

LATE CARBONIFEROUS BRACHIOPODS FROM KARAKORUM, PAKISTAN

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Riassunto. Vengono descritte per la prima volta cinque diverse successioni sedimentarie di età Carbonifera, appartenenti a distinte unità tettoniche, affioranti nel settore centrale della copertura sedimentaria del Karakorum settentrionale. Tali successioni mostrano spessori e caratteri litologici estremamente diversi, essendo presenti sia sottili unità di arenarie e di calcari a crinoidi, scarsamente fossilifere, che successioni a sedimentazione mista terrigeno-carbonatica, caratterizzate da elevato spessore e contraddistinte dalla presenza di due orizzonti fossiliferi. Il livello fossilifero inferiore contiene brachiopodi di età Bashkiriana (*Pustula* sp., *Rhipidomella* sp., *Choristites* sp., *Martiniopsis* sp., *Afghanospirifer* sp., *Gypospirifer* sp., *Composita* sp.). L'orizzonte superiore si trova 90 m sopra il primo e contiene coralli, crinoidi e brachiopodi di età Moscoviana-Kasimoviana (*Densepustula* cf. *losarensis*, *Dowhatania sulcata* n. sp., *Brachythyris* sp., *Rhipidomella* sp., *Septacamera dowhatensis*, *Alispirifer middlemissi*). I brachiopodi del Carbonifero superiore del Karakorum settentrionale sono correlabili a quelli del Carbonifero superiore dell'Afghanistan centrale, Himalaya (Manang, Spiti, Tibet), e del Blocco di Lhasa (regione di Xainza).

Inoltre, le successioni sedimentarie analizzate testimoniano l'attivazione di semi-graben in connessione con i fenomeni di rifting verificatisi tra il Blocco del Karakorum e il margine settentrionale del Gondwana durante il Carbonifero.

Abstract. Carboniferous rocks from North Karakorum display sharp lateral variations in lithology and thickness suggesting accumulation in half-grabens during continental rifting between the Karakorum block and northern Gondwana. Different Carboniferous successions, belonging to distinct tectonic units, have been detected. Thin, poorly fossiliferous successions of arenites and crinoidal limestones contrast with very thick terrigenous-carbonate successions comprising two distinct fossiliferous horizons. The lower fossiliferous horizon yielded brachiopods (*Pustula* sp., *Rhipidomella* sp., *Choristites* sp., *Martiniopsis* sp., *Afghanospirifer* sp., *Gypospirifer* sp., *Composita* sp.) of Bashkirian age. The upper fossiliferous horizon, lying about 90 m above the former, contains corals, crinoids and brachiopods (*Densepustula* cf. *losarensis*, *Dowhatania sulcata* n. sp., *Brachythyris* sp., *Rhipidomella* sp., *Septacamera dowhatensis*, *Alispirifer middlemissi*) of Moscovian to Kasimovian age.

The Carboniferous brachiopods of North Karakorum are similar to those collected in the Late Carboniferous of Central Afghanistan, Himalaya (Manang, Spiti, Tibet), and Lhasa Block (Xainza area).

Introduction.

The quest for the Carboniferous in the sedimentary cover of North Karakorum was elusive during our earlier three expeditions to northern Pakistan (1986, 1991, 1992). Conclusive evidence of the existence of Carboniferous fossils was found only in the 1996 expedition. However, the relationships of the Carboniferous succession to those of the Permian and Devonian remain unclear, because of sharp lateral variations in lithology and thickness and scarcity of significant fossils. These characteristics and the strong tectonic deformation affecting the Karakorum Range make the stratigraphic study of the Carboniferous successions difficult.

Carboniferous ages previously documented for the North Karakorum sedimentary cover are few and unsupported by conclusive fossil findings. In fact, the Lun Shales reported to be Carboniferous by Desio (1966) were proved to be Devonian by Talent et al. (1981).

Lower Carboniferous basalts and tuffs of the Tash Kupruk Unit are documented by Kafarskyi & Abdullah (1976) from the Wakhan side of the North Karakorum, who based their age determination on the interdigitation with limestones containing Tournaisian foraminifers.

The base of the Gircha Fm. in the Upper Hunza Valley lacks fossils (Casnedi & Nicora, 1985; Gaetani et al., 1995), but has been tentatively given a Late Carboniferous age on the basis of its stratigraphic position. The same holds true for the bioclastic crinoidal limestones cropping out at Baroghil (Upper Yarkhun Valley), dated as Early Carboniferous because of their stratigraphic position between the Late Devonian Shogram Fm. and the ?Upper Carboniferous-Permian Gircha Fm. at Baroghil (Gaetani et al., 1996).

The reliable discovery of Carboniferous rocks only occurred during the 1996 expedition investigating the region between the Chapursan Valley (Upper Hunza Valley) and Chitral, where two distinct fossiliferous

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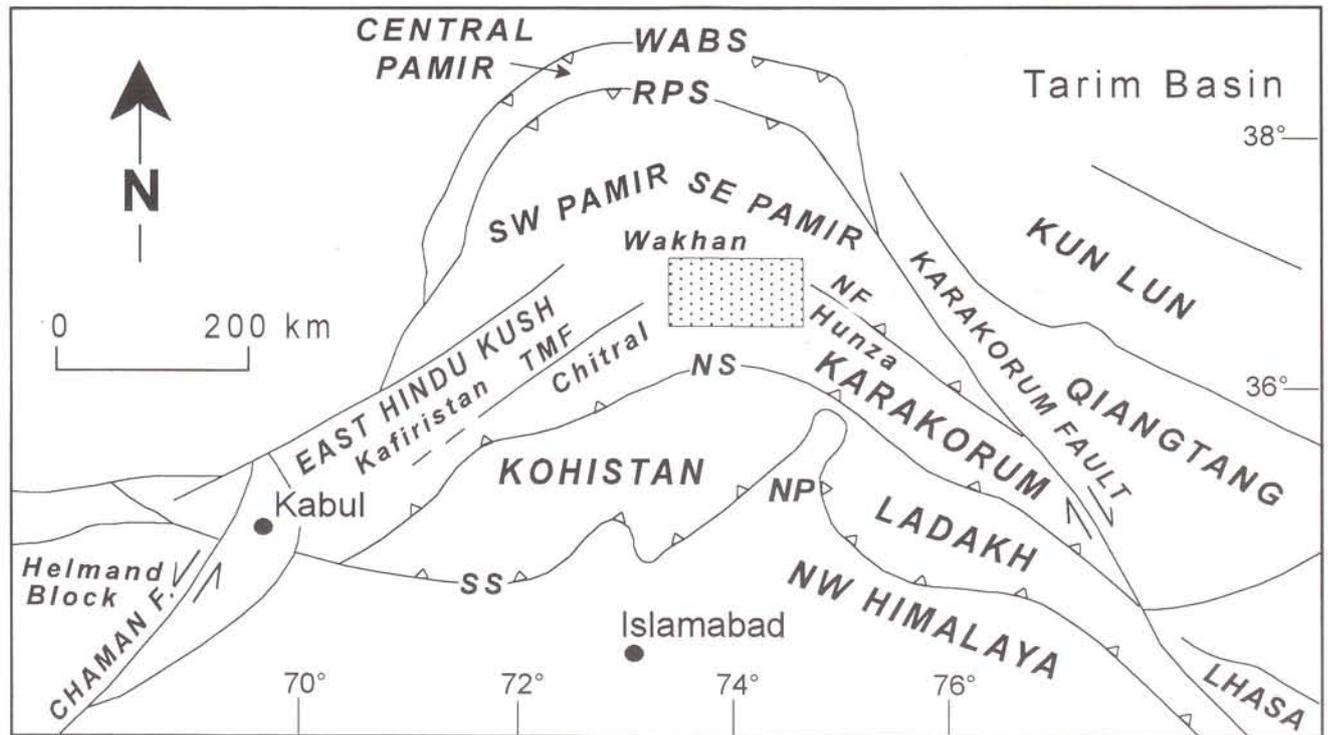


Fig. 1 - The geopuzzle of Central Asia crustal blocks (modified from Gaetani et al., 1996), showing the area depicted in Fig. 2. SS: Main Mantle Thrust; NP: Nanga Parbat; NS: Northern suture; RPS: Rushan-Pshart zone; WABS: Wanch-Ak Baital suture; NF: Northern Fault; TMF: Tirich Mir Fault.

horizons have been collected in two different localities, near the Karambar Pass and in the Upper Yarkhun Valley (Fig. 1, 2). The lower fossiliferous horizon yielded brachiopods (*Pustula* sp., *Rhipidomella* sp., *Choristites* sp., *Martiniopsis* sp., *Afghanospirifer* sp., *Gypospirifer* sp., *Composita* sp.) of Bashkirian age. The upper fossiliferous horizon comprises brachiopods (*Densepustula* cf. *losarensis*, *Dowhatania sulcata* n. sp., *Brachythyris* sp., *Rhipidomella* sp., *Septacamera dowhatensis*, *Alispirifer middlemisi*) of possible Moscovian to Kasimovian age.

The aim of this paper is to provide new geological, lithostratigraphic and paleontological data on the poorly known Carboniferous succession of North Karakorum and to document the affinities of the Karakorum fossiliferous horizons with the Late Carboniferous brachiopod assemblages of Central Afghanistan, of the Tethys Himalaya and of the Lhasa Block.

Regional geological framework.

The Karakorum Range (Fig. 1) is one of the most remote belts of Central Asia. It is located along the Afghan/Pakistan and the Chinese/Pakistan borders, in a politically sensitive region. Geologically the Karakorum largely encompasses the geographical Karakorum, including also the Hindu Raj and part of the Hindu Kush ranges (Gaetani, 1997).

The Karakorum block is one of the peri-Gondwanan microplates which separated from Gondwana du-

ring the Late Paleozoic and was accreted to the southern Eurasian margin during the latest Triassic-middle Jurassic, well before the collision of the Indian plate (Gaetani et al., 1990; Searle, 1991; Crawford & Searle, 1992; Zanchi et al., 1997). The Shyok Suture Zone (Pudsey et al., 1985; Pudsey, 1986; Coward et al., 1986; Searle et al., 1987; Searle, 1991) and the Rushan-Pshart Zone (Shvolman, 1981; Burtman & Molnar, 1993; Leven, 1995) are respectively interpreted as the southern and northern margins of the block. However, recent observations suggest a possible western termination of Karakorum against the Eastern Hindu Kush along the Tirich Mir Fault in the Chitral area (Zanchi et al., 1997). In the study area, the continuation of this boundary may be tentatively located between the Wakhan slates, cropping out just north of the Afghan border, and the sedimentary units of North Karakorum.

The North Karakorum terrain (Searle, 1991) includes a thick sedimentary cover cropping out north of the Karakorum Batholith (Le Fort & Gaetani, 1997). These sedimentary successions comprise Jurassic sandstones of orogenic provenance and are unconformably overlain by the Tupop and Reshun Formations of Late Cretaceous to Early Tertiary age, recording a complex pattern of microplates and arcs docking to the Eurasian margin before the collision of India (Gaetani, 1997).

The central sector of North Karakorum comprises an Ordovician to Mesozoic sedimentary succession overlying a quartzitic basement intruded by pre-Arenigian

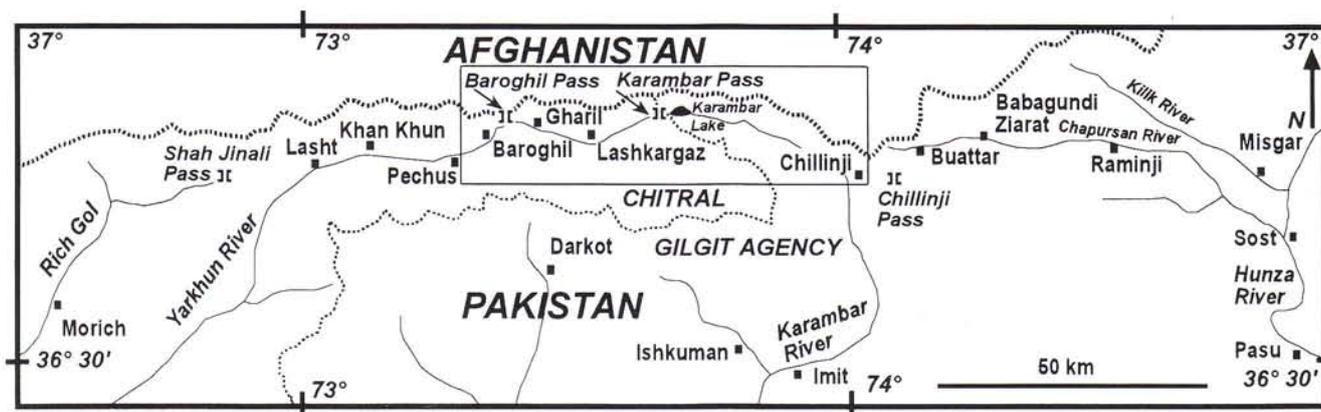


Fig. 2 - Geographic sketch map of North Karakorum, showing the study area depicted in Fig. 3.

granitoids (Fig. 2). These units are separated from the Wakhan slates by the Tash Kupruk Unit, a thick tectonic slice including massive basalts and dolostones of uncertain paleogeographic provenance possibly of Late Devonian to Carboniferous age (Kafarshki & Adullah, 1976; Gaetani et al., 1996). The entire sedimentary succession escaped strong metamorphism during the Mesozoic collisional events; nevertheless intensive deformation of the sedimentary units is testified by polyphase folding and intensive thrust-stacking resulting in a complex tectonic setting. On the basis of detailed geological mapping (Zanchi et al., in prog.), eight tectonic units, each including several thrust-slices and characterized by a peculiar tectonic and stratigraphic setting (Fig. 3), have been recognized south of the Tash Kupruk Unit in the central sector of North Karakorum. In the following paragraphs, only the tectonic units comprising Carboniferous rocks will be briefly described.

The relationships between the tectonic units of the central part of Karakorum and those of the Upper Hunza Valley (Gaetani et al., 1990; Zanchi & Gaetani, 1994) are still uncertain: in fact we were unable to follow the lateral continuity of the Hunza thrust stack, part of which continues further north into the Wakhan, in the Afghanistan territory.

The carboniferous succession of Karakorum.

The Carboniferous sedimentary succession of North Karakorum displays significant lateral variations of thickness, lithology and fossil content. Up to now, four different Carboniferous successions and a newly discovered one, can be described: the Lasht, Baroghil, Karambar Pass-Lashkargaz (including the tectonic slices cropping out at the Buattar Glacier), Chillinji and Upper Hunza Valley successions. The newly discovered Karambar Pass-Lashkargaz succession is here described in more detail, the others having been previously reported by Gaetani et al. (1995), Gaetani et al. (1996) and Gaetani (1997).

These successions belong to different tectonic units (Fig. 3), whose mutual relationships are still unclear (for details see the geological map in progress by Zanchi et al.). From West to East they are:

1) Lasht - According to Gaetani et al. (1996) 180 m-thick crinoidal limestones with fragments of brachiopods and bryozoans, cropping out at Rukut around Lasht (Fig. 2), have been tentatively given an Early Carboniferous age, due to their stratigraphic position. In fact, they are erosionally overlain by the arenites and shales of the ?Upper Carboniferous-Lower Permian Gircha Fm. This Carboniferous succession belongs to the Lasht tectonic unit, which is overthrust by the Tash Kupruk Unit. The relationships with the Baroghil Unit are still unclear. In fact, the two units display overall similar characters, but they are isolated slices separated by the Yarkhun Unit (Fig. 3).

2) Baroghil - About 80 km East of Lasht in the Upper Yarkhun Valley, near Gharil (Baroghil area), 50 m-thick crinoidal limestones with shaly intercalations crop out between the Late Devonian Shogram Fm. and the Gircha Fm. in the Baroghil Unit. The basal contact with the Shogram Fm. was not observed, the Yarkhun River flowing over it (Fig. 3), whereas the contact with the overlying Gircha Fm. is gradual and conformable (Gaetani et al., 1996, p. 693). Due to the lack of fossils, the crinoidal limestones have been tentatively attributed to the Lower Carboniferous (Gaetani et al., 1996), on the basis of their stratigraphic position. The Baroghil unit is one of the less deformed tectonic unit of North Karakorum, being affected only by minor thrusting and strike-slip faults. It is bounded northward by the Karambar units and it forms a south-vergent thrust stack overthrusting a slice of the Cretaceous Reshun Fm. and the Yarkhun Unit.

3) Karambar Pass-Lashkargaz - The newly discovered fossiliferous Carboniferous succession belongs to

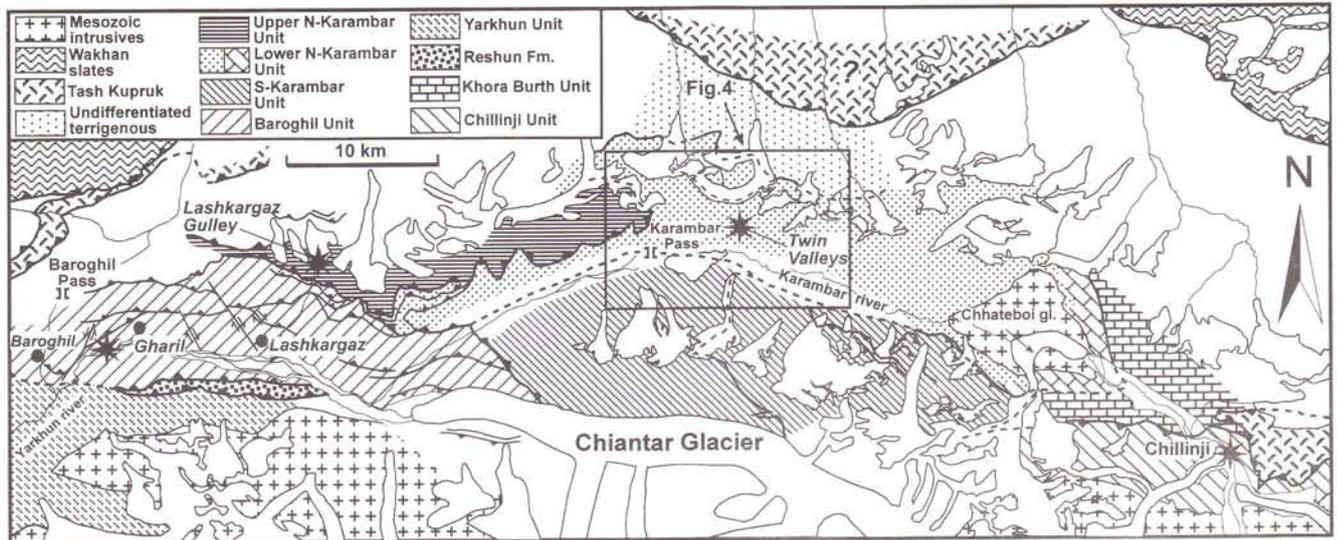


Fig. 3 - Main geological features of the Karakorum Range, locating four studied localities from Chillinji to Baroghil.

two tectonic units displaying overall similar characters: The Upper N-Karambar Unit and the Lower N-Karambar Unit separated by a complex system of faults (Figs. 3-4). Westward, the Upper N-Karambar Unit is located north of the Baroghil Unit and stacked above the Lower N-Karambar Unit along a SW-vergent thrust (Fig. 3). The Lower N-Karambar Unit is also in tectonic contact with the S-Karambar Unit, which is located south of the Karambar Pass and comprises a thick terrigenous succession probably including the Carboniferous, stratigraphically overlying the Devonian Shogram Fm. To the north, the N-Karambar units are tectonically bounded by an undifferentiated terrigenous unit possibly including Carboniferous rocks, which is overthrust further to the north by the Tash Kupruk Unit.

Carboniferous rocks of the Upper N-Karambar unit have been studied in the Lashkargaz gulley (Fig. 4), where the succession is truncated at the base by a ENE-WSW trending reverse fault. In fact only the upper fossiliferous horizon has been found in marly limestones about 20 m above the thrust plane.

The Lower N-Karambar unit contains the most complete Carboniferous section measured up to now in the North Karakorum. Northward and westward of the Karambar Lake, the Carboniferous succession is deformed by intensive folding and thrust stacking. The direction in which folds face and the thrust faults suggest WSW-ward motion of the units.

Eastward, the Carboniferous succession passes to a monotonous sequence of black slates and arenites belonging to the Gircha Fm. and thus ranging up into the Permian. Around the Chhateboi pluton the Gircha Fm. makes gradual transition to massive limestones.

The Twin Valleys section, located just northeast of the Karambar Lake (36°53'00"N-73°45'36"E), represents one of the best outcrops of the Carboniferous suc-

cession of the Lower N-Karambar unit and it comprises from the base to the top (Fig. 5):

- at least 200 m of black marly limestones with thick intercalations of massive bioclastic limestones;
- 100 m of black marls, calcareous siltites, calcareous sandstones and marly limestones containing bryozoans, corals, and Bashkirian brachiopods such as *Rhipidomella* sp., *Choristites* sp., *Martiniopsis* sp., *Afghanospirifer* sp., *Gypospirifer* sp., *Composita* sp. and an undermined schuchertellid;
- 30-50 m of massive, cross bedded coarse sandstones, bioclastic sandstones and conglomerates with rounded quartz pebbles;
- 20-40 m of varicoloured calcareous siltites and fine arenites with intercalation of marly limestones containing bryozoans, corals and Moscovian to Kasimovian brachiopods such as *Densepustula* cf. *losarensis*, *Dowhatania sulcata* n. sp., *Brachythyris* sp., *Rhipidomella* sp., *Sep-tacamera dowhatensis*, and *Alispirifer middlemissi*. Very large crinoid stems have been detected in green and red siltites;
- 30-100 m of massive bioclastic limestones containing bryozoans, crinoids and recrystallized brachiopods and corals. This calcareous unit shows sharp lateral variations in thickness.

The section is topped by a very thick (at least 500 m) terrigenous unit, comprising black slates and fine sandstones with coarse sandstones and conglomerates, which belongs to the ?Upper Carboniferous-Lower Permian Gircha Fm. In fact, on the path leading from Suinji to the Karambar Pass, Lower Permian brachiopods (*Trigonotreta* sp., *Spirelytha* sp.) similar to the cool-water brachiopod fauna of the middle Gircha Fm. have been found lose from quartzarenites in locality CK581 (Fig. 4).

The Karambar Pass-Lashkargaz succession records two transgressive phases, punctuated by Bashkirian and

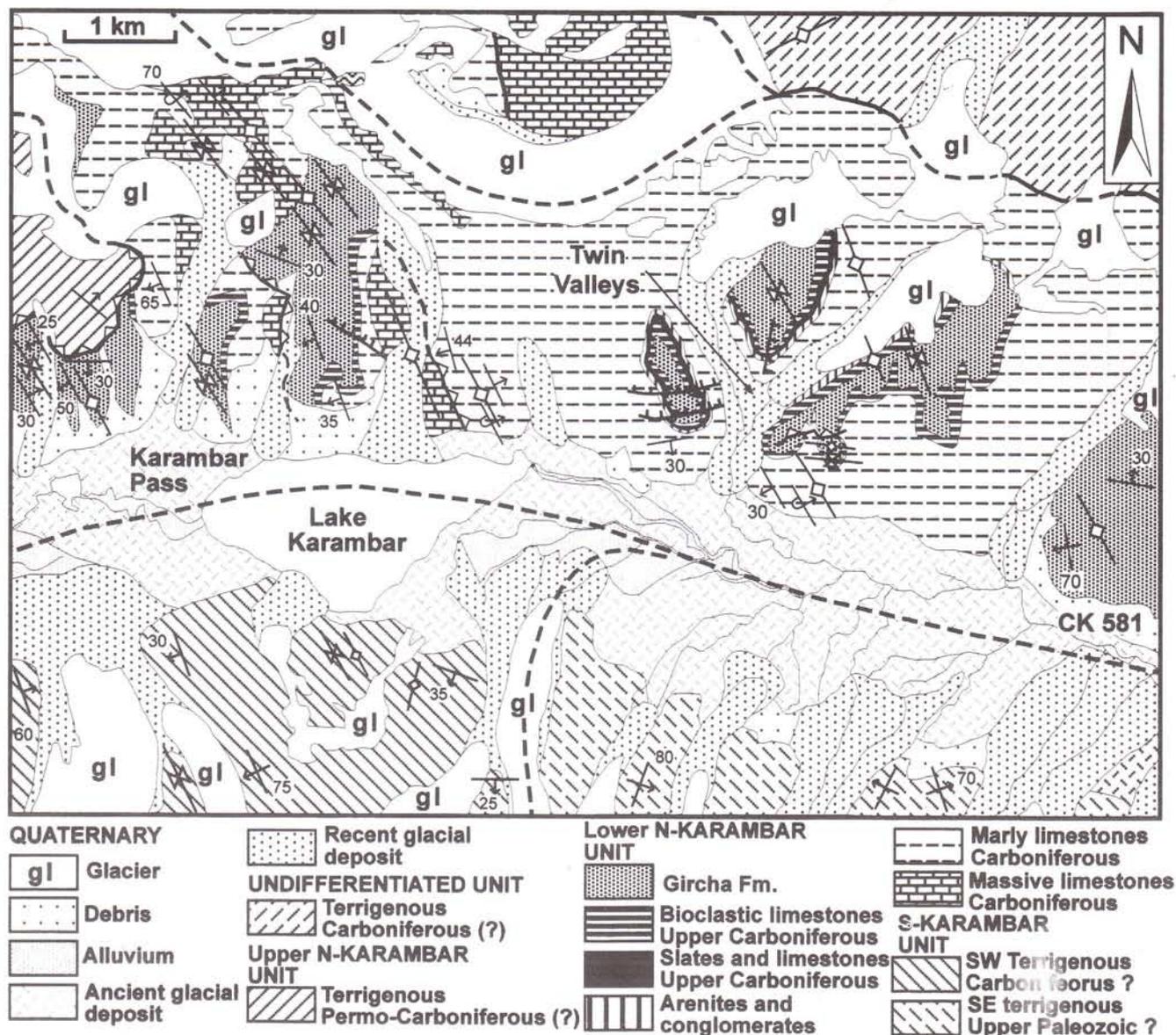


Fig. 4 - Geological map of Karambar Pass area. Section measured along the Twin Valleys is indicated.

Moscovian fossiliferous levels and separated by the deposition of coarse sandstones and conglomerates. This is in agreement with the evolution recognized by Garzanti et al. (1998) along the Tethys Himalaya, where a first cooling stage in the Viséan-Serpukhovian (Garzanti & Sciunnach, 1997) is followed by a major transgression and warming in the Bashkirian; subsequent tectonic activity and local glaciations are followed by a second transgression and warming in the Moscovian, abruptly interrupted by the climax of the Gondwana glaciation. However, no evidence of glaciation is known from the Karakorum terranes located at lower latitudes in warmer climates.

4) Chillinji - In the Upper Karambar Valley, around Chillinji, a tectonic unit, named Chillinji unit, crops out below the Tash Kupruk unit (Fig. 3). The Chillinji unit comprises Ordovician to Permian sediments transgressive onto the crystalline basement (Ishkarwaz grani-

te). However the Carboniferous part of the section is devoid of diagnostic fossils and has been dated only on the basis of its stratigraphic position. In fact a 500 m-thick terrigenous unit affected by faults and folds is bracketed between the Upper Devonian Shogram Fm. at the base and Permian dolostones at the top (Gaetani et al., 1996, p. 697). The first 80 m of this unit consist of fine-grained arenites, hybrid arenites, siltites and dark slates and yield at 3.2 m from the base a poorly preserved Schuchertellid (sample CK555): they have been ascribed to the Carboniferous. Above, a polygenic conglomerate followed by a monotonous, thick sequence of burrowed siltstones with intercalations of fine-grained quartzarenites probably belongs to the Gircha Fm. (Gaetani et al., 1995).

5) Buattar Glacier - On the southeastern slope of the Chillinji Pass, on the left side of the Buattar Glacier

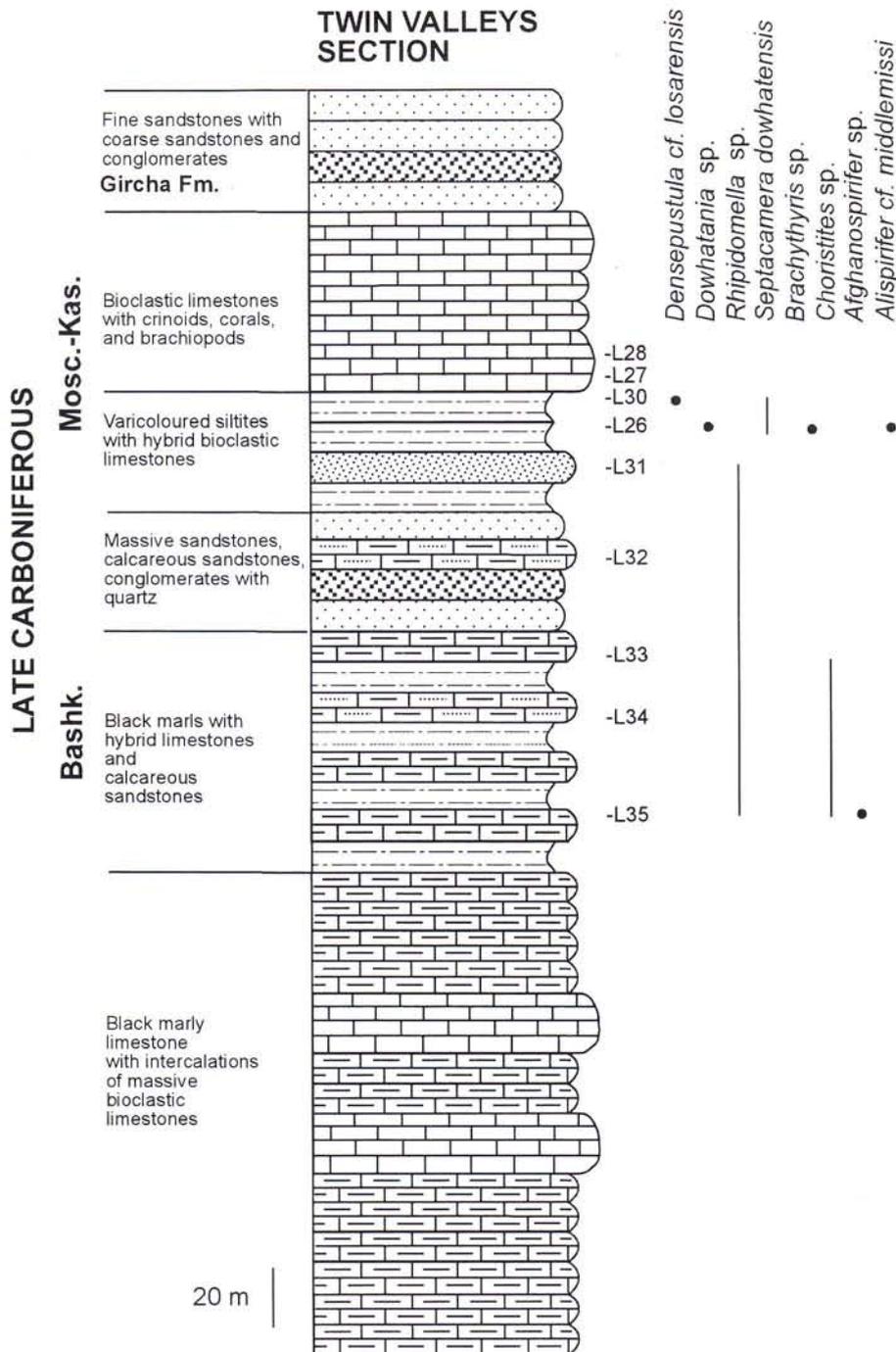


Fig. 5 - Stratigraphic column of the Carboniferous succession of the Twin Valleys section, Karambar Pass.

with the very thick (exceeding 1000 m) terrigenous Gircha Fm., which contains late Asselian-early Sakmarian (Early Permian) brachiopods in its middle part (Gaetani et al., 1995; Angiolini, 1995). No diagnostic fossils have been found in the lower part of the formation, but a Late Carboniferous age for its base cannot be excluded.

Climatic and tectonic evolution: preliminary considerations.

Excluding the Upper Hunza Valley, where the base of the sedimentary succession is never exposed and the oldest fossils are Early Permian in age, the Carboniferous units of North Karakorum display sharp variations of lithology and thickness: from the thin and poorly fossiliferous crinoidal limestones of Lasht and Baroghil to the very thick terrigenous or mixed terrigenous-carbonatic succession cropping out from the Lashkargaz gully to Shuinji through the Karambar Pass, and again to the less thick siltites and sandstones of Chillinji.

The sharp lateral variability of lithologic intervals of the Carboniferous succession is in contrast with the rather uniform character of the underlying Ord-

ovician to Devonian succession and may be explained by accumulation in rift-troughs during the rifting between the Karakorum block and the northern Gondwanan margin. In fact, close to the rift shoulder the Carboniferous rift sequence consists of reduced terrigenous sediments or it is lacking, whereas on subsiding rift-throughs thick successions of shales and limestones may accumulate. This interpretation is no more than a working hypothesis as the available data are few, fragmentary and poorly constrained.

6) Upper Hunza Valley - In the Upper Hunza Valley and its side valleys the sedimentary succession starts

at 4420 m a.s.l., black marly limestones and bioclastic limestones yielding poorly preserved specimens of *Rhipidomella* sp. (resembling the species collected in the Karambar Pass area), corals and large crinoids (samples L14-15) form thrust slices along the hangingwall of the Upper Hunza fault. These limestones represent the easternmost outcrop of fossiliferous Carboniferous rocks found in the region and are very similar to the Upper Carboniferous bioclastic limestones of the Karambar Pass-Lashkargaz area (see above).

However, this preliminary reconstruction is in agreement with the much more detailed Carboniferous evolution of the Tethys Himalaya described by Garzanti

et al. (1998), who documented a Lower Paleozoic to lowermost Carboniferous pre-rift sequence and a mid to Upper Carboniferous syn-rift sequence, which accumulated in rapidly subsiding half-grabens during rifting between northern Gondwana and the Peri-Gondwanan blocks (e.g. the Karakorum block). Furthermore, the onset of continental rifting and the continuation of extensional tectonics in the Peshawar Basin and in the Southern Swat region (Pakistan) have been dated as Early-middle Carboniferous by Pogue et al. (1992a; 1992b), followed by a Late Carboniferous-Permian climax of rifting.

According to Dickins (1993; pers. comm.) and to Garzanti et al. (1998) the Carboniferous was characterized by complex and rapid climatic changes, with a discontinuous cooling trend from the Visean to the latest Carboniferous-Asselian (Early Permian), when the Gondwana glaciation reached its climax. This climatic evolution is linked both to a southward latitudinal drift and to an uplift related to the onset of continental rifting along the northern Gondwana margin (Garzanti et al., 1998).

Along the Tethys Himalaya, Garzanti et al. (1998) recognized a first cooling stage in the Visean-Serpukhovian, followed by a major transgression and warming in the Bashkirian. Subsequent tectonic activity and local glaciations were followed by a second transgression and warming in the Moscovian, abruptly interrupted by the approaching climax of the Gondwana glaciation.

No evidence of glaciation is known from the Peri-Gondwanan terranes located at lower latitudes in warmer climates, except for a doubtful occurrence of Visean-Serpukhovian tilloids in Central Afghanistan (Montenat et al., 1978, p. 288). However, the Karambar Pass-Lashkargaz Carboniferous succession of North Karakorum records the Bashkirian and Moscovian transgressive phases, punctuated by fossiliferous levels similar to the Tethys Himalayan assemblages (see paragraph below). As in the Himalayas, these two stages are separated by a phase of tectonic activity, recorded by the deposition of coarse sandstones and conglomerates (Fig. 5). Nothing can be said about the pre-Bashkirian and the latest Carboniferous-earliest Permian evolution of North Karakorum, except that in the late Asselian-early Sakmarian a cool temperate brachiopod fauna developed (Angiolini, 1995; Gaetani et al., 1995).

The brachiopod fauna.

The Carboniferous brachiopods described in the present paper have been collected from two localities (Fig. 3):

- along the Twin Valleys section (Fig. 4-5), located at 36°53'00"N-73°45'36"E (WGS84), northeast of the Karambar Lake in the Lower N-Karambar unit;

- at 4450 m a.s.l. in the Lashkargaz gully located about 1 km east of the Lashkargaz houses, about 20 m above the basal thrust of the Upper N-Karambar unit.

The brachiopods collected from Chillinji are not described because of their poor preservation.

Along the Twin Valleys section two distinct brachiopod assemblages have been collected (Fig. 5). The lower assemblage occurs in black marly limestones (beds L33-L35 of the section and samples CK587, CK588, CK590, CK591 collected in the scree of the same lithozone) and comprises: a Schuchertellid indet., a Productidae indet., *Rhipidomella* sp., *Choristites* sp., *Martiniopsis* sp., *Afghanospirifer* sp., *Gypospirifer* sp., and *Composita* sp. A single specimen of *Pustula* sp. has been collected on the path from Suinji to Karambar Pass, seemingly coming from the scree of the same lithozone.

The upper assemblage has been collected in vari-coloured calcareous siltites (beds L26, L30 of the section) and consists of *Densepustula* cf. *losarensis* Angiolini & Brunton, 1998, *Dowhatania* sp., *Septacamera dowhatensis* (Diener, 1915), *Alispirifer middlemissi* (Diener, 1915), *Brachythyris* sp., *Permasyrinxinae* gen. indet.

The two assemblages are separated by a barren interval coinciding with a sharp change of lithofacies, from marls and hybrid limestones to sandstones and conglomerates (Fig. 5). In fact only *Rhipidomella* sp. ranges higher up to bed L31, but it does not occur in the upper assemblage.

In the Lashkargaz gully only the upper assemblage has been detected in marly limestones (sample L42), yielding *Densepustula* cf. *losarensis*, *Dowhatania sulcata* n. sp., *S. dowhatensis*, *A. middlemissi*, *Brachythyris* sp. and a *Permasyrinxinae* gen. indet.

Age.

Both brachiopod assemblages have been assigned a Late Carboniferous age on the basis of the occurrence of the Late Carboniferous *Densepustula* and *Dowhatania* and of genera which are not older than Bashkirian such as *Septacamera*, *Martiniopsis* and *Gypospirifer*.

More specifically, the lower assemblage has been dated as Bashkirian because of the occurrence of fine ribbed Late Carboniferous representatives of the genus *Choristites* together with *Martiniopsis* sp. and the genus *Afghanospirifer*, introduced by Plodowski (1968) for the Namurian (corresponding to most of the Serpukhovian and early Bashkirian) of Central Afghanistan (SW Dasht-e-Nawar). Furthermore, the Karakorum species of *Choristites* is very similar to *C. xainzangensis* Yang, 1983 from the mid-Carboniferous of Xainza (Central Tibet) (Yang & Fan, 1983).

The upper brachiopod assemblage has been given a probable Moscovian-Kasimovian age according to its stratigraphic position and occurrence of *Densepustula* cf.

losarensis, known from the Bashkirian-Moscovian of Spiti (Garzanti et al., 1998), together with a species of *Brachythyris* similar to *B. ufensis* (Tschenrýshev, 1902) from the Kasimovian of Russia.

Correlations.

Late Carboniferous brachiopods from North Karakorum show affinities with the faunas of contiguous Peri-Gondwanan terranes, such as Central Afghanistan and the Lhasa Block, and also with those of the Tethys Himalaya. In fact, these faunas start to differentiate from the late Early Permian onwards, when the Peri-Gondwanan blocks drifted northwards away from Gondwana as spreading was initiated in the Neotethys Ocean (Garzanti et al., 1998). This is in agreement with Smith (1988) and Smith & Xu (1988), who did not identify any endemic fauna or significant barrier between the Lhasa Block and the Tethys Himalaya of South Tibet during Carboniferous to mid Permian times. However, those authors recorded a N-S decreasing diversity-trend across the whole Tibetan Plateau. The same holds true for the Karakorum brachiopod assemblages, which show higher diversity and are usually associated with corals, indicating warmer climatic conditions with respect to all Tethys Himalayan localities and to the Peshawar Basin and the Southern Swat region (Pakistan), where the Lower-Middle Carboniferous mostly terrigenous Jafar Kandao Fm. was deposited (Pogue et al., 1992a; 1992b).

According to Garzanti et al. (1998), the higher faunal diversity of the Peri-Gondwanan terranes with respect to the Tethys Himalaya may be ascribed to the lower southern latitudinal position of the former, resulting in warmer temperate climates influenced by oceanic currents carrying equatorial waters along the Gondwanan margin (Golonka et al., 1994).

Central Afghanistan - The Carboniferous succession of Central Afghanistan (Termier et al., 1974; Montenat et al., 1978) shows conspicuous similarities with that of the North Karakorum in lithology and sudden lateral variations of thickness. In fact, according to Termier et al. (1974, p. 37), the Upper Carboniferous succession of Central Afghanistan triplicates its thickness over a distance of only 1 km.

In the Wardak region, Tournaisian to Visean bioclastic limestones are overlain by a 1000 m-thick Carboniferous to Lower Permian terrigenous succession (Montenat et al., 1978). According to the French authors, tilioids at the base of this succession contain Visean to Serphukovian brachiopods and foraminifers (*Syringothyris* sp., *Athyris lamellosa*, *Archeodiscus* sp.) indicating the beginning of the Gondwana glaciation (Termier et al., 1977). Within the terrigenous succession Termier et al. (1974) described 200 m of green slates with lenticular

intercalations of sandstones, yielding Late Carboniferous brachiopods (*Canocrinella* sp., "*Productus dowhatensis*" Diener, *Asyrinx* sp.) and bryozoans. However, due to the strong tectonic deformation, they could not evaluate the position of this fauna with respect to the Lower Carboniferous limestones (Termier et al., 1974, p. 16). The upper part of the terrigenous succession has been dated as Sakmarian (Early Permian) with brachiopods and bivalves (Termier et al., 1974).

Plodowski (1968, 1970) described a Lower Silurian to Permian succession from Nawar, located SW of Wardak, where Lower Carboniferous crinoidal limestones are conformably overlain by a 1500 m-thick Namurian to Lower Permian terrigenous succession, chiefly consisting of shales with intercalations of arenites. Plodowski (1970) identified a Namurian brachiopod assemblage comprising *Antiquatonia* sp., *Flexaria* sp., *Linoproductus* sp., "*Productus*" *afghanensis* Reed, *Rugosochonetes* sp., *Rotata kusbassi* (Rotai), *Neospirifer incipiens*, *Afghanospirifer burgutschensis* Plodowski, different species of *Syringothyris*, *Athyris* cf. *pectinifera* L veill , *Composita* sp. together with gastropods and orthoceratids. However, from his paper it is not clear if this assemblage was found in a single level and from which part of the stratigraphic column the brachiopods were collected (seemingly near the base of the shales and arenites overlying Lower Carboniferous limestones). Furthermore, only the Spiriferids were described and illustrated so that a detailed comparison with the Karakorum fauna is prevented.

In conclusion, the Upper Carboniferous successions of Karakorum and Central Afghanistan are similar in lithology and thickness and probably also in faunal content; in fact they share the endemic genus *Afghanospirifer*, and the genera *Dowhatania* and *Composita*. However, a more significant comparison of the two faunas requires revision of the Central Afghanistan productids and rhynchonellids.

Lhasa - Except for a brief account of the genera *Punctospirifer*, *?Alispirifer*, *?Chaoiella*, *?Phricodothyris*, *Sculptospirifer* from the Pondo Group by Smith & Xu (1988), Late Carboniferous brachiopods from the Lhasa Block are known only from the work of Yang & Fan (1983) and the revision by Jin & Waterhouse (1986). These authors described four successive brachiopod assemblages from Yungzhu (Xainza area) ranging in age from Visean to Bashkirian. The uppermost assemblage, named *Rugoconcha-Choristites* assemblage, shows strong affinities with the lower assemblage from North Karakorum, including *Choristites* and *Rhipidomella* species.

Himalaya - Late Carboniferous brachiopod assemblages of North Karakorum compare closely with those of the Tethys Himalaya, having at least two species and four genera in common (the genera *Dowhatania*, *Dense-*

pustula, *Pustula*, *Choristites* and the species *Septacamera dowhatensis* and *Alispirifer middlemissi*). More specifically, the highest similarity is attained between the Bashkirian fossiliferous horizon of the Tethys Himalaya and the Bashkirian lower assemblage of Karakorum. However, the two common species *S. dowhatensis* and *A. middlemissi* seem to have appeared slightly later in North Karakorum (Moscovian-Kasimovian upper assemblage) with respect to the NW Tethys Himalaya (Garzanti et al., 1998). This lag may record a dispersal route from SE to NW of the brachiopod larvae carried by southern equatorial surface currents running from east to west along the Gondwana margin (Ziegler et al., 1981). This is in agreement with the wind vector pattern suggested by Golonka et al. (1994) for the Carboniferous: South-east winds came from the Paleopacific to the eastern tip of Gondwana, where they give way to north-east winds blowing from Australia to the Lhasa Block.

In fact, the Australian genus *Alispirifer*, which appeared in Eastern Australia during the Namurian, reached South Tibet in the Bashkirian, Spiti (NW Himalaya) in the Late Bashkirian reaching the North Karakorum only in the Moscovian-Kasimovian. *Septacamera dowhatensis* seemingly appeared in South Tibet and Manang (Central Himalaya) during Bashkirian, reaching Karakorum only in the Moscovian-Kasimovian.

Brachiopod systematics

(L. Angiolini and H. Brunton)

All the described specimens are housed in the Paleontological Museum of the University of Milan, Italy. Field numbers of single fossiliferous beds are reported along with catalogue numbers (prefixed MPUM).

The systematic study follows the supra-ordinal classification of Williams et al. (1996) and the classifications of Brunton et al. (1995) for the productids, Carter et al. (1994) for the spiriferids and of Savage (1996) for the rhynchonellids.

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

Order Productida Sarytcheva & Sokolskaya, 1959

Suborder Productidina Waagen, 1883

Superfamily *Productoidea* Gray, 1840

Family *Productidae* Gray, 1840

Subfamily *Productinae* Gray, 1840

Genus *Dowhatania* Waterhouse and Gupta, 1979

Type-species: *Productus dowhatensis* Diener, 1915

Remarks - The genus *Dowhatania* is placed for the Treatise revision in the Productinae, as set out in Brunton et al. (1995). According to Garzanti et al. (1998) the genus *Dowhatania* occurs in the Bashkirian Fenestella Shales of Spiti and Kashmir, in the Carboniferous of Selong (S Tibet) and of Mt. Everest region (Tibet) and it may be present in the Late Carboniferous of Central Afghanistan.

Dowhatania sulcata n. sp.

Pl. 1, fig. 1-10

Material - 7 ventral valves: MPUM 8345 (L42-21), 8346 (L42-24), 8347 (L42-29), 8348 (L42-31), 8349 (L42-32), 8350 (L42-42), 8351 (L42-43). 2 dorsal valves: MPUM 8352, 8353 (L42-39,46).

Etymology - Species named for its ventral sulcus.

Holotype - MPUM 8345 (L42-21), ventral valve.

Type locality and age - Pakistan, Karakorum, Lashkargaz gulley, 4450 m a.s.l., bed L42. Moscovian-Kasimovian.

Occurrence and age - Lashkargaz gulley, locality at 4450 m a.s.l., bed L42. Moscovian-Kasimovian.

Diagnosis - Small representative of *Dowhatania* with sharp, angular ears and ventral sulcus.

Description - Concavo-convex shell with deep corpus cavity. Small for the genus, the maximum width of the corpus reaching approximately 35 mm. Ears sharp, angular, well separated from the corpus.

Ventral valve convex, thick-shelled posteriorly and forward to the anterior margin of the adductor scars, then thinning. A shallow, persistent ventral sulcus starts about 10 mm anteriorly to the umbo, widening only slightly towards the anterior margin.

Dorsal valve with flat visceral disc and thickened cardinal region.

Ornamentation of ventral valve with regular and fine ribs, numbering 6 per 5 mm at 30 mm from the umbo; a weak concentric ornament, producing nodose ribs and a slightly reticulate pattern to the disc posteriorly to the end of the muscle field (to about 1/2 the length of the disc); spines scattered sparsely on the valve, lacking swollen bases. Ears ornamented only by finer spines on finer ribs, numbering 10 per 5 mm.

Ornamentation of dorsal valve with more strongly reticulate disc, pits and no spines; the reticulate pattern stops towards the margin of the disc.

Interior of ventral valve with striated diductor scars sunk into the shell substance, with traces of muscle migration preserved posteriorly; adductor scars are small and elongate between the posterior ends of the diductor scars.

Interior of dorsal valve with sessile, bilobed, externally quadrifid cardinal process, which is anteriorly thickened; adductor scars lobate, raised, weakly ridged posteriorly and more thickened anteriorly; dorsal median septum thin and weak, widening posteriorly.

Discussion - The available specimens differ from *Dowhatania dowhatensis* Diener, 1915 from the lower-

middle part of the Fenestella Shale of Kashmir (Diener, 1915) by their smaller size, the wider, sharper and more angular ears ornamented by less dense spines and the occurrence of a ventral sulcus.

Productidae genus and species undetermined

Material - 1 ventral valve: MPUM 8354 (CK591-2).

2 dorsal valves: MPUM 8355 (CK591-1; CK587-4).

Occurrence and age - Karambar Pass, Twin Valleys section, scree of black marly limestones (second lithozone), sample CK587, CK591. Bashkirian.

Description - Concavo-convex shell, with deep cup cavity. Dorsal valve flat and geniculated. Ornamentation of dorsal valve with ribs and weak rugae. Interior of ventral valve with lobate adductor scars.

Superfamily *Echinoconchoidea* Stehli, 1954

Family *Echinoconchidae* Stehli, 1954

Subfamily *Pustulinae* Waterhouse, 1981

Genus *Pustula* Thomas, 1914

Type-species: *Producta pustulosa* Phillips, 1836

***Pustula* sp.**

Pl. 1, fig. 11

Material - 1 dorsal valve: MPUM 8356 (CK582-1).

Occurrence and age - scree along the path from Suinji to Karambar Lake. Late Lower to early Upper Carboniferous.

Description - Large dorsal valve with flat visceral disc and geniculated trail. Shell substance thin.

Ornamentation of dorsal valve with dense, elongate pits and spines. Spine bases are concentrated along the geniculation. Accentuated growth lines are also present.

Discussion - The state of preservation of the available specimen prevents a specific assignment. However the Karakorum specimen is rather similar to *Pustula rongbukensis* Angiolini & Brunton in Garzanti et al. (1998) from the Bashkirian of S Tibet.

A smaller, pustulose non-rugose specimen of *Pustula* has been found by Carter & Poletaev (1998) from the Late Bashkirian-Early Moscovian Hare Fiord Formation of Ellesmere Island (Canadian Arctic Archipelago).

Subfamily *Juresaniinae* Muir-Wood and

Cooper, 1960

Genus *Densepustula* Lazarev, 1982

Type-species: *Flexaria russiensis* Semenova, 1972

Densepustula* cf. *losarensis Angiolini & Brunton, 1998

Pl. 1, fig. 12-14

Material - 2 ventral valves: MPUM 8357-8 (L42-53,54).

1 segment of dorsal valve external mould: MPUM 8359 (L30-4).

Occurrence and age - Karambar Pass, Twin Valleys section, bed L30; Lashkargaz gulley, locality at 4450 m a.s.l., bed L42. Moscovian-Kasimovian.

Description - Ventral valve convex with triangular outline. A shallow median sulcus is present on the trail. Dorsal valve with long trail.

Ornamentation of ventral valve with coarse spine bases roughly quincuncially arranged, increasing in size anteriorly.

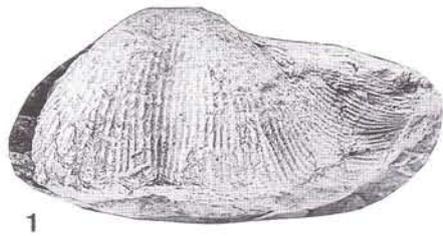
Ornamentation of dorsal valve with thin rugae, dense growth lines, elongated dimples, and coarse spines.

Discussion - The available specimens are rather similar to *Densepustula losarensis* Angiolini & Brunton, 1998 from the Late Bashkirian-Moscovian of Spiti (Hi-

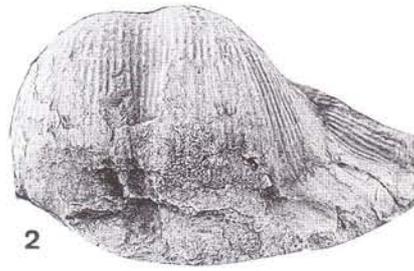
PLATE 1

(All x 1, except when specified)

- Fig. 1 - *Dowhatania sulcata* n. sp. Ventral valve, holotype, specimen MPUM 8345 (L42-21).
 Fig. 2 - *Dowhatania sulcata* n. sp. Ventral valve, holotype, specimen MPUM 8345 (L42-21).
 Fig. 3 - *Dowhatania sulcata* n. sp. Ventral valve, holotype, specimen MPUM 8345 (L42-21).
 Fig. 4 - *Dowhatania sulcata* n. sp. Ventral valve, specimen MPUM 8348 (L42-31).
 Fig. 5 - *Dowhatania sulcata* n. sp. Ventral valve, specimen MPUM 8347 (L42-29).
 Fig. 6 - *Dowhatania sulcata* n. sp. Ventral valve, specimen MPUM 8351 (L42-43).
 Fig. 7 - *Dowhatania sulcata* n. sp. Ventral valve internal mould, specimen MPUM 8346 (L42-24).
 Fig. 8 - *Dowhatania sulcata* n. sp. Partially decorticated ventral valve showing internal mould, specimen MPUM 8350 (L42-42).
 Fig. 9 - *Dowhatania sulcata* n. sp. Dorsal valve interior, specimen MPUM 8352 (L42-39).
 Fig. 10 - *Dowhatania sulcata* n. sp. Dorsal valve interior showing cardinal process, specimen MPUM 8353 (L42-46), x 3.
 Fig. 11 - *Pustula* sp. Exfoliated, incomplete dorsal valve interior, specimen MPUM 8356(CK582-1).
 Fig. 12 - *Densepustula* cf. *losarensis*. Segment of dorsal valve external mould, specimen MPUM 8359 (L30-4).
 Fig. 13 - *Densepustula* cf. *losarensis*. Incomplete ventral valve exterior, specimen MPUM 8358 (L42-54).
 Fig. 14 - *Densepustula* cf. *losarensis*. Lateral-oblique view of previous specimen.
 Fig. 15 - *Rhipidomella* sp. Incomplete ventral valve exterior, specimen MPUM 8364 (L31-5).
 Fig. 16 - *Rhipidomella* sp. Dorsal valve exterior, specimen MPUM 8365 (L31-4).
 Fig. 17 - *Rhipidomella* sp. Exfoliated dorsal valve, specimen MPUM 8366 (CK590-3).



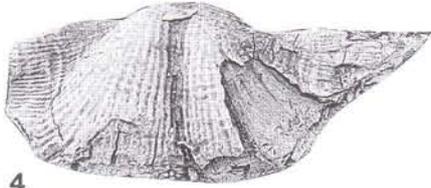
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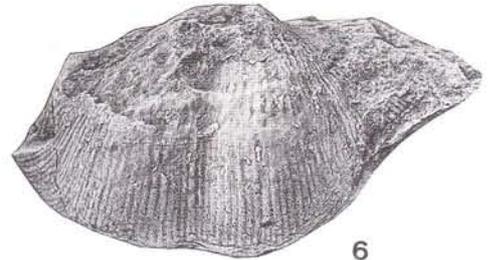
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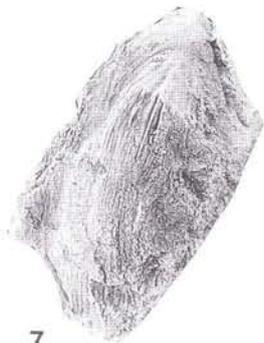
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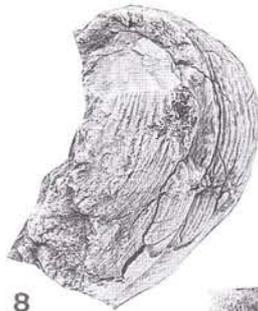
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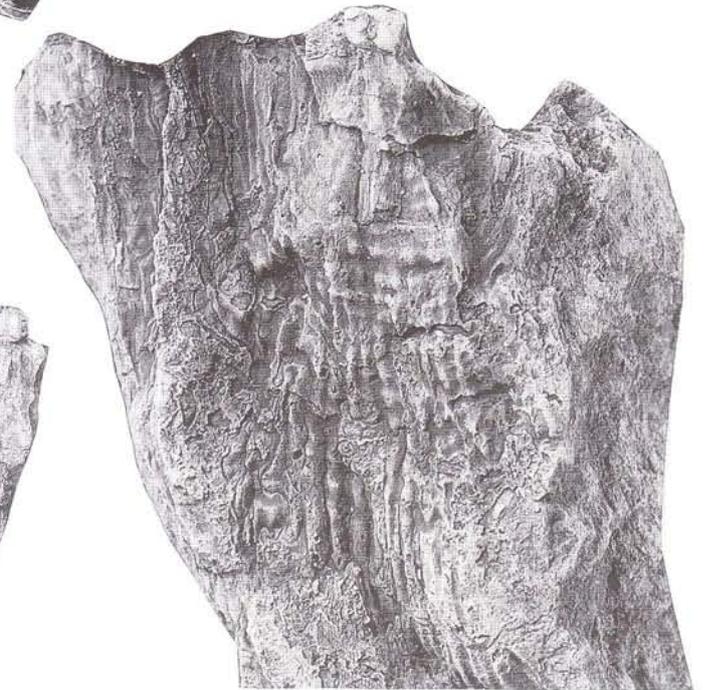
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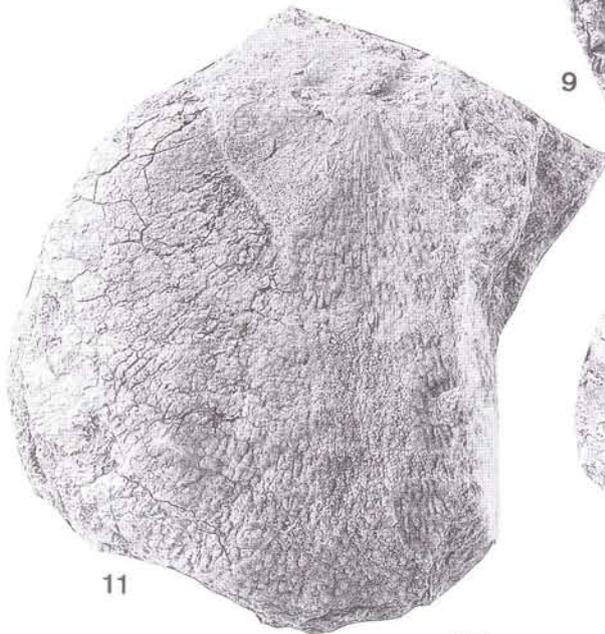
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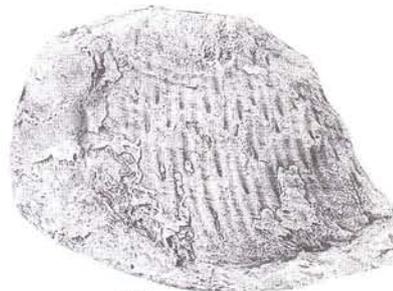
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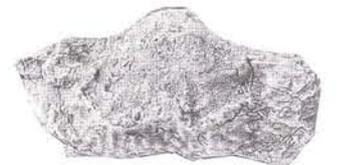
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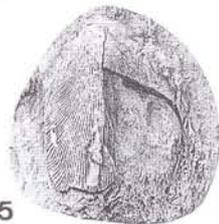
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13



14



15



16



17

malaya) differing only by the ornamentation of coarser spines.

Other occurrences - *D. losarensis* occurs in the Late Bashkirian-Moscovian of Spiti, Himalaya (Garzanti et al., 1998).

Class *Rhynchonellata* Williams, Carlson,

Brunton, Holmer & Popov, 1996

Order Rhynchonellida Kuhn, 1949

Superfamily *Stenosismatoidea* Oehlert, 1887

Family *Stenosismatidae* Oehlert, 1887

Genus *Septacamera* Stepanov, 1937

Type-species: *Camarophoria kutorgae* Tschernyshev, 1902

Septacamera dowhatensis (Diener, 1915)

Pl. 2, fig. 1-3

1915 *Camarophoria dowhatensis* Diener, p. 45, pl. 5, fig. 1-4.

1977 *Rotaia dowhatensis* - Waterhouse and Gupta, p. 165, pl. 3, fig. 9-13.

1982 *Rotaia dowhatensis* - Yang and Zhang, p. 306, pl. 3, fig. 1-4.

1983 *Rotia dowhatensis* - Yang and Fan, pl. 2, fig. 12-14.

1985 *Rotaia dowhatensis* - Gupta et al., p. 152, pl. 2, fig. 10, 13.

1994 *Stenosisma dowhatensis* - Garzanti et al., p. 169, pl. 1, fig. 6-7.

1998 *Septacamera dowhatensis* - Garzanti et al., p. 138, fig. 9-1.

non 1979 *Rotaia dowhatensis* - Waterhouse and Gupta, p. 130, pl. 10, fig. 10.

non 1985 *Rotaia dowhatensis* - Gupta et al., p. 152, pl. 2, fig. 7.

Material - 5 dorsal valves: MPUM 8360, 8361, 8362, 8363 (L26-7; L30-1; L42-15,-16,-18).

Occurrence and age - Karambar Pass, Twin Valleys section, beds L26, L30; Lashkargaz gully, locality at 4450 m a.s.l., bed L42. Moscovian-Kasimovian.

Description - Large dorsal valve with very thick shell substance. Dorsal fold low.

Ornamentation of strong simple costae, broadening and less accentuated anteriorly, numbering 6 on the fold and 5-6 on each flank.

Interior of dorsal valve with camarophorium on a very high and long median septum.

Discussion - The available dorsal valves show the internal and external characters typical of *S. dowhatensis* Diener, 1915 from the Fenestella Shale of Kashmir. Attribution of this species to the Late Carboniferous-Permian genus *Septacamera* has been discussed by Garzanti et al. (1998). The specimen of *Septacamera* described by Carter & Poletaev (1998) from the Late Bashkirian-Early Moscovian Hare Fiord Formation of Ellesmere Island (Canadian Arctic Archipelago) differs by having fewer costae and a more triangular outline.

Other occurrences - *Septacamera dowhatensis* occurs in the lower-middle part of the Fenestella Shale of Kashmir (Diener, 1915; Waterhouse and Gupta, 1977; Gupta et al., 1985), in the Carboniferous of S Tibet (Selong, Xiaxiabangma Mt.) (Yang and Zhang, 1982; Yang and Fan, 1983) and in the Bashkirian Marsyandi Fm. of Manang (Garzanti et al., 1998).

Order Orthida Woodward, 1852

Suborder Orthidina Woodward, 1852

Superfamily *Enteletioidea* Waagen, 1884

Family *Rhipidomellidae* Schuchert, 1913

Genus *Rhipidomella* Oehlert, 1890

Type species - *Terebratula michelini*, Lèveillé, 1835.

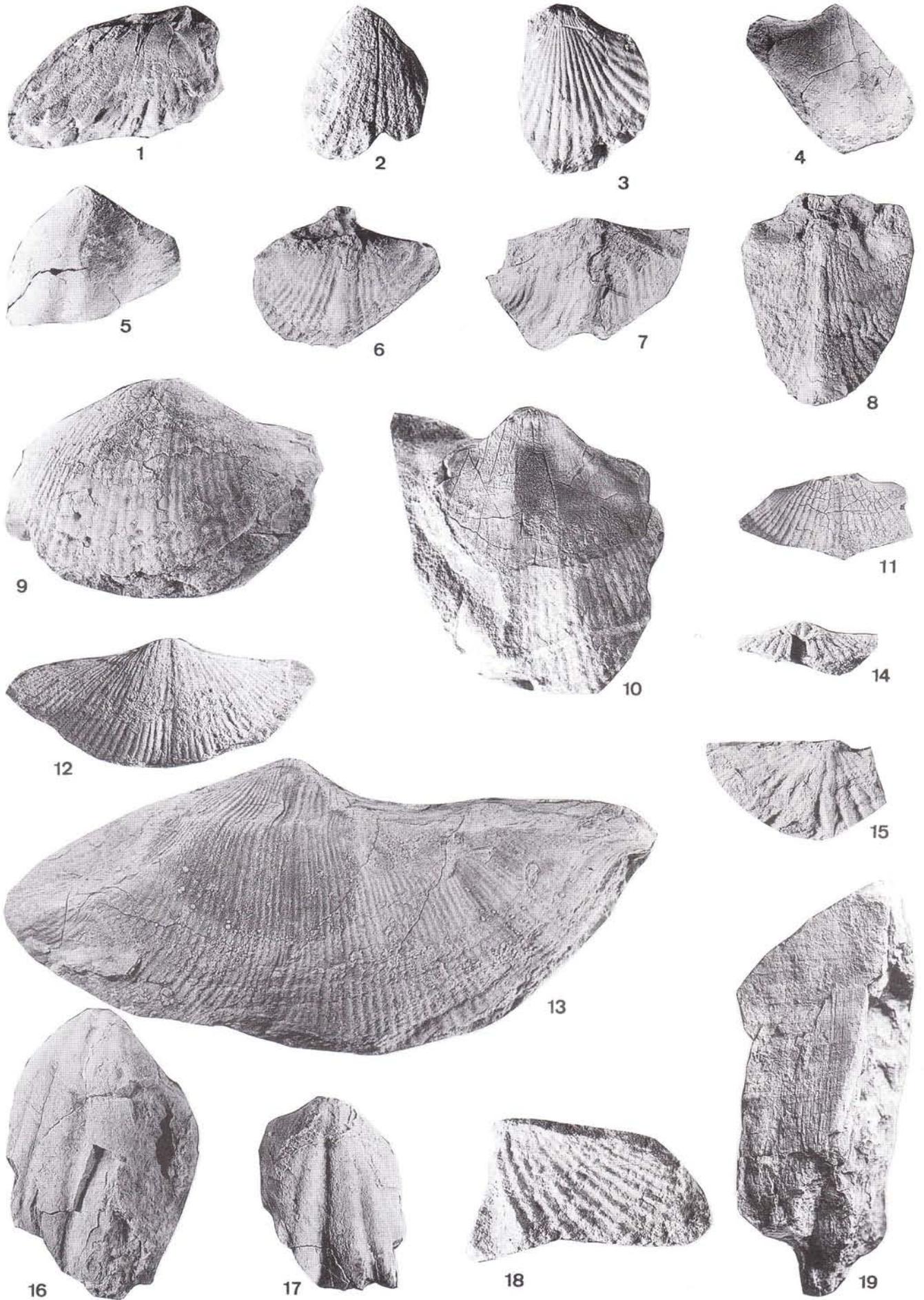
Rhipidomella sp.

Pl. 1, fig. 15-17

PLATE 2

(All x 1)

- Fig. 1 - *Septacamera dowhatensis* (Diener, 1915). Dorsal valve internal mould showing median septum, specimen MPUM 8360 (L26-7).
 Fig. 2 - *Septacamera dowhatensis* (Diener, 1915). Dorsal valve internal mould showing median septum, specimen MPUM 8363 (L42-18).
 Fig. 3 - *Septacamera dowhatensis* (Diener, 1915). Incomplete dorsal valve exterior, specimen MPUM 8362 (L42-16).
 Fig. 4 - *Martiniopsis* sp. - Ventral valve exterior, specimen MPUM 8369 (CK588-1).
 Fig. 5 - *Martiniopsis* sp. - Ventral valve exterior, specimen MPUM 8369 (CK588-1).
 Fig. 6 - *Afghanospirifer* sp. - Dorsal view of an articulated shell, specimen MPUM 8371 (CK591-3).
 Fig. 7 - *Afghanospirifer* sp. - Dorsal view of an articulated shell, specimen MPUM 8372 (CK591-4).
 Fig. 8 - *Choristites* sp. - Dorsal view of an articulated shell, specimen MPUM 8375 (CK591-5).
 Fig. 9 - *Choristites* sp. - Ventral valve exterior, specimen MPUM 8379 (CK587-2).
 Fig. 10 - *Choristites* sp. - Exfoliated ventral valve exterior, specimen MPUM 8376 (L33-1).
 Fig. 11 - *Gyospirifer* sp. - Ventral valve exterior, specimen MPUM 8384 (CK591-6).
 Fig. 12 - *Gyospirifer* sp. - Ventral valve exterior, specimen MPUM 8382 (CK587-8).
 Fig. 13 - ?*Gyospirifer* sp. - Ventral valve exterior, specimen MPUM 8385 (L36).
 Fig. 14 - *Alispirifer* cf. *middlemissi* (Diener, 1915). Incomplete ventral valve exterior, specimen MPUM 8387 (L42-14).
 Fig. 15 - *Alispirifer* cf. *middlemissi* (Diener, 1915). Dorsal valve internal mould, specimen MPUM 8388 (L42-4).
 Fig. 16 - *Brachythyris* sp. - Incomplete ventral valve exterior, specimen MPUM 8393 (L42-9).
 Fig. 17 - *Brachythyris* sp. - Incomplete ventral valve exterior, specimen MPUM 8392 (L42-8).
 Fig. 18 - *Permasyrinxinae* gen. indet. Dorsal valve external mould, specimen MPUM 8397 (L26-9).
 Fig. 19 - *Permasyrinxinae* gen. indet. Segment of ventral interarea, specimen MPUM 8395 (L42-1).



Material - 1 ventral valve: MPUM 8364 (L31-5).

12 dorsal valves: MPUM 8365-6 (L31-4, CK590-3), MPUM 8367 (L31-2,-6,-8,-9,-10), MPUM 8367 (L35-3,-4,-5,-6,-7).

2 fragments: MPUM 8368 (L14, L15).

Occurrence and age - Karambar Pass, Twin Valleys section, beds L30, L35; scree of black marly limestones (second lithozone), CK590. Left side of the Buattar Glacier, 4420 m a.s.l., samples L14, L15. Late Carboniferous.

Description - Biconvex shell with pentagonal outline. Shell substance densely endopunctate, the punctae numbering 8 per 3 mm transversally at the anterior margin. Shell thickness decreasing anteriorly. Hinge wide, corresponding to 4/5 of the maximum width.

Ventral valve flatter than the dorsal valve which shows a median sulcus.

Ornamentation of fine ribs increasing by bifurcation, numbering 12-14 per 5 mm at the anterior margin.

Discussion - The available specimens differ from the Australian Early Carboniferous species (e.g. *R. fortimuscula* Cvancara, 1958, *R. australis* M'Coy) by their shape, ornamentation and occurrence of a median sulcus. *R. michelini* (Léveillé, 1835) from the Lower Carboniferous of Belgium has no sulcus and a shorter hinge.

The North Karakorum *Rhipidomella* is rather similar in the general shape and ornamentation to the specimens described as *R. michelini* from the Lower Carboniferous Murabak Limestone of Iran (Gaetani, 1968), which however do not show any sulcus.

According to Yang & Fan (1983) and Jin & Waterhouse (1986) a species of *Rhipidomella*, *R. altaica* (Tolmatchow), occurs in the middle Carboniferous Sisuo Fm. of Yungzhu (Xainza County, Central Tibet); however the illustrations they provide are too poor to allow a comparison with the Karakorum *Rhipidomella*.

Order Spiriferida Waagen, 1883

Suborder Spiriferidina Waagen, 1883

Superfamily *Martinioidae* Waagen, 1883

Family *Martiniopsidae* Kotlyar & Popeko, 1967

Genus *Martiniopsis* Waagen, 1883

Type-species: *Martiniopsis inflata* Waagen, 1883.

Martiniopsis sp.

Pl. 2, fig. 4-5

Material - 3 ventral valves: MPUM 8369 (CK588-1); MPUM 8370 (CK588-4, CK590-5).

Occurrence and age - Karambar Pass, Twin Valleys section, scree of black marly limestones (second lithozone), samples CK588, CK590. Bashkirian.

Description - Wide-hinged, convex valves with sub-rhomboidal outline. Shell smooth, with weak median sulcus. Interior with thin dental plates.

Discussion - These specimens are assigned to the Late Carboniferous-Permian genus *Martiniopsis* on the basis of the occurrence of dental plates, although the absence of dorsal valves makes this assignment less secure. The presence of dorsal adimacula is critical in discriminating *Martiniopsis* from other genera, such as the Permian *Heteraria* Cooper & Grant and the Lower Carboniferous *Eomartiniopsis* Sokolskaya. However, the type-species of the former, *Heteraria blakemorei* Cooper & Grant, 1976 differs in its characteristic color bands, a more pronounced sulcus and the occurrence of strong growth lines and lamellae. The Lower Carboniferous genus *Eomartiniopsis* has a deeper sulcus and a shorter hinge.

Superfamily *Spiriferoidea* King, 1846

Family *Spiriferidae* King, 1846

Subfamily *Sergospiriferinae* Carter, 1994

Genus *Afghanospirifer* Plodowski, 1968

Type-species: *Afghanospirifer burgutschensis* Plodowski, 1968

Remarks - The genus *Afghanospirifer* was introduced by Plodowski (1968) for spiriferidae with rounded cardinal extremities and ornamented by few, simple, bifurcating costae and growth lamellae from the Namurian of Central Afghanistan (SW Dascht-e-Nawar).

Carter et al. (1994) doubtfully placed *Afghanospirifer* in the Sergospiriferinae, indicating that the nature of the hingeline and micror ornamentation are poorly known. The specimens of *Afghanospirifer* from North Karakorum proves that the hinge is denticulate, but, because of the poor state of preservation, the type of micror ornamentation is indeterminate. In fact, the micror ornamentation, when preserved, chiefly consists of growth lamellae, and in specimens CK587-7 radial capillae occur very doubtfully.

Afghanospirifer sp.

Pl. 2, fig. 6-7

Material - 2 complete specimens: MPUM 8371-2 (CK591-3,-4).

5 ventral valves: MPUM 8373 (CK587-5,-6,-7; CK588-6; L35-2).

1 dorsal valve: MPUM 8374 (CK591-7).

Occurrence and age - Karambar Pass, Twin Valleys section, bed L35; scree of black marly limestones (second lithozone), samples CK587, CK588, CK591. Bashkirian.

Description - Biconvex shell with subrectangular outline. Hinge width slightly less than maximum width. Cardinal extremities rounded. Anterior commissure uniplicate.

Ventral valve with shallow, "V" shaped median sulcus, widening only slightly anteriorly. Ventral interarea triangular with vertical traces of denticulations. Dorsal valve with low fastigium, widening anteriorly.

Ornamentation of large, bifurcating costae on the entire valve surface. Costae number about 13-14 on each flank. Sulcus ornamented by one central rib and two lateral ones. Dorsal fastigium ornamented by 3-4 ribs. Micror ornamentation of growth lamellae, when observable; radial capillae have been doubtfully detected on specimen CK587-7.

Interior of ventral valve (Fig. 6 a) with short delthyrial plate and divergent dental plates apically included in the apical callosity. Muscle field sunk in the shell substance.

Dimensions.

	Width	Length
CK591-3	34.1	27.5
CK591-4	38.5	>24
CK587-7	47	>28.6
CK587-5	36.6	25
CK588-6	40.9	23.4

Discussion - The available specimens are assigned to the genus *Afghanospirifer* Plodowski because of their ornamentation and internal characters. The Karakorum specimens show a different outline, with a less pointed umbo with respect to *Afghanospirifer burgutschensis* Plodowski, 1968. However the state of preservation is too poor to be certain of a specific determination.

Family *Choristitidae* Waterhouse, 1968

Subfamily *Choristitinae* Waterhouse, 1968

Genus *Choristites* Fischer de Waldheim, 1825

Type-species: *Choristites mosquensis* Fischer de Waldheim, 1825

Choristites sp.

Pl. 2, fig. 8-10

Material - 1 complete specimen: MPUM 8375 (CK591-5).

13 ventral valves: MPUM 8376 (L33-1); 8377 (L34-1,-2,-3; L35-1,-3; CK590-1,-2); 8378 (CK587-1,-9,-10); 8379 (CK587-2), 8380 (CK588-4).

Occurrence and age - Karambar Pass, Twin Valleys section, beds L33, L34, L35; scree of black marly limestones (second lithozone), samples CK587, CK588, CK590, CK591. Bashkrian.

Description - Biconvex shell with subpentagonal outline. Maximum width at the hinge. Anterior commissure uniplicate. Shell substance very thick posteriorly.

Ventral valve very convex, with elongate outline and recurved umbo. Ventral interarea low, concave, with open delthyrium.

Median sulcus shallow, widening anteriorly, ornamented by 6-8 ribs. Dorsal valve with low, rounded fastigium, widening anteriorly.

Ornamentation of flat, thin, simple, regularly and evenly spaced costae, dividing only on the umbo, num-

bering 3-4 per 5 mm at 20 mm from the umbo. Growth lamellae occur at the anterior margin.

Interior of ventral valve with long, closely spaced and slightly diverging dental plates. A serial section between the planes (a) and (b) (for the orientation of these planes see Legrand-Blain, 1970, p. 1067) shows that the dark lines of the dental plates are slightly external to the midline. Adductor scars long, oval, sunk in the shell substance, longitudinally striated. Interior of dorsal valve without crural plates.

Discussion - The available specimens have been placed in the genus *Choristites* because of their long, almost subparallel dental plates and the absence of crural plates.

The Karakorum specimens are characterized by fine and evenly spaced ribbing, thus resembling the late Bashkrian-Moscovian representatives of the genus: in fact according to Legrand-Blain (1970, p. 1075) both in Russia and in Algeria the early Bashkrian species of *Choristites* are replaced in the late Bashkrian-Moscovian by finer-ornamented species.

The Karakorum *Choristites* is most similar to *C. xainzangensis* Yang 1983 from the middle Carboniferous Sisuo Fm. of Yungzhu, Xainza County (Central Tibet) (Yang & Fan, 1983), from which it differs by the more convex ventral valve and more recurved umbo. In fact, the available material is characterized by a strong convexity which is typical of *Choristites globosus* Ivanov, 1937 from the Moscovian of the Moscow Basin, but differs from the latter in having a narrower sulcus, a different outline and less numerous sulcal ribs.

Very similar representatives of *Choristites* have been also reported by Garzanti et al. (1998) from the Bashkrian Marsyandi Fm. of Manang (Nepal). However, these specimens have fewer ribs and a less recurved umbo than the Karakorum material.

Finally, the available material shows affinity with *Choristites* cf. *gobicus* Chao, 1929 from the late Bashkrian-Moscovian of Bechar (Algeria) (Legrand-Blain, 1970) in the flat and evenly spaced costae and in the morphology and orientation of the dental plates.

Family *Trigonotretidae* Schuchert, 1893

Subfamily *Neospiriferinae* Waterhouse, 1968

Genus *Gypospirifer* Cooper & Grant, 1976

Type-species: *Gypospirifer nelsoni* Cooper & Grant, 1976.

Remarks - According to Cooper & Grant (1976) and to Legrand-Blain (1986) the genus *Gypospirifer* is characterized by its transverse outline, ornamentation of rounded to sharply crested costae slightly fasciculating near the umbo, a micror ornamentation which is finely reticulate posteriorly and lamellose anteriorly and by dental plates with slightly diverging adminicula.

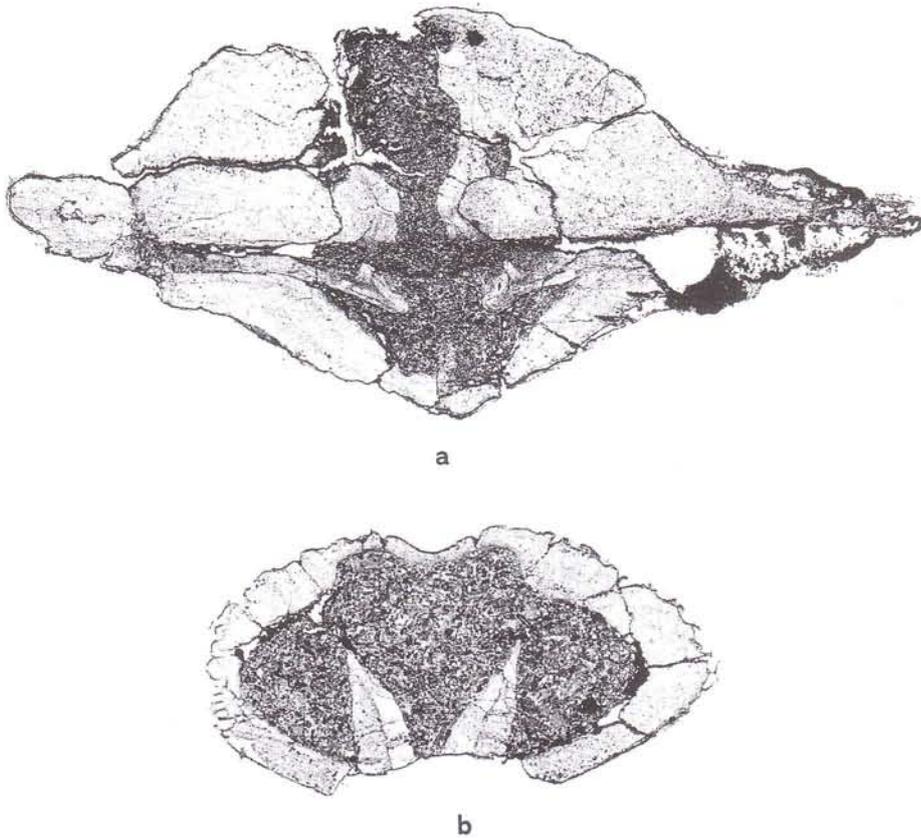


Fig. 6 - a) Section of *Afghanospirifer* sp., specimen CK591-4, x 4.1.
b) Section of *Gypospirifer* sp., specimen CK591-6, x 5.2

Interior with dental plates with thick dental flange and shorter, diverging adminicula (Fig. 6 b).

Discussion. The available material fits well with the diagnosis of the genus *Gypospirifer* by Cooper & Grant (1976). In fact, the transverse outline, the regular costal pattern and the occurrence of fasciculation in the posterior region exclude the assignment of these specimens to the genus *Spirifer* Sowerby.

The studied specimens are rather similar to *Gypospirifer guelmounensis* Legrand-Blain, 1986 from the Visean-Serpukhovian of the Algerian Sahara, differing by the fewer and less regularly spaced ribs, less pronounced umbonal fasciculation of costae and thinner ventral adminicula.

Among the West Texas *Gypospirifer*, the Karakorum specimens are most similar to the Pennsylvanian-Lower Permian *G. anancites* Cooper & Grant, 1976 by their size and costal pattern, but differ by their shallower and narrower sulcus.

Material - 1 ventral valve: MPUM 8385 (L36).
Occurrence and age - Karambar Pass, scree on the northern bank of the Karambar Lake, sample L36. Carboniferous.

?*Gypospirifer* sp.

Pl. 2, fig. 13

Material - 1 ventral valve: MPUM 8385 (L36).

Occurrence and age - Karambar Pass, scree on the northern bank of the Karambar Lake, sample L36. Carboniferous.

Description - Very large, convex, transverse ventral valve with very pointed, mucronate cardinal extremities. Maximum width >120 mm at hinge; corresponding length 52 mm. Median sulcus shallow starting at the umbo and widening anteriorly. Ornamentation of fine ribs bifurcating at least twice from the umbo, numbering 5-6 per 5 mm at 20 mm from the umbo. The sulcus is ornamented by 16 ribs at the anterior margin. Widely spaced growth lamellae occur anteriorly.

Discussion - A very large specimen resembling the previously described *Gypospirifer* sp., but attaining a much larger size and showing finer ribs, has been collected in the scree on the northern bank of the Karambar Lake. This single specimen resembles also the Chinese genus *Grandispirifer* Yang in its large size and transverse

According to Legrand-Blain (1986) the genus *Gypospirifer* occurs in the Visean-Serpukhovian of the Algerian Sahara, in the Moscovian of the Moscow Basin, in the Late Carboniferous-Permian of West Texas and in the Permian of Bolivia.

Gypospirifer sp.

Pl. 2, fig. 11-12

Material - 4 ventral valves: MPUM 8381-2-3-4 (CK587-5,-8; CK588-2; CK591-6).

Occurrence and age - Karambar Pass, Twin Valleys section, scree of black marly limestones (second lithozone), samples CK587, CK588, CK591. Bashkirian.

Description - Convex, transverse ventral valves with pointed cardinal extremities. Maximum width (47 to 62 mm) at hinge. Interarea low and very transverse, concave, with horizontal striations and longitudinal traces of denticles. Median sulcus starting at the umbo, widening and shallowing anteriorly.

Ornamentation of fine ribs with rounded crests, bifurcating at least twice from the umbo, numbering 4 per 5 mm at 20 mm from the umbo. Three subtle fascicles of 2-3 ribs at each side of the sulcus occur only in the umbonal region. The sulcus is ornamented by one central rib, symmetrically bifurcating at about 16 mm from the umbo, and by 2-3 ribs on each side. Growth lamellae occur at the anterior margin. Microornament reticulate posteriorly.

outline. However, the fine, numerous, bifurcating costae of the Karakorum specimen differ from the ornamentation of *Grandispirifer*.

Superfamily *Paeckelmanelloidea* Ivanova, 1972

Family *Strophopleuridae* Carter, 1974

Subfamily *Pterospiriferinae* Waterhouse, 1975

Genus *Alispirifer* Campbell, 1961 = *Adminiculoria*

Waterhouse & Gupta, 1979

Type-species: *Alispirifer laminosus* Campbell, 1961

***Alispirifer* cf. *middlemissi* (Diener, 1915)**

Pl. 2, fig. 14-15

Material - 4 ventral valves: MPUM 8386 (L42-3,-12,-13); MPUM 8387 (L42-14).

2 dorsal valves: MPUM 8388 (L42-4,-11).

1 fragment of ventral valve: MPUM 8390 (L26-8).

Occurrence and age - Karambar Pass, Twin Valleys section, beds L26, L30; Lashkargaz gulley, locality at 4450 m a.s.l., bed L42. Moscovian-Kasimovian.

Description - Biconvex shell with transverse outline. Maximum width at the hinge.

Ventral valve with "V" shaped shallow sulcus ornamented by three ribs. Dorsal valve with low fastigium, rounded on top, widening anteriorly, bearing 2 finer ribs on its flanks.

Ornamentation of simple rounded costae, numbering at least 7 on each flank and dense growth lamellae. Micror ornamentation finely capillate.

Discussion - Attribution of the species *middlemissi* Diener, 1915 to the genus *Alispirifer* Campbell, 1961 has been discussed in detail by Garzanti et al. (1998). The assignment is also supported by the material from Karakorum, which although poor and fragmentary, shows the characteristic ornamentation, micror ornamentation and shape of the genus *Alispirifer*.

Other occurrences - *A. middlemissi* has been described by Diener (1915) and Waterhouse and Gupta (1977, 1979) from the lower-middle part of the Fenestella Shale of Kashmir, by Yang and Fan (1983) from Selong (Xiaxiabangma Mt.) and by Garzanti et al. (1998) from the upper part of the Late Bashkirian Fenestella Shales of Spiti and from the Bashkirian Marsyandi Fm. of Manang (C Nepal).

Family *Brachythyrididae* Frederiks, 1924

Genus *Brachythyris* McCoy, 1844

Type-species: *Spirifera ovalis* Phillips, 1836

***Brachythyris* sp.**

Pl. 2, fig. 16-17

Material - 6 ventral valves: MPUM 8391 (L30-3; L42-5,-6,-7), 8392 (L42-8); 8393 (L42-9); 83910 (L42-10).

Occurrence and age - Karambar Pass, Twin Valleys section, bed L30. Lashkargaz gulley, locality at 4450 m a.s.l., bed L42. Moscovian-Kasimovian.

Description - Ventral valve convex, with elongate oval outline. Shell substance very thick. Median sulcus shallow and narrow.

Ornamentation of large delayed costae starting at 8 mm from the umbo. The costae number 3-4 for each flank, the pair flanking the umbo being wider (attaining 5-6 mm in width at 30 mm from the umbo) and spreading into it. Widely spaced growth lamellae occur on the whole valve.

Interior of ventral valve with apical callus and large, oval muscle field; dental plates absent.

Dimensions.

	W	L
L42-8	24.4	31
L42-9	34.7	52

Discussion - The available specimens are similar to *B. ufensis* (Tschernyshev) from the Kasimovian (Late Carboniferous) of Russia in the ornamentation of large, flat and few costae, but differ by their narrower sulcus.

Order Spiriferinida Ivanova, 1972

Suborder Spiriferinidina Ivanova, 1972

Superfamily *Syringothyridoidea* Frederiks, 1926

Family *Syringothyridae* Frederiks, 1926

Subfamily *Permasyrinxinae* Waterhouse, 1986

***Permasyrinxinae* gent. indet.**

Pl. 2, fig. 18-19

Material - 2 ventral valves: MPUM 8395-6 (L42-1,-2).

1 dorsal valve: MPUM 8397 (L26-9).

Occurrence and age - Karambar Pass, Twin Valleys section, bed L26. Lashkargaz gulley, locality at 4450 m a.s.l., bed L42. Moscovian-Kasimovian.

Description - Ventral valve large sized, with very high, concave and horizontally and vertically striated interarea. Dorsal valve rather flat with shallow, rounded fastigium, widening anteriorly.

Ornamentation of at least 13 rounded, simple costae on each flank and growth lamellae.

Interior of ventral valve with dental plates and delthyrial plate.

Discussion - The state of preservation prevents a sure specific or generic determination. As the syrinx has not been detected with certainty, these specimens have

been placed in the Lower Carboniferous-Permian subfamily Permasyrinxinae.

Order Athyridida Boucot, Johnson & Staton, 1964

Suborder Athyrididina Boucot, Johnson & Staton, 1964

Superfamily *Athyridoidea* Davidson, 1881

Family *Athyrididae* Davidson, 1881

Genus *Composita* Brown, 1849

Type species: *Spirifer ambiguus* Sowerby, 1823

Composita sp.

Material - 1 complete specimen: MPUM 8398 (CK590-6).

Occurrence and age - Karambar Pass, Twin Valleys section, scree of black marly limestones (second lithozone), sample CK590. Bashkirian.

Description - Small sized (21.7 mm long and 16.8 mm wide), biconvex shell with oval outline. Anterior commissure slightly uniplicate. Hinge narrow. Ventral umbo with epithyrid foramen.

A shallow median depression occurs anteriorly on the ventral valve. Valve surface bald.

Discussion - This specimen is placed in the genus *Composita*, because of its narrow hinge, lack of interarea, and epithyrid foramen.

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