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EARLY ORDOVICIAN AND DEVONIAN CONODONTS FROM THE WESTERN KARAKORAM AND HINDU KUSH, NORTHERNMOST PAKISTAN

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Riassunto. Estesi affioramenti di rocce Devoniane o più antiche affiorano nella regione assiale del Karakorum occidentale in Pakistan settentrionale, su una distanza di oltre 200 km, tra l'alta valle di Karambar (Gilgit Agency) sino al Chitral sudoccidentale. I dati forniti dai conodonti indicano che l'unità sedimentaria più antica sinora identificata in questa fascia, la Formazione Yarkhun, include orizzonti di età Arenigiana (Ordoviciano). Questo dato è consistente con un'età Arenigiana già fornita, per gli stessi livelli, sulla base degli acritarchi. I dati dei conodonti sulle "Lun Shales", un miscuglio stratigrafico con spezzoni mal definiti di Siluriano e Devoniano, dimostra la presenza di livelli del Devoniano inferiore (Emsiano inferiore). La Formazione Shogrām, ampiamente diffusa nella regione, occupa un considerevole intervallo del Devoniano medio e superiore, dalla parte centrale del Givetiano al Famenniano inferiore. Una lacuna di sedimentazione abbastanza importante può essere presente, in corrispondenza di tutto o almeno della metà inferiore del Frasniano. Viene descritta una specie nuova di importanza biostratigrafica e forse anche paleobiogeografica: *Icriodus homeomorphus*. Essa è stata rinvenuta in orizzonti di età Famenniana inferiore (Zona superiore a *triangularis* sino a ? Zona inferiore a *crepida*).

Abstract. Extensive tracts of Devonian and older sedimentary and igneous units occur within the axial region of the western Karakoram Block of northernmost Pakistan over a distance in excess of 200 km between the the headwaters of the Karambar valley in northwestern Gilgit Agency to southwestern Chitral. Conodont data indicate that the oldest sedimentary unit so far discriminated within this belt, the Yarkhun Formation, includes horizons of Ordovician (Arenig) age, consistent with an earlier-presented acritarch-based Arenig age for part of the same unit. Conodont data from the "Lun Shales", a stratigraphic potpourri with little-known Silurian and Devonian tracts, demonstrate the presence of Early Devonian (early Emsian) horizons. The Shogrām Formation, widely distributed through the region, spans an appreciable interval of the Middle and Late Devonian mid-Givetian through until at least early Famennian. A major lacuna in sedimentation may be present, represented by all or most of the earlier half of Frasnian time. A biostratigraphically and possibly biogeographically important new species, *Icriodus homeomorphus*, is described; it is encountered in horizons of early Famennian age (Late *triangularis* Zone to ?Early *crepida* Zone).

Introduction.

The axial region of the Karakoram Block of northernmost Pakistan is characterised by major thrust-repetition of Palaeozoic sedimentary sequences and intrusives of various ages including pre-Ordovician plutonics. Devonian and older tracts have been discriminated in this axial region over a distance of about 200 km (Fig. 1) between Chillinji in the Karambar valley of north-western Gilgit and southwestern Chitral (McMahon & Hudleston, 1902, Hayden, 1915; Tipper, 1922, 1924; Pascoe, 1959, pp. 665-667; Desio, 1963, 1966; Stauffer, 1967, 1975; Diemberger, 1968; Vogeltanz, 1968, 1969; Vogeltanz & Diemberger-Sironi, 1969; Talent et al., 1976, 1982; Talent & Mawson, 1979; Klootwijk & Conaghan, 1979; Calkins et al., 1981; Gamerith, 1982; Buchroithner & Gamerith, 1986; Leake et al., 1989; Gaetani et al., 1990, 1996; Le Fort et al., 1994; Zanchi & Gaetani, 1994; Klootwijk et al., 1994; Zanchi et al., 1997; Gaetani, 1997; Le Fort & Gaetani, 1998; Buchroithner, 1998). Various interpretations of the geology of the region have been presented in recent broad-scale maps of northern Pakistan and briefly discussed in several reviews (Tahirkheli, 1982, 1996; Searle, 1991; Bender & Raza, 1995; Searle & Khan, 1996; Kazmi & Qasim Jan, 1997).

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It has been asserted in one of these reviews (Kazmi & Qasim Jan, 1997, pp. 202, 203) that "The stratigraphy of this region is largely based on scattered reconnaissance mapping and remains incoherent... compounded by... authors [who] have coined different formation names for overlapping stratigraphic units", and that "The Devonian fossils from Chitral... described without tangible description of lithostratigraphic sections... [have not been] very helpful in sorting out stratigraphic correlation problems... particularly lateral changes in lithofacies, and correlation of the lithostratigraphic units overlying and underlying the Shogrām Formation".

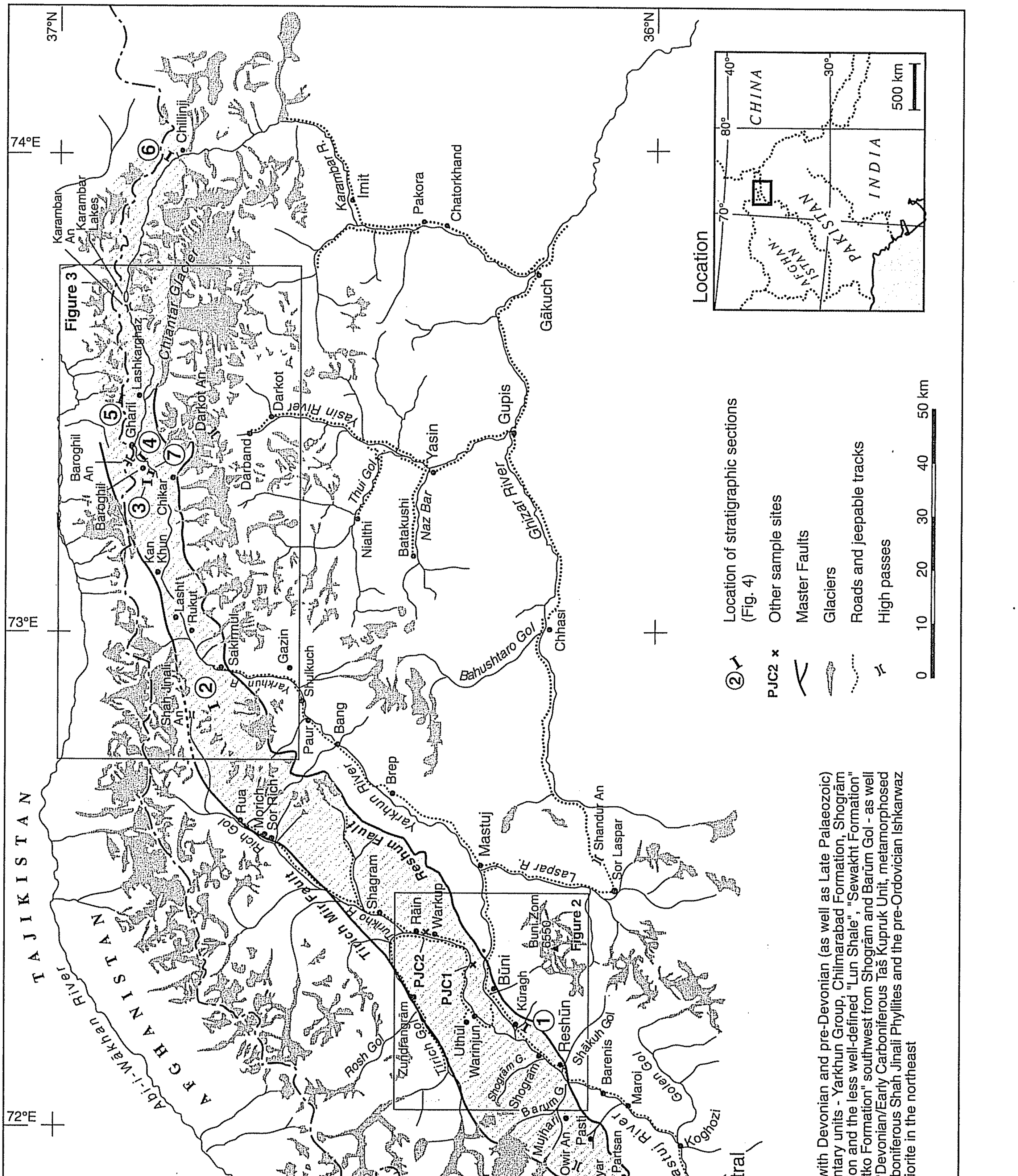
In this report we attempt to ameliorate this situation by presenting documentation of Ordovician-Devonian conodont faunas from samples stratigraphic sections and spot-samples localities through the western Karakoram and Hindu Kush from the upper Karambar and Yarkhun valleys in the northeast to the Istar-Kurāgh-Shogrām area and the Lutko valley some 200 km to the southwest. Much of our sampling - principally because of regional metamorphism and shearing - has not proved productive. Numerous limestone-bearing sequences and isolated outcrops in the Mastūj and Yarkhun River valleys of Chitral (Fig. 1) were sampled by Talent and colleagues in 1973 and 1975 in quest of palaeontologic data to improve chronologic underpinning of sedimentary sequences in northwest Pakistan. Preliminary results from sampling along the Kurāgh Spur, from Gosh Lasht on the right flank of the Mastūj valley opposite the Kurāgh section (Fig. 2), and from the Baroghil area northwest of Ishkarwaz (Fig. 3), have been communicated, though without documentation (Talent & Mawson, 1979; Talent et al., 1976, 1982). Some of the conodont materials from these areas and from spot samples near Istar (Turikho valley) and near Ojchor Gol (Lutko valley) were documented in an unpublished thesis by Molloy (1979), and chitinozoans were documented from a Frasnian horizon low in the Shogrām Formation on the Kurāgh Spur (Winchester-Seeto & Paris, 1995). Additional sampling for macro- and microfossils by Gaetani and colleagues undertaken during mapping and structural interpretation of the area between Chillinji in the upper Karambar valley and the upper part of the Yarkhun valley has provided improved understanding of regional stratigraphy and tectonic relationships in the western Karakoram (Gaetani et al., 1996; Le Fort & Gaetani, 1998). This sampling, incidentally, produced acritarchs from the Yarkhun Formation in the Baroghil-Vidiakot area indicative of an Early Ordovician (Arenig) age (Le Fort et al., 1994; Tongiorgi et al., 1994; Amerise et al., 1998). The conodont faunas obtained from the above initiatives are here documented and ages inferred so that there will be a better chronologic framework within which stratigraphic/sedimentary and tectonic inferences can be made, and so that the Devonian macro-faunas from the region (Reed, 1911, 1922; von Schouppé, 1965; Sartenaer, 1965; Vandercammen, 1965; Gaetani, 1967), presently being revised and amplified (Talent et al., in prep.), will be chronologically better underpinned.

Notes on stratigraphy.

Tahirkheli (1982, pp. 5, 7, 18, 47, Fig. 20) introduced the name **Broghil Formation** (= Baroghil Limestone of Tahirkheli, 1996) for a sedimentary sequence, with Ordovician conodonts (Molloy, 1979; Talent & Mawson, 1979; Talent et al., 1982) obtained from sampling by Tahirkheli and Talent in 1973 in the Baroghil area about 2.5 km west-northwest of the Ishkarwaz bridge; the Baroghil Formation nonconformably overlies the Ishkarwaz Granodiorite. Subsequently Gaetani et al. (1996) introduced the names **Yarkhun Formation** for the lower terrigenous succession and **Chilmarabad Formation** for the overlying dolomitic unit. The former was thought to be Early Ordovician and ?Silurian, the latter possibly Devonian. The name **Vidiakot Formation** is here introduced for the upper, finer-grained part of the former Yarkhun Formation; the latter is here restricted to the stratigraphically lower and lithologically coarser part of the succession (cf. Fig. 4). These three formations, as an assemblage, correspond to Tahirkheli's (1982, 1996) Baroghil Formation; it perhaps warrants group-status.

The **"Lun Shale"** (Desio, 1966) is problematic. Hayden (1915) first described the strata which might now be referred to as Lun Shale and considered them to be probably Carboniferous in age. Desio (1966, p. 313) accepted a Carboniferous age for this unit, but with some reservation. More recent data suggest it is a poutpourri of rocks of various ages from Silurian, e.g. at the top of Mt Shogrām, where it has produced monograptids (Talent et al., 1982) through Early Devonian (Emsian) at nearby Gosh Lasht (this report) and Late Devonian (e.g. in Barkm Gol, Fig. 2). It is not clearly differentiated from the Chitral Slates to the southwest, a unit which includes horizons from which Permian brachiopods have been reported though not documented (Tipper, 1922; G. A. Cooper & R. Grant in Stauffer, 1975).

Fig. 1 - Locality map of northern Pakistan - Chitral to Karambar River valley of northwestern Gilgit Agency - showing tract with Ordovician-Devonian sedimentary rocks, location of sampled sections, and some of the spot-sampled localities mentioned in the text. Pattern of glaciers from Gamerith (1982).


T A J I K I S T A N
A F G H A N I S T A N
Location
CHINA
INDIA
PAKISTAN
AFGHANISTAN
500 km
Figure 3
Figure 2
Tirich Mir Fault
Reshun Fault
Chitral
Mastuj
Yasin
Gupis
Gākuch
Chiantar Glacier
Yarkhun River
Ghizar River
Location of stratigraphic sections (Fig. 4)
PJC2 × Other sample sites
Master Faults
Glaciers
Roads and jeepable tracks
High passes
0 10 20 30 40 50 km
Tracts with Devonian and pre-Devonian (as well as Late Palaeozoic) sedimentary units - Yarkhun Group, Chilmarabad Formation, Shogrām Formation and the less well-defined "Lun Shale", "Sewakht Formation" and "Lutko Formation" southwest from Shogrām and Barūm Gol - as well as the ?Devonian/Early Carboniferous Taš Kupruk Unit, metamorphosed pre-Carboniferous Shah Jinali Phyllites and the pre-Ordovician Ishkarwaz Granodiorite in the northeast

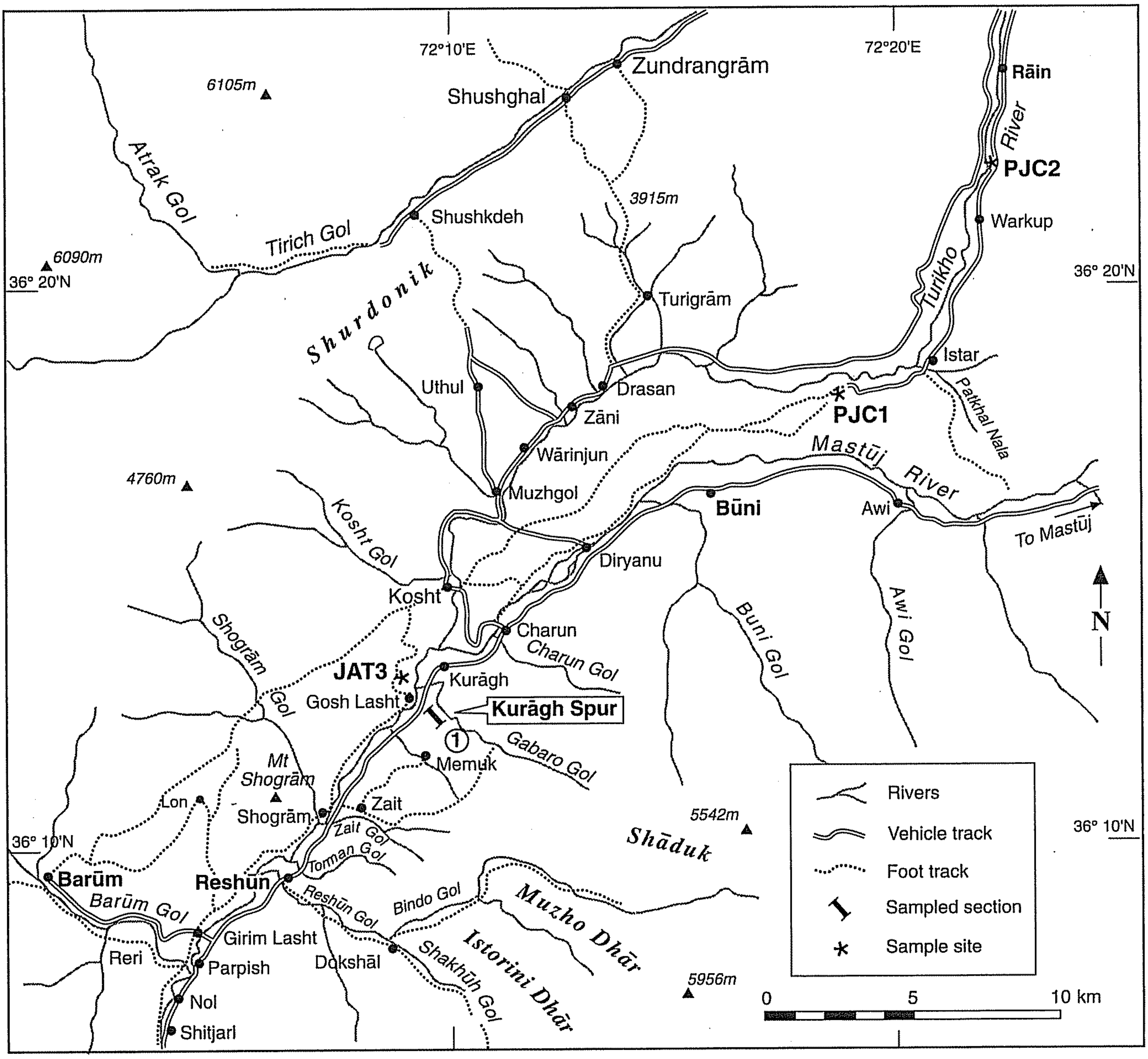


Fig. 2 - Reshūn-Shogrām-Kurāgh lower Turikho River valley showing location of Kurāgh Spur section and spot-sampled localities.

Buchroithner (1998) has identified as Lun Shale a 1-4 km-wide tract of shales and phyllites with subordinate quartzites, calcareous schists and acid tuffs extending from the vicinity of Krinj southwards across the Kalash valleys about 10-15 km west of the Chitral River valley. It is separated from the typical Chitral Slates of the Chitral-Ayun area by the 2-3 km-wide tract of Krinj Limestone, known from rudist bivalves and Orbitolina to be Cretaceous (Desio, 1958, 1959). Cursory examination in 1973 of part of this "Lun Shale" tract, between the Bumboret and Birir valleys, by Talent and Akbar Khattak of the Geological Survey of Pakistan, failed to produce fossils.

Relationships of the "Lun Shale" to the approximately 100 m thick **Charun Quartzite** (Figs. 4, 5; Stauffer, 1975; Talent et al., 1982) of the Reshūn-Kurāgh area (Figs. 4, 5) are not known. The latter however passes gradationally upwards into the **Shogrām Formation** (Desio, 1966). The Charun Quartzite has produced poorly preserved moulds of brachiopods of little precise chronologic value (Talent & Mawson, 1979; Talent et al., 1982). It is not well constrained chronologically apart from an age of Middle *varcus* Subzone age (mid-Givetian) for its uppermost beds transitional to the Shogrām Formation (see below). How the Charun Quartzite might relate to the **Chilmarabad Formation** (Gaetani et al., 1996) of the upper Yarkhun valley (Fig. 4) is not clear, but they may - in a general way - be lateral equivalents. No fossils were previously known from the Chilmarabad Formation, though a horizon with poorly preserved stromatoporoids "not younger than Middle Devonian" was found above Lashkargaz (H. Flügel, pers. comm., 1994). Another hint to a Devonian age was the coral horizon (H. Flugel in Gaetani et al., 1996, p. 697)

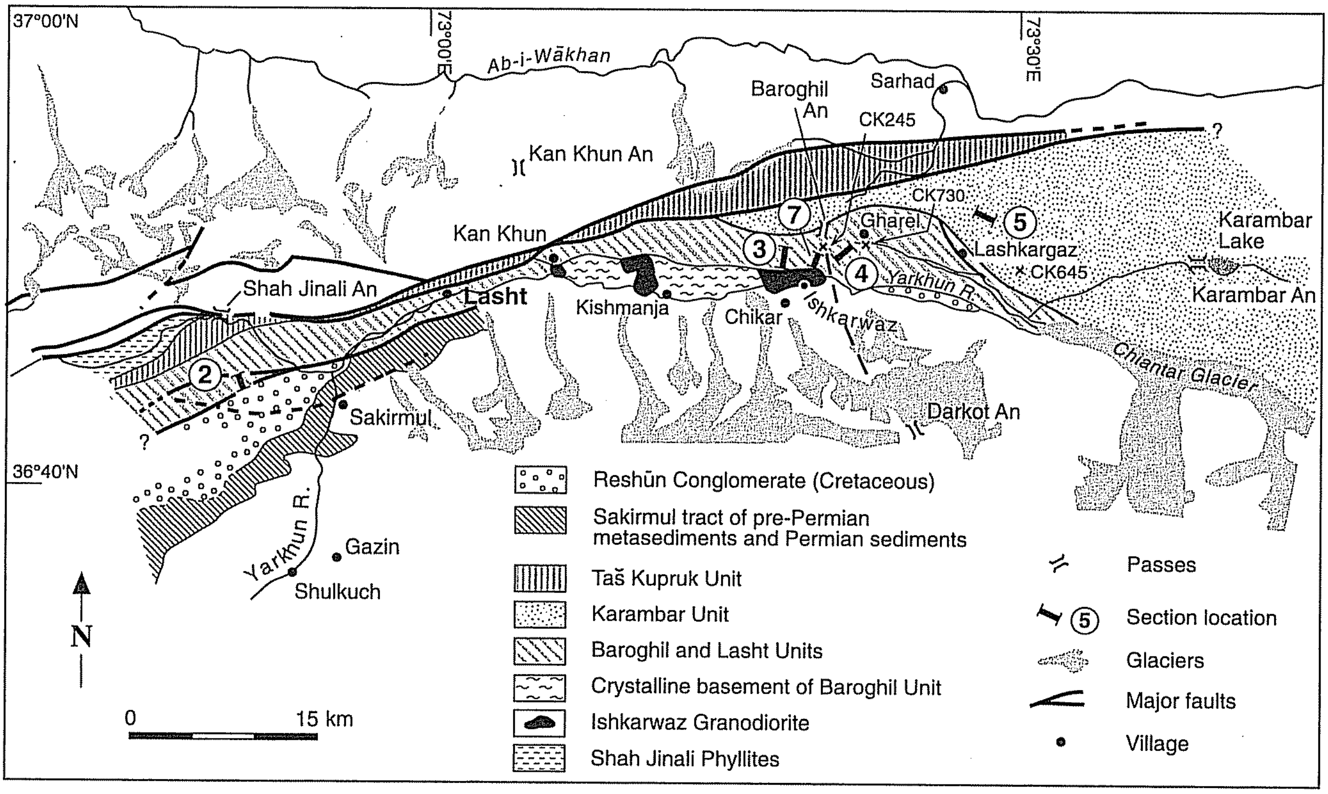


Fig. 3 - Upper Yarkhun River and headwaters of the Karambar River showing tracts of predominantly Ordovician-Devonian sedimentary rocks and location of sampled stratigraphic sections (based on Gaetani et al., 1996, Fig. 3).

from a unit of up to 200 m of fine clastics alternating with arenaceous limestones or dolostones near Chillinji (Gaetani et al., 1996, Fig. 13); this unit overlies an approximately 150 m interval of peritidal dolostones correlated by Gaetani et al. (1996) with their Chilmarabad Formation.

The Shogrām Formation, best exposed along the spur immediately south of Kurāgh, extends southwestwards across the Mastūj River to Shogrām. Farther to the southeast, across Barūm Gol and Owir Gol towards Ojchor Gol and the Lutko valley (Fig. 1), stratigraphic nomenclature and structural relations are not clear. Calkins et al. (1981) included this tract within the Sarikol Shale, though that unit was based on sequences in southwestern Xinjiang, China. Leake et al. (1989) described this tract as consisisting of greenschists, carbonates, cherts, arenites and breccias, and coined the name **Sewakht Formation** for it. Zaman & Tori (1997, Fig. 2A) showed the same tract as embracing the Lun Shales as well as a "Devonian carbonate unit and Yarkhun Limestone". The Shogrām Formation, as construed until now, is demonstrated in the present report to span at least the interval from mid-Givetian to early Famennian and, in what we might refer to as the classic section on Kurāgh Spur, it displays clear sedimentologic differentiation into two units. Because equivalents of these have not been discriminated with confidence along strike northeastwards up the Yarkhun River valley, or southwestwards towards the Lutko valley, we hesitate to raise it to group-level. In the upper Yarkhun valley, the Shogrām Formation is overlain by crinoidal limestones, thought to be Early Carboniferous in age (Gaetani et al., 1996), and these in turn by the Late Palaeozoic Gircha Formation (Fig. 4; Gaetani et al., 1996) a unit based originally on quartzarenites and arenaceous slates with minor carbonates developed in the Hunza and Chapursan valleys (Desio, 1963, 1964) east of the area considered in the present report.

Areas sampled.

1. Kurāgh-Shogrām-Barūm Gol. A stratigraphic section within the Shogrām Formation, cropping out on Kurāgh Spur (Lat. 36° 13' N, Long. 72° 10' E), was sampled by Talent and colleagues in 1973 and 1975. Kurāgh Spur is located on the eastern side of the Mastūj River, approximately 7.5 km northeast of Reshūn (Fig. 1, 2). The location of this section, and the relationship of the Shogrām Formation to the underlying Charun Quartzite is shown in the profile of the southern face of Kurāgh Spur (Fig. 2 and 5 inset). Because of excellence of exposure and good palaeontologic data from the Shogrām Formation, we designate the section through the Charun Quartzite and Shogrām Formation along the Kurāgh Spur to be the type sections of these two formations. In this area (Fig. 2) the Charun Quartzite - a

more heterolithic unit than the name would imply - passes gradationally upwards into the approximately 230-m-thick shale-limestone-arenite succession (Figs. 4, 5) to which the name Shogrām Formation was first applied. The Shogrām Formation has been said to be about 800 m thick (Bender & Raza, 1995; Kazmi & Qasim Jan, 1997), but we know of no areas where thicknesses approach this figure; thicknesses elsewhere appear to be generally less than at Kurāgh, e.g., 180 m on the Yarkhun River section and about 80 m at Chillinji (Fig. 4). The Kurāgh sequence is faulted down on the northwest against a tract of quartzarenites thought to be a repetition of Charun Quartzite, and these in turn against a sequence of slates with subordinate arenites and limestones to which the name Lun Shale was applied by Desio (1966).

2. Istar and Warkup. The strata exposed on the Kurāgh Spur extend northeastwards to Istar and Warkup in the Turikho River valley (Fig. 1) and from there towards the Shah Jinali Pass (Fig. 1, 3). Very fossiliferous limestone "of probably upper Devonian" age was earlier reported (Tipper, 1924, p. 47) from Warkup. Samples for acid-leaching for conodonts were collected from several localities but only two, PJC 1 and 2 (see Appendix), produced biostratigraphically useful faunas.

3. Upper Yarkhun River and upper Karambar River watersheds. Only two outcrops of indubitably Devonian rocks had been recorded from the upper Yarkhun valley prior to the early 1970s. In 1899, I. H. Grant collected a macro-fauna from a dark grey limestone sequence at Showar Shur. This fauna, for which there is insufficient locality data, was examined and described by Reed (1911) who suggested an Early Devonian age. The fauna could be younger; it is in need of re-study. Hayden (1915) reported quartzites and siliceous limestones on the "southern shore of a lake, south of Baroghil Village"; he reported a macro-fauna of poorly-preserved spiriferid brachiopods which he considered to be Late Devonian. Reed (1922), who examined Hayden's fauna, considered the brachiopods to indicate a Middle Devonian age. Preliminary reports on investigations in the Baroghil area in 1973 were given by Talent et al. (1976, 1982) and Tahirkheli (1982); a preliminary report on the presence of strata of Ordovician age in the region was presented by Talent & Mawson (1979, p. 83). More extensive regional mapping and tectonic interpretation was undertaken subsequently by Gaetani and colleagues in 1992 and 1996 (Gaetani, 1997; Gaetani et al., 1990, 1996; Zanchi, 1993; Le Fort et al., 1994; Le Fort & Gaetani, 1998; Tongiorgi et al., 1994; Amerise et al., 1998). Conodont data derived from sampling undertaken during the Gaetani expeditions are presented in this report. Acritarch floras obtained from shales, siltstones and arkosic sandstones collected by Gaetani et al. from the Yarkhun Formation low in the Vidiakot section (Fig. 4) have been shown (Amerise et al., 1998) to be indicative of the interval late early Arenig (*nitidus* or *gibberulus* Graptolite Zone) to late Arenig (*hirundo* Graptolite Zone).

4. Owir An. The southernmost occurrence of indubitable Devonian in Chitral is a sequence of siliceous shales, quartzose conglomerate, red argillaceous shales, siliceous limestones and quartzites, and fossiliferous oolitic limestones in the vicinity of Owir An on the flank of Tirich Mir (Fig. 1); this tract is clearly a continuation of the Kurāgh-Shogrām-Barūm Gol Devonian outcrop-tract, extending across Owir Gol (the main right bank tributary of Barūm Gol) into Ojchor Gol. It was first noted by Tipper (1924, p. 47) in the Owir gorge where he reported it as containing "typical upper Devonian fossils" including corals; he suggested that the section extended to higher horizons than preserved at Kurāgh and Shogrām. Subsequently *Receptaculites neptuni* Defrance was reported from limestones from what was believed to be the top of the sequence on "the western ridge between the Ojchor Valley and Owir An, close by the mule-track" at an altitude of 4000 m. The limestones were reported to be much recrystallised oolitic biosparites with crinoid ossicles partly or entirely replaced by haematite and sporadically with small chamosite crystals (Vogeltanz, 1968, 1969; Diemberger, 1968; Vogeltanz & Diemberger-Sironi, 1969). This sequence has not been investigated by us, but a block of oolitic limestone with *Receptaculites* (sample PJC 3), found loose in Ojchor Gol about a kilometre above its junction with the Lutkho River, is assumed to have been probably derived from the *Receptaculites* horizon or thereabouts. This block has produced a chronologically constraining fauna of Frasnian (but not latest Frasnian) conodonts (see below). The geographically nearest previously described receptaculitids, also of Frasnian age, are from 16 localities in the Dasht-e-Nawar area of east-central Afghanistan about 400-500 km southwest of Owir An. Because these were described (Nitecki & de Lapparent, 1976) as a new species, *Receptaculites chardini*, the taxonomic assignment of the receptaculitid from the vicinity of Owir An should perhaps be reconsidered.

Conodont data and implications.

The data presented here were derived from acid-leaching more than 100 samples mostly from six stratigraphic sections (Fig. 4); more than half of the samples came from Kurāgh Spur and the adjacent area between

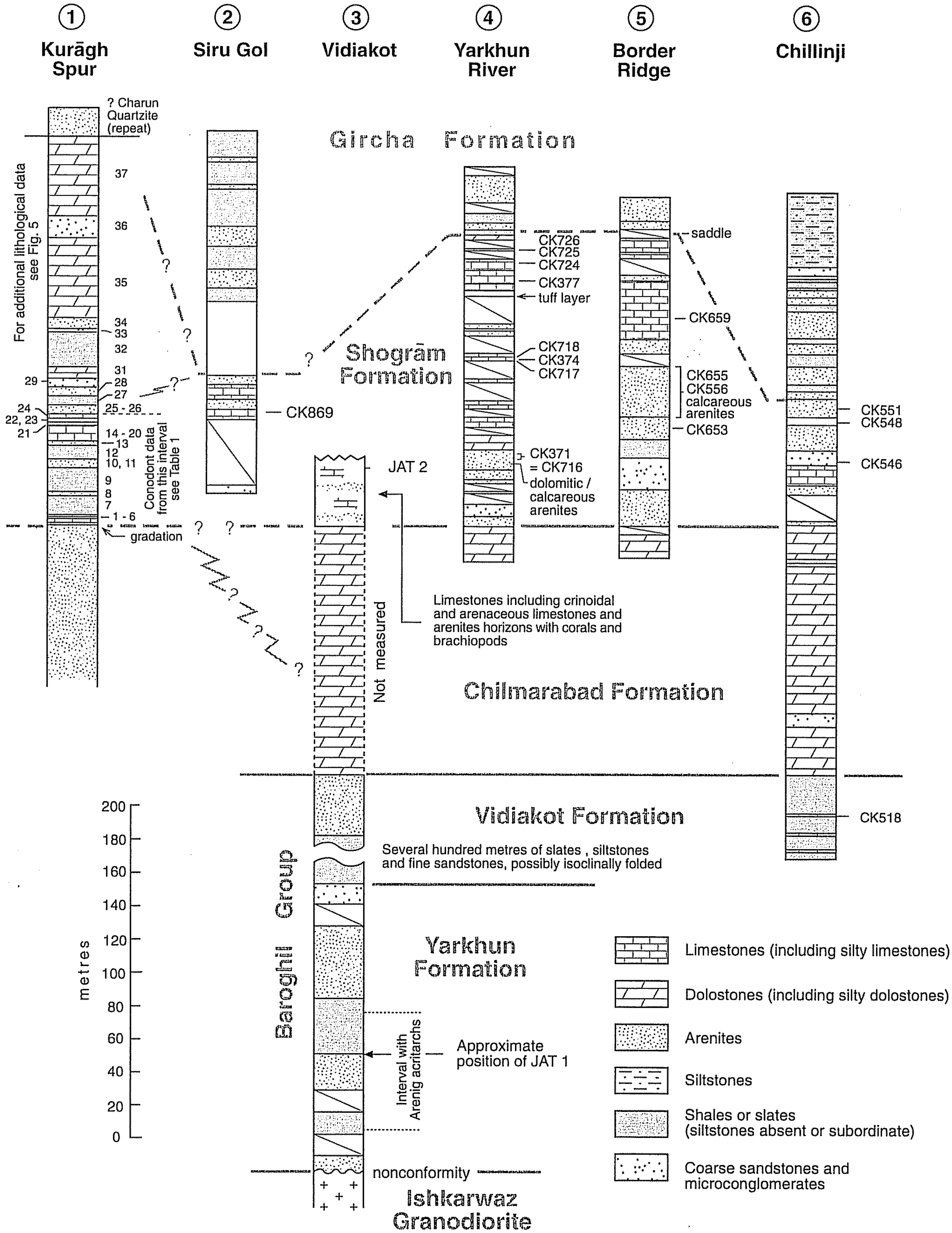


Fig. 4 - Generalised stratigraphic columns for the Ordovician to Devonian sequences in the watershed of the Mastūj/Yarkhun River and the upper Karambar River - the Kurāgh Spur section sampled by Talent and colleagues and five other sections sampled by Gaetani and colleagues. Only horizons productive for macro- and microfauna are indicated.

Barūm Gol and Istar (Fig. 2). The conodont zonal scheme forming the basis of the discussion of data from each area is presented in Fig. 6.

1. Kurāgh Spur section (KUR). A total of 45 samples (averaging 1 kg in weight) were treated from this section (Fig. 5), five from the dolostone intervals (units 31, 35 and 37) in the upper 161 m of section, the remaining 40 from carbonate intervals in the limestones, calcareous sandstones, shales and arenites making up the lower part of the section. Samples from the dolostones were barren, but 25 samples from the lower portion of the section produced conodonts. In addition to 597 conodont specimens, a large collection of other micro-fossils including vertebrate micro-remains, scolecodonts, ostracodes, foraminifers and tentaculitids was recovered. The conodonts are medium to dark grey in colour, opaque and moderately well preserved. With the exception of the vertebrate remains, all other micro-fossils are preserved as very fine-grained iron-oxide pseudomorphs. The fauna is dominated by specimens of *Icriodus* indicating a shallow shelf environment (cf. Sandberg & Dreesen, 1984). The distribution of conodonts is shown in Table 1 and summary of inferred ages in Fig. 7.

Conodont data indicate that the lowest horizons of the KUR section are Givetian in age. At 18-20 m above the base of the section, in the vicinity of interval 9A, it passes into horizons of Frasnian age. Between intervals 17 and 19 - at 51-53.5 m above the base of the section - it passes into Famennian. In sample KUR A, a horizon transitional from the Charun Quartzite, the presence of *Polygnathus linguiformis weddigei* shows that the basal beds of the section are no younger than Middle *varcus* Subzone. The occurrence of *P. varcus* in KUR 5, at 4.9 m above the base of the section, is indicative of the Middle to Late *varcus* Subzones. The last occurrence of *P. timorensis* in sample KUR 8, c. 18 m above the base of the section, indicates that this horizon is no younger than *hermanni* Zone. The fauna of sample KUR 9A includes specimens of *Icriodus subterminus*, which first appears in the *disparilis* Zone in North America, e.g. the Slave Point Formation (Uyeno in Norris & Uyeno, 1983) and the Cedar Valley Limestone (Rogers, 1998). In other parts of the world it appears close to the Givetian-Frasnian boundary, e.g., in China (Ji & Ziegler, 1993). In the same sample (KUR 9A), *P. brevilamiformis*, a form considered to make its first appearance in the early Frasnian (e.g., Barskov et al.,

Conodont Taxa \ Sample No.		KUR A	KUR 1	KUR 2	KUR 3	KUR 5	KUR 6	KUR 8	KUR 9A	KUR 9C	KUR 9E	KUR 11	KUR 12	KUR 13	KUR 14	KUR 15	KUR 16	KUR 17	KUR 18	KUR 19	KUR 20	KUR 21	KUR 22	KUR 23	KUR 24	CK 374	CK718
Icriodus alternatus alternatus morph 1	I																			1	5	5	4	1	3		6
Ic. a. alternatus morph 2	I																			10	12	7	5	3		2	3
Ic. a. mawsonae	I																					6	1			1	3
Ic. brevis	I	8		4																							
Ic. expansus	I	4	11	10	1	9	22	4	1																		
Ic. homeomorphus	I																			21	39	20	1	2	1	2	17
Ic. iowaensis iowaensis	I																					3				?2	?1
Ic. i. ancylus	I																										cf.1
Ic. latericrescens latericrescens	I				5		17	3																			
Ic. subterminus subterminus	I								2			3	6	5	15	3	7	1	3								
Ic. s. uyenoi	I												4	5	4			1									
Ic. symmetricus	I									2	3	7	12	22	25		10	6	11								
Icriodid elements	M				7		1	1													1						
Palmatolepis minuta minuta	Pa																			2							
Pal. tenuipunctata	Pa																			2							
Polygnathus unicostatus	Pa							1																			
P. webbi	Pa																				1				2		
P. politus	Pa																					2	1	2	3		
P. aspelundi	Pa																			2	1						
P. brevilamiformis	Pa								2	1			1						1								
P. cf. *brevilaminus*	Pa																					5			1		
P. capollocki	Pa																	1		2		11	4	3	28		
P. decorosus	Pa										1			1				1	1	3	4						
P. cf. *decorosus*	Pa																				1	2	2	3	16		
P. linguiformis klapperi	Pa	1					1																				
P. l. weddigei	Pa						1																				
P. timorensis	Pa			1		1		2																			
P. varcus	Pa					1																					
P. ssp.	Pa						1	2		1										2				4			
Unassigned elements	Pb																					1		1	3		
	M																				1		1				
	Sb	1																							1		
	Sc						1						1							1		1	2	4	4		

Tab. 1 - Conodonts from the Shogrām Formation on the Kurāgh Spur (KUR) and from sections in the watershed of the upper Yarkhun River (prefix CK).

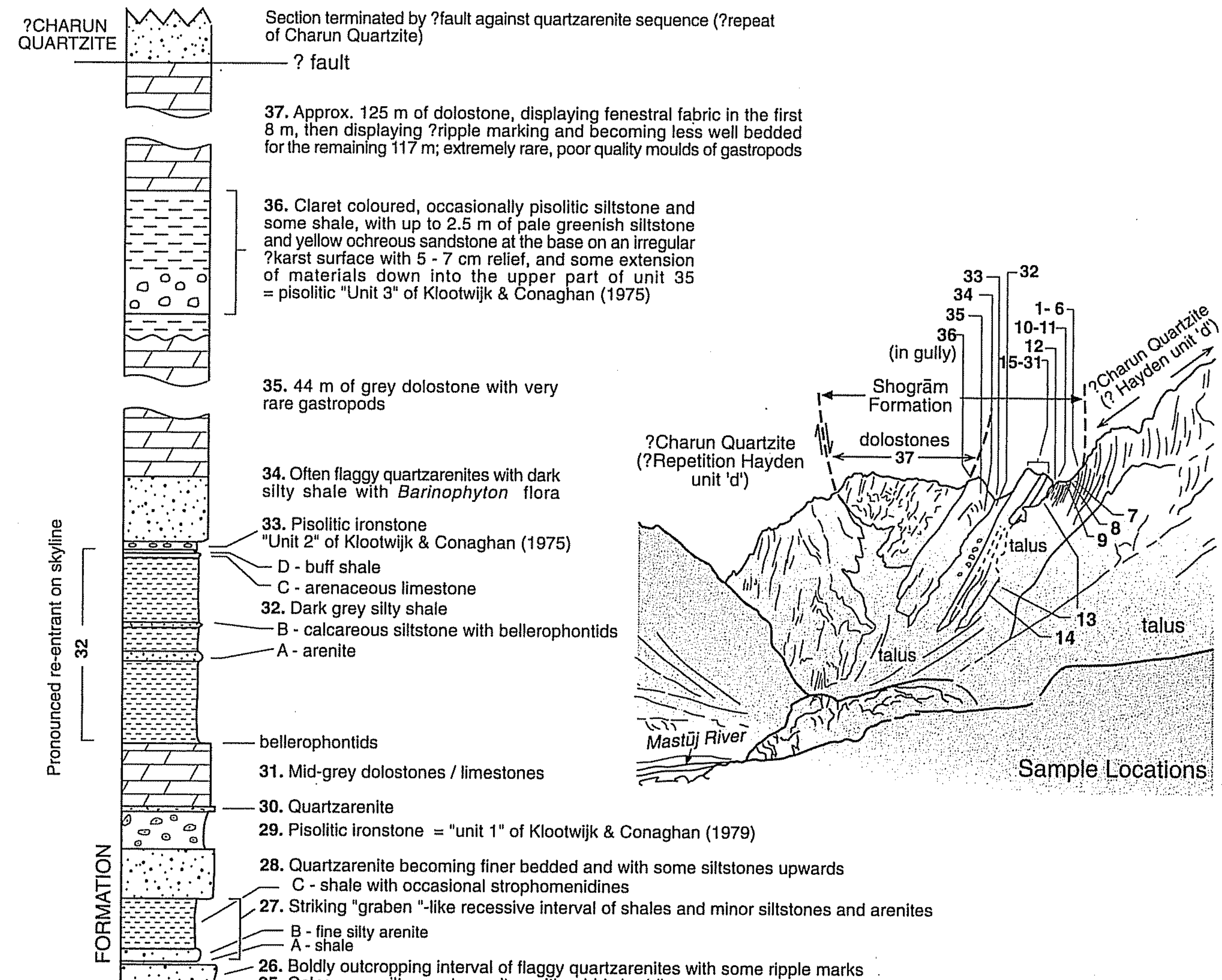


Fig. 5 - Kurāgh Spur stratigraphic column measured and sampled by Talent and colleagues in 1973 and 1975, with profile of the spur from the southwest showing topographic expression of salient horizons sampled - drawn (JAT) from a photograph. All carbonate intervals were sampled for macrofauna and conodont data; horizons producing identifiable conodonts are indicated in Table 1.

1991), also occurs, but as there is some uncertainty as to the status of this species, a definite Frasnian age for the sample cannot be advanced with confidence. Based on ages given in the Catalogue of Conodonts (Ziegler ed., 1973), and Klapper (1997), the first appearance of *P. decorosus* in KUR 9E indicates an age no older than Late *hassi* Zone.

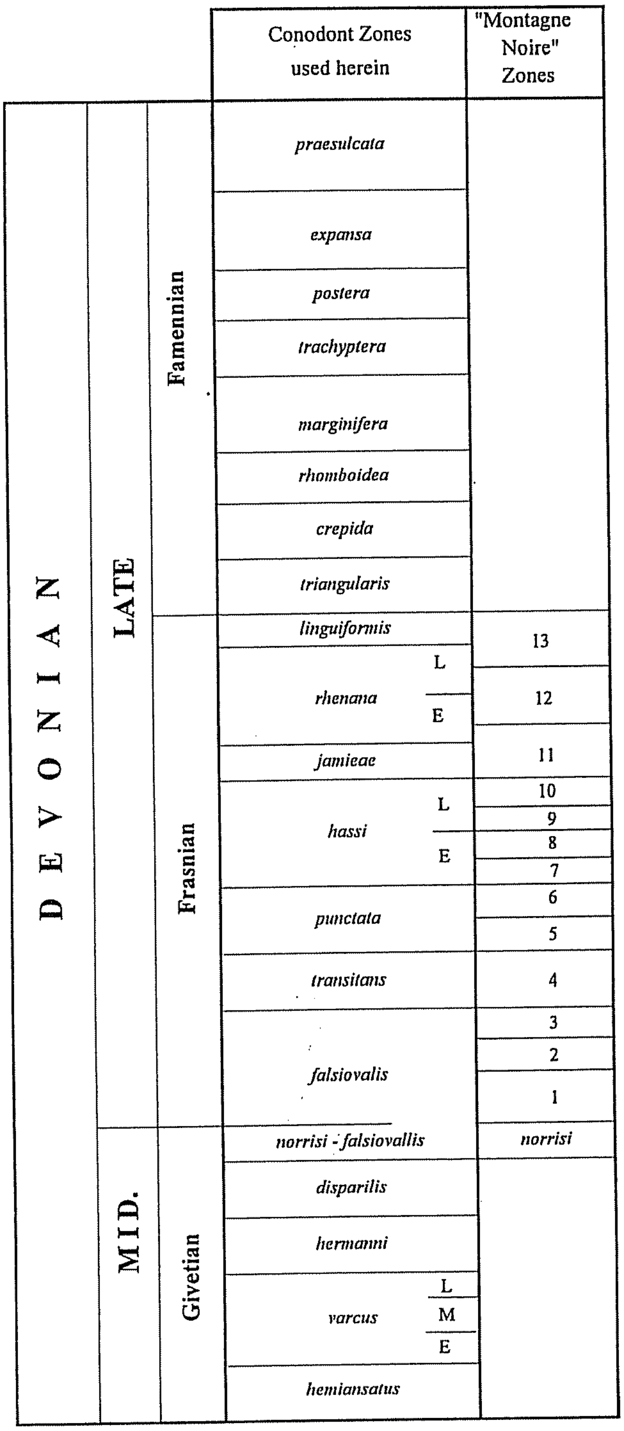


Fig. 6 - Alignment of Devonian conodont zonal schemes. The zonation in the column on the left is based on Ziegler & Sandberg (1990), the portion of the Middle Devonian follows Weddige (1996), and the Montagne Noire intervals in the column on the right are based on Klapper (1989) and Klapper & Beckker (1998, 1999).

Savage (1992) suggested that *I. subterminus uyenoi* was restricted to the *rhenana* Zone. Faunas from his locality 9 in the Wadleigh Limestone of southeastern Alaska lack zonally diagnostic taxa which might help specify a lower age limit but the presence of *P. angustidiscus* in his locality 10 suggests the last occurrence to be no younger than Early *rhenana* Zone. The highest occurrence of *I. s. uyenoi* in KUR 17 is assumed to be similarly restricted in age.

At KUR 19, the presence of *Palmatolepis tenuipunctata*, and *Pal. minuta minuta* indicates an age no older than Late *triangularis* Zone. From KUR 21 to KUR 24, a new Famennian icriodontid species, *I. homeomorphus*, makes its first appearance together with *I. alternatus mawsonae*, a possible *Icriodus iowaensis iowaensis*, and other species which cross the Frasnian-Famennian boundary such as *I. alternatus alternatus* morph A, *I. a. alternatus* morph 2, *Polygnathus politus* (= *P. pacificus*) and *P. webbi*. As sections in Iran (Yazdi, 1996, 1999) give the range for *I. alternatus mawsonae* as from Late *triangularis* Zone to Early *crepida* Zone, a similar age is assigned to these horizons (see discussion of the age of *I. homeomorphus* sp. nov. in the section on taxonomy below).

The post-KUR 24 portion of the Kurāgh Spur section, about 161 m dominated by coarser clastics and dolostones displays at least three significant regressions/hiatuses indicated by intervals of chamositic, pisolitic sedimentary ironstones and plant fossils (Conaghan in Klootwijk & Conaghan, 1979, and in Klootwijk et al., 1994). The sequence is assumed to extend well up into the Famennian and conceivably could extend into post-Famennian horizons.

2. Upper Yarkhun valley Ordovician. Sample JAT 1 is a fine-grained limestone from a carbonate-siltstone interval 50 m or more above the base of a reconnaissance stratigraphic section (approximating the Vidiakot section - No 3 of Fig. 1 and 3 - sampled by Gaetani) commencing 2.5 km west-northwest of the bridge over the Yarkhun River near Ishkarwaz. It produced a small Ordovician conodont fauna of 19 specimens (Table 2). A preliminary single-element evaluation of the fauna was presented earlier (Molloy in Talent & Mawson, 1979, and in Talent et al., 1982). Arenig acritarchs have been reported from a small outcrop on the left side of the track from Ishkarwaz bridge to Baroghil Pass (No 7 on Fig. 3; Tongiorgi et al., 1994; Le Fort et al., 1994; Amerise et al., 1998). Acritarchs were also found by Tongiorgi at approximately the same levels and somewhat higher in the shales, siltstones and arkosic sandstones of the Vidiakot section - from broadly the same stratigraphic interval as the conodonts documented here (Pl. 1). The age-range of the acritarch floras has been

LOCALITY	PRODUCTIVE SAMPLES	AGE DETERMINATION
Shogrām Formation at Kurāgh Spur	25	KUR 21–24: Famennian (Late *triangularis* to Early *crepida* Zone) KUR 19: early Famennian (no older than Late *triangularis* Zone) KUR 17: Frasnian (no older than Early *rhenana* Zone) KUR 9E: Frasnian (no older than Late *hassi* Zone) KUR 9A: close to the Givetian–Frasnian boundary KUR 8: late Givetian (no younger than *hermanni* Zone) KUR 6: late Givetian (Middle to Late *varcus* Zone) KUR A: late Givetian (no younger than Middle *varcus* Zone)
CK 718	1	Early Famennian (Late *triangularis* to Early *crepida* Zone)
CK 374	1	Early Famennian (probably Late *triangularis* to Early *crepida* Zone)
PJC 3 (Ojchor Gol)	1	Late Frasnian (Late *hassi* to Early *rhenana* Zone)
PJC 1 (3.2 km SW of Istar)	1	Late Frasnian (? Late *hassi* Zone)
PJC 2 (near Warkup)	1	Late Givetian (possibly *hermanni* Zone)
JAT 2 (Upper Yarkhun valley)	1	Late Frasnian (no younger than Early *rhenana* Zone)
JAT 3 (Gosh Lasht)	1	Early Emsian (*dehiscens* Zone)
JAT 1 (Upper Yarkhun valley)	1	Arenig-?Llanvirn

Fig. 7 - Summary of ages inferred from conodont data from northernmost Pakistan.

suggested (Amerise et al., 1998) as being between late early Arenig (*nitidus* or *gibberulus* Graptolite Zone) and late Arenig (*hirundo* Graptolite Zone).

Elements of a species of the conodont genus *Baltoniodus* are present including: 1) an M (oistodiform) element; 2) an Sa (trichonodelliform) element; 3) an Sb - oepikodiform according to Lindström's terminology (in Ziegler, ed., 1977), or a belodontiform/?paracordylodontiform according to Löfgren (1978); 4) an Sd (tetraprioniodiform) element; and possibly, 5) a P (ambalodiform) element. For confident identification, an amorphognathiform P element is required. The range of the genus *Baltoniodus* is Arenig (Billingen Substage) *Oepikodus evae*-Llanvirn *Pygodus anserinus* conodont zone, but a more precise age may de derived from closer examination of the forms present. *Baltoniodus medius*, with which the form of *Baltoniodus* has been closely compared (see Systematics) ranges from the lower *variabilis* Zone (uppermost Arenig) to upper *suecicus* Zone (lowermost Darriwilian = lower Llanvirn). The *Drepanoistodus* M element is referred to *D. basiovalis*; this is consistent with the age indicated by *B.* cf. *medius*. There is thus broad agreement with the age indicated by the acritarch floras.

Conodont Taxa \ Sample		JAT 1 (Upper Yarkhun valley)
Baltoniodus cf. *medius*	P	1
	M	1
	Sa	1
	Sb	1
	Sd	1
Plectodina? sp.	?	1
Drepanoistodus basiovalis	M	1
	Sa	1
Drepanoistodus sp.	S	3
Cornuodus sp. cf. *C. longibasis*	?	2
Paraprioniodus? sp.	?	2
Lenodus? sp.	?	2

Tab. 2 - Ordovician conodonts from the upper Yarkhun valley (JAT 1).

3. Gosh Lasht. The single sample (JAT 3; Fig. 2) produced 46 specimens belonging to nine conodont species (Table 3). The fauna includes several extremely long fragile Sb and Sc elements. All specimens are opaque, dark grey to black and not particularly well preserved; some are cracked, but there is no evidence of reworking.

Based on the occurrence of *Polygnathus dehiscens* Philip & Jackson together with *Pandorinellina steinhornensis steinhornensis* (Ziegler), *Pand. s. miae* (Bultynck), and *Ozarkodina prolata* Mawson, the age of the fauna can be given as late Early Devonian, early Emsian *dehiscens* or *gronbergi* (= *perbonus*) zones. Whereas *P. dehiscens* is normally restricted to the *dehiscens* Zone in most parts of the world, it has been recorded as extending into the *gronbergi* Zone in Nevada (Klapper & Johnson, 1975), the Salmontrout Limestone in east–central Alaska (Lane & Ormiston, 1979), the Khodzha Kurgan and Zinzilban sections in the Zeravshan Range of

Uzbekistan (Apekina & Mashkova, 1978; Mashkova, 1978) and Australia (Mawson, 1987).

4. Upper Yarkhun valley Devonian. Sample JAT 2 from 38 m above the base of the Shogrām Formation in the Baroghil tectonostratigraphic unit 2.5 km west-northwest of Ishkarwaz bridge (Fig. 3) produced an assemblage of 21 ichthyoliths and 33 conodonts, 31 of which were generically identifiable. Only two genera, *Icriodus* and *Polygnathus*, are represented in the fauna; two specimens of *Polygnathus* and 15 specimens of *Icriodus* were sufficiently well preserved to be identified at species-level. Two forms of *Icriodus* are represented, similar to *I. subterminus subterminus* and *I. subterminus uyenoi* - both encountered in the faunas from Kurāgh. These give a late Frasnian age (no younger than Early *rhenana* Zone) and, because of the composition of the fauna, possibly equate with intervals KUR 12-17 in the Kurāgh Spur section (see above).

Few of the many limestone samples collected by Gaetani and colleagues from the five sections between Chillinji and Siru Gol produced conodonts when acid-leached. Of special interest is CK 718 (Table 1) from 104 m above the base of the Shogrām Formation in the Yarkhun River section (Fig. 4). It is dated as early Famennian - within the interval from Late *triangularis* Zone to Early *crepida* Zone. This inference is based on co-occurrence of *Icriodus alternatus alternatus* morph 1 with *I. a. alternatus* morph 2, *I. a. mawsonae*, *I. iowaensis iowaensis* and a new icriodontid *I. homeomorphus* (Table 1). Except for one Pb element, the fauna consists of icriodontids suggesting a shallow shelf environment. The association is indicative of a horizon approximately identical in age to the youngest productive horizon on the section at Kurāgh Spur. Sample CK 374 from the same section, approximately 1 m below CK 718, contains fragments of what appears to be *I. a. mawsonae* and is assumed to be the same age as CK 718. The faunas from CK 371 and 724 consist of a few specifically unidentifiable non-platform elements with, in the case of CK 371, an icriodontid of uncertain affinities.

Sample CK 823, from the Vidiakot section about 250 m below the base of the Chilmarabad Formation, within the interval shown in Fig. 4 as consisting of "several hundred metres of slates, etc." has produced fragments of icriodontids - as well as specifically unidentifiable fragments of two polygnathids - indicating that the horizon is indubitably Devonian, late Pragian or younger.

Perhaps significant is that no late Givetian-early Frasnian interval has been identified in the sequences sampled in the upper Yarkhun River watershed or at Chillinji in the headwaters of the Karambar River, but the number of productive samples was minimal and none were from the basal 100 or so metres of the Shogrām Formation, nor from the underlying dolostones of the Chilmarabad Formation. Further sampling in the upper Yarkhun-upper Karambar region is therefore warranted to determine if the late Givetian-early Frasnian interval occurs in that region and if the limestones stratigraphically above CK 718 extend into middle Famennian and younger horizons.

Sample / Conodont Taxa		JAT 3 (Gosh Lasht)
Belodella sp. cf. *B. triangularis*		2
Ozarkodina excavata excavata	Pa	3
	M	4
	Sa	5
	Sb	1
	Sc	4
Oz. prolata	Pa	2
	Pb	7
Pandorinellina steinhornensis miae	Pa	4
Pand. s. steinhornensis	Pa	4
Polygnathus dehiscens	Pa	4
Pseudooneotodus beckmanni		1
Unassigned elements	M	1
	Sa	1
	Sb	5
	Sc	2

Tab. 3 - Early Devonian (early Emsian) conodonts from the "Lun Shale" at Gosh Lasht (JAT 3).

5. Southwest of Istar. Sample PJC 1 (Fig. 2) produced a comparatively large but poorly preserved fauna of 67 conodonts (Table 4) and 14 ichthyoliths. The conodonts are dark grey and have a sucrose appearance. Using the composite standard ranges of Klapper (1997), co-occurrence of *Icriodus symmetricus*, and *Polygnathus decorosus* is consistent with a Frasnian age, no older than Late *hassi* Zone. Ji & Ziegler (1993) have these two species occurring together with *I. expansus* from the *falsiovalis* Zone to the Early *hassi* Zone in the Lali section of southern China. The illustrated specimens identified by them as *P. decorosus* (Ji & Ziegler, 1993, pl. 40, figs 16-18) lack the geniculation points and distinctive geniculate anterior margins of *P. decorosus*. It is possible that their species-concept may have focused on forms slightly older than the typical forms of *P. decorosus* illustrated in the Catalogue of Conodonts (Ziegler ed., 1973). The age of the spot sample collected close to Istar may therefore be as young as Late *hassi* Zone, but this alignment is tenuous.

Conodont Taxa \ Sample		PJC 1 (SW of Istar)
Belodella resima		3
Belodella triangularis		1
Belodella sp.		1
Icriodus expansus	I	6
Icriodus symmetricus	I	19
Polygnathus decorosus	Pa	29
Unassigned non-platform elements		8

Tab. 4 - Late Frasnian conodonts from southwest of Istar (PJC 1).

6. Warkup. A 1 kg sample (PJC 2; Fig. 2) from an outcrop of limestone turbidites about 1.9 km north of the village of Warkup, produced 32 poorly preserved, dark grey, opaque conodonts, most of which were deformed. The fauna is dominated by icriodontids, some of which have a lateral process meeting the main platform just anterior to the posterior extremity of the unit, as occurs in *Icriodus latericrescens.* A single polygnathid specimen can be assigned to the *Polygnathus linguiformis* group because of its broad, ridged posterior platform tongue. Because of poor preservation, no precise age can be assigned to the fauna, but the icriodontid and polygnathid are consistent with a late Middle Devonian, possibly *hermanni* Zone attribution, and possible alignment with units 3 to 8 low in the Kurāgh Spur section where *I. latericrescens* and polygnathids of the *P. linguiformis* group occur. It should be noted that the section in the vicinity of Warkup - and probably also Istar - is turbiditic and generally thick-bedded with grading, cross-lamination and thick intervals of dark slatey mudrock; the graded limestone beds contain abundant brachiopods and coral detritus indicating a shallower upslope source. It is interpreted as being a generally deeper-water context (probably slope environment) than the Kurāgh section.

Conodont Taxa \ Sample		PJC 3 (Ojchor Gol)
Ancyrodella curvata	Pa	11
Ancyrognathus coeni	Pa	1
Belodella triangularis		1
Icriodus alternatus	I	18
Palmatolepis sp.	Pa	1
Polygnathus webbi	Pa	6
Polygnathus aspelundi	Pa	1
Unassigned non-platform elements		11

Tab. 5 - Late Frasnian conodonts from Ojchor Gol (PJC 3).

7. Ojchor Gol. Sample PJC 3 (see Appendix) consists of dark red, oolitic limestone containing receptaculitids; it produced an acid-resistant residue of haematitic ooids, bryozoans and crinoid fragments, vertebrate micro-remains and 61 conodonts, two-thirds of which could be identified to species level (Table 5). Vogeltanz (1968, 1969), Diemberger (1968) and Vogeltanz & Diemberger-Sironi (1969) had earlier reported the occurrence of *Receptaculites neptuni* (Defrance) in the uppermost oolitic limestone horizons in a sequence of siliceous shale, quartzose conglomerate, red argillaceous shale, siliceous limestone and fossiliferous oolitic limestone from the head of Ojchor Gol, cropping out on the western ridge between it and Owir An. It is assumed that the loose sample may have come from the uppermost horizons of the same unit.

The late form of *Ancyrodella curvata*, first appearing in Late *hassi* Zone (= Montagne Noire Zone 10 of Klapper, 1989 and 1997), provides a maximum age for the sample. Using graphic correlation ranges, Klapper (1997) showed *Polygnathus aspelundi* to span Zones 8 to 11 (late Early *hassi* Zone to Early *rhenana* Zone) but as this is based on only three localities, the range is not necessarily certain. However, as *Ancyrognathus coeni* has a similar range, it appears that the Ojchor Gol fauna is probably not younger than Early *rhenana* Zone. The fauna, considered as a whole, is consistent with an age-range of Late *hassi* Zone to Early *rhenana* Zone. Faunas of similar composition occur in the uppermost Fort Simpson Shale, Redefine and Quakes Formations, southwestern Northwest Territories (Klapper & Lane, 1985), in the Luscar Mountain and Mount Haulation areas, Alberta Rocky Mountains (Klapper & Lane, 1989), and in the Montagne Noire of southern France (Klapper, 1989).

Geographic Relations.

The Karakorum-Hindu Kush conodont faunas show little relationship to faunas described from adjacent regions. The geographically nearest conodont faunas to have been documented are an isolated early Frasnian fauna (late *falsiovalis* Zone) and a sequence of faunas spanning the interval from early Famennian (Middle *crepida* Zone) to mid-Tournaisian (Early *crenulata* Zone) from the southeastern part of the Khyber region of Pakistan (Molloy et al., 1997). These faunas - from zones or intervals not represented in northern Chitral - understandably have little in common with the Givetian-Frasnian and seemingly earliest Famennian faunas from northern Chitral. Ordovician and Devonian conodont faunas from the Karakorum region of western China and from northwest Qiangtang documented by

Wang (1998) also represent intervals mainly not encountered in northernmost Pakistan. For instance, no Frasnian assemblages were encountered among the Qiangtang and Karakorum faunas. Devonian faunas documented from the two regions also diverge in biofacies - icriodontid for northernmost Pakistan, palmatolepid for the horizons from which Wang's samples came.

Systematics.

One stratigraphically and possibly biogeographically important new species is present in the Devonian faunas from northernmost Pakistan. All other forms encountered in this study have been thoroughly documented elsewhere, especially in the Catalogue of Conodonts (Ziegler ed., 1973-1991). They are therefore not formally described, but are illustrated (Plates 1-8), recorded on the distribution charts (Tables 1-4), and their chronologic importance is discussed in the text. Figured specimens are housed in the collections of the Australian Museum, Sydney (AM). Locality data for each sample number can be obtained by reference to the illustrations and distribution charts.

Family B a l o g n a t h i d a e Hass, 1959

Genus *Baltoniodus* Lindström, 1971

Baltoniodus cf. **medius** (Dzik, 1976)

Pl. 1, fig. 1, 11, 12

For synonymy see:
1994 *Baltoniodus medius* (Dzik, 1976) - Dzik, p. 82.

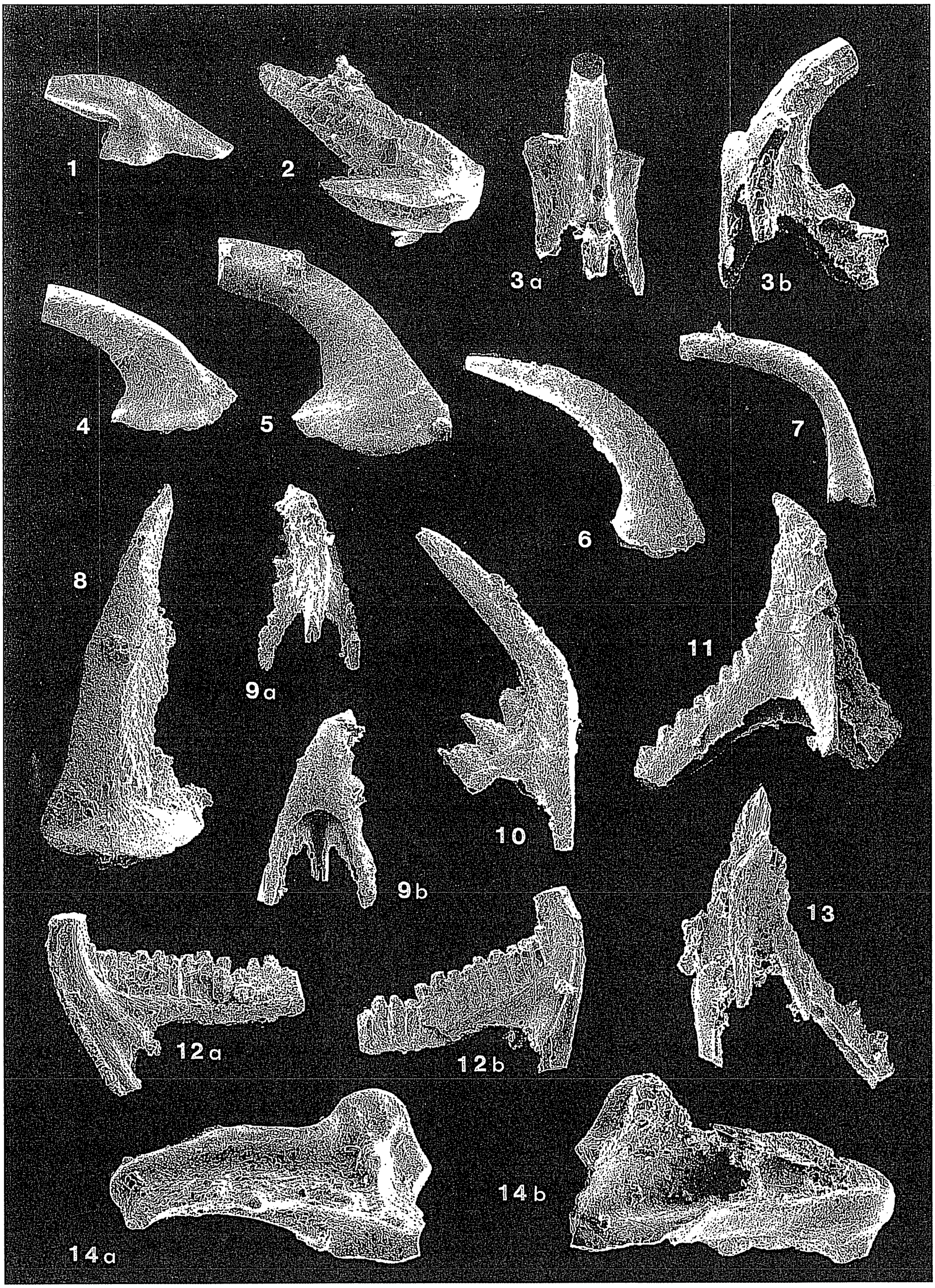
Remarks. The following comment has been supplied by Oliver Lehnert:

The undenticulated M element from the Yarkhun Formation (Pl. 1, fig. 1) is unlike M elements of the oldest species of the genus (*B. navis* and *B. triangularis*) which are denticulate. Undenticulate and a few denticulate M elements have been observed by Löfgren in the slightly younger *B. parvidentatus* (Sergeeva) (=B. *norrlandicus* Löfgren according to Stouge & Bagnoli), but these in general have a long base (cf. Stouge & Bagnoli, 1990). Younger taxa such as *B. medius* and *B. prevariabilis* have undenticulate but highly variable M elements - as occurs in the material from the Yarkhun Formation - but the morphology of this element cannot be used to discriminate between these taxa. Of more importance is that the S elements from the Yarkhun Formation exhibit regular denticulation, whereas younger elements of *B. prevariablis* have hindeodellid denticulation: irregular alternation of smaller and larger denticles on the posterior processes.

The Sb element from the Yarkhun Formation (Pl. 1, fig. 12) shows very regular denticulation of the posterior process. As pointed out by Löfgren (1978), the gothodontiform/Sb element of her *Prioniodus (Baltoniodus) norrlandicus* is highly characteristic for the species. This element has a prominent lateral costa - a kind of process (cf. Dzik, 1994, fig. 14a) which is not present in the Baroghil form. According to Löfgren, the denticles on the posterior process of *B. parvidentatus* are "fused, equal-sized and erect or slightly proclined". It is similar in *B. medius*, but in stratigraphically younger elements of *B. medius* the lateral process becomes "shorter and less free from the aboral margin" (Löfgren, 1978, p. 86). The denticulation of the Sb element from the Yarkhun Formation points to *B. parvidentatus* or *B. medius* but the short lateral process (which seems to be complete) is more typical of *B. medius*. It displays the the thickened edges of the S elements of *B. medius* illustrated by Stouge & Bagnoli (1990). What appears to be a Pa element of *B. medius* (= *Baltoniodus* n. sp. A of Stouge & Bagnoli, 1990) (Pl. 1, fig. 11) has the denticles of the posterior process smaller than in typical *B. medius*. According to

PLATE 1

Fig. 1 - *Baltoniodus* cf. *medius* (Dzik, 1976). JAT 1. AMF 107470. M oistodiform element in lateral view; x 120.
Fig. 2 - *Drepanoistodus basiovalis* (Sergeeva, 1963). JAT 1. AMF 107471. M oistodiform element in oblique lateral view; x 80.
Fig. 3 a,b - *Plectodina*? sp. JAT 1. AMF 107472. Respectively inner and lateral view of fragment showing posterior process; x 120.
Fig. 4 - *Drepanoistodus* sp. JAT 1. AMF 107473. S homocurvatiform element in lateral view; x 80.
Fig. 5 - *Drepanoistodus* sp. JAT 1. AMF 107474. S homocurvatiform element in lateral view; x 80.
Fig. 6 - *Drepanoistodus* sp. JAT 1. AMF 107475. S homocurvatiform element in lateral view; x 80.
Fig. 7 - *Cornuodus* sp. cf. *C. longibasis* (Lindström, 1955). JAT 1. AMF 107476. Element in lateral view showing recurved cusp and sub-circular basal cavity margin; x 80.
Fig. 8 - *Drepanoistodus basiovalis* (Sergeeva, 1963). JAT 1. AMF 107477 Sa subrectiform element in lateral view; x 80.
Fig. 9 a,b - *Baltoniodus* cf. *medius* (Dzik, 1976). JAT 1. AMF 107478. Sa trichonodelliform element, respectively inner and outer view showing basal cavity; x 120.
Fig. 10 a,b- *Paraprioniodus*? sp. JAT 1. AMF 107479. Lateral view of broken specimen; x 120.
Fig. 11 - *Baltoniodus* cf. *medius* (Dzik, 1976). JAT 1. AMF 107480. P ambalodiform element with one denticulated and one undenticulated antero-lateral process in addition to denticulated posterior process, in oblique lateral view; x 120.
Fig. 12 - *Baltoniodus* cf. *medius* (Dzik, 1976). JAT 1. AMF 107481. Sb element with almost complete posterior process in lateral view; x 120.
Fig. 13 - *Baltoniodus* cf. *medius* (Dzik, 1976). JAT 1. AMF 107482. Poorly preserved Sd element with 4 processes in oblique antero-lateral view; x 120.
Fig. 14 a,b- *Lenodus*? sp. JAT 1. AMF 107483. Respectively upper and lower view showing deeply excavated cavity; x 120.


1
2
3 a
3 b
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5
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9 a
9 b
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11
12 a
12 b
13
14 a
14 b

Stouge & Bagnoli (1990, p. 13) the denticles of the lateral process of *B. medius* are mainly confluent whereas the anterior process is serrated to denticulate. The Sa element (Pl. 1, fig. 9a, 9b) is not very characteristic for determination of *Baltoniodus* species. Unfortunately, the Sd/tetraprioniodiform element (Pl. 1, fig. 13) is too poorly preserved to observe a hindeodellid or regular pattern in denticulation of the posterior process.

Family Icriodontidae Müller & Müller, 1957

Genus *Icriodus* Branson & Mehl, 1938

Icriodus homeomorphus n. sp. Mawson

Pl. 5, fig. 2-5, 8, 12-14; Pl. 7, fig. 12, 13, 16

1999 *Icriodus alternatus* morphotype 2 Dreesen & Houllebergh̀s - Yazdi, Pl. 1, fig. 11, 13, 14.

Material. Numerous specimens including 10 figured specimens, AMF 107504-7, 14-16, 40, 41 and 43.

Derivation of name. *homeo* (Gr.) = like, resembling; *morphe* (Gr.) = form or shape; in reference to the similarity of this Famennian icriodontid to forms occurring in the Middle Devonian.

Holotype. AMF 107515, the specimen illustrated herein as Pl. 5, fig. 13.

Type locality. CK 718 (Fig. 4).

Type stratum. Shogrām Formation.

Diagnosis. A species of *Icriodus* with an asymmetrically expanded basal cavity and with lateral rows of subcircular, isolated denticles tapering outwards from a single node at the anterior end and with the slightly laterally compressed denticles of the median row vertically connected to form a fine nodose medial crest that extends posteriorly and curves outwardly for at least two nodes beyond the lateral rows.

Description. From the anterior, the basal cavity closely follows the shape of the spindle for half the length of the unit before expanding asymmetrically - with the inner expansion being at maximum width at mid-length of the unit, and the outer expansion reaching maximum width close to the posterior margin. The spindle is long, narrow, with its posterior end curved outwardly and tapering rapidly from mid-length to the anterior extremity. In upper view, 7 or 8 pairs of round, discrete lateral-row denticles extend posteriorly from a single node for slightly more than three-quarters the length of the unit. In large specimens, the lateral denticles show a tendency to be horizontally compressed but do not form a tie with the median denticles, except for the first one or two at the anterior extremity. In contrast, the median row is made up of laterally compressed denticles that are vertically fused to form a medial, nodose crest extending posteriorly beyond the lateral rows. The nodes of this extension are less clearly defined, curving outwardly, and the posterior extremity of the upper surface of the unit overhangs the basal cavity slightly. In lateral view, the lateral denticles appear to be slightly higher than those of the median row. The dorsal profile is generally level with a slight tapering from the posterior to the anterior end of the unit.

Remarks. This early Famennian species of icriodontid resembles several Middle Devonian species. It has a basal cavity reminiscent of that of *I. fusiformis* but the arrangement of the denticles on the upper surface differs greatly; the lateral denticles are not clearly tied to the median denticles and the median row does not extend posteriorly as a single row. *I. corniger* lacks the outward curvature of the extension of the median row of denticles. The basal cavity of *I. expansus* is much more symmetrical than that of *I. homeomorphus.*

Yazdi (1999, Pl. 1, fig. 11, 13, 14), in documenting Late Devonian-Carboniferous conodont faunas from eastern Iran, illustrates this new species, referring it to *I. alternatus* Morphotype 2. As *I. alternatus* is a narrow form with the rows of lateral denticles subparallel, two of Yazdi's illustrated specimens are assigned to the new

PLATE 2

Fig. 1 - *Ozarkodina excavata excavata* (Branson and Mehl, 1933). JAT 3. AMF 107484. Lateral view of fragmentary Pa element showing narrow triangular basal cavity in inner lateral view; x 45.

Fig. 2 a,b - *Pandorinellina steinhornensis steinhornensis* (Ziegler, 1956). JAT 3. AMF 107485. Respectively lateral and upper view of typical specimen with anteriormost denticles slightly larger than other denticles, inwardly deflected posterior third of blade, and asymmetrical cavity margins with small node on outer margin shown in (a); x 45.

Fig. 3 a,b - *Pandorinellina steinhornensis steinhornensis* (Ziegler, 1956). JAT 3. AMF 107486. Respectively upper and lower view of a Pa element with outer margin atypically more angular; x 45.

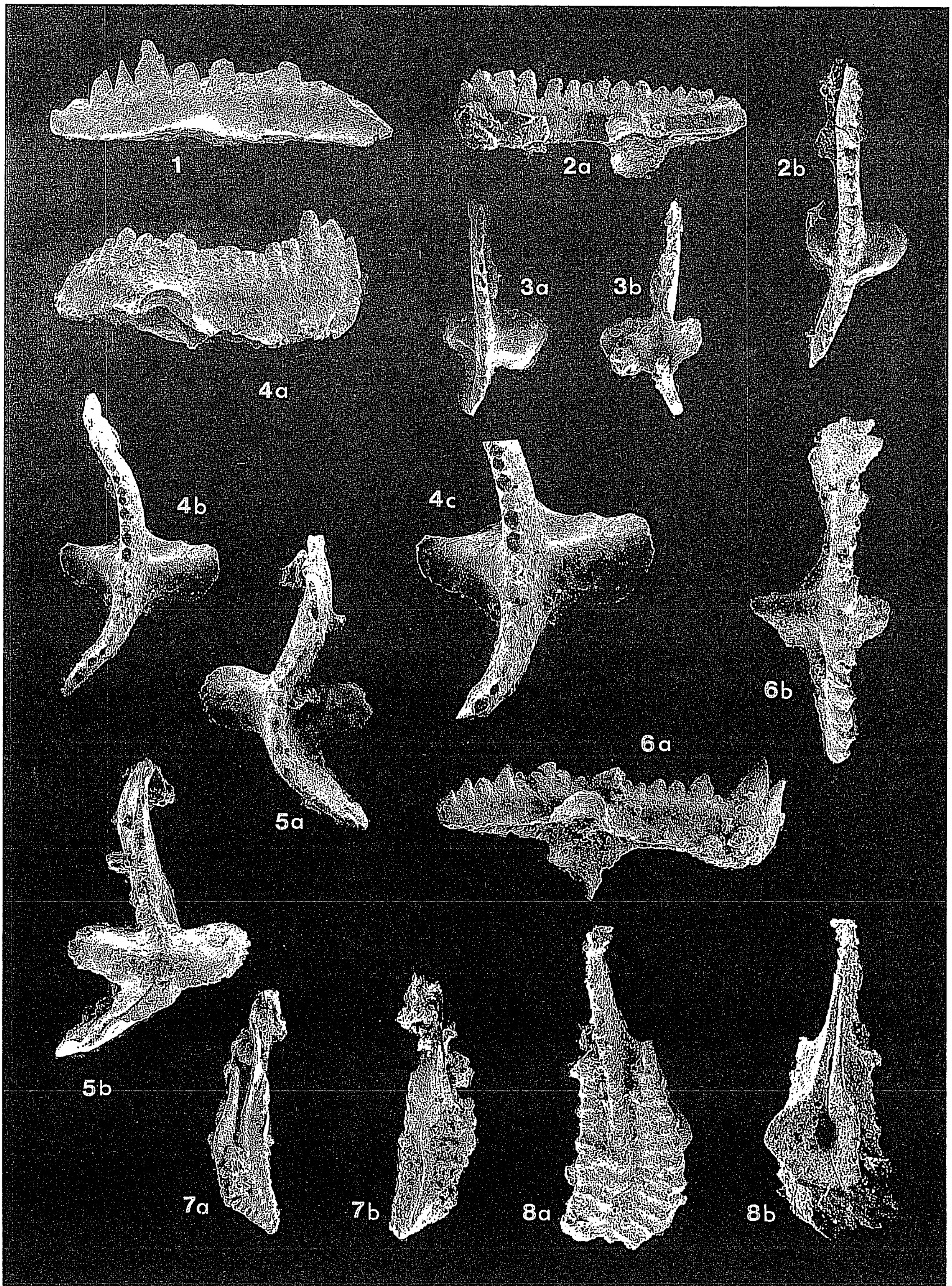
Fig. 4 a,b,c- *Pandorinellina steinhornensis miae* (Bultynck, 1971). JAT 3. AMF 107487. Pa element in (a) lateral view showing three anteriormost denticles larger than remaining denticles, (b) upper view showing strong curvature of blade, (c) enlargement of asymmetrical basal cavity with wide outer margin in upper view; x 45, x 45, x 80.

Fig. 5 a,b - *Pandorinellina steinhornensis miae* (Bultynck, 1971). JAT 3. AMF 107488. Respectively upper and lower view of Pa element with strongly curved blade; x 45.

Fig. 6 a,b - *Ozarkodina prolata* Mawson, 1987. JAT 3. AMF 107489. Respectively lateral and upper view of Pa element; x 45.

Fig. 7 a,b - *Polygnathus dehiscens* Philip & Jackson, 1967. JAT 3. AMF 107490. Respectively upper and lower view of encrusted Pa element showing large basal cavity; x 45.

Fig. 8 a,b - *Polygnathus dehiscens* Philip & Jackson, 1967. JAT 3. AMF 107491. Respectively upper and lower view of fragmentary Pa element showing flared outer basal cavity; x 45.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genus. They occur in his sample 103 together with *I. alternatus mawsonae*, *I. iowaensis iowaensis*, *Palmatolepis minuta minuta*, *Pal. quadrantinodosolobata*, *Pal. tenuipunctata* and *Pal. subperlobata*, an assemblage referred to the Early *crepida* Zone.

As the incoming of *I. homeomorphus* in the Kurāgh section coincides with the appearance of *Pal. minuta minuta* and *Pal. tenuipunctata*, it appears that the new species can be no older than Late *triangularis* Zone. It occurs with *I. alternatus mawsonae* in KUR 21 and 22, a form argued by Yazdi (1996, 1999) to range from Late *triangularis* Zone to Early *crepida* Zone.

Range. Late Devonian (early Famennian), Late *triangularis* Zone to ?Early *crepida* Zone.

PLATE 3

Fig. 1 a,b,c - *Icriodus latericrescens latericrescens* Branson & Mehl, 1958. KUR 6. AMF 107492. I element in (a) upper view, (b) enlargement of posterior upper surface showing small discrete denticles of the median row, (c) lower view; x 45, x 90, x 45.

Fig. 2 a,b - *Icriodus latericrescens latericrescens* Branson & Mehl, 1958. KUR 3. AMF 107493. I element with broken anterior in (a) upper view showing laterally compressed denticles of the median row, (b) enlargement of posterior upper surface showing ridge-like development of the median row posterior lateral denticles; x 45, x 90.

Fig. 3 a,b,c - *Icriodus latericrescens latericrescens* Branson & Mehl, 1958. KUR 3. AMF 107494. I element in (a) upper view, (b) lower view, (c) enlargement of posterior upper surface showing small, laterally compressed medial denticles; x 45, x 45, x 90.

Fig. 4 a,b,c - *Icriodus expansus* Branson & Mehl, 1938. KUR 2. AMF 107495. I element in (a) lateral view showing sulcus in inner cavity margin, (b) upper view showing three to four median denticles fused to form a ridge-like structure, (c) lower view showing straight posterior margin of basal cavity; x 80.

Fig. 5 a,b,c - *Icriodus expansus* Branson & Mehl, 1938. KUR 2. AMF 107496. I element in (a) lateral view showing fused denticles of median row posterior to lateral denticles, (b) upper view showing denticles of median and lateral rows in an aligned arrangement, (c) oblique lower view showing sulcus in inner margin of basal cavity; x 80.

PLATE 4

Fig. 1 a,b,c - *Icriodus brevis* Stauffer, 1940. KUR 2. AMF 107497. I element in (a) lateral view showing 5 posteriormost denticles of median row fused to form a "ridge-like" structure, (b) upper view showing subalternating median and lateral denticles, (c) lower view showing widest expansion of outer basal cavity margin with a sinus; x 80.

Fig. 2 a,b,c - *Icriodus brevis* Stauffer, 1940. KUR 1. AMF 107498. I element in (a) lateral view showing large, posteriorly inclined main cusp, (b) upper view showing sub-alternating median and lateral denticles in anterior portion with fused median denticles extending beyond lateral denticles in posterior portion, (c) lower view showing basal cavity with sulcus in inner margin and expanded outer margin near posterior end; x 80.

Fig. 3 a,b,c - *Icriodus subterminus subterminus* Youngquist, 1947. KUR 11. AMF 107499. I element in (a) lateral view showing lateral denticles above basal cavity margin and small upright main cusp, (b) upper view showing alternating denticles with only one denticle of median row posterior to lateral rows, (c) lower view; x 80.

Fig. 4 a,b,c - *Icriodus subterminus subterminus* Youngquist, 1947. KUR 14. AMF 107500. Juvenile I element in (a) lateral, (b) upper, (c) lower view; x 80.

Fig. 5 a,b,c - *Icriodus subterminus subterminus* Youngquist, 1947. KUR 11. AMF 107501. Juvenile I element in (a) lateral, (b) upper, (c) lower view; x 80.

Fig. 6 a,b,c - *Icriodus subterminus uyenoi* Savage, 1992. KUR 14. AMF 107502. I element with incomplete main cusp in (a) lateral view showing lateral denticles extending to main cusp and lower margin at anterior portion angled upward, (b) upper view showing widely flared symmetrical basal cavity and alternating denticles, (c) lower view showing almost circular basal cavity margin with fold on inner side; x 80.

PLATE 5

Fig. 1 - *Icriodus* cf. *iowaensis ancylus* Sandberg & Dreesen,1984. CK 718. AMF 107503. Upper view of I element; x 60.

Fig. 2 a,b - *Icriodus homeomorphus* n. sp. CK 718. AMF 107504. Respectively upper and lower view; x 75.

Fig. 3 - *Icriodus homeomorphus* n. sp. CK 718. AMF 107505. Upper view of I element; x 60.

Fig. 4 - *Icriodus homeomorphus* n. sp. CK 718. AMF 107506. Upper view of I element; x 75.

Fig. 5 - *Icriodus homeomorphus* n. sp. CK 718. AMF 107507. Upper view of I element; x 75.

Fig. 6 a,b - *Icriodus alternatus alternatus* Branson & Mehl, 1934 Morph 1. CK 718. AMF 107508. Respectively upper and lower view of I element; x 110.

Fig. 7 - *Icriodus* cf. *iowaensis iowaensis* Youngquist & Peterson, 1947. CK 718. AMF 107509. Upper view of I element; x 60.

Fig. 8 - *Icriodus homeomorphus* n. sp. CK 718. AMF 107510. Upper view of I element; x 60.

Fig. 9 - *Icriodus alternatus mawsonae* Yazdi, 1999. CK 718. AMF 107511. Upper view of I element showing small, indistinct centre nodes; x 90.

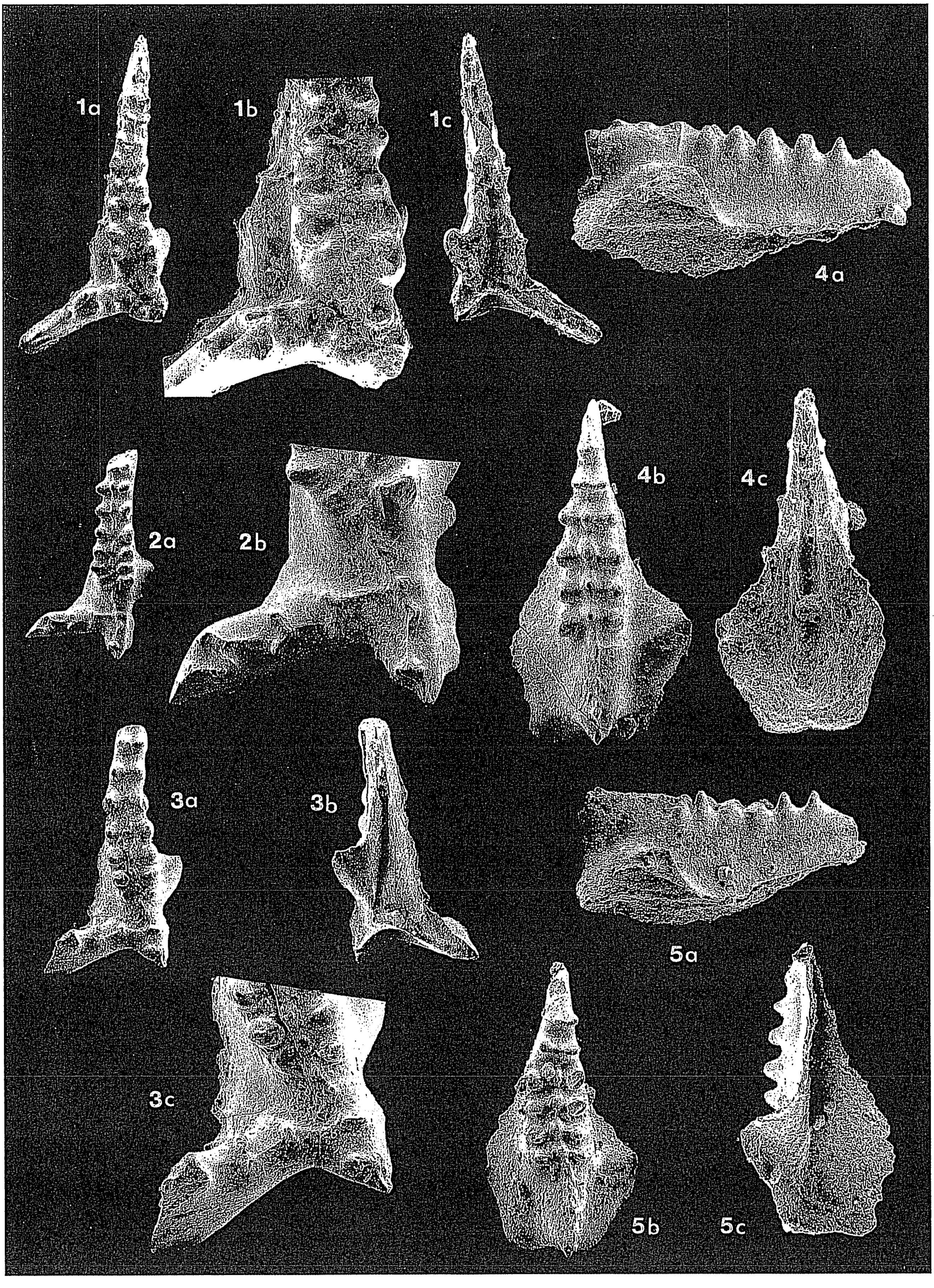
Fig. 10 - *Icriodus* cf. *latericrescens latericrescens* Branson & Mehl, 1938. CK 718. AMF 107512. Upper view of I element showing small, indistinct and irregular centre nodes; note breakage around posterior lateral margins of basal cavity. Probably reworked specimen; x 60.

Fig. 11 - *Icriodus alternatus alternatus* Branson & Mehl, 1934 Morph 2. CK 718. AMF 107513. Upper view of juvenile I element; x 150.

Fig. 12 - *Icriodus homeomorphus* n. sp. CK 718. AMF 107514. Upper view of I element; x 60.

Fig. 13 - *Icriodus homeomorphus* n. sp. CK 718. AMF 107515. Upper view of I element (holotype); x 60.

Fig. 14 a,b - *Icriodus homeomorphus* n. sp. CK 718. AMF 107516. Respectively upper and lower view of I element; x 105.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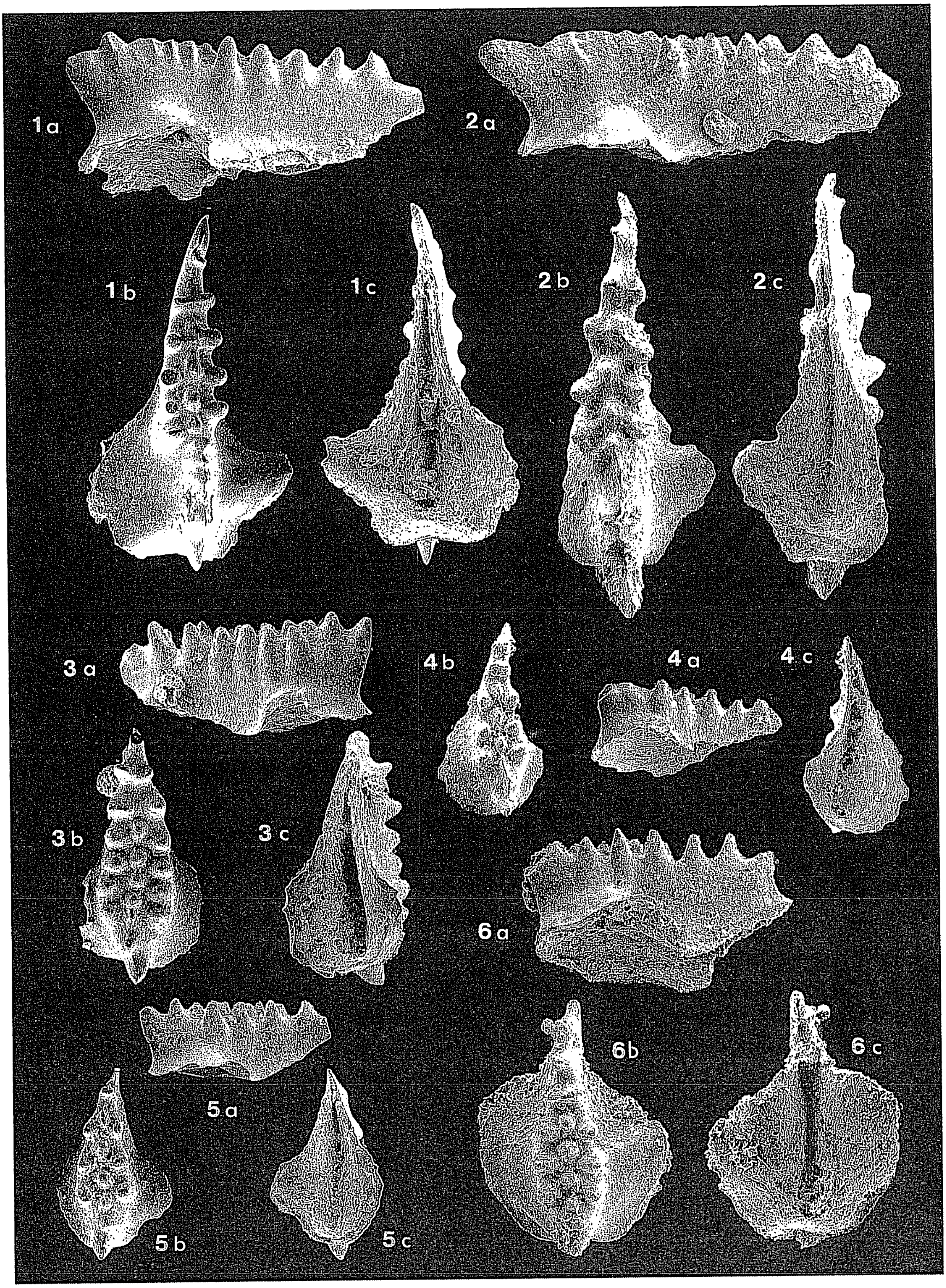
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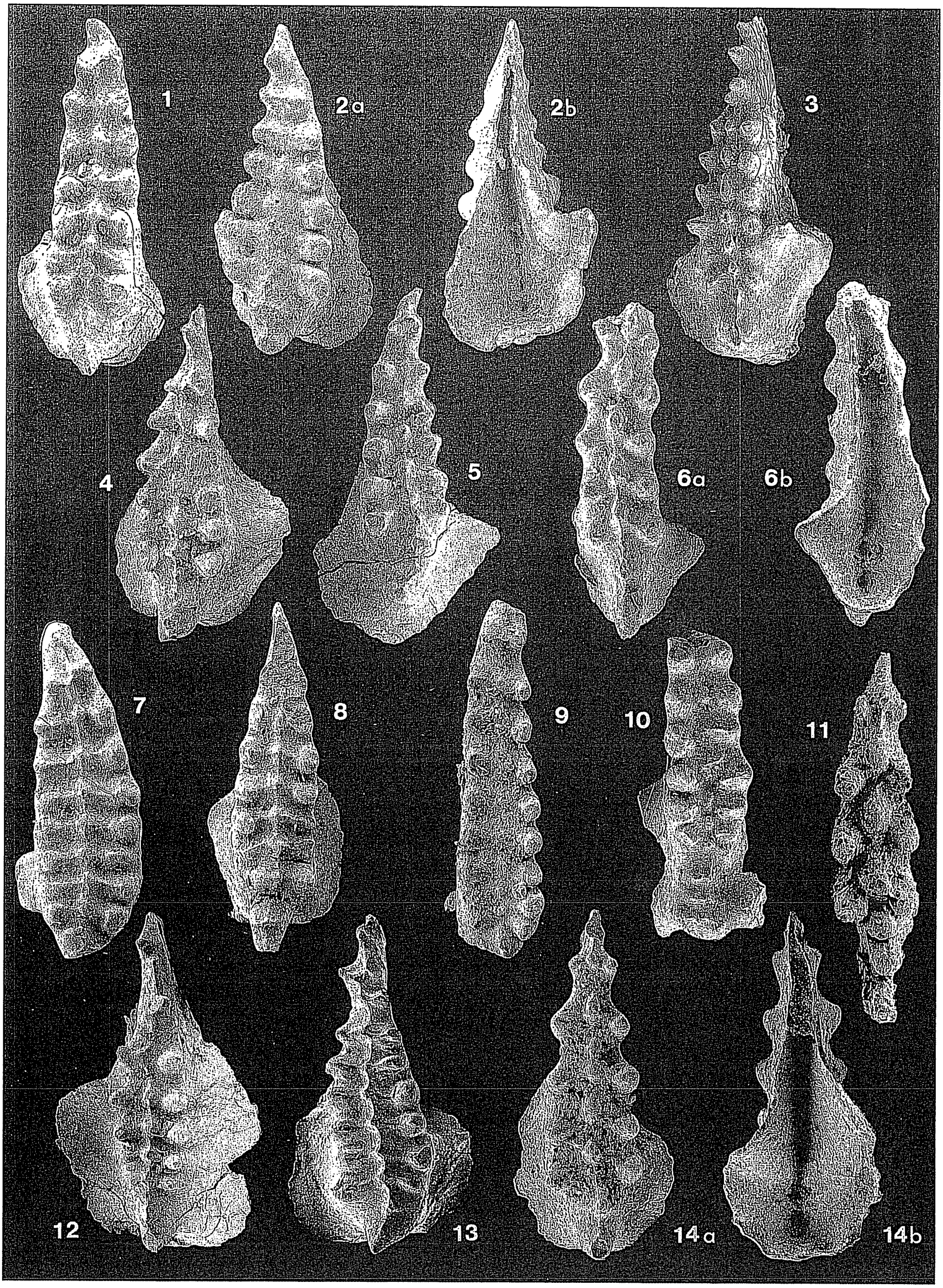
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PLATE 6

Fig. 1 a,b,c - *Polygnathus timorensis* Klapper, Philip & Jackson, 1970. KUR A. AMF 107517. Pa element with broken anterior blade in (a) upper view, (b) enlargement of platform in upper view showing offset anterior platform margins and outward bowing of outer anterior margin, (c) lateral view showing basal cavity at junction of blade and platform; x 80, x 120, x 80.

Fig. 2 - *Polygnathus timorensis* Klapper, Philip & Jackson, 1970. KUR 5. AMF 107518. Upper view of Pa element showing long free blade, broken anteriorly, and outward bowing of outer lateral margin; x 80.

Fig. 3 a,b - *Polygnathus linguiformis klapperi* Clausen et al., 1979. KUR A. AMF 107519. Poorly preserved Pa element in (a) lower view, (b) oblique lateral view showing transverse ridges on tongue-like posterior; x 45.

Fig. 4 - *Polygnathus varcus* Stauffer, 1940. KUR 5. AMF 107520. Pa element in lateral view; x 80.

Fig. 5 - *Polygnathus brevilamiformis* Ovnatanova, 1976. KUR 9A. AMF 107521. Broken Pa element in (a) upper view showing parallel platform margins, (b) lower view showing basal cavity slightly posterior to platform anterior margin; x 80.

Fig. 6 - *Polygnathus decorosus* Stauffer, 1938. KUR 9E. AMF 107522. Broken Pa element in (a) upper view showing lanceolate outline of platform, (b) lower view showing basal cavity located posterior to anterior margin of platform; x 80.

Fig. 7 - *Polygnathus linguiformis weddigei* Clausen et al., 1979. KUR A. AMF 107523. Broken fragment of Pa element in (a) lateral view, (b) lower view; x 80.

Fig. 8 - *Icriodus* sp. KUR 8. AMF 107524. Lateral view of M element; x 120.

Fig. 9 a,b,c - *Icriodus subterminus uyenoi* Savage, 1992. JAT 2. AMF 107525. I element in (a) lateral view showing fold in inner cavity margin, (b) upper view showing alternating arrangement of denticles and a single median denticle located posterior to posteriomost lateral denticles, (c) lower view of widely flared basal cavity; x 80.

Fig. 10 a,b - *Icriodus subterminus subterminus* Youngquist, 1947. JAT 2. AMF 107526. I element in (a) upper view showing alternating arrangement of denticles, (b) lower view showing maximum expansion of basal cavity in posterior portion; x 80.

Fig. 11 a,b - *Icriodus subterminus subterminus* Youngquist, 1947. JAT 2. AMF 107527. I element in (a) upper view showing a single median row denticle located posterior to posteriormost lateral denticles, (b) lower view; x 80.

PLATE 7

Fig. 1 a,b - *Palmatolepis minuta minuta* Branson & Mehl, 1934. KUR 19. AMF 107528. Respectively oblique upper and lateral view of Pa element; x 90.

Fig. 2 - *Palmatolepis tenuiplicata* Sanneman, 1955. KUR 19. AMF 107529. Upper view of Pa element; x 90.

Fig. 3 - *Polygnathus capollocki* Yazdi, 1999. KUR 22. AMF 105530. Lateral view of Pa element; x 75.

Fig. 4 - *Polygnathus capollocki* Yazdi, 1999. KUR 24. AMF 107531.Upper view of Pa element; x 75.

Fig. 5 - *Polygnathus capollocki* Yazdi, 1999. KUR 22. AMF 107532. Upper view of Pa element; x 90.

Fig. 6 a,b - *Polygnathus* cf. *decorosus* Stauffer, 1938. KUR 22. AMF 107533. Pa element in (a) lateral view, (b) upper view showing lanceolate outline of platform; x 60.

Fig. 7 a,b - *Polygnathus decorosus* Stauffer, 1938. KUR 17. AMF 107534. Pa element in (a) upper view showing lanceolate outline of platform, (b) lower view; x 60.

Fig. 8 - *Polygnathus* sp. cf. *P. webbi*. KUR 24. AMF 107535. Upper view of left-hand Pa element; x 75.

Fig. 9 - *Polygnathus aspelundi* Savage & Funai, 1980. KUR 24. AMF 107536. Upper view of Pa element; x 75.

Fig. 10 a,b - *Polygnathus* sp. cf. *P. decorosus*. KUR 20. AMF 107537. Respectively upper and lower view of Pa element; x 60.

Fig. 11 a,b - *Polygnathus politus* Ovnatanova, 1969. KUR 24. AMF 107538. Respectively upper and lower view of Pa element; x 75.

Fig. 12 - *Polygnathus webbi* Stauffer, 1938. KUR 24. AMF 107539. Upper view of right-hand Pa element; x 60.

Fig. 13 a,b - *Icriodus homeomorphus* n. sp. KUR 23. AMF 107540. Respectively upper and lower view of I element; x 60.

Fig. 14 - *Icriodus homeomorphus* n. sp. KUR 19. AMF 107541. Respectively upper and lower view of I element; x 75.

Fig. 15 a,b - *Icriodus subterminus subterminus* Youngquist, 1947 Morph 2. KUR 16. AMF 107542. Respectively lateral and upper view of I element; x 90.

Fig. 16 - *Icriodus homeomorphus* n. sp. KUR 19. AMF 107543. Upper view of I element; x 60.

PLATE 8

Fig. 1 a,b - *Icriodus alternatus alternatus* Branson & Mehl, 1934 Morph 1. PJC 3, AMF 107544. Respectively oblique upper and lower view of Pa element; x 80.

Fig. 2 a,b,c - *Icriodus alternatus alternatus* Branson & Mehl, 1934 Morph 1. PJC 3, AMF 107545. Respectively upper and lower view of Pa element and enlargement of posterior third of upper view showing two medial row denticles posterior of lateral rows; x 80, x 80, x 120.

Fig. 3 a,b,c - *Icriodus alternatus alternatus* Branson & Mehl, 1934 Morph 1. PJC 3, AMF 107546. Respectively upper, lower and lateral view of Pa element. Note laterally compressed denticles in medial row; x 80.

Fig. 4 a,b - *Palmatolepis* sp. PJC 3, AMF 107547. Respectively upper and lower view of Pa element with broken lobe; x 45.

Fig. 5 a,b - *Ancyrognathus* coeni Klapper, 1990. PJC 3, AMF 107548. Respectively upper and lower view of juvenile Pa element; x 60.

Fig. 6 a,b - *Polygnathus aspelundi* Savage & Funai, 1980. PJC 3, AMF 107549. Respectively lateral and oblique upper view of Pa element; x 80.

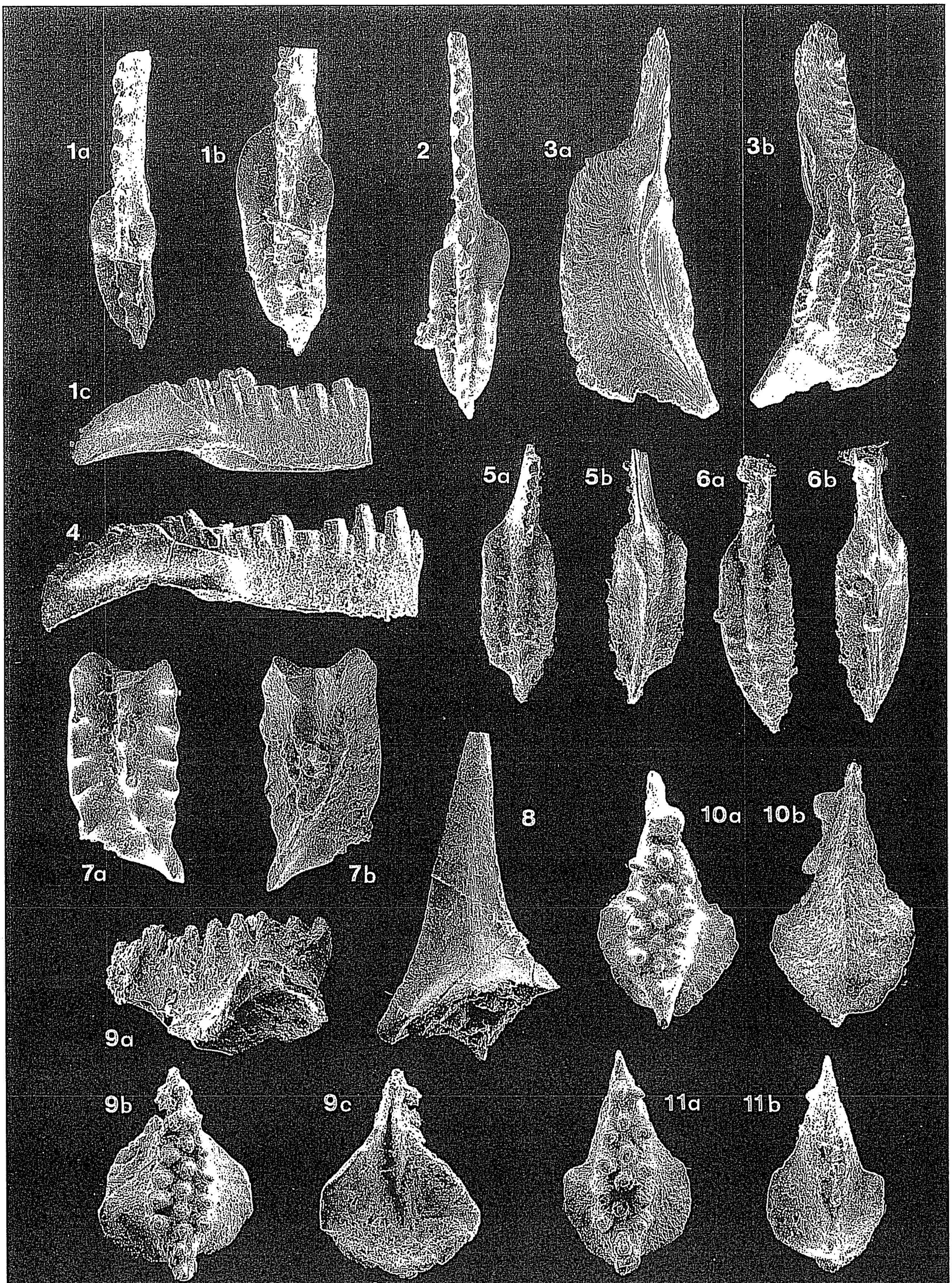
Fig. 7 a,b *Polygnathus webbi* Stauffer, 1938. PJC 3, AMF 107550. Respectively upper and lower view of Pa element; x 45.

Fig. 8 a,b *Polygnathus* cf. *webbi* Stauffer, 1938. PJC 3, AMF 107551. Respectively upper and lower view of Pa element; x 45.

Fig. 9 a,b *Ancyrodella curvata* (Branson & Mehl, 1934) late form. PJC 3, AMF 107552. Respectively upper and lower view of juvenile Pa element; x 45.

Fig. 10 a,b - *Ancyrodella curvata* (Branson & Mehl, 1934) late form. PJC 3, AMF 107553. Respectively upper and lower view of Pa element; x 45.

Fig. 11 a,b - *Ancyrodella curvata* (Branson & Mehl, 1934) late form. PJC 3, AMF 107554. Respectively upper and lower view of Pa element; x 45.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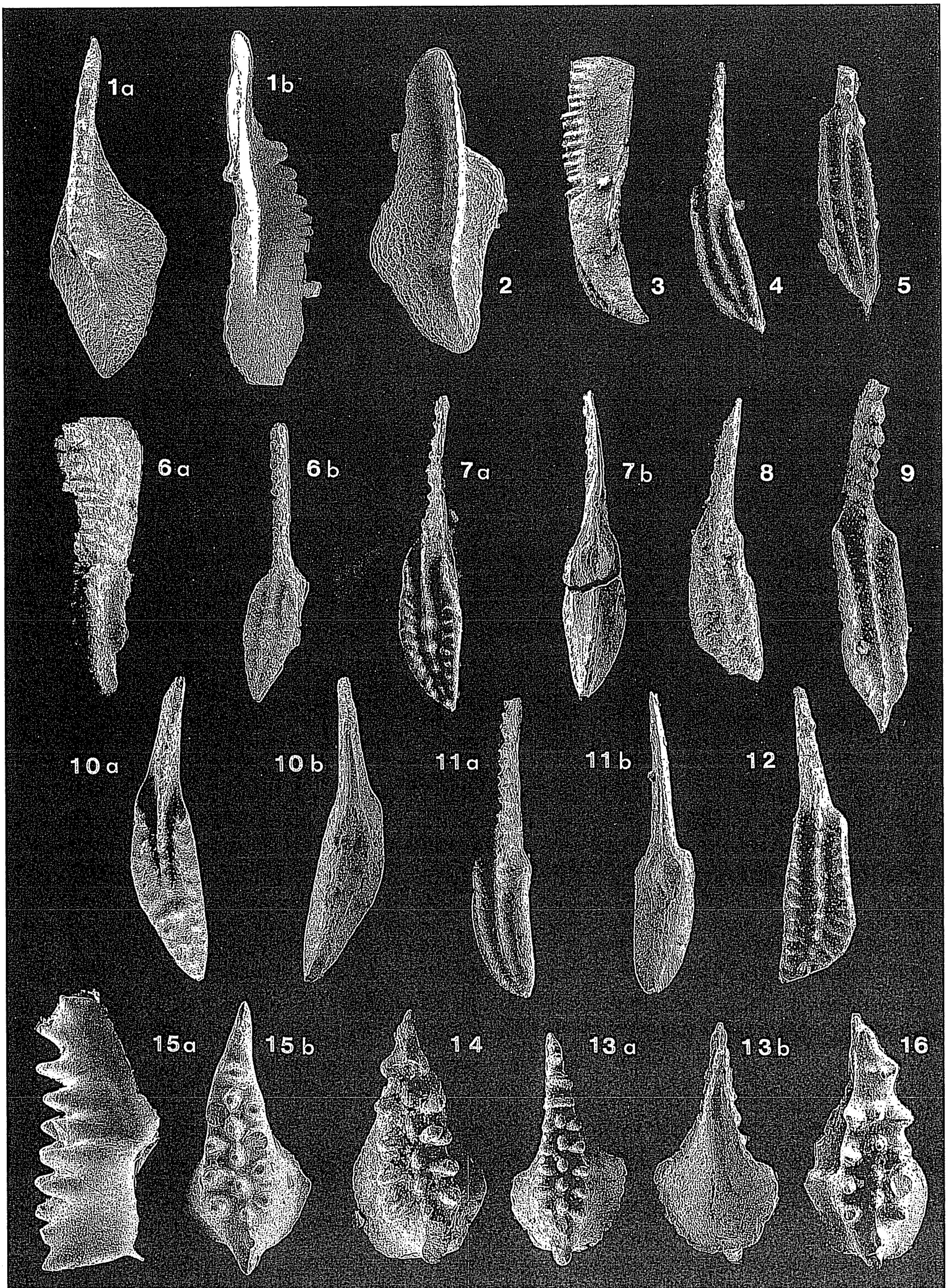
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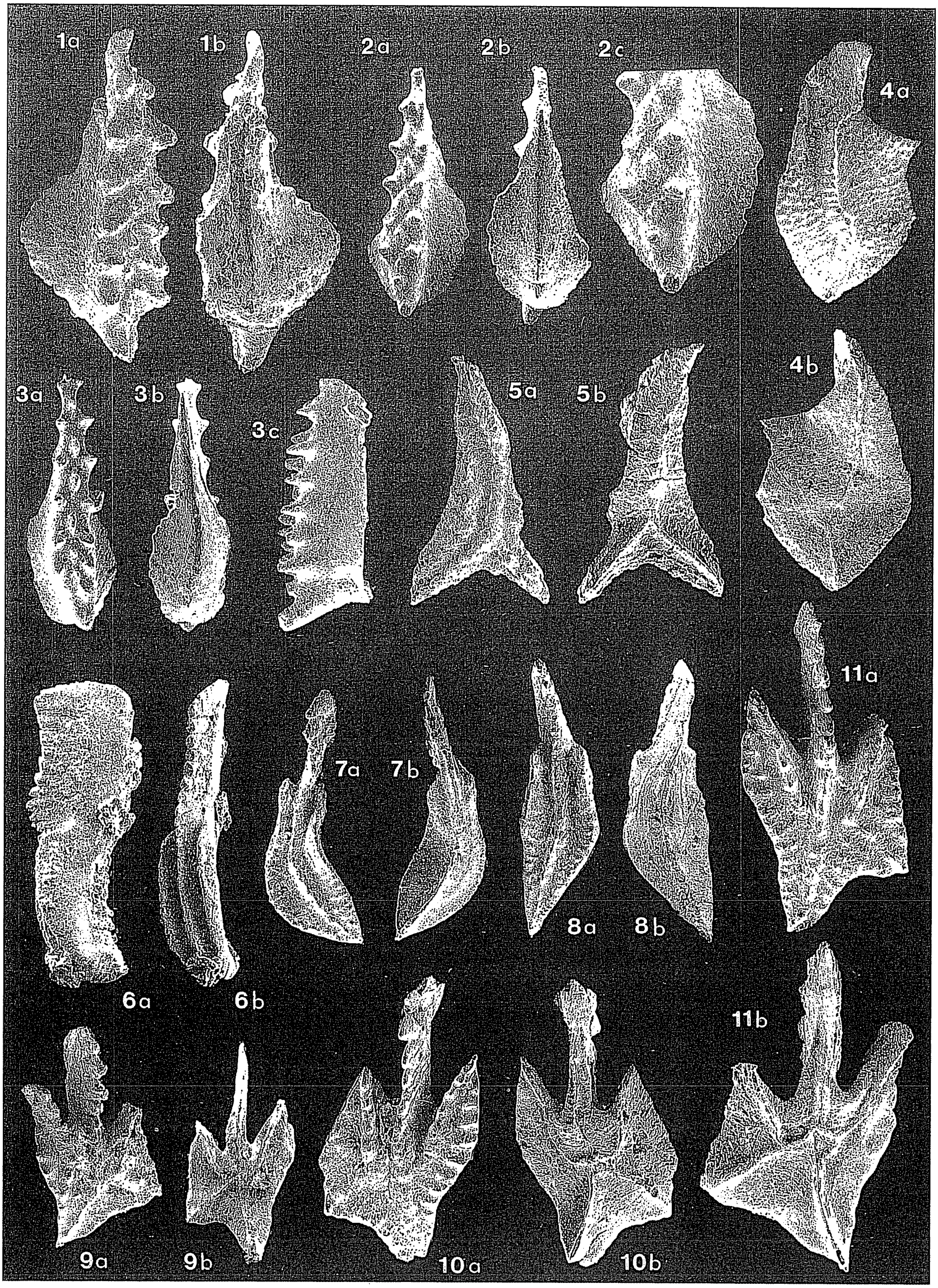
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Appendix: Register of Spot Localities.

Horizons which have produced conodonts and macrofauna are indicated on the maps (Figs 1-3) and stratigraphic columns (Figs 4, 5).

KUR - stratigraphic section within the Shogrām Formation (see Fig. 5) at Kurāgh Spur (Lat. 36° 13' N, Long. 72° 10' E) sampled by Talent and colleagues in 1973 and 1975. Kurāgh Spur is located on the eastern side of the Mastūj River, approximately 7.5 km north-east of Reshūn (Fig. 2). The relationship of the Shogrām Formation to adjacent units at this locality, is shown in the schematic diagram of the southern face of Kurāgh Spur (Fig. 5 inset).

Samples prefixed by CK were sampled by Gaetani and colleagues. These are indicated on the stratigraphic columns (Fig. 4) except for three spot localities with macro-faunas (Talent et al., in prep) which failed to produce conodonts:

CK 245 - loose block with atrypids and cyrtospiriferids at the top of the Chilmarabad Formation dolostones on the right side of the Yarkhun River at the water's edge, immediately in front of the Yarkhun River section, collected M. Gaetani.

CK 645 - loose block with cyrtospiriferids from debris below the first large gully east of Lashkargaz, collected L. Angiolini.

CK 730 - small accumulation of loose blocks of crinoidal limestone about 50 m stratigraphically above the top of the Yarkhun River section above a covered interval; in the field, it was thought to possibly correlate with crinoidal limestones in a measured section on the opposite side of the river, tentatively attributed to the Early Carboniferous; possibly derived from upslope; collected M. Gaetani.

JAT 1 - interval of about 3.5 m of rusty coloured carbonates and siltstones on the east flank but close to the crest of the north-south ridge (Fig. 4, reconnaissance - close to section 3) about 2.5 km west-northwest of the bridge at Ishkarwaz (Fig. 4); collected 1973 by R. A. K. Tahirkheli and J. A. Talent. The carbonate–siltstone interval is underlain by at least 50 m of generally fine-grained quartzites and overlain by about 10 m of poorly outcropping siltstones, followed by a conspicuous interval of 20 m of very coarse quartzites to granule conglomerates, and a further interval of about 1 m of limestone with quartz pebbles up to 10 mm in diameter.

JAT 2 - 38 m above the base of the Shogrām Formation along the same reconnaissance section as JAT 1; collected 1973 by R. A. K. Tahirkheli and J. A. Talent.

JAT 3 - a 2 kg sample of limestone from the "Lun Shales" beside the foot track linking the hamlets of Gosh Lasht and Kosht, 1.5 km northeast of Gosh Lasht (Lat. 36°13' N; Long. 72°9' E); collected J. A. Talent 1973; for locality see Fig. 2.

PJC 1 - Shogrām Formation cropping out on the south side of the track along the eastern bank of the Turikho River about 3.2 km southwest of Istar on the foot-track to Awi, collected P. J. Conaghan & C. McA. Powell 1973 - their sample C191.

PJC 2 - Shogrām Formation: limestone turbidites above the Turikho River on the track to Rāin, about 1.9 km north of the village of Warkup (in the vicinity of the hamlet of Zindrauli), collected P. J. Conaghan & C. McA. Powell 1973 - their sample C184C.

PJC 3 - loose block of limestone with *Receptaculites*, about 600 m up Ojchor Gol from the Shogot (also known as Shogor) Rest House, collected P. J. Conaghan 1973 - his sample C215.

Acknowledgements.

The initial sampling in the Baroghil area was by Talent and R. A. Khan Tahirkheli in 1973. Associated with him in sampling in the Reshūn-Kurāgh area variously in 1973 and 1975 were M. Ataullah Khan, Patrick Conaghan, Chris Powell, John W. Pickett, Joan G. Talent, the late Ross Talent, and S. A. H. Naqvi and S. M. I. Shah of the Geological Survey of Pakistan. Sampling by Gaetani (sections 2 to 7 and various spot samples) was undertaken in connection with two Italian expeditions in 1992 and 1996 with Lucia Angiolini, Patrick Le Fort, and Alda Nicora in 1992 and Lia Gaetani and Andrea Zanchi in 1996. Oliver Lehnert and Julie Trotter provided the information on the Ordovician conodonts. Taxonomy of the Devonian conodonts is by Mawson, Molloy and Talent; they are grateful to Drs. Gilbert Klapper (University of Iowa, USA) and Charles Sandberg (USGS, Denver, USA) who, with characteristic precision, commented on taxonomic allocation of various forms. Art Boucot commented helpfully on the manuscript. Talent records his gratitude to his long-time Peshawar University friends Emeritus Profs R. A. Khan Tahirkheli and M. Ataullah Khan and Dr Fazli-i-Rabbi Khan for providing memorable hospitality to him, his family and colleagues on visits to Pakistan; they were of pivotal importance with logistical organization for his investigations. Prof. Dr Manfred Buchroithner (Dresden University of Technology, Germany) and Dr Herfried Gamerith (Leonding, Austria) kindly provided copies of maps resulting from their field work in northern Pakistan. SEM photography was by Molloy and Michael Englebretsen; plate preparation was by Margaret Anderson and George Wilson; drafting was by Dean Oliver. Funding for field work by Talent and Conaghan was provided by research grants from Macquarie University and the Australian Research Council. We are very grateful to all of the above. This is a contribution to IGCP Project 421: *North Gondwana mid-Palaeozoic bioevent/biogeography patterns in relation to crustal dynamics.*

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