Zeitschrift: Eclogae Geologicae Helvetiae
Herausgeber: Schweizerische Geologische Gesellschaft
Band: 90 (1997)
Heft: 3

Artikel: A new occurrence of the Upper Permian Ammonoid Stacheoceras trimurti Diener from the Himalayas, Himachal Pradesh, India

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DOI: https://doi.org/10.5169/seals-168199

0012-9402/97/030599-06 $1.50 + 0.20/0
Birkhäuser Verlag, Basel, 1997

Eclogae geol. Helv. 90 (1997) 599–604

A new occurrence of the Upper Permian Ammonoid *Stacheoceras trimurti* DIENER from the Himalayas; Himachal Pradesh, India

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Key words: Ammonoid, *Stacheoceras trimurti* DIENER, Dzulfian, Upper Permian, Kuling Formation, Permian-Triassic boundary, Himachal Pradesh, India

ABSTRACT

The Dzhulfian vidrioceratid ammonoid *Stacheoceras trimurti* DIENER was found associated with the brachiopod *Elivina tibetana* (DIENER) in the Kuling Formation in the northwestern Himalayas in Himachal Pradesh province, India. It was recovered from a horizon of dark weathering phosphatic limestone nodules 2 m below the Permian Triassic boundary in the Lingti River valley near Chumik Marpo. The Triassic ammonoid *Ophiceras* sp. indet. was found a few metres above the base of the overlying Tamba Kurkur Formation, the transgressive base of which is correlated with the *Otoceras* bed of the Spiti area. The Permian-Triassic boundary is marked by a distinctive 10 cm thick red-weathering, iron oxide-rich layer at the top of the Kuling Formation. For this part of the Gondwana shelf, this horizon suggests erosion accompanied by weathering during latest Permian time (Dorashamian).

RESUME

L'association d'âge Djulfien comprenant l'ammonoïdé *Stacheoceras trimurti* DIENER (Fam. Vidrioceratidae) et le brachiopode *Elivina tibetana* (DIENER) caractérise le sommet de la Formation Kuling du nord-ouest de l'Himalaya (Himachal Pradesh, Inde). Cette faune, provenant d'un horizon de nodules de calcaire phosphaté noir, se situe stratigraphiquement 2 m en dessous de la limite Permien-Trias. *Ophiceras* sp. indet. du Trias inférieur apparaît quelques mètres au dessus de la base transgressive de la Formation Tamba Kurkur, base corrélée avec les couches à *Otoceras* du Spiti. La limite Permien-Trias est soulignée par un horizon rougeâtre, enrichi en oxydes de fer et épais d'environ 10 cm au toit de la Formation Kuling. Pour cette région de la plate-forme gondwanienne, cet horizon suggère une érosion subarienne accompagnée par une altération météorique durant le Permien terminal (Dorashamien).

Introduction

The vidrioceratid ammonoid *Stacheoceras* GEMMELLARO, 1887 is a morphologically stable taxon that is widely distributed around the world in strata ranging from Lower Permian (Artinskian) to Upper Permian (Changsingian) [see Table 1 for the chronostratigraphic subdivisions of the Permian]. Only 6 or 7 specimens are known from Dzhulfian strata in the Himalayas in India and Tibet and from the Salt Range in Pakistan (Furnish 1966). Through much of this area representatives of *Stacheoceras* are directly associated with *Cyclolobus;* the latter is confined to Chidruan (Dzhulfian) strata in the Salt Range and to the contemporaneous Kuling Formation and equivalent strata in the Himalayas. A number of other species of *Stacheoceras* have also been described from the pre-Dzhulfian middle Permian; that is Moukouan (=Wordian, Capitanian) strata mainly north of the high Himalayas in Tibet (Sheng 1984, 1987, 1988).

The purpose of this report is to describe a single specimen of *Stacheoceras trimurti* DIENER, 1897 that one of us (HB) recovered from the Kuling Formation in the Himalayas in the Chumik Marpo area of Himachal Pradesh province, India (Fig. 1). There, *S. trimurti* was found in a thin concretionary bed two metres below the top of the upper Gungri Member of the Kuling Shale (Fig. 2) in association with brachiopods that were identified for us by the late Richard E. Grant as *Elivina tibetana* (Diener 1897, Grant, pers. comm. 1993) assigned a Dzhulfian age.

Stacheoceras trimurti bears an extremely close resemblance to *Stacheoceras tschernyschewi* (STOYANOW) from Dzhulfian strata at Dzhulfa, Armenia (Furnish 1966, see also Ruzhencev & Sarycheva 1965). The former was first discovered by Diener (1897) at Chitichun 1, near the 6000 m level of the Himalayas in southern Tibet; *Elivina tibetana* is known from the same locality (Waterhouse 1976, p. 144). It is particularly important to note that the holotype of *Cyclolobus walkeri* was also collected from Chitichun 1 (Furnish 1966, Furnish & Glenister 1970). Furnish & Glenister (1970) and Furnish et al. (1973) showed

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Tab. 1. Chronostratigraphic subdivisions of Permian System (from Jin Yugan, 1996).

SERIES		STAGES	Ammonoids	Conodonts	Fusulinids
Triassic		Gries-bachian	*Ophiceras* *Otoceras*	*Hindeodus parvus*	
PERMIAN	LOPINGIAN	Changh-singian (= Dora-shamian)	*Pseudotirulites* *Paratirolites - Shevyrevites* *Iranites - Phisonites*	*Clarkina changxingensis* *C. subcarinata*	*Pataeofusulina sinensis*
		Wuchia-pingian (= Dzhulfian)	*Araxoceras-Konglingites* *Anderssonoceras* *Roadoceras - Doulingoceras*	*C. orientalis* *C. leveni* *C. dukouensis* *C. posthitteri*	*Nanlingella simplex-Codonofusiella kwangsiana*
	GUADALUPIAN	Capitanian	*Turonites*	*Jinoogondolella altudaensis* *J. postserrata*	*Lepidolina* *Yabeina* *Polydiexodina shumardi*
		Wordian	*Waagenoceras*	*J. asserata*	*Neochwagerina craticalifera*
		Roadian	*Demaretzites* *Stacheoceras discoedale*	*J. nankingensis*	*Praesumatrina neoschwagerinoides* *Cancellina cutalensis-Armmenica*
	CISURALIAN	Kungurian	*Pseudovidrioceras dunbari* *Propinacoceras busterenese*	*Mesogandolella idahoensis* *Neostreptognathodus previ-* *N. exulpptus*	*Misellina claudiae* *Brevaxina dyhrenfurthi*
		Artinskian	*Uraloceras fedooorowi* *Aktubinskia notabilis-* *Artinskia artiensis*	*N. pequopensis* *Sweetognathuss whitei-* *M. bisselli*	*Pamirina* *Charaloschwagerina valgaris*
		Sakmarian	*Sakmarites inflatus* *Svetlanoceras strigosum*	*S. primus* *Streptognathodus postfusus*	*Robustoschwagerina schellwieni* *Sphaeroschwagerina sphaerica*
		Asselian	*S. serpentinum* *S. primore*	*S. constrictus* *S. isolatus*	*S. moelleri - P. fecunda* *S. vulgaris*
Carbo-niferous		Gzelian	*S. serpentinum* *S. primore* *Shumardites confessus-* *Emilites plummmeri*	*S. wabaunsensis* *S. elongatus*	*Daixina robusta-* *D. boshytauensis* *T. stuckenbergi*

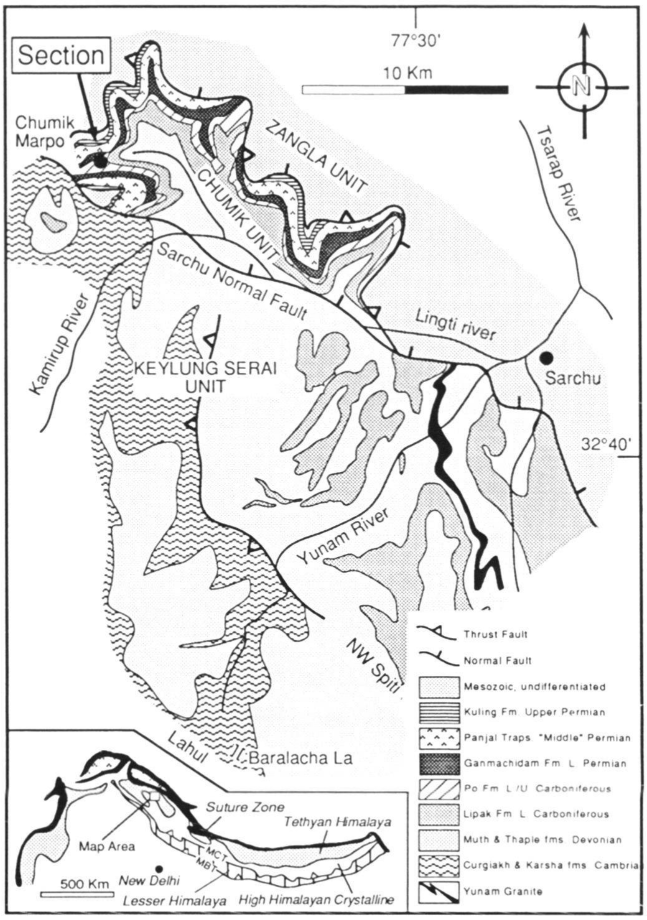

Fig. 1. Geological map (after Spring 1993) showing the location of a stratigraphic section of the Kuling Formation that yielded *Stacheoceras trimurti* DIENER in the Chumik Marpo area, Himachal Pradesh province, India.

that *Cyclolobus walkeri* also occurs at a number of localities in the Kuling Shale in the Himalayas. It is also known from the Zewan in Kashmir, from the Chidru Formation in the Salt Range, from the Ambilobé beds of northern Madagascar and from the Kitakami Massif in Japan. *Stacheoceras antiquum* (WAAGEN) also occurs in the Chidru in the Salt Range (Teichert 1965) and in the Zewan in Kashmir (Furnish 1966). Furnish (ibid.) recognized *Stacheoceras trimurti* associated with *Cyclolobus kraffti* in collections at the University of Copenhagen that were assembled from the Kuling Shale at Muth in the Spiti area by the 1950 Eigil Nielsen party; *Cyclolobus kraffti* is probably conspecific with *Cyclolobus walkeri.*

As noted above, Dzhulfian strata that contain representatives of *Cyclolobus* in the Himalayas of India and Tibet, in the Salt Range of Pakistan and elsewhere in the world often yield representatives of *Stacheoceras.* Besairie (1936) and Furnish (1966) showed that *Stacheoceras collignoni* (Besairie 1936) occurs with *Cyclolobus walkeri* in the upper part of the Permian succession near Ambilobé. Similarly, *Stacheoceras tridens* (ROTHPLETZ) occurs with *Cyclolobus persulcatus* ROTHPLETZ in Amarassian (= Dzhulfian) shale in Timor (Furnish 1973). In southeastern Japan, *Cyclolobus* cf. *C. walkeri, Stacheoceras* cf. *S. trimurti, Stacheoceras otomoi* and *Stacheoceras* sp. have been recovered from Dzhulfian strata in the Kitakami massif (Ehiro & Bando 1975, Ehiro et al. 1986). According to Glenister et al. (1990) a representative of *Cyclolobus* is known from the Owens Valley Formation in the Inyo Range of California. The species was first identified as *Timorites* cf. *T. uddeni* by Gordon & Merriam (1961) who showed that it was associated with several ammonoid species including *Stacheoceras* aff. S. *antiquum* (WAAGEN). *Cyclolobus kiselevae* ZACHAROV (1983) occurs in probable Dzhulfian strata in the lower part of the Lyudyanza Formation, southern Primor'ye, Soviet Far-Eastern Maritime province. *Stacheoceras* is absent from the *Cyclolobus* beds in the Lyudyanza but *Stacheoceras orientale* ZACHAROV occurs near the top of the underlying Chandalaz Formation (Zacharov & Pavlov 1986). In the Kap Stosch area of central East Greenland *Cyclolobus kullingi* (FREBOLD) occurs in association with representatives of *Paramexicoceras, Eumedlicottia* and *Episageceras* in the "*Martinia* beds" at the top of the Foldvik Creek Formation (Nassichuk 1995). Trümpy (1960) reported the occurrence of a representative of *Stacheoceras* from another locality in the "*Martinia* beds" but the species was never figured or described.

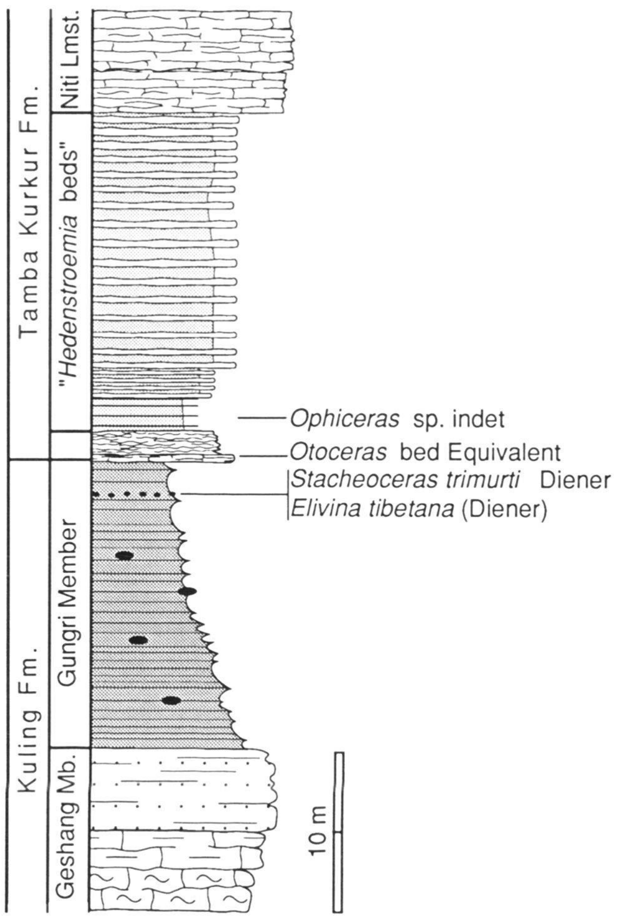

Fig. 2. Stratigraphic section across the Permian-Triassic boundary showing the occurrence of *Stacheoceras trimurti* DIENER in the upper part of the Kuling Formation in the Chumik Marpo area.

Unequivocal post-Dzhulfian (Dorashamian) Permian fossils have never been recovered from the Kuling Shale in the Himalayas but Bhatt et al. (1981) and Bhatt & Arora (1984) listed Dorashamian conodonts from overlying *Otoceras* beds (that we consider to be Griesbachian) at Guryul Ravine, Kumuan, Spiti and Zanskar. They listed and illustrated a number of species of *Neogondolella,* including species they identified as *N. subcarinata* and *N. changxingensis* but Orchard *in* Orchard et al. (1994) concluded that typical Permian elements are absent from their illustrations and accordingly rejected their Permian interpretation. Subsequently, Orchard examined conodonts in collections from the *Otoceras* beds in the Lingti Valley in Spiti, the same locality described by Bhatt et al. (1981). Orchard (pers. comm., 1995) recognized no Permian species in the collections, only the same Lower Triassic (Griesbachian) forms that he described in Orchard et al. (1994) from the *Otoceras* beds at Selong, Tibet; that is *Neogondolella carinata* (CLARK 1959), *N. tulongensis* TIAN, 1982, and *N. taylorae* ORCHARD, 1994.

Geological setting

Upper Permian rocks of the Tethyan Himalayan sedimentary belt between the Zanskar and Lahul districts to the northwest and the Spiti District to the southeast have been recognized since exploration was conducted in the late nineteenth century by officers of the Geological Survey of India. Stoliczka (1886) first introduced the term Kuling Shales for the dark grey to black silty shales underlying rocks of earliest Triassic age (*Otoceras* beds). More recently, the scope of the Kuling Formation was extended to the next underlying rocks by Srikantia et al. (1980), who established a two-fold formal subdivision of the Kuling Formation. The Geshang Member in the lower half of the formation includes sandstone, quartzarenite, sandy bioclastic limestone, siltite, and black argillites, while the upper Gungri Member corresponds exactly to the former Kuling Shales of Stoliczka. The most recent contributions that refer to Permian rocks in the region (Zanskar, Lahul, and Spiti) follow this lithostratigrapic scheme (Fuchs 1982 & 1987, Nicora et al. 1984, Spring 1993, Vannay 1993, Garzanti et al. 1995).

The investigated section is at an elevation of about 5120 m on the left slope of the Lingti River Valley, just north of the Chumik Marpo summer pasture. This area was mapped by Fuchs (1987), but subsequent detailed mapping was conducted by Spring (1993) who made significant improvements. The structural history of the area was thoroughly investigated by Steck et al. (1993) to which the reader is referred for further details. The section is contained by the Chumik Structural Unit, whose low grade greenschist facies contrasts with adjoining tectonic units of higher metamorphic grade (Spring 1993, Steck et al. 1993). The Chumik Unit is bounded to the south by the Sarchu Normal Fault. The northern boundary of the Chumik Unit is defined by an unnamed thrust fault which juxtaposes Mesozoic rock of the Zangla Unit on top of the Chumik Unit.

In the Chumik Marpo area, the stratigraphic thickness of the Geshang Member is about 20 m and the Gungri Member 20 to 25 m. The upper part of the Gungri contains a conspicuous horizon of small nodules (up to 10 cm in diameter) of dark phosphatic limestone, which yield rare, although well preserved ammonoids that escaped ambient cleavage and strain (Fig. 2). This horizon occurs 2 meters below the top of the Gungri and also yields brachiopods (*Elivina tibetana*), both in the nodules and in the embedding shales.

The contact with the basal strata of the Triassic Tamba Kurkur Formation (Fig. 2) is extremely sharp. On the Chumik section, the basal bed of the Triassic Tamba Kurkur did not yield representatives of *Otoceras,* as has been reported from the Spiti District (see summary of early contributions in Diener, 1912). This basal bed, about 0.4 m thick, consists of impure limestone with minor scour discontinuities. The underlying topmost centimeters of the Gungri Shales have an earthy texture and are enriched in iron-oxides, which suggests that these beds underwent subaerial ferralitic weathering. The basal bed of the Tamba Kurkur most probably represents a la-

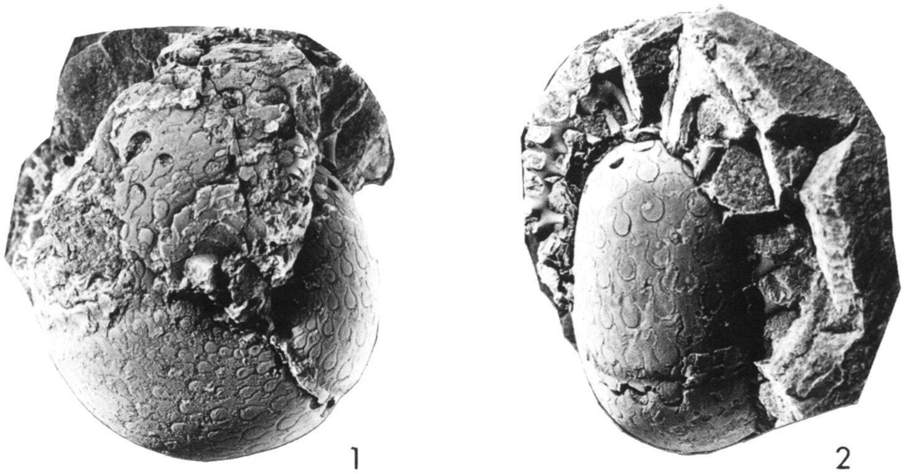

Fig. 3. *Stacheoceras trimurti* DIENER. a, b; lateral and apertural views respectively of hypotype (GSC 109841) from 2 m below the top of the the Kuling Formation at Chumik Marpo, Himachal Pradesh province, India, x2.

teral equivalent of the *Otoceras* bed. It is overlain by about 1.8 m of very thin bedded (centimeters thick), wavy nodular limestone, in turn followed by about 2 m of thin bedded (cm to dm), micritic limestone beds alternating with shales. The latter interval yielded poorly preserved specimens of *Ophiceras* sp. indet.

We have recognized the lateral extension of this equivalent of the *Otoceras* bed from the Chumik Marpo area to exposures east of the Chandra Valley, in the next tributary south of Tokpo Yongma, towards northwest Spiti. In the upper Spiti Valley (Losar section), the rusty-brown weathering *Otoceras* bed is about 50 cm thick and its fossiliferous base has a high pyrite content along with lags of centimetric, moderately rounded extraclasts of black phosphatic limestone. The petrography of these extraclasts is similar with that of concretions from the underlying Gungri Shales. The *Otoceras* bed also contains centimetric, spherical nodules of iron-oxides. Unlike the Chumik section, the horizon enriched in iron-oxides at the upper limit of Gungri is absent in the Losar section. Bhat et al. (1981) reported this iron-oxides horizon again from the Lilang section in south-eastern Spiti and suggested subaerial weathering for the origin of this limonitic horizon.

In the Losar section, a horizon of small nodules of phosphatic limestone yielding abundant brachiopods (*Elivina tibetana*) occurs 3.2 m below the top of the Gungri. It is regarded here as an equivalent of the bed that yielded *Stacheoceras trimurti* in the Chumik section. The stratigraphic position of this marker horizon below the P/T boundary suggests that the amount of unconformity is almost equivalent between these two sections which are about 100 km apart.

The trangressive nature of the *Otoceras* bed, the common occurrence of iron oxides at the top of the Gungri Shales and the absence of any latest Permian (Dorashamian or Changsingian) rocks strongly suggest the presence of a significant sedimentary gap spanning the latest Permian time. Garzanti et al. (1995) inferred that the sedimentation was nearly continuous across the P/T boundary in this part of the Tethys Himalaya but such a conclusion is not supported by our data and interpretations.

Systematic paleontology

Family Vidrioceratidae PLUMMER and SCOTT, 1937
Genus *Stacheoceras* GEMMELLARO, 1887
Stacheoceras trimurti DIENER, 1897
(Figs. 3, 4)

1897 *Popanoceras (Stacheoceras) trimurti* DIENER, 1897, p. 9–11, Pl. 1, figures 1a–f.
1966 *Stacheoceras trimarti* FURNISH, 1966, p. 281, Textfig. 1b, Pl. 24, figures 3–5.

Description. A single specimen of *Stacheoceras trimurti* (Fig. 3) was found embedded within a dark weathering phosphatic limestone concretion. The specimen is entire up to a diameter of 31 mm but fragments of septa within the concretion are apparent for an additional complete volution and suggest that the specimen was septate to a diameter of at least 37 mm. At a diameter of 24 mm, the shell width approximates 15 mm. The umbilical shoulder is quite distinct. Shell ornament is absent but three constrictions are apparent in a single volution up to a diameter of 31 mm, each forming a low lateral salient and an extremely shallow ventral sinus. External suture is well displayed and shows 11 pairs of external lobes; the first seven pairs show four, three or two subdivisions. Prongs of ventral lobe are inflated, bifid.

Discussion. As shown in figure 4, the external suture of our specimen from the Kuling Shale at Chumik Marpo shows

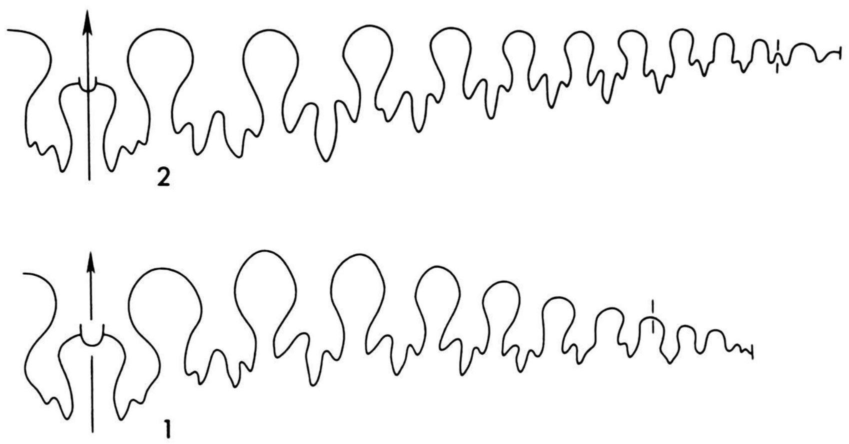

Fig. 4. External sutures of *Stacheoceras trimurti* DIENER from the Kuling Shale in the Himalayas. 1, hypotype (GSC 109841) from 2 m below the top of the Kuling Formation at Chumik Marpo, Himachal Pradesh province, India, at a diameter of 24 mm. 2, the hypotype from Muth in the Spiti area in the University of Copenhagen collections at a diameter of 45 mm (from Furnish, 1966, p. 281, textfig. 1b).

the same basic plan at a diameter of 24 mm as the larger, somewhat more mature hypotype from Spiti in the University of Copenhagen collections; see Furnish (1966, p. 281). Indeed, we agree with Furnish (ibid.) who suggested that *Stacheoceras trimurti* is practically indistinguishable, except for minor details from other Dzhulfian species, particularly *Stacheoceras tschernyschewi* (STOYANOW) from Dzhulfa, *Stacheoceras antiquum* (WAAGEN) from the Salt Range and *Stacheoceras collignoni* (BESAIRIE) from Madagascar. Ehiro et al. (1986) described *Stacheoceras otomoi* and *Stacheoceras* sp. as well as *Cyclolobus* cf. *C. walkeri* from probable Dzhulfian strata in the southern Kitakami massif, southeastern Japan. Specimens of *S.* sp. are too worn and deformed for significant comparisons but conch proportions and sutural character of *S. otomoi* bear a general resemblance to *S. trimurti*. Further, the Working Group on the Permian-Triassic Systems (1975), Ehiro & Bando (1975) and Ehiro et al. (1986) indicated that undescribed materials assigned to *Stacheoceras* cf. *S. trimurti* have also been recovered from Kitakami. Upper Permian (Dzhulfian and Dorashamian) species all appear to have at least ten pairs of external lobes but the biostratigraphic significance of subtle variations in the shape of individual lobes and particularly the degree to which lobes are subdivided is difficult to assess. Simply to illustrate this point the lateral lobes of *Stacheoceras chaotianense* from the Changsingian (= Dorashamian) of South China (Zhao et al. 1978, p. 78) do not appear to be as markedly subdivided as all of the older Upper Permian (Dzhulfian) species discussed in this report.

Acknowledgements

Field work has been funded by the Swiss National Science Foundation (Project No. 20-30297.90). Hans Rieber and Wolfgang Weitschat are thanked for their constructive reviews.

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Manuscript received June 19, 1996
Revision accepted July 2, 1997