------|
| CK365-8    | 42    |        | 23        |
| CK365-18   | 37.1  | 35.1   | 19.7      |
| CK365bis-1 | 36    | 24.4   |           |

Discussion. The distinctive characters of these specimens are the fine costation, absence of reticulation on the visceral disc and long trail.

Geographic and stratigraphic distribution. In Western Karakorum *Chaoiella* sp. ind. is present in the Kubergandian Mb. 4 of Lashkargaz Fm. of Lashkargaz.

Genus *Costiferina* Muir-Wood & Cooper, 1960Type-species: *Productus indicus* Waagen, 1884

Comments. *Costiferina* differs from *Callytharrella* Archbold and *Reticulatia* Muir-Wood & Cooper by its massive cardinal process, longer lateral ridges, coarser costae and spines and deeper ventral sulcus.

**Costiferina** sp. ind.

Material. 3 Ventral valves: MPUM7858 (CK189-17,-50; KK93-6).

Description. Large sized, convex ventral valves, with thick shell. Trail with deep sulcus. Ornamentation of very coarse costae, 3-4.5 mm wide, converging towards the sulcus.

Discussion. The specimens to hand are only fragments of ventral valves, thus preventing a more detailed determination.

Geographic and stratigraphic distribution. In Western and Central Karakorum *Costiferina* sp. ind. is present in the Kubergandian Mb. 4 of Lashkargaz Fm. of Baroghil Pass and in the Kubergandian Mb. 1 of Panjshah Fm. of Panjshah.



Genus *Reticulatia* Muir-Wood & Cooper, 1960Type-species: *Productus huecoensis* King, 1831**Reticulatia chitralis** Angiolini, 1995

Pl. 3, fig. 1-8

- 1925 *Productus transversalis* - Reed, p. 33, pl. 4, fig. 8; pl. 5, fig. 1, 2.  
 1932 *Productus transversalis* - De Terra, p. 161, pl. 13, fig. 13.  
 1932 *Productus semireticulatus* - De Terra, p. 161, pl. 14, fig. 4.  
 1940 *Productus semireticulatus* - Renz, pp. 21, 144, pl. 2, fig. 8.  
 1940 *Productus semireticulatus* var. *transversalis* - Renz, pp. 22, 145.  
 1965b *Reticulatia* cf. *transversalis* - Fantini Sestini, p. 188, pl. 22, fig. 4.  
 1995 *Reticulatia chitralis* Angiolini, p. 207, fig. 16.7.

**Material.** 35 Ventral valves: MPUM7859 (CK189-13,-38,-41,-45); MPUM7860 (CK269-0); MPUM7861 (CK269-10); MPUM7862 (CK269-12); MPUM7863 (CK269-29); MPUM7864 (CK269-30); MPUM7865 (CK269-5,-11,-14,-15,-17,-24,-27,-32); MPUM7866 (CAL4-1,-5,-6,-19,-20,-35,-39,-40,-45,-48,-49,-53,-54,-55,-69,-83,-84,-85).

21 Dorsal valves: MPUM7867 (CK189-33); MPUM7868 (CK189-39,-154); MPUM7869 (CK269-1); MPUM7870 (CK269-2,-6,-13,-22,-25,-26,-28,-31); MPUM7871 (CAL4-17); MPUM7872 (CAL4-21,-22,-31,-51,-59,-71,-73,-81).

**Discussion.** The description of *Reticulatia chitralis* from Karakorum and its relationships with allied species have been given in Angiolini (1995). Peculiar characters of this species are the large dimensions, shallow sulcus and the ornamentation of large costae and costellae with narrow intercostal troughs.

**Geographic and stratigraphic distribution.** *R. chitralis* occurs in the Permian of Kun Lun (De Terra, 1932) and of Shaksgam (Renz, 1940; Fantini Sestini, 1965b).

In Western Karakorum it is present in the Kuber-gandian Mb. 4 of Lashkargaz Fm. of Baroghil Pass and Lashkargaz.

Superfamily *Linoproductacea* Stehli, 1954Family *Linoproductidae* Stehli, 1954Subfamily *Auriculispininae* Waterhouse, 1986Genus *Magniplicatina* Waterhouse, 1983Type-species: *Cancrinella magniplica* Campbell, 1953

**Comments.** *Magniplicatina* Waterhouse, 1983 differs from *Cancrinella* Fredericks, 1928 by its shorter and less enroled trail, stronger rugae increasing in width and height anteriorly, coarser spines occurring only on the ventral valve. According to Grigorieva et al. (1977) and Singh & Archbold (1993) the genus *Cancrinella* must be restricted to species with spines also on the dorsal valve.

**Magniplicatina inassueta** (Reed, 1925)

Pl. 4, fig. 1, 2

- 1925 *Productus inassueta* Reed, p. 29, pl. 5, fig. 6, 6a.

**Material.** 2 Ventral valves: MPUM7873 (CK319-7); MPUM7874 (CK319-13).

**Description.** Ventral valve with transversally oval outline. The valve is swollen with arcuate longitudinal profile. Maximum width anterior to the hinge. Umbo and ears small.

Ornamentation with thin ribs, numbering 8-10 per 5 mm at the anterior margin; spine bases coarse (0.5-0.7 mm), not elongated; rugae low, thin (0.5-0.8 mm wide), irregular, more evident on the flanks than on the venter where they are discontinuous. The rugae become more evident anteriorly.

Dimensions (in mm):

|         | Width | Length |
|---------|-------|--------|
| CK319-7 | 23    | 16.3   |

**Discussion.** These specimens fit well with the description of *Productus inassueta* Reed, 1925 from the Baroghil Pass. *Magniplicatina inassueta* (Reed) differs from *Magniplicatina vindicata* (Reed, 1925) by its oval outline and the rugae which are more evident anteriorly.

**Geographic and stratigraphic distribution.** *M. inassueta* has been reported by Reed (1925) for the Baroghil Pass.

In Western Karakorum *M. inassueta* is present in the Bolorian Mb. 2 of Lashkargaz Fm. of Lashkargaz.

**Magniplicatina johannis** Angiolini, 1995

Pl. 4, fig. 3-10

- 1925 *Productus cancriniformis* - Reed, p. 24, pl. 5, fig. 7, 8.  
 1939 *Productus cancriniformis* - Renz, p.18, pl. 3, fig. 6, 7.  
 1965b *Cancrinella cancriniformis* - Fantini Sestini, p. 190.  
 1995 *Magniplicatina johannis* Angiolini, p. 209, fig. 16.5.

**Material.** 1 Complete specimen: MPUM7875 (KK93-79).

17 Ventral valves: MPUM7876 (KK93-25); MPUM7877 (KK93-14,-53,-88); MPUM7878 (CK189-26,-53); MPUM7879 (CK269-8); MPUM7880 (CK365-3); MPUM7881 (CK365-14); MPUM7882 (CK365-15); MPUM7883 (CK365bis-5,-7,-8,-15,-16); MPUM7884 (CAL4-29); MPUM7885 (CAL4-60).

5 Dorsal valves: MPUM7886 (CK189-112,-126); MPUM7887 (CK365-12); MPUM7888 (CK365-21; CK365bis-4).

**Discussion.** This species was erected by Angiolini (1995). *M. johannis* differs from the allied species *Magniplicatina magniplica* (Campbell, 1953) and *Magniplicatina undulata* Waterhouse, 1986 by its elongated spine ridges, prominent and irregular rugae and less numerous ribs.

**Geographic and stratigraphic distribution.** *M. johannis* occurs in the Permian of Shaksgam (Renz, 1939; Fantini Sestini, 1965b).

In Western and Central Karakorum it is present in the Kubergandian Mb. 4 of Lashkargaz Fm. of Baroghil-Lashkargaz area and in the Kubergandian Mb. 1 of Panjshah Fm. of Chapursan valley.

**Magniplicatina vindicata** (Reed, 1925)

Pl. 4, fig. 11

1925 *Productus vindicatus* Reed, p. 34, pl. 5, fig. 10, 11.

Material. 3 Ventral valves: MPUM7889 (CK365-7; CK365bis-10); MPUM7890 (CK365bis-11).

2 Dorsal valves: MPUM7891 (CK365bis-13; CAL4-72).

Description. Concavo-convex shell with transversally oval outline. Maximum width at the hinge.

Ventral valve moderately convex in longitudinal direction, less convex transversally. Umbo flat, large, not prominent. Ears large, flat and triangular. A very shallow sulcus occurs near the anterior margin of the valve. Dorsal valve concave with transverse outline. Ornamentation of thin irregular rugae (0.9-1.2 mm wide), becoming enlarged at coarse spine bases. The rugae are more prominent and regular on the ears. Capillae number 10-12 per 5 mm. Fine and numerous prostrate spines occur on the rugae.

Dimensions (in mm):

|             | Width | Length |
|-------------|-------|--------|
| CK365bis-11 | 31.2  | 26.3   |
| CK365bis-10 | 33.8  | 20     |

Discussion. The distinctive characters of *Magniplicatina vindicata* (Reed, 1925) are the large dimensions, the transverse outline, the low convexity of the ventral valve, the large ears, the median ventral depression and the prostrate, densely arranged spines. For these characters it differs from *M. inassueta* (Reed) and *M. johannis* Angiolini.

Geographic and stratigraphic distribution. *M. vindicata* has been reported by Reed (1925) for the Baroghil pass.

In Western Karakorum it is present in the Kubergandian Mb. 4 of Lashkargaz Fm. of Lashkargaz and of Yarkhun river (2 km W of Lashkargaz).

Subfamily *Striatiferinae*

Muir-Wood & Cooper, 1960

Genus *Compressoproductus* Sarytcheva, 1960

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

**Compressoproductus** sp. ind.

Material. 1 Dorsal valve: MPUM7892 (CK315-18).

Description. Dorsal valve slightly concave with semicircular outline. Maximum width anterior to the hinge. Ears small, triangular, flat. Ornamentation capillate with large interspaces; the capillae number 9-10 per 5 mm at the anterior margin. Thin concentric rugae are also present.

Dimensions (in mm):

|          | Width | Length |
|----------|-------|--------|
| CK315-18 | 10.2  | 8.7    |

Discussion. This specimen has been placed with some doubt in the genus *Compressoproductus* because of its bad preservation.

Geographic and stratigraphic distribution. *Compressoproductus* sp. ind. is present in the Bolorian Mb. 2 of Lashkargaz Fm. of Lashkargaz.

Order Rhynchonellida Kuhn, 1949

Superfamily *Rhynchonellacea* Gray, 1848

Family *Allorhynchidae* Cooper & Grant, 1976

Genus *Aldina* Angiolini, 1995

Type-species: *Aldina exilis* Angiolini, 1995

Comments. The genus *Aldina* was included by Angiolini (1995) in the Family Allorhynchidae on the basis of its internal characters.

**Aldina exilis** Angiolini, 1995

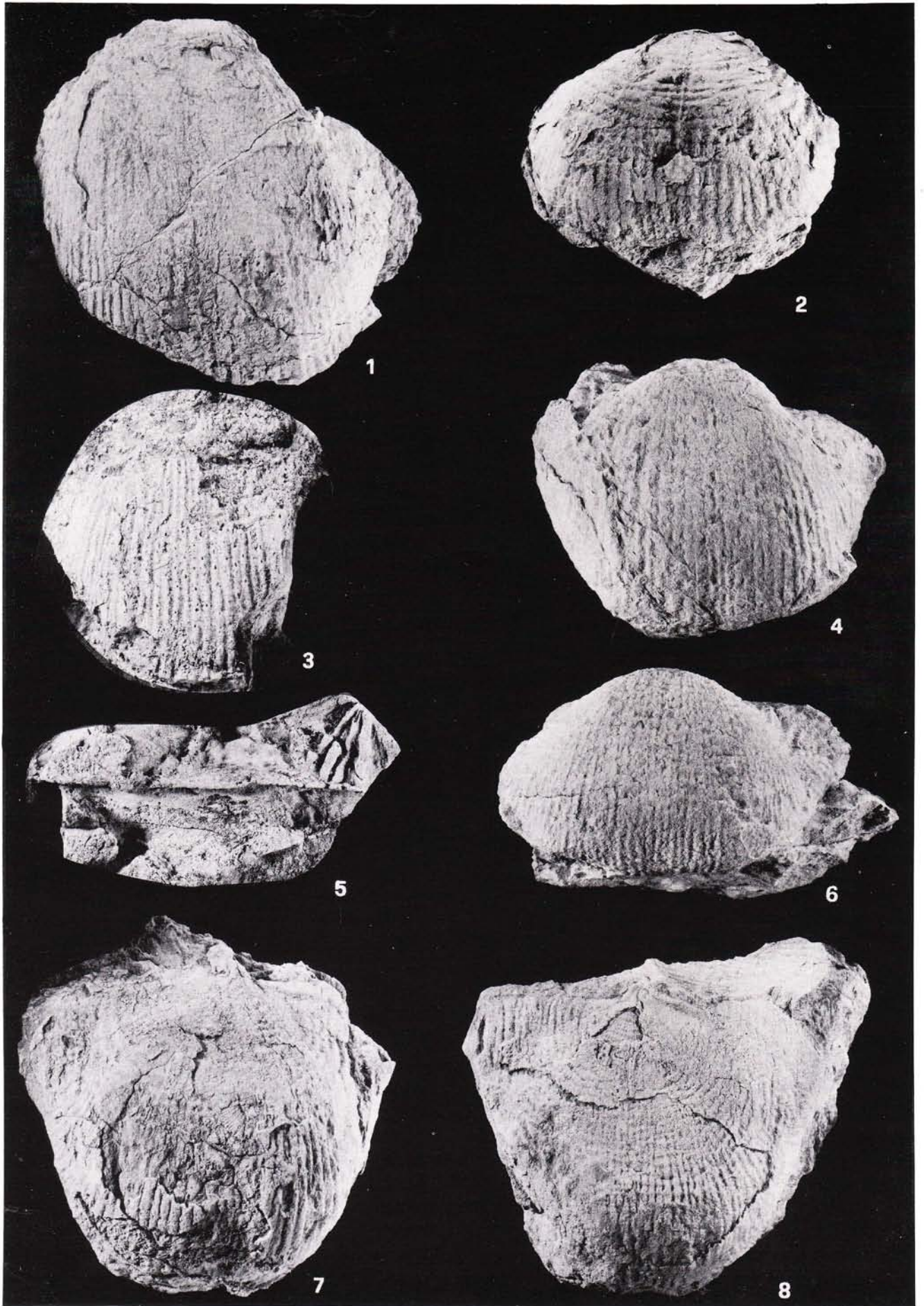
Pl. 4, fig. 12-28; Text-fig. 7-10

1995 *Aldina exilis* Angiolini, p. 209, fig. 16.8, 16.9, 17.

PLATE 3

(All x 1, except when specified)

- Fig. 1 - *Reticulatia chitralis* Angiolini. Ventral valve. Specimen MPUM7862 (CK269-12).  
 Fig. 2 - *Reticulatia chitralis* Angiolini. Dorsal valve. Specimen MPUM7867 (CK189-33).  
 Fig. 3 - *Reticulatia chitralis* Angiolini. Ventral valve. Specimen MPUM7860 (CK269-0).  
 Fig. 4 - *Reticulatia chitralis* Angiolini. Ventral valve. Specimen MPUM7864 (CK269-30).  
 Fig. 5 - *Reticulatia chitralis* Angiolini. Spines on the ears of a ventral valve. Specimen MPUM7860 (CK269-0).  
 Fig. 6 - *Reticulatia chitralis* Angiolini. Ventral valve. Specimen MPUM7863 (CK269-29).  
 Fig. 7 - *Reticulatia chitralis* Angiolini. Dorsal valve. Specimen MPUM7869 (CK269-1).  
 Fig. 8 - *Reticulatia chitralis* Angiolini. Dorsal valve. Specimen MPUM7871 (CAL4-17).



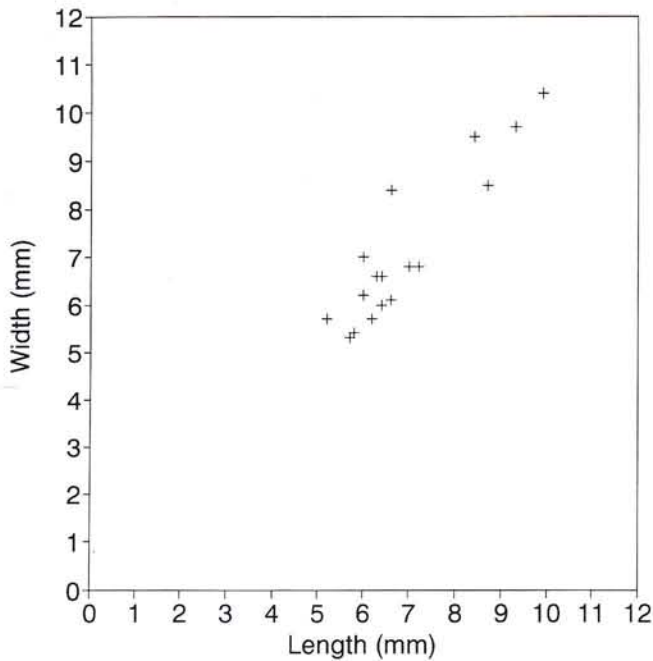


Fig. 7 - Width versus length diagram of *A. exilis* showing a rather regular increase in width during the growth of the shell.

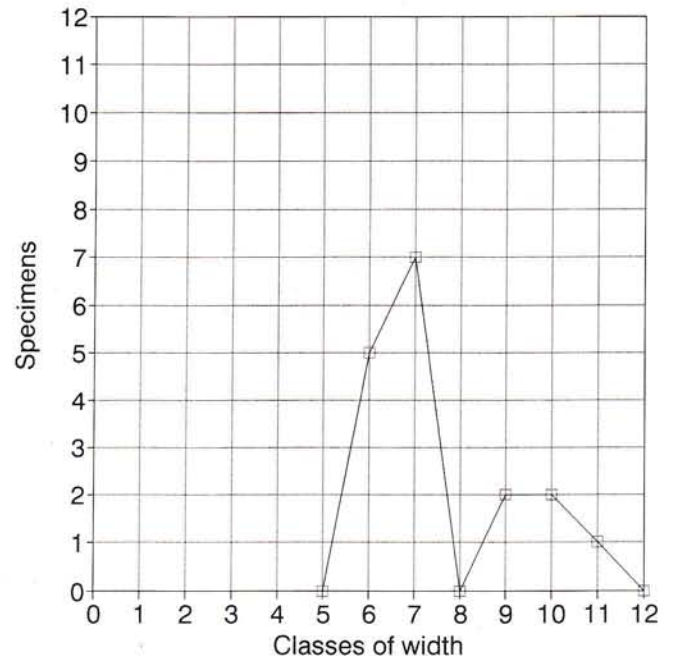
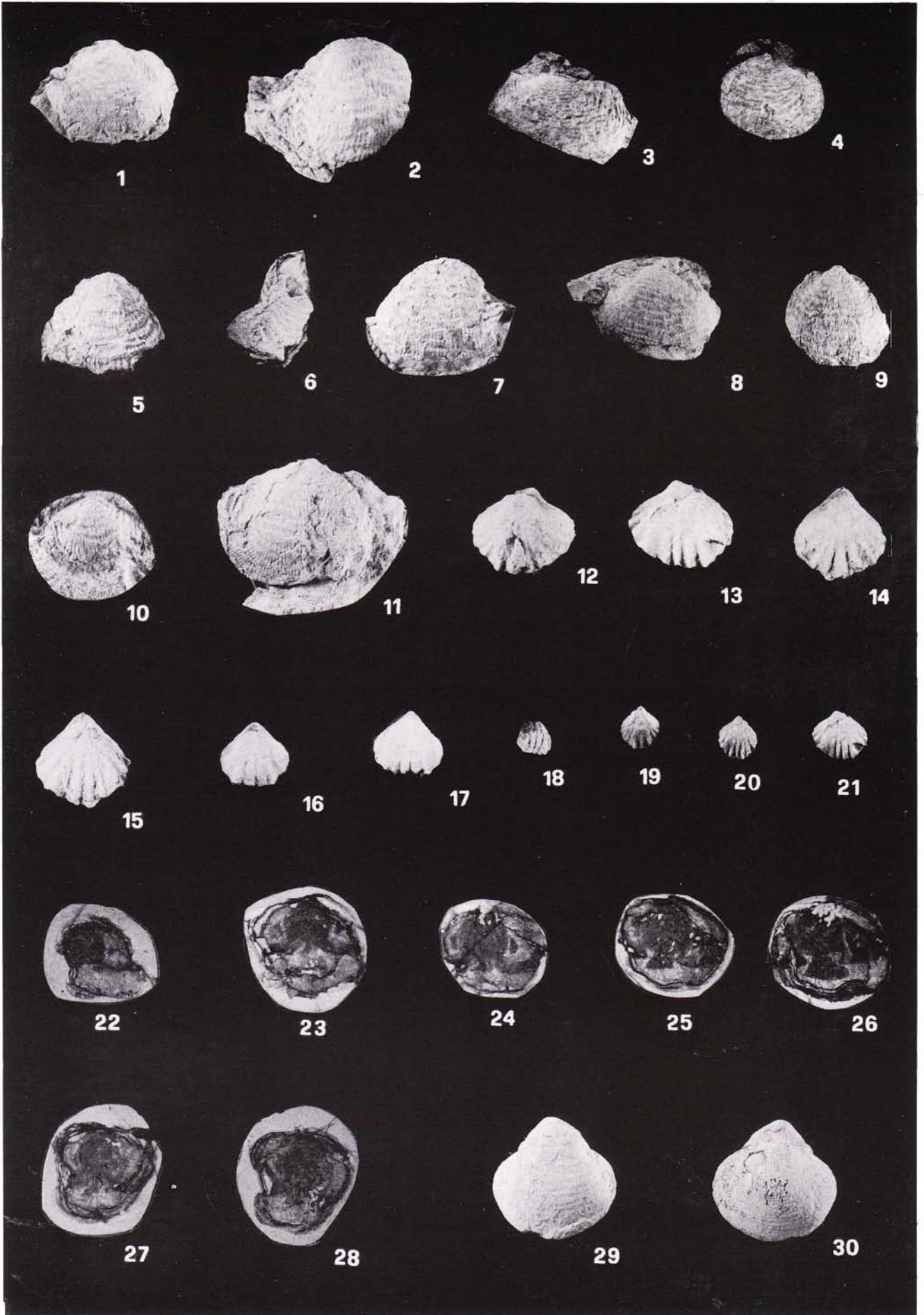


Fig. 8 - Diagram showing the number of specimens of *A. exilis* for each class of width. The bimodality of the curve can not be easily interpreted, because of the low number of specimens for each class of width. In fact the lack of specimens 8 mm wide could be due to incomplete sampling and the second peak is not significant, consisting only of two specimens.

PLATE 4

(All x 1, except when specified)

- Fig. 1 - *Magniplicatina inassueta* (Reed). Ventral valve. Specimen MPUM7873 (CK319-7).  
 Fig. 2 - *Magniplicatina inassueta* (Reed). Ventral valve. Specimen MPUM7874 (CK319-13).  
 Fig. 3 - *Magniplicatina johannis* Angiolini. Dorsal valve external cast. Specimen MPUM7887 (CK365-12).  
 Fig. 4 - *Magniplicatina johannis* Angiolini. Ventral valve. Specimen MPUM7880 (CK365-3).  
 Fig. 5 - *Magniplicatina johannis* Angiolini. Ventral valve. Specimen MPUM7876 (KK93-25).  
 Fig. 6 - *Magniplicatina johannis* Angiolini. Dorsal view of a complete specimen. Specimen MPUM7875 (KK93-79).  
 Fig. 7 - *Magniplicatina johannis* Angiolini. Ventral valve. Specimen MPUM7879 (CK269-8).  
 Fig. 8 - *Magniplicatina johannis* Angiolini. Ventral valve. Specimen MPUM7885 (CAL4-60).  
 Fig. 9 - *Magniplicatina johannis* Angiolini. Ventral valve. Specimen MPUM7881 (CK365-14).  
 Fig. 10 - *Magniplicatina johannis* Angiolini. Ventral valve. Specimen MPUM7884 (CAL4-29).  
 Fig. 11 - *Magniplicatina vindicata* (Reed). Ventral valve. Specimen MPUM7890 (CK365bis-11).  
 Fig. 12 - *Aldina exilis* Angiolini. Dorsal valve. Specimen MPUM7895 (CK319-27); x 1.5.  
 Fig. 13 - *Aldina exilis* Angiolini. Ventral valve. Specimen MPUM7895 (CK319-27); x 1.5.  
 Fig. 14 - *Aldina exilis* Angiolini. Dorsal valve. Specimen MPUM7894 (CK319-26); x 1.5.  
 Fig. 15 - *Aldina exilis* Angiolini. Ventral valve. Specimen MPUM7894 (CK319-26); x 1.5.  
 Fig. 16 - *Aldina exilis* Angiolini. Dorsal valve. Specimen MPUM7898 (CK319-41); x 1.5.  
 Fig. 17 - *Aldina exilis* Angiolini. Ventral valve. Specimen MPUM7898 (CK319-41); x 1.5.  
 Fig. 18 - *Aldina exilis* Angiolini. Anterior commissure. Specimen MPUM7898 (CK319-41).  
 Fig. 19 - *Aldina exilis* Angiolini. Dorsal valve. Specimen MPUM7896 (CK319-34).  
 Fig. 20 - *Aldina exilis* Angiolini. Ventral valve. Specimen MPUM7896 (CK319-34).  
 Fig. 21 - *Aldina exilis* Angiolini. Ventral valve. Specimen MPUM7895 (CK319-27).  
 Fig. 22 - *Aldina exilis* Angiolini. Specimen MPUM7899 (CK319-56). Section at 0.9 mm from the umbo; x 5.5.  
 Fig. 23 - *Aldina exilis* Angiolini. Specimen MPUM7899 (CK319-56). Section at 1.1 mm from the umbo; x 5.5.  
 Fig. 24 - *Aldina exilis* Angiolini. Specimen MPUM7899 (CK319-56). Section at 1.3 mm from the umbo; x 5.5.  
 Fig. 25 - *Aldina exilis* Angiolini. Specimen MPUM7899 (CK319-56). Section at 1.6 mm from the umbo; x 5.5.  
 Fig. 26 - *Aldina exilis* Angiolini. Specimen MPUM7899 (CK319-56). Section at 1.8 mm from the umbo; x 5.5.  
 Fig. 27 - *Aldina exilis* Angiolini. Specimen MPUM7897 (CK319-39). Section at 1.1 mm from the umbo; x 5.5.  
 Fig. 28 - *Aldina exilis* Angiolini. Specimen MPUM7897 (CK319-39). Section at 1.3 mm from the umbo; x 5.5.  
 Fig. 29 - *Permophricodothyris* sp. ind. Ventral view of a complete specimen. Specimen MPUM7901 (CK365-5).  
 Fig. 30 - *Permophricodothyris* sp. ind. Dorsal view of a complete. Specimen MPUM7901 (CK365-5).



**Material.** 27 Complete specimens: MPUM7893 (CK315-29,-46,-63,-93); MPUM7894 (CK319-26); MPUM7895 (CK319-27); MPUM7896 (CK319-34); MPUM7897 (CK319-39); MPUM7898 (CK319-41); MPUM7899 (CK319-56); MPUM7900 (CK319-25,-30,-32,-33,-35,-36,-37,-38,-40,-42,-43,-44,-46,-47,-48,-49,-50).

**Discussion.** *Aldina exilis* Angiolini, 1995 is characterized by its strongly recurved ventral umbo, the trape-

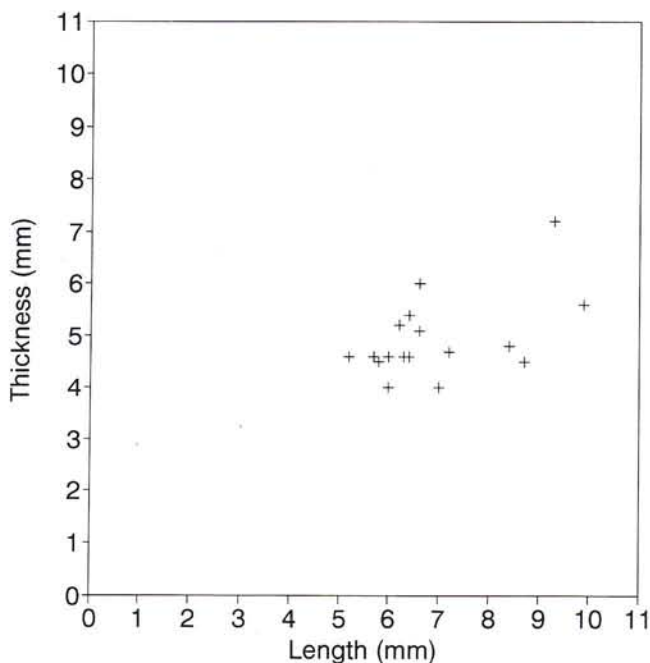


Fig. 9 - Thickness versus length diagram of *A. exilis* showing that this parameter is variable and does not increase much during growth.

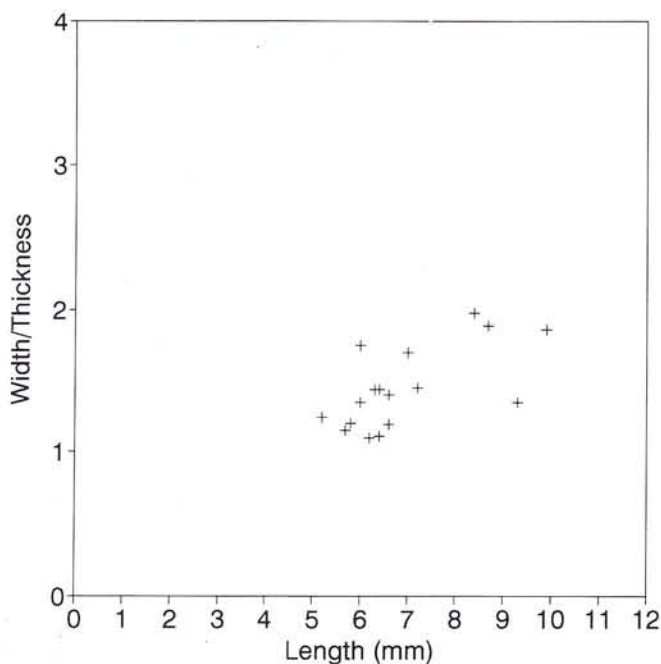


Fig. 10 - Width/thickness ratio versus length diagram of *A. exilis* showing that the width increases faster than thickness during growth. Only few specimens are remarkably flatter.

zoidal ventral tongue, the globose dorsal valve and the ornamentation of coarse, angular delayed costae starting anteriorly to mid-length. Most of the specimens of *A. exilis* are very globose (the globosity resulting from the swollen dorsal valve), their width-thickness ratio being about 1.1-1.4 and reaching 1.6 in few specimens. However four specimens (CK319-32; CK319-56; CK319-26; CK319-27) are remarkably flatter, their width/thickness ratio being 1.7-1.9. These specimens are not included in a separate species because the width/thickness ratio seems to be a variable character, increasing during growth.

**Geographic and stratigraphic distribution.** In Western Karakorum *A. exilis* is present in the Bolorian Mb. 2 of Lashkargaz Fm. of Lashkargaz.

Order Spiriferida Waagen, 1883

Suborder Spiriferidina Waagen, 1883

Superfamily *Reticulariaceae* Waagen, 1883

Family *Elythidae* Fredericks, 1924

Genus *Permophricodothyris* Pavlova, 1965

Type-species: *Permophricodothyris ovata* Pavlova, 1965

**Comments.** Pavlova (1965) and Archbold & Thomas (1984) include in the genus *Permophricodothyris* large and elongated species characterized by postero-laterally directed spiralia. These authors, together with Grant (1976), agree in retaining invalid *Neophricodothyris* Licharew, 1934 with type-species *Squamularia asiatica* Chao, 1929: in fact the internal structure of Chao's species is not known, the original material is not available for revision and no other characters distinguish it from *Phricodothyris* George, 1932.

#### *Permophricodothyris* sp. ind.

Pl. 4, fig. 29, 30

**Material.** 1 Complete specimen: MPUM7901 (CK365-5).

**Description.** Biconvex shell with oval outline. Hinge short. Anterior commissure rectimarginate.

Ventral valve with sub-triangular outline, given by the high ventral umbonal area. Umbo pointed and recurved; interarea high. Dorsal valve with transversally oval outline. Umbo small. Ornamentation of growth lamellae.

**Dimensions (in mm):**

|         | Width | Length |
|---------|-------|--------|
| CK365-5 | 23.7  | 23     |

Discussion. This specimen is very similar to *Neophricadothyris asiatica* (Chao, 1929) as described by Fantini Sestini (1965b) for Shaksgam.

Geographic and stratigraphic distribution. *Permo-phricadothyris* sp. ind. is present in the Kubergandian Mb. 4 of Lashkargaz Fm. of Lashkargaz.

#### Acknowledgements.

I am deeply grateful to M. Gaetani, for his suggestions and assistance in the field and during the three years-study of the collections of Karakorum. N. Archbold, H. Brunton, T. Grunt and G. Kotlyar revised the paper and gave very precious suggestions. A. Nicora and A. Zanchi are thanked for the field assistance.

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Received November 16, 1995; accepted February 15, 1996