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EARLIEST TRIASSIC CONODONTS FROM CHITRAL, NORTHERNMOST PAKISTAN

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Abstract. Extensive tracts of very shallow water carbonates in the valleys of the Yarkhun and Mastuj rivers of Chitral (northernmost Pakistan) previously though to be Permian (or Cretaceous) are shown by conodonts from two horizons in sequences 110 km apart—near Torman Gol (Mastuj valley) and near Sakirmul (upper Yarkhun valley)—to include earliest Triassic (Scythian—Induan) horizons. Both faunas have *Isarcicella staeschei* Dai & Zhang, *Is. lobata* Perri, *Is. turgida* (Kozur et al.) and *Hindeodus parvus* (Kozur & Pjatakova), whereas *Is. isarcica* (Huckriede) has been recognised only in the Torman Gol occurrence. The presence, respectively, of *Is. staeschei* in the Sakirmul and *Is. isarcica* in the Torman Gol occurrences, allows discrimination of the *staeschei* and *isarcica* zones respectively the third and the fourth conodont biozones of the Early Triassic conodont biozonation of Perri (in Perri & Farabegoli 2003). Such faunas, consisting mainly of isarcicellids and hindeodids but lacking gondolellids, are characteristic of restricted sea environments across the Permian–Triassic boundary and in the earliest Triassic in other Tethyan areas. The conodont faunas from these two occurrences are remarkably similar, nearly contemporaneous, and indicate shallow water biofacies. They are inferred to equate with the Ailak Dolomite, a sequence of Late Permian–?Late Triassic dolostones discriminated farther up the Yarkhun valley and extending eastwards into the upper Hunza region of northernmost Pakistan. The Zait Limestone and Sakirmul carbonate sequence are consistent with extension of the previously inferred Triassic carbonate platform at least 110 km farther to the SW than previously supposed.

Riassunto. Estesi tratti di carbonati di acque molto basse nelle valli dei fiumi Yarkhun e Mastuj in Chitral (estremo nord del Pakistan), precedentemente ritenuti permiani (o cretacei), includono orizzonti scitici (Induano–Triassico Inferiore). Lo si è potuto dimostrare per mezzo di conodonti provenienti da due orizzonti in successioni presso Sakirmul nella alta valle dello Yarkhun e Torman Gol nella valle del Mastuj, distanti fra loro 110 km. Entrambe le faune presentano *Isarcicella staeschei* Dai & Zhang, *Is. lobata* Perri, *Is. turgida* (Kozur et al.) e *Hindeodus parvus* (Kozur & Pjatakova), mentre *Is. isarcica* (Huckriede) è stata riconosciuta solamente a Torman Gol. La presenza di *Is. staeschei* nella associazione di Sakirmul e di *Is. isarcica* in quella di Torman Gol ha permesso di identificare la *staeschei* e la *isarcica* Zone, rispettivamente la terza e la quarta biozona a conodonti della biozonazione a conodonti del Triassico Inferiore proposta da Perri (in Perri & Farabegoli 2003). Simili faune, prevalentemente costituite da isarcicellidi e hindeodidi e privi di gondolellidi, sono caratteristiche di ambienti di mare ristretto al limite Permo–Triassico e alla base del Triassico in altre aree tetidee. Le faune a conodonti provenienti dai due orizzonti sono molto simili, pressoché contemporanee, e indicano biofacies di acque basse. Si presume che equivalgano alla Ailak Dolomite, una sequenza dolomitica del Permiano Superiore–? Triassico Superiore riconosciuta più lontano nella parte alta della valle dello Yarkhun che si estende verso est nella parte superiore della regione di Hunza nell'estremo nord del Pakistan. Lo Zait Limestone e la sequenza carbonatica di Sakirmul sono compatibili con l'estensione della piattaforma carbonatica triassica precedentemente supposta, di almeno 110 km più a SO di quanto ipotizzato.

Introduction

Conodont data (Perri et al. 2000) are showing that Triassic sequences are more widely distributed in N Pakistan than formerly thought; these include metamorphic sequences with marbles once thought to be Palaeozoic or Proterozoic, for example around the NW margin of the Peshawar Basin. In this report we document very early Triassic conodonts from two localities in massive carbonate units of the Karakorum Terrane or Block (Gaetani 1997) of northernmost Pakistan:

1) In road cuttings on the Mastuj–Lasht road on the left flank of the Yarkhun River 2 km N of Sakirmul (2.5 km N of Dobargar) in NE Chitral, NW Pakistan.

2) From biomicrite float "about 300 m towards Zait from the crossing over Torman (= Dorman) Gol" (between Reshun and Kuragh) on the left flank of the Mastuj River 100 km to the SW, in central Chitral.

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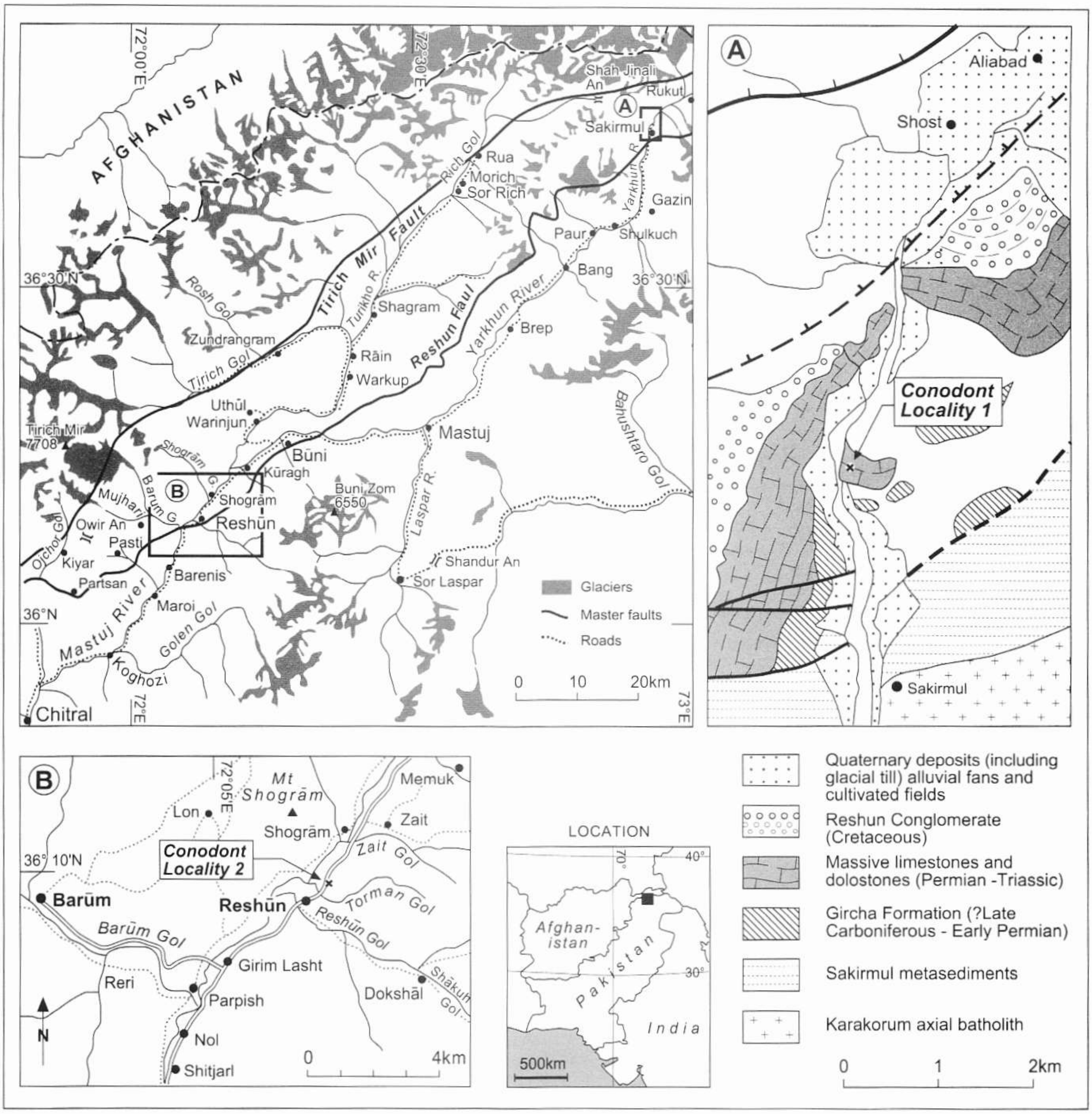

Fig. 1 - Portion of NE Chitral, Pakistan (portion of Talent et al. 1999, Fig. 1, with modification of some fault-alignments from Zanchi et al. 2000). A. Situation of locality 1 in relation to geology of the Shosht–Sakirmul area (based on Gaetani et al. 1996, Fig. 8); B. Situation of locality 2 (from Talent et al. 1999, Fig. 2).

The first of these localities (Fig. 1A), sampled in 1999, has been portrayed in recent mapping (Gaetani et al. 1996, fig. 5) as falling within a tract of "Upper Permian carbonates" within the Axial unit of the Northern Sedimentary Belt of northernmost Pakistan, or within a tract referred to as "?Devonian–Carboniferous–early Permian" flanked on the NW by Jurassic–Cretaceous (Searle & Khan 1996). This limestone tract was first noted by Hayden (1915, p. 289) as forming "great cliffs on either side of the [Yarkhun] river and also on the high hills on the right bank behind Turipotk, where the Koksum steam from the Shah Janali pass enters the Yarkhun".

The second of these localities (Fig. 1B), sampled in 1973, has been described in some detail by Conaghan (in Talent et al. 1982, 87–89). This unit, formally named the Zait Limestone (Talent et al. 1982, p. 88), is believed to be more than 600 m in thickness. Many samples were taken in 1973, 1975, 1999 and 2000 from the Charun-Diryani area, from the vicinity of Zait, and from farther SW along strike at Girim Lasht (Fig. 1). A splendid section through

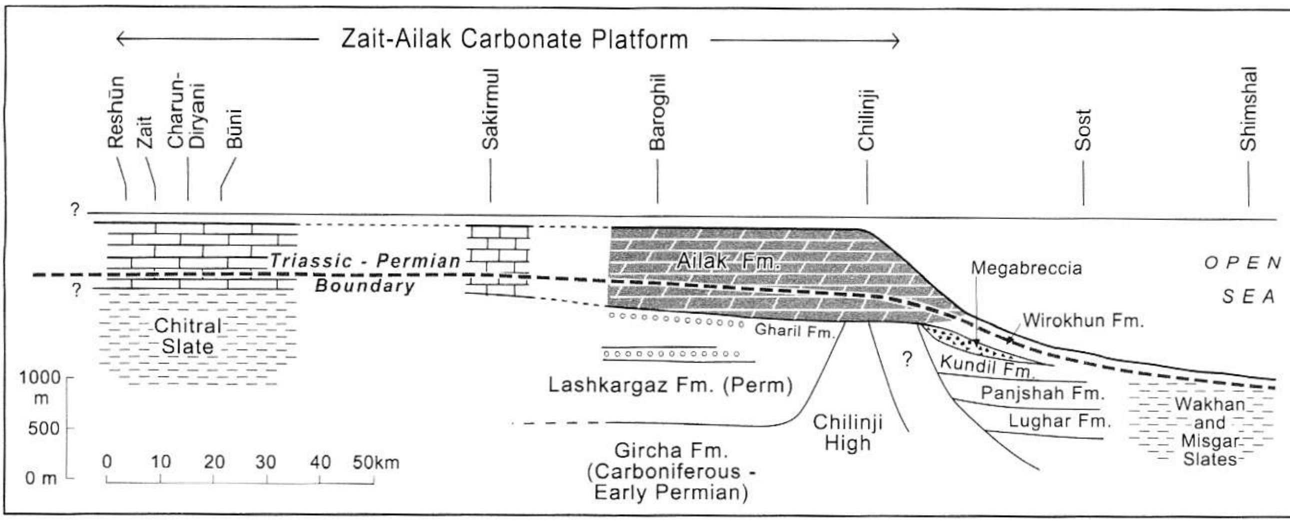

Fig. 2 - Palaeogeographic cartoon cross-section from Zait through Sakirmul and Baroghil in upper Chitral to the Chapursan and Shimshal valleys of upper Hunza, northernmost Pakistan (Baroghil-Shimshal portion from Gaetani 1997, Fig. 6).

massive carbonates apparently gradational from the Chitral Slate on the left (N) flank of Barum Gol behind and upstream from the village of Parpish may be a sequence of Zait Limestone but could be a tectonically isolated tract of Krinj Limestone (Cretaceous). Spot samples of this occurrence collected in 2000 failed to produce conodonts or other microfauna. Only one sample, collected in 1973 from near Torman Gol, produced conodonts.

Because the conodont faunas from these two samples indicate near contemporaneity, remarkable similarity of shallow-water litho- and biofacies, and imply extension of the Triassic carbonate platform much farther to the SE than formerly imagined, we document their conodont faunas.

Carbonate units believed to span the Permian–Triassic boundary—to which the Sakirmul and Torman Gol occurrences might be compared—include the Ailak Dolomite, a name introduced by Gaetani et al. (1995) for a 1000+ m sequence of dolostones discriminated farther up the Yarkhun valley and extending eastwards. It has produced a diverse fauna of Late Permian foraminifers from dark grey, thick bedded limestones at 160 m above the base and, towards the top, ghosts of foraminifers suggestive of a Late Triassic attribution (Gaetani et al. 1995). Farther E the Permian–Triassic boundary occurs within the much thinner (60 m) Wirokhun Formation of the Chapursan and Shimshal valleys (Zanchi & Gaetani 1994, Gaetani et al. 1995). This unit has produced *Neospathodus dieneri* and *Gondolella carinata* (Nicora in Gaetani et al. 1995) indicative of a slightly younger horizon and deeper sea in the Early Triassic than the Sakirmul and Torman Gol faunas described herein.

Gaetani (1996 and 1997) has hypothesised a former Late Permian to Late Triassic carbonate platform extending from the upper Hunza region of Gilgit into the upper Yarkhun valley of Chitral. Both the Torman Gol and Sakirmul occurrences occur within major carbonate belts; we believe them to be parts of the very same Late Permian and Triassic carbonate platform already hypothesised: in other words identifying it as extending at least an additional 110 km to the SW—through a geologically virtually unknown tract of the Hindu Kush between Sakirmul and the Charun–Diryani (Buni–Kuragh)/Reshun/Girim Lasht tract. Photointerpretation (Gamerith 1982) indicates the presence of prominent carbonate bodies in the mountainous tract between Sakirmul and Charun–Diryani; some or all of these carbonate units may be Late Permian–Triassic equating with the Zait Limestone. We suggest that the entire belt of carbonate platform might be referred to as the Ailak–Zait Carbonate Platform (Fig. 2). The Ailak Dolomite, incidentally, passes eastwards (Fig. 2) into slope and offshore facies in the Chapursan and Shimshal valleys of upper Hunza (Gaetani et al. 1996, Gaetani 1997).

Relationships between this carbonate platform and sediments to the SW and E of it in central Chitral are rather speculative. An account has been presented elsewhere (Talent et al. 1982) of the Permian fusulinid limestones occurring as tectonic slivers, float and as clasts in Cainozoic conglomerates in central Chitral, and of the extensively outcropping but stratigraphically intractable Chitral Slate, a prominent flyschoid (essentially quartz flysch) sequence of central and S Chitral. It includes horizons from which Permian brachiopods have been reported though not documented (Tipper 1922, Cooper & Grant in Stauffer 1975), specifically from Chitral Gol and near Phasti, SW of the area shown in Fig. 1B. It has been noted that there is a general trend towards increase in proportion of carbonate in the Chitral Slate from SW to NE, with noteworthy exposures of calcareous flysch in

Shakuh Gol (the principal tributary of Reshun Gol) and in the Mastuj valley between Awi and Sanoghar (Talent et al. 1982, p. 90). Because of the rugged terrain and the tectonic complexity resembling a "pack of cards" (Talent et al. 1982, p. 77), unravelling the transition from the southern part of the Ailak–Zait Carbonate Platform to flysch may be impossible because of loss of sequences due to faulting, or at the very least will be a daunting task.

Conodont faunas

The conodont faunas from the two productive localities present similar associations. Both consist mainly of isarcicellids and hindeodids; both faunas, strikingly, lack gondolellids. Such associations are characteristic of restricted sea environments across the Permian–Triassic boundary (P–TB) and in the earliest Triassic.

Elsewhere in Pakistan, but on the Indian continental block, are classic sections for the Permian–Triassic boundary and the Early Triassic, specifically in the Salt Range and Trans-Indus Ranges (Sweet 1970b, Pakistan-Japan Research Group 1985, Nakazawa 1993); these occurrences have gondolellids in their conodont faunas. These are considered to reflect deeper or at least more open sea environments. Hindeodids and isarcicellids are associated with gondolellids in most areas with well-displayed Permian–Triassic boundary sections, notably in Kashmir (Sweet 1970a, Matsuda 1981, Budurov & Gupta 1988, Wang 1995, Kozur 1996, Orchard & Krystyn 1998), Malaysia (Metcalfe 1995), Armenia (Zakharov 1992, Kotlyar et al. 1993), Iran (Iran-Japan Research Group 1981), Tibet (Orchard et al. 1994, Jin et al. 1996) and in China, including the P–T Stratotype Section and Point at Meishan (Li et al, 1989, Tian 1993, Wang 1995, Ding et al. 1996, Yin et al 1996, Zhang et al. 1996, Yin et al. 2001, Nicoll et al. 2002—the last with taxonomy restricted to *Hindeodus*).

Representatives of *Hindeodus* Rexroad & Furnish 1964 and *Isarcicella* Kozur 1975 are considered to reflect shallow water environments and tend to have ubiquitous species, for example, *Hindeodus parvus* (Kozur & Pjatakova 1976). For this reason, the first appearance of the latter has been chosen as the criterion for defining the base of the Mesozoic (Yin 1993). Sections with shallow water sequences present possibilities for study of intraspecific variation and evolutionary tendencies in the two genera utilized for conodont zonation of the Early Triassic. The conodonts from the two localities of the Chitral region are relatively abundant and well preserved even though having the same Color Alteration Index (CAI) of 4.5. Pa elements of *Isarcicella* and *Hindeodus* predominate in the studied material; the few ramiforms occurring with them have allowed unequivocal identification of elements of the *Hadrodontina aequabilis* Staesche 1964 apparatus. No confident reconstruction of the apparatus of any species of *Hindeodus* or *Isarcicella* was possible. *Is. lobata* Perri (in Perri & Farabegoli 2003), *Is. staeschei* Dai & Zhang 1989, *Is. turgida* (Kozur, Mostler & Rahimi-Yazd 1975) in association with *Hi. parvus* and some elements belonging to the apparatus of *Ha. aequabilis* Staesche1964 have been identified in both areas, whereas *Is. isarcica* (Huckriede 1958) has been recognised only at Torman Gol. The presence of *Is. staeschei* in the sample from near Sakirmul and of *Is. isarcica* in Torman Gol allows identification of the *staeschei* and *isarcica* zones respectively (Tab. 1), the third and the fourth conodont biozones of the Early Triassic conodont biozonation (Perri in Perri & Farabegoli 2003) based on shallow water facies. Associations of hindeodids and isarcicellids lacking gondolellids occur in the Southern Alps of Italy (Huckriede 1958, Staesche 1964, Perri 1991, Schönlaub 1991, Farabegoli & Perri 1998, Nicora & Perri 1999, Perri & Farabegoli 2003). Deposits of the latest Permian and of the earliest Triassic are represented by the uppermost carbonate levels of the *Bellerophon* Formation and the carbonate-terrigenous succession of the Werfen Formation—a shallow water sequence reflecting restricted marine conditions (Farabegoli in Farabegoli & Perri 1998, and in Perri & Farabegoli 2003). The systematics and stratigraphic distribution of conodonts across the Permian–Triassic boundary in the Southern Alps (Perri 1986, 1991, 1998, Farabegoli et al. 1986, Perri & Andraghetti 1987, Farabegoli & Perri 1998; Perri & Farabegoli 1998, Nicora & Perri 1999) have been recently reviewed (Perri & Farabegoli 2003). In the Bulla section,

		Sakirmul BRG12 *staeschei Z.* 6.5 kg	Torman Gol C174F *isarcica Z.* 1.3 kg
Hadrodontina	Pa		3
aequabilis	Pb	1	
	M		3
	Sb		3
	Sc		6
Hindeodus parvus	Pa	2	3
Isarcicella lobata	Pa	5	1
Isarcicella staeschei	Pa	8	66
Isarcicella turgida	Pa	1	2
Isarcicella isarcica	Pa		4
Isarcicella n.sp. A	Pa		1
Other ramiforms	Pb		3
	M	1	3
	Sa	2	2
	Sb	1	
	Sc	3	4

Tab. 1 - Numerical distribution of conodonts.

where forms transitional from *Hi. praeparvus* Kozur 1996 to *Hi. parvus* are displayed, the Permian–Triassic boundary was identified at the first appearance of *Hi. parvus*: at 1.3 m above the base of the Werfen Formation. The Bulla and Tesero sections produced well-preserved (Color Alteration Index = CAI 1) and relatively abundant conodonts allowing documentation of the gradual transition between hindeodids and isarcicellids, description of new species, revised diagnoses, and the proposal of new biozones. The medium to high sedimentation rate of the sequence across the P–T boundary in the Southern Alps facilitated investigation of the transition and discrimination of the boundary. The same conodont faunas occur through a few metres in China, Kashmir and Pakistan, but in the Alps range through 20-40 metres. In the present paper the conodont taxa have been identified according to the revised (or new) species descriptions presented by Perri (in Perri & Farabegoli 2003) where seven conodont biozones were discriminated, three defined for the first time: Lower and Upper *praeparvus*, *parvus*, *lobata*, *staeschei*, *isarcica* and *aequabilis* zones. In the Southern Alps the *staeschei* Zone is characterised by association of *Isarcicella staeschei*, *Is. inflata* Perri (in Perri & Farabegoli 2003), *Is. lobata*, *Hadrodontina aequabilis*, *Hi. parvus* and *Is. turgida*, the last two species becoming extinct within the biozone, whereas the *isarcica* Zone is recognised by the presence of *Isarcicella isarcica* associated with *Is. inflata*, *Is. lobata*, *Is. staeschei* and *Ha. aequabilis*.

The associations from the Chitral areas are extremely close to those from the Alps, lacking only *Is. inflata*. This species, characterised by a very expanded and therefore fragile basal cavity, is rare also in the Alps where, very often, it is found only as broken elements. The ranges of *Hi. parvus* and *Is. turgida* end at the top of the *staeschei* Zone in the Alps, whereas in Chitral they seem to extend into the *isarcica* Zone. It is not possible for us to speculate usefully on how differing sedimentation rates and sampling intervals may be reflected in the slight divergence in apparent ranges of taxa in the Early Triassic carbonate sequences of Chitral and the Alps.

Shallow water conodont faunas lacking gondolellids have been reported from the Dongling and Yangou sections in Jiangxi Province, China (Zhu et al. 1994). Wang & Wang (1997), after having re-sampled these sections bed by bed, proposed a new *staeschei* Zone between the *parvus* and *isarcica* zones on the basis of the first appearance of *Is. staeschei*. They demonstrated that the first entry of the species in several localities around the globe is stratigraphically below the first appearance of *Is. isarcica*. The faunas from Chitral and the Southern Alps look remarkably similar to those from Jiangxi, but precise comparison with the new and redescribed species presented by Perri (in Perri & Farabegoli 2003) cannot be undertaken solely on the basis of the illustrations presented by Wang & Wang (1997). Nevertheless both faunas justify discrimination of the *staeschei* and *isarcica* biozones and, moreover, the conodont biostratigraphy of the Southern Alps documents that the *staeschei* Zone is stratigraphically below the *isarcica* Zone.

The first reports of Early Triassic conodonts from Chitral presented here allow ease of allocation of the Sakirmul sample to the *staeschei* Zone and the Torman Gol sample to the *isarcica* Zone of the Early Triassic. More intensive sampling may prove that it is possible to discriminate the P–T boundary in both sequences, as well as identify other Late Permian through Early Triassic conodont biozones.

Systematics

Only Pa elements of *Hindeodus* Rexroad & Furnish 1964 and *Isarcicella* Kozur 1975 are described. The ramiforms do not allow confident reconstruction of apparatuses of any species of these two genera. Synonymies are limited to key citations. For more complete synonymies of some species see Perri & Farabegoli (2003). Figured specimens are housed in the collections of the Museo Capellini of the Dipartimento di Scienze della Terra e Geologico-Ambientali, University of Bologna, Italy and of Department of Earth & Planetary Sciences, Macquarie University, Sydney, Australia.

Genus *Hindeodus* Rexroad & Furnish, 1964

Type species: *Trichonodella imperfecta* Rexroad, 1957

(= *Spathognathodus cristulus* Youngquist & Miller, 1949)

The scaphate elements assigned to the Pa position of the multielement apparatus of *Hindeodus* present a symmetrical or slightly asymmetrical lachrymiform basal cavity not bordered by flange-like brims. In upper view the surface of the basal cavity is smooth. Blade, attachment area of the denticles, and basal cavity show no swelling and thickening. The posterior tip can end either abruptly or with denticles decreasing in height and reaching the tip. We have approached species-definition in a different way to Nicoll et al. (2002). They focused on supposed growth patterns, and on the morphology of the posterior portion of the element—something which could be primarily intraspecific variability.

They proposed four new forms of *Hindeodus* (two named; two informal) from the Permian–Triassic transition at Shangsi and in the P/T stratotype at Meishan in central China. None of these forms occur with certainty among the Early Triassic conodont faunas encountered in the Southern Alps of Italy (Perri & Farabegoli 2003) nor in the coeval faunules from northernmost Pakistan documented here. This may reflect biogeographic differentiation.

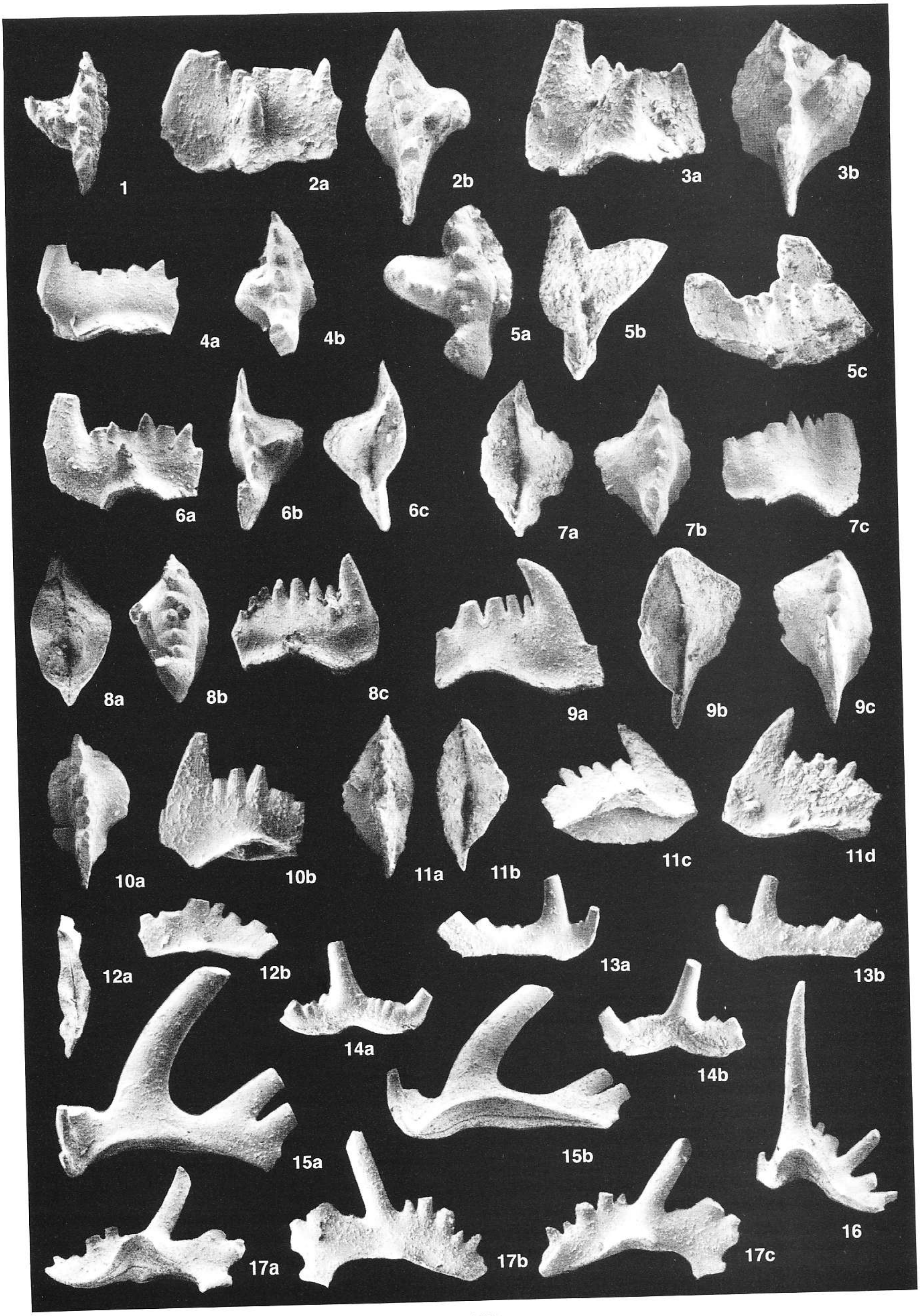
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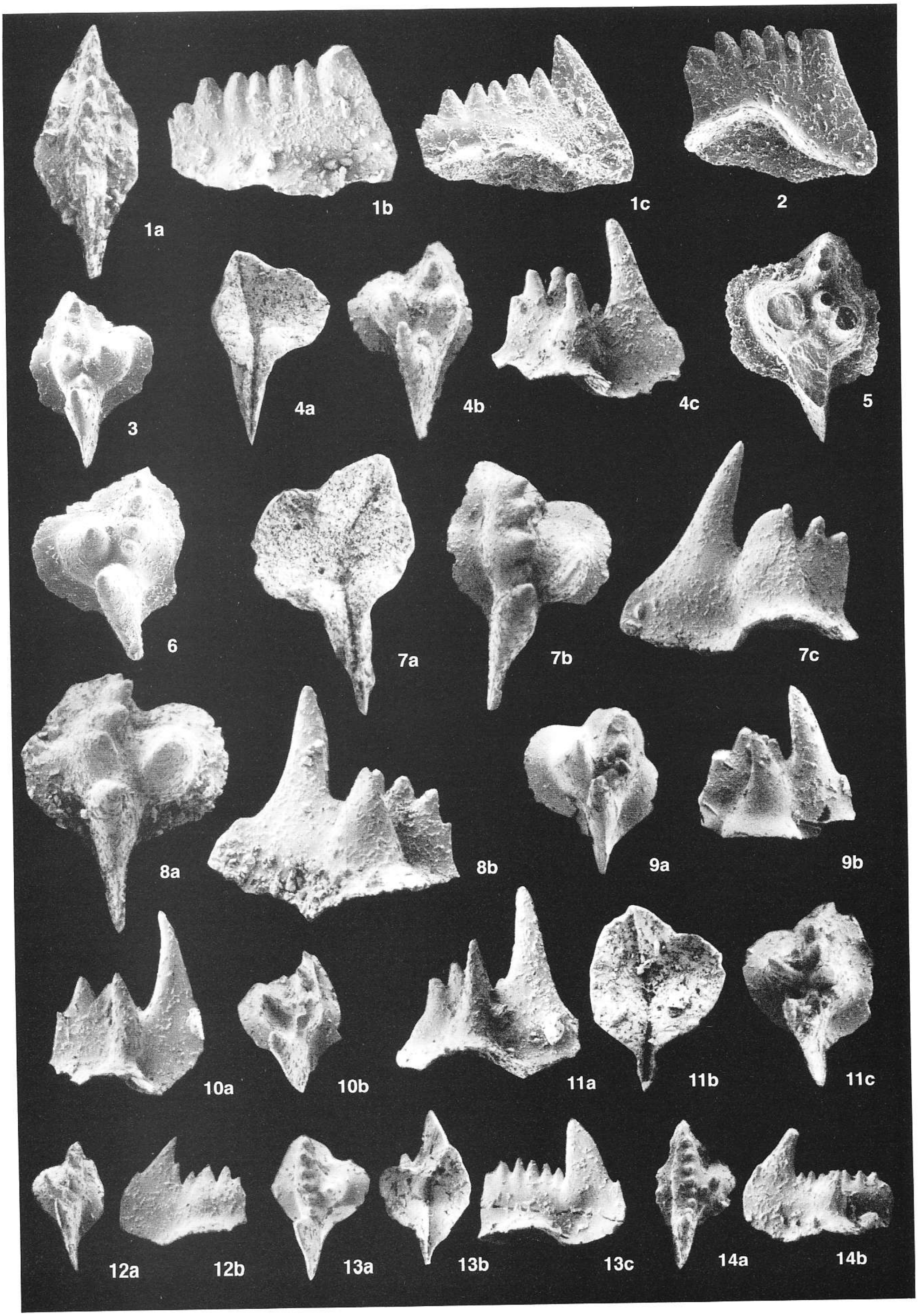
PLATE 1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14b

PLATE 2

Hindeodus parvus (Kozur & Pjatakova, 1975)

Pl. 1, figs 10a-b–11a-d; pl. 2, figs 1a-c

1975 *Anchignathodus parvus* Kozur & Pjatakova in Kozur, Mostler & Rahimi-Yazd, 4, pl. 1, figs 13-15, pl. 7, figs 7, 9.

1976 *Anchignathodus parvus* Kozur & Pjatakova – Kozur & Pjatakova, 123, figs 1a-b, d-e.

2003 *Hindeodus parvus* (Kozur & Pjatakova) – Perri & Farabegoli, pl. 2, figs 4-12 *cum syn*.

PLATE 1

Conodonts from Sakirmul, upper Yarkhun valley, sample BRG12, *staeschei* Zone, figs 1-14b.

Conodonts from Torman Gol, Mastuj valley, sample C174F, *isarcica* Zone, figs 15a-17c.

Magnifications: x125 figs 1-11d; x63 figs 12a-17c.

Figs 1–6a-c - *Isarcicella staeschei* Dai & Zhang 1989, 1. Upper view, ICI1790 82-223247; 2a,b. Lateral and upper views, ICI1791 82-223248; 3a,b. Lateral and upper views, ICI1792 82-223241; 4a,b. lateral, upper views, ICI1793 83-223245; 5a-c. Upper, lower and lateral views respectively, ICI1794 82-223242; 6a-c. Lateral, upper and lower views respectively, ICI1795 82-223243.

Figs 7a-c; 9a-c - *Isarcicella lobata* Perri 2003, 7a-c. Lower, upper and lateral views respectively, ICI1796 82-223246; 9a-c. Lateral, lower and upper views respectively, ICI1797 82-223239.

Figs 8a-c - *Isarcicella turgida* (Kozur, Mostler & Rahimi-Yazd 1975). Lower, upper and lateral views respectively, ICI1798 82-223244.

Figs 10a,b; 11a-d - *Hindeodus parvus* (Kozur & Pjatakova 1975), 10a,b. Upper and lateral views, ICI1799 82-223240; 11a-d. Upper, lower, lower-lateral and lateral views respectively, ICI1800 82-223238.

Figs 12a,b; 15a,b–17a-c - *Hadrodontina aequabilis* Staesche 1964, 12a-b. Pb element, lower and lateral views, ICI1801 82-223249; 15a,b. Sc element, inner- and outer-lateral views, 84-223205; 16. M element, posterior view, 84-223207; 17a-c. Sb element, lower-inner-lateral, inner-lateral and outer-lateral views respectively, 84-223206, STB 1-12.

Figs 13a,b–14a,b - Ramiforms: 13a,b. Sc element, inner-, outer-lateral views, ICI1802 82-223236; 14a,b. Sb element, anterior, posterior views, ICI1803 PT82-223237.

PLATE 2

Conodonts from Torman Gol, Mastuj valley, sample C174F, *isarcica* Zone. Magnifications: x125.

Figs 1a-c - *Hindeodus parvus* (Kozur & Pjatakova 1975), upper, lateral and lower-lateral views respectively, 83-223210.

Fig. 2 - *Isarcicella* n.sp. A, lower-lateral view, STB 3-1.

Figs 4a-c–5 - *Isarcicella isarcica* (Huckriede 1958), 4a-c. Lower, upper and lateral views respectively; 83-223208; 5. upper view, STB 2-3.

Figs 3, 6–14a,b - *Isarcicella staeschei* Dai & Zhang 1989, 3. Upper view, STB 2-5; 6. Upper view; 7a-c. Lower, upper and lateral views respectively, 83-223215; 8a,b. Upper and lateral views, 83-223212; 9a,b. Upper and lateral views, 83-223214; 10a,b. Lateral and upper views, 83-223219; 11a-c. Lateral, lower and upper views respectively, 83-223221; 12a,b. Upper and lateral views, 83-223223; 13a-c. Upper, lower and lateral views respectively, 83-22320; 14a,b. Upper and lateral views, 83-223217.

Description. The Pa element is small, short, with a big and rather slender cusp conspicuously higher than the succeeding denticles.

Remarks. Forms lacking swelling of the blade and lacking thickening and swelling of the attachment area of the denticles and of the basal cavity are here included in the species. The posterior end can be either adenticulate, abruptly ending, or with denticles decreasing in height towards the tip — a common characteristic in conodonts across the Permian-Triassic boundary — distinguishing two morphotypes: respectively morphotypes 1 and 2. Both morphotypes have been recognised in the Torman Gol sample, only morphotype 1 in the Sakirmul sample. Elements showing enlargement of the blade, and thickening and swelling of the attachment area of the denticles and of the basal cavity have been referred to as species of *Isarcicella*, such as *Is. prisca*, *turgida* and *lobata*.

Occurrence. Sakirmul, sample BGR12 and Torman Gol, sample C174F.

Known range. *Parvus-isarcica* (*isarcica* = *staeschei* Z. + *isarcica* Z.) zones (Kozur 1996), *parvus–staeschei* zones (Perri & Farabegoli 2003): Early Triassic, Induan (early Scythian).

Genus *Isarcicella* Kozur, 1975

Type species: *Spathognathodus isarcicus* Huckriede, 1958

The original definition of the genus given by Kozur (1975) for Pa scaphate elements showing a very wide and inflated cup and bearing denticles lateral to the blade, has been extended to include elements with weakly to highly asymmetrical and swollen cup, bordered by flange-like brims, but without lateral denticles, and with a swollen blade or attachment area of the denticles (Perri & Farabegoli 2003).

Unequivocal generic attribution of Pa elements from youngest Permian and earliest Triassic levels with shape resembling *Hindeodus* Pa elements but having basal cavity, blade or attachment area of denticles swollen (as above) to the genus *Hindeodus* or *Isarcicella* will be solved only when reconstructions are available for the apparatus of *Isarcicella* and for species with shape transitional between the two genera.

Isarcicella isarcica (Huckriede, 1958)

Pl. 2, figs 4a-c–5

1958 *Spathognathodus isarcica* Huckriede, 162, pl. 10, fig. 7

2003 *Isarcicella isarcica* (Huckriede) - Perri & Farabegoli, pl. 4, figs 1-6 *cum syn*.

Description. The Pa element is characterised by a wide and inflated cup bearing one or more denticles on both sides of the cup.

Remarks. A few elements have one denticle on both sides of the expanded cup.

Occurrence. Torman Gol, sample C174F.

Known range. *Isarcica-postparvus* zones (Wang & Wang 1997), *isarcica* Zone (Perri & Farabegoli 2003): Early Triassic, Induan (early Scythian).

Isarcicella lobata Perri, 2003

Pl. 1, figs 7a-c, 9a-c

1964 *Spathognathodus isarcicus* Huckriede – Staesche, text-fig. 61.

1981 *Hindeodus parvus* (Kozur & Pjatakova) – Matsuda, 91, pl. 5, fig. 3.

1991 *Hindeodus parvus* (Kozur & Pjatakova) - Schönlaub, pl. 1, fig. 3.

1991 *Isarcicella isarcica* morphotype 1 (Huckriede) - Perri, pl. 4, fig. 8.

1993 *Isarcicella turgida* (Kozur, Mostler & Rahimi-Yazd) – Gullo & Kozur, fig. 2/2-3.

1995 *Isarcicella ? turgida* (Kozur, Mostler & Rahimi-Yazd) – Kozur, pl. 2, fig. 8.

1995 *Hindeodus parvus* (Kozur & Pjatakova) – *Isarcicella* Transition? – Metcalfe, pl. 1, figs 12-13.

1996 *Isarcicella ? turgida* (Kozur, Mostler & Rahimi-Yazd) – Kozur, pl. 5, figs 7-8.

1998 *Hindeodus parvus* morphotype 2 (Kozur & Pjatakova) trans. form to *Isarcicella isarcica staeschei* Dai & Zhang – Farabegoli & Perri, pl. 4.3.1, fig. 13.

1999 *Hindeodus parvus erectus* Kozur - Nicora & Perri, pl. 3, fig. 7.

1999 *Hindeodus parvus parvus* (Kozur & Pjatakova) – Nicora & Perri, pl. 3, fig. 14.

2003 *Isarcicella lobata* Perri in Perri & Farabegoli, pl. 2, figs 1-3; pl. 3, figs 15-29; pl. 4, figs 12-14.

Description. The Pa element is characterised by an asymmetrical to highly asymmetrical swollen and thickened cup with a lateral bulge forming a lobe. The cup has no lateral denticles. The cusp is higher than the succeeding denticles.

Remarks. The cup is always asymmetrical and swollen; it has a lateral bulge forming an inflated lobe on the inner side. The outer side of the cup is usually more reduced than the inner side and may show undulations. The lateral views of the forms included in *Is. lobata* are very close to those of other species either of *Hindeodus* like *Hi. parvus* and *Isarcicella* such as *Is. turgida*, and some elements of *Is. staeschei* and *Is. isarcica*, from which they are distinguished only by lack of lateral nodes or denticles. Specimens previously included in *Hi. parvus* and *Is. turgida* have been assigned to *Is. lobata*. *Hi. parvus* lacks thickening and swelling of the attachment area of the denticles and of the basal cavity. *Is. turgida* displays swelling of the attachment area of the denticles but a reduced and nearly symmetrical basal cavity. Two morphotypes can be discriminated by the shape of the posterior end.

The first appearance of *Is. lobata* has been utilised in the Southern Alps to define the base of the *lobata* Zone located between the *parvus* and *staeschei* zones.

Occurrence. Sakirmul, sample BGR12 and Torman Gol, sample C174F.

Known range. *Lobata–isarcica* zones (Perri & Farabegoli 2003): Early Triassic, Induan (early Scythian).

Isarcicella staeschei Dai & Zhang, 1989

Pl. 1, figs 1–6a-c; pl. 2, figs 3, 6–14a-b

1964 *Spathognathodus isarcicus* Huckriede – Staesche, 288, figs 62-63.

2003 *Isarcicella staeschei* Dai & Zhang – Perri & Farabegoli, pl. 3, figs 1-14, pl. 4, figs 7-9 *cum syn*.

Description. The Pa element is characterised by a very asymmetrical wide and usually inflated cup with a lateral lobe bearing one or a series of nodes or one or more denticles on only one side of the cup.

Remarks. It is the most abundant species in the studied material, showing very wide intraspecific variability in shape and swelling of the cup. The number of denticles on the lateral lobe varies from one to three. Usually the elements included in *Is. staeschei* have a very wide and inflated cup with more or less pronounced lobe. The Chitral material has several elements with all morphological peculiarities of the species but with the cup tending to be less developed and swollen. Some of those elements with a series of three lateral denticles develop a lateral lobe quite discrete from the cup. The lateral lobe originates close to the cusp in the majority of elements; in some it seems to develop from the middle of the short blade with a variable angle up to 90°. Numerous elements have the first denticle of the blade immediately behind the cusp, slightly off-centre on the opposite side to the lobe. These are interpreted as transitional to *Is. isarcica*.

Occurrence. Sakirmul, sample BGR12 and Torman Gol, sample C174F.

Known range. *Staeschei–isarcica* zones (Wang & Wang 1997, Perri & Farabegoli 2003): Early Triassic, Induan (early Scythian).

Isarcicella turgida (Kozur, Mostler & Rahimi-Yazd, 1975)

Pl. 1, figs 8a-c

1975 *Anchignathodus turgidus* Kozur, Mostler & Rahimi-Yazd, 5, pl. 7, figs 11-12.

1993 *Isarcicella turgida* (Kozur, Mostler & Rahimi-Yazd) – Gullo & Kozur, fig. 2/7-9.

1995 *Isarcicella? turgida* (Kozur, Mostler & Rahimi-Yazd) – Kozur, 72, pl. 2, fig. 5.

1996 *Isarcicella? turgida* (Kozur, Mostler & Rahimi-Yazd) – Kozur, 100, pl. 4, fig. 8.

Description. The Pa element is characterised by a thickened blade and slightly asymmetrical basal cavity. In upper view, the surface corresponding to the basal cavity, is smooth.

Remarks. Some elements close to the holotype (Kozur 1975, pl. 7, fig. 12), in which the blade is weakly inflated and the basal cavity is very slightly asymmetrical, have been found in the Chitral faunas. Only forms presenting the same peculiarities stipulated in the original description have been included in the species. The denticulation is the same as in *Hindeodus parvus* from which *I. turgida* can be discriminated only by having a swollen blade. Elements with a very wide asymmetrical and swollen cup resembling the specimen referred to *I. turgida* figured by Gullo & Kozur (1993, fig. 2/2-3) and Kozur (1995, 1996) are assigned to *Is. lobata*.

Occurrence. Sakirmul, sample BGR12 and Torman Gol, sample C174F.

Known range. *Staeschei-isarcica* zones (Wang & Wang 1997), *parvus–lobata* zones (Perri & Farabegoli 2003): Early Triassic, Induan (early Scythian).

Isarcicella n.sp. A

Pl. 2, fig. 2

1998 Transitional form between *Isarcicella ?prisca* M1 Kozur 1995 and *Isarcicella turgida* (Kozur, Mostler & Rahimi-Yazd, 1975) – Farabegoli & Perri, pl. 4.3.1, fig. 12.

Remarks. One element short and high with the cusp apparently higher than the following 5 denticles. Swollen blade and large asymmetrical basal cavity suggest including this form in *Isarcicella* following the revised diagnosis of the genus proposed by Perri (in Perri & Farabegoli 2003). One conodont very close to that from Torman Gol was found in the Southern Alps in the Bulla section, sample BU12C.

This form resembles elements figured by Nicoll et al. (2002, figs 7 and 8) referred by them to *Hindeodus eurypyge* Nicoll, Metcalfe & Wang, 2002.

Occurrence. Torman Gol, sample C174F.

Known range. *Parvus* Zone in the Southern Alps; *isarcica* Zone in Chitral, Pakistan: Early Triassic, Induan (early Scythian).

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REFERENCES

Budurov K.J. & Gupta V.J. (1988) – Triassic conodont stratigraphy of some sections of Kashmir Himalaya. *Bull. Indian Geol. Assoc.*, 21:21–39, Chandigarh.

Dai J. & Zhang J. (1989) – Conodonts. In: Study on the Permo–Triassic Biostratigraphy and Event Stratigraphy of northern Sichuan and southern Shaanxi. *Geol. Mem.*, 2 (9): 428–435, Beijing.

Ding M., Zhang K. & Lai X. (1996) – Evolution of *Clarkina* lineage and *Hindeodus-Isarcicella* lineage at Meishan section, South China. In: Yin H. (ed.). The Palaeozoic–Mesozoic Boundary Candidates of The Global Stratotype Section and Point of the Permian–Triassic Bondary; IGCP 359: 65–71, Wuhan.

Farabegoli E., Levanti D. & Perri M.C. (1986) – The *Bellerophon* Formation in the southwestern Carnia. The boundary Bellerophon–Werfen Formation. In: Broglio Loriga, C. et al. (eds), Permian and Permian–Triassic boundary in the South–Alpine segment of the Western Tethys. S.G.I., IGCP 203, Excursion Guidebook, 4–12 July 1986: 69–75, Pavia.

Farabegoli E. & Perri M.C. (1998) – Permian–Triassic boundary and Early Triassic of the Bulla section (Southern Alps, Italy): lithostratigraphy, facies and conodont biostratigraphy. In: Perri M.C. & Spalletta C. (eds), Southern Alps Field Trip Guidebook, ECOS VII. *Giornale di Geologia,* 60 (Spec. Issue): 292–310, Bologna.

Gaetani M. (1997) – The Karakoram Block in central Asia, from Ordovician to Cretaceous. *Sed. Geol.*, 109: 339–359, Amsterdam.

Gaetani M., Angiolini L., Garzanti E., Jadoul F., Leven E., Nicora A. & Sciunnach D. (1995) – Permian stratigraphy of the northern Karakorum. *Riv. Ital. Paleont. Stratigr.*, 101: 107–152, Milano.

Gaetani M., Le Fort P., Tanoli S., Angiolini L., Nicora A., Sciunnach D. & Khan A. (1996) – Reconnaissance geology in upper Chitral, Baroghil and Karambar districts (northern Karakoram, Pakistan). *Geol. Runds.*, 85: 683–704, Stuttgart.

Gamerith H. (1982) – Geologische Karte von Gilgit/Chitral/Whakhan (Nordpakistan und Ostafghanistan) 1:250,000. Graz, privately published.

Gullo M. & Kozur H. (1993) – First evidence of Scythian conodonts in Sicily. *Neues Jahrb. Geol. Paläont. Monatsh*, 8: 477–488, Stuttgart.

Hayden H.H. (1915) – Notes on the geology of Chitral, Gilgit and the Pamirs. *Rec. Geol. Sur. India*, 45: 271–335, Calcutta.

Huckriede R. (1958) – Die Conodonten der mediterranen Trias und ihr stratigraphischer Wert. *Paläont. Zeit.*, 32: 141–175, Stuttgart.

Jin Y., Shen S.-H., Zhu Z., Mei S.-L. & Wang W. (1996) – The Selon section, candidate of the Global Stratotype section and point of the Permian–Triassic boundary. In: Yin H. (ed.). The Palaeozoic–Mesozoic Boundary Candidates of The Global Stratotype Section and Point of the Permian–Triassic Bondary; IGCP 359: 127–137, Wuhan.

Kotlyar G.V., Kozur H. & Zakharov Yu. D. (1993) The Transcaucasian sections Dorasham 2 (Azerbaidzhan) and Sovetashen (Armenia), two candidates for P/T boundary reference sections. *Albertiana*, 12: 36–38, Utrecht.

Kozur H. (1975) – Beiträge zur conodontenfauna des Perm. *Geol.–Paläontol. Mitt. Innsbruck*, 5 (4): 1–44, Innsbruck.

Kozur H. (1995) – Some remarks to the conodonts *Hindeodus* and *Isarcicella* in the latest Permian and earliest Triassic. *Palaeoworld*, 6: 64–77, Nanjing.

Kozur H. (1996) – The conodonts *Hindeodus*, *Isarcicella* and *Sweetohindeodus* in the uppermost Permian and lowermost Triassic. *Geol. Croatica*, 49: 81–115, Zagreb.

Kozur H., Mostler H. & Rahimi-Yazd A. (1975) – Beitrage zur Mikrofauna permotriadischer Schichtfolgen.-Teil II: Neue Conodonten aus dem Oberperm und der basalen Trias von Nord - und Zentraliran. *Geol.–Paläont. Mitt. Innsbruck*, 5(3): 1–23, Innsbruck.

Kozur H. & Pjatakova M. (1976) - Die Conodonten art *Anchignathodus parvus* n.sp., eine wichtige Leitform der basalen Trias. *Proc. Kkl. Nederl. Akad. Wetensch.*, ser. B, 79(2): 123–128, Amsterdam.

Iranian-Japanese Research Group (1981) – The Permian and the Lower Triassic systems in Abadeh region, Central Iran. *Mem. Fac. Sci., Kyoto Univ., Ser. Geol. Min.*, 47 (2): 61–133, Kyoto.

Li Z.-S., Zhan L.-P., Dai J.-Y., Jin R.-G., Zhu X.-F., Zhang J.-H., Huang H.-Q., Xu D.-Y., Yan Z. & Li H.-M. (1989) – Study on the Permian–Triassic biostratigraphy and event stratigraphy of northern Sichuan and southern Shaanxi. *Geol. Mem., Ser.* 2 (9): 435 pp., Geological Publishing House, Beijing.

Matsuda T. (1981) – Early Triassic conodonts from Kashmir, India. Part I: *Hindeodus* and *Isarcicella*. *J. Geosci.*, 24: 75–109, Osaka.

Metcalfe I. (1995) – Mixed Permo–Triassic boundary conodont assemblages from Gua Sei and Kampong Gua, Pahang, Peninsular Malaysia. *Cour. Forsch.-Inst. Senckenberg*, 182: 487–495, Frankfurt am Main.

Molloy P.D. (1979) – Conodont faunas from north-west Pakistan: 283 pp., 32 pls, MSc dissertation, Macquarie University, Sydney.

Nakazawa K. (1993) – Stratigraphy of the Permian-Triassic transition and the Paleozoic/Mesozoic boundary. *Bull. Geol. Surv. Japan*, 44: 425–445, Tsukuba.

Nicoll R.S., Metcalfe I. & Wang C.-Y. (2002) – New species of the conodont genus *Hindeodus* and the conodont biostratigraphy of the Permian–Triassic boundary interval. *Jour. Asian Earth Sci.*, 20: 609–631, Amsterdam.

Nicora A. & Perri M.C. (1999) – The P–T Boundary in the Tesero section, western Dolomites (Trento). 3.3 Bio-and chronostratigraphy: conodonts. In: Cassinis, G. et al. (eds). Stratigraphy and facies of the Permian deposits between eastern Lombardy and the western Dolomites. Field Trip Guidebook, International field conference on "The Continental Permian of the Southern Alps and Sardinia (Italy), Regional Reports and General Correlations", 15-25 September 1999, Brescia, Italy: 97–100, Pavia.

Orchard M.J., Nassichuk W.W. & Rui L. (1994) – Conodonts from the lower Griesbachian *Otoceras latilobatum* bed of Selong, Tibet and the position of the Permian-Triassic boundary. *Canadian Soc. Petrol. Geol., Mem.*, 17: 823–843, Calgary.

Orchard M.J. & Krystyn L. (1998) – Conodonts of the lowermost Triassic of Spiti, and new zonation based on *Neogondolella* succession. *Riv. Ital. Paleont. Stratigr.*, 104: 341–368, Milano.

Pakistani-Japanese Research Group (1985) – Permian and Triassic Systemsin the Salt Range and Surghar Range, Pakistan. In: Nakazawa K. & Dickins J.M. (eds). The Tethys, her paleogeography and paleobiogeography from Paleozoic to Mesozoic: 221–312, Tokai University Press, Tokai.

Perri M.C. (1986) – A Spathian conodont fauna from the Cencenighe Member of the Werfen Formation (Scythian), southeastern Dolomites, Italy. *Boll. Soc. Paleont. Ital.*, 24: 23–28, Modena.

Perri M.C. (1991) – Conodont biostratigraphy of the Werfen Formation (Lower Triassic), Southern Alps, Italy. *Boll. Soc. Paleont. Ital.*, 30: 23–46, Modena.

Perri M.C. (1998) – Evolutionary tendencies in the hindeodids and isarcicellids of the latest Permian and earliest Triassic. In: Perri, M.C. & Spalletta, C. (eds). Southern Alps Field Trip Guidebook, ECOS VII. *Giornale di Geologia*, 60 (Special Issue): 120–122, Bologna.

Perri M.C. & Andraghetti M. (1987) – Permian–Triassic boundary and Early Triassic conodonts from the Southern Alps, Italy. *Riv. Ital. Paleont. Stratig.*, 93: 291–328, Milano.

Perri M.C. & Farabegoli E. (1998) – New conodont data from the Permian–Triassic boundary of the Werfen Formation (Southern Alps, Italy). In: Bagnoli, G. (ed.). ECOS VII (Bologna-Modena, 1998) Abstracts: 85–86, Tipografia Compositori, Bologna.

Perri M.C. & Farabegoli E. (2003) – Conodonts across the Permian–Triassic boundary in the Southern Alps. AUSCOS 2 Proceedings. *Cour. Forsch.-Inst. Senckenberg*, 245: 281–313, Frankfurt a. Main.

Perri M.C., Talent J.A., Ahmad I, Ali A., Molloy P.D. & Conaghan P.J. (2000) – Prevalence of Triassic limestone sequences in northern Pakistan. *Geol. Soc. Australia Abstr.*, 61: 79–82, Sydney.

Rexroad C.B. (1957) – Conodonts from the Chester Series in the type area of southwestern Illinois. *Illinois Geol. Surv. Rept Investigations*, no. 199: 1–43, Chicago.

Rexroad C.B. & Furnish W.M. (1964) – Conodonta from the Pella Formation (Mississippian), south-central Iowa. *J. Paleont.*, 38: 667–676, Tulsa.

Schönlaub H.P. (1991) – The Permian–Triassic of the Gartnerkofel 1 Core (Carnic Alps, Austria): Conodont biostratigraphy. *Abh. Geol. Bund.*, 45: 79–98, Wien.

Searle M P. & Khan A. (eds) (1996) – Geological map of north Pakistan, 1:650,000. Blackwell, Oxford.

Staesche U. (1964) – Conodonten aus dem Skyth von Sudtirol. *Neues Jahrb. Geol. Paläont. Abh.*, 119: 247–306, Stuttgart.

Stauffer K.W. (1975) – Reconnaissance geology of the central Mastuj valley, Chitral State, West Pakistan. US Geol. Surv. Open File Rept, no. 75-556 (PK-24): 51 pp., Reston.

Sweet W.C. (1970) – Permian and Triassic conodonts from a section at Guryul Ravine, Vihi District, Kashmir. *Univ. Kansas Paleont. Contrib.*, 49: 1–10, Kansas City. [1970a]

Sweet W.C. (1970) – Uppermost Permian and Lower Triassic conodonts of the Salt Range and Trans-Indus Ranges, West Pakistan. *Univ. Kansas Dept Geol. Spec. Pub.*, 4: 207–275, Kansas City. [1970b]

Talent J.A., Conaghan P.J., Mawson R., Molloy P.D. & Pickett J.W. (1982) – Intricacy of tectonics in Chitral (Hindu Kush): faunal evidence and some regional implications. In Himalayan Seminar (1976), Section IIA. *Geol. Surv. India, Misc. Publ.*, 41, pt. III: 77–101, Calcutta.

Talent J.A., Gaetani M., Mawson R., Molloy P.D. & Conaghan P.J. (1999) – Early Ordovician and Devonian conodonts from the western Karakorum and Hindu Kush, northernmost Pakistan. *Riv. Ital. Paleont. Stratigr.*, 105: 201–230, Milano.

Tian S.G. (1993) – Late Permian–earliest Triassic conodont palaeoecology in northwestern Hunan. *Acta Palaeont. Sinica*, 32: 332–345, Nanjing.

Tipper G.H. (1922) - Chitral. In Fermor, L.L., General report for 1921. *Rec. Geol. Surv. India*, 54, pt 1: 55–57, Calcutta.

Wang C.-Y. (1995) – Conodonts of Permian–Triassic boundary beds and biostratigraphic boundary. *Acta Palaeont. Sinica*, 34: 129–151, Nanjing.

Wang C.-Y. & Wang S.-Q. (1997) – Conodonts from Permian–Triassic boundary beds in Jiangxi, China and evolutionary lineage of *Hindeodus-Isarcicella*. *Acta Palaeont. Sinica*, 36: 151–168, Nanjing.

Yin H. (1993) – A proposal for the global stratotype section and point (GSSP) of the Permian–Triassic boundary. *Albertiana*, 11: 4–30, Utrecht.

Yin H., Wu S. & Ding M. (1996) – The Meishan section , candidate of the global stratotype section and point of Permian-Triassic boundary. In: Yin H. (ed.). The Palaeozoic–Mesozoic Boundary Candidates of The Global Stratotype Section and Point of the Permian–Triassic Bondary; IGCP 359: 31–48, Wuhan.

Yin H., Zhang K., Tong J., Yang Z. & Wu S. (2001) – The Global Stratotype Section and Point (GSSP) of the Permian-Triassic Boundary. *Episodes*, 24 (2): 102–114, Benjing.

Youngquist W. & Miller A.K. (1949) – Conodonts from the Late Mississippian Pella Beds of south-central Iowa. *Jour. Paleont.*, 23: 671–622, Tulsa.

Zakharov Yu.D. (1992) – The Permian-Triassic boundary in the southern and eastern USSR and its international correlation. In: Sweet W.C., Yang Z.Y., Dickins J.M. & Yin H.F. (eds), Permo-Triassic events in the eastern Tethys: 146-157, Cambridge University Press, Cambridge.

Zanchi A. & Gaetani M. (1994) – Introduction to the geological map of the North Karakorum Terrain from the Chapursan valley to the Shimshal Pass 1:150,000 scale. *Riv. Ital. Paleont. Stratigr.*, 100: 125–136, Milano.

Zanchi A., Poli S., Fumagalli P. & Gaetani M. (2000) – Mantle exhumation along the Tirich Mir Fault Zone, NW Pakistan: pre-mid-Cretaceous accretion of the Karakoram terrane to the Asian margin. *Geol. Soc. London Sp. Publ.*, 170: 237–252, London.

Zhang K., Ding M., Lai X.-L. & Liu J.-H. (1996) – Conodont sequences of the Permian-Triassic boundary strata at Meishan section, South China. In: Yin H. (ed.). The Palaeozoic–Mesozoic Boundary Candidates of the Global Stratotype Section and Point of the Permian–Triassic Boundary; IGCP 359: 57–64, Wuhan.

Zhu X.-S., Wang C.-Y., Lu H. et al. (1994) – Permian–Triassic boundaries in Jiangxi, China. *Acta Micropalaeont. Sinica*, 11: 439–452, Nanjing.