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LATE DEVONIAN-CARBONIFEROUS CONODONTS FROM EASTERN IRAN

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Riassunto. Vengono presentati i risultati del trattamento di 110 campioni per conodonti provenienti da due sezioni di Devoniano superiore - Carbonifero nella Shotori Range in Iran orientale (regione di Tabas). La successione di Howz-e-Dorah, (con 88 campioni) inizia nella parte alta della Formazione Barham (Givetian-Frasniano inferiore), prosegue attraverso la Formazione Shishtu (dal Frasniano, Zona a *hassi*, sino al Tournesiano terminale, Zona a *anchoralis-latus*) e la Formazione Sardar (dal Viseano basale, Zona a *texanus*, sino alla Zona a *sinuatus-corrugatus-sulcatus*) per concludersi nella Formazione Jamal del Permiano. Altre 4 sezioni stratigrafiche, campionate in modo meno esaustivo (22 campioni) indicano che l'area di Kale Sardar è più complicata tettonicamente della zona di Howz-e-Dorah.

Utili orizzonti guida della sezione Howz-e-Dorah, ben calibrati dai conodonti sono risultati i seguenti:

1) i banchi biostromali della Formazione Shishtu, non più antichi della Zona a *hassi* inferiore, 2) un intervallo di calcari oolitici del Famenniano inferiore (Zona a *triangularis alta* o *crepida* inferiore), 3) una sequenza ciclotemica che passa attraverso il limite Carbonifero inferiore - Carbonifero superiore, ed infine 4) un intervallo di arenarie silicee (la "white quartzite" degli Autori), riferibile al Permiano inferiore. Inoltre, diversi orizzonti ferriferi, facilmente correlabili, sono ben calibrati mediante le età a conodonti. Sono identificate 85 specie di conodonti, che rappresentano 24 generi. Infine sono descritte 2 nuove specie, *Polygnathus capollocki* e *Polygnathus ratebi*, ed una nuova sottospecie, *Icriodus alternatus mawsonae*.

Abstract. Conodont data from acid-leaching 110 samples from two Late Devonian-Carboniferous areas in the Shotori Range (Tabas region) of eastern Iran are presented. At Howz-e-Dorah, a section (88 samples) commencing high in the Bahram Formation (Givetian-early Frasnian) extended through the Shishtu Formation (Frasnian, Early *hassi* Zone or older, to latest Tournaisian, *anchoralis-latus* Zone) and the Sardar Formation (earliest Visean, *texanus* Zone, to late Namurian, *sinuatus-corrugatus-sulcatus* Zone) and into the Jamal Formation (Permian). Four less exhaustively sampled sections (22 samples) show the Kale Sardar area to be tectonically more complicated than the Howz-e-Dorah area. Useful marker horizons in the Howz-e-Dorah section, well constrained by conodont data, are: the early Frasnian (no older than Early *hassi* Zone) biostromal beds of the Shishtu Formation, an early Famennian (Late *triangularis* to Early *crepida*) interval of oolitic limestone, a cyclothem sequence straddling the Early Carboniferous-Late Carboniferous boundary, and an Early Permian interval of siliceous sand ("the white quartzite" of previous authors). Additionally, several iron-rich horizons, readily traceable from locality to locality, are well constrained by conodont ages.

Eighty-five conodont species/subspecies are documented representing 24 genera. Two new species, *Polygnathus capollocki* and *Polygnathus ratebi* and one new subspecies, *Icriodus alternatus mawsonae* are described.

Introduction.

Reconnaissance investigations of the Shotori Range in eastern Iran (e.g. Stöcklin *et al.* 1965, 1991) demonstrated the existence of an excellent Late Devonian-Carboniferous succession in the Tabas region (Fig. 1). There has been very little previous palaeontologic work in the area; nothing of significance has been published on the diverse macrofaunas during the past 30 years but older publications include work on Devonian and Lower Carboniferous goniatites by Walliser (1966), Frasnian rhynchonellid brachiopods by Sartenaer (1966), *Iranoblastus*, a new Early Carboniferous blastoid by E. Flügel (1966) and *Receptaculites* by H. Flügel (1961). Weddige's (1984) more recent conodont studies concentrated on faunas to the north of the area presently under consideration. In order to address this deficiency, sections aggregating 1360 m were sampled for conodonts in the Howz-e-Dorah area (Fig. 2, 4) and in the vicinity of Kale Sardar (Fig. 3) with the aim of establishing a stratigraphic framework within which other faunal groups (for example, ammonoid and nautiloid cephalopods, brachiopods and mollusks) will be able to be accurately located and bioevents and transgression--regression patterns compared with others elsewhere (Yazdi, 1999, in press).

The revised Late Devonian zonal scheme of Ziegler & Sandberg (1984, 1990) is used herein; in some instances, for clarity, alongside the zone quoted, appears, in square brackets, the original zonal equivalent (*sensu* Ziegler 1962, 1971), eg. Early *rhenana* Zone [= Lower

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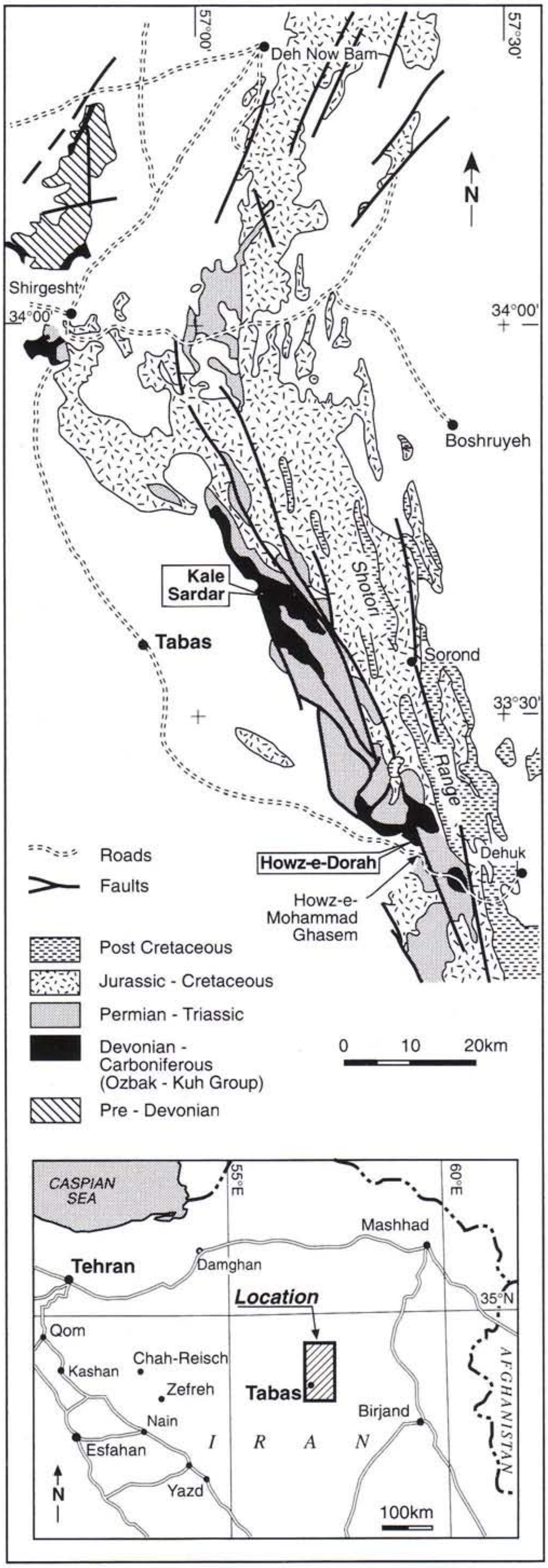


Fig. 1 - Geology of the Shotori Range in the vicinity of Tabas, eastern Iran simplified from Stöcklin et al. (1965) with minor modifications from subsequent traverses.

gigas Zone]. The Carboniferous zonal scheme used throughout is based on the outcomes of the Carboniferous Subcommission Meeting, Provo, Utah, 1988 (Brenckle & Manger, 1991). Conodont genera mentioned in the text and on Tables 1, 2 and 3 are abbreviated as follows:

Ad.=Ancyrodella; Alt.=Alternognathus; An.=Ancyrognathus; Cl.=Clydagnathus; D.=Declinognathodus; Do.=Dollymae; Gn.=Gnathodus; I.=Icriodus; Id.=Idiognathodus; L.=Lochriea. Ng.=Neognathodus; P.=Polygnathus; Po.=Polylophodonta; Pal.=Palmatolepis; Pel.=Pelekysgnathus; Ps.=Pseudopolygnathus; Rh.=Rhachistognathus; Sc.=Scaliognathus; S.=Scaphignathus; Si.=Siphonodella.

Previous work.

Reference to the geology of the Shotori Range in the Tabas area in eastern Iran was first made by Sven Hedin (1927), who, during his expedition to Central Asia some 20 years earlier, named the prominent mountain, Kuh-e-Shotori and collected an Early Jurassic sedimentary sequence at its base. Late Palaeozoic limestones were reported by Furon (1941) from the ranges east and west of Tabas and in 1951 Gansser climbed Kuh-e-Shotori; he was the first geologist to do so. Gansser (1955) gives a brief account of Carboniferous shales, Triassic dolomites and red shales and Late Jurassic reefal limestones of the area. Stöcklin (1961) reported the first Devonian cephalopods from Iran. The first systematic investigation of the area, undertaken under the auspices of the Geological Survey of Iran, was carried out by J. Stöcklin, J. Eftekhar-Nezhad and A. Hushmand-Zadeh with the assistance of M. Nabavi, M. Zahedi, N. Valeh S. Tatavussian; their findings are summarised in Stöcklin *et al.* (1965, 1991). The study was comprehensive covering the geology of the Precambrian to the Quaternary.

Geological setting.

Stöcklin *et al.* (1965) named three pre-Permian formations of the Ozbak-Kuh Group: the Bahram Formation, the Shishtu Formation and the Sardar Formation; the Permian sequence lying above these was named the Jamal Formation. The Sardar conglomerate was thought to have lain unconformably between the Shishtu and Sardar formations.

The sedimentary sequence of the Shotori Range is characterised by numerous hiatuses, unconformities and

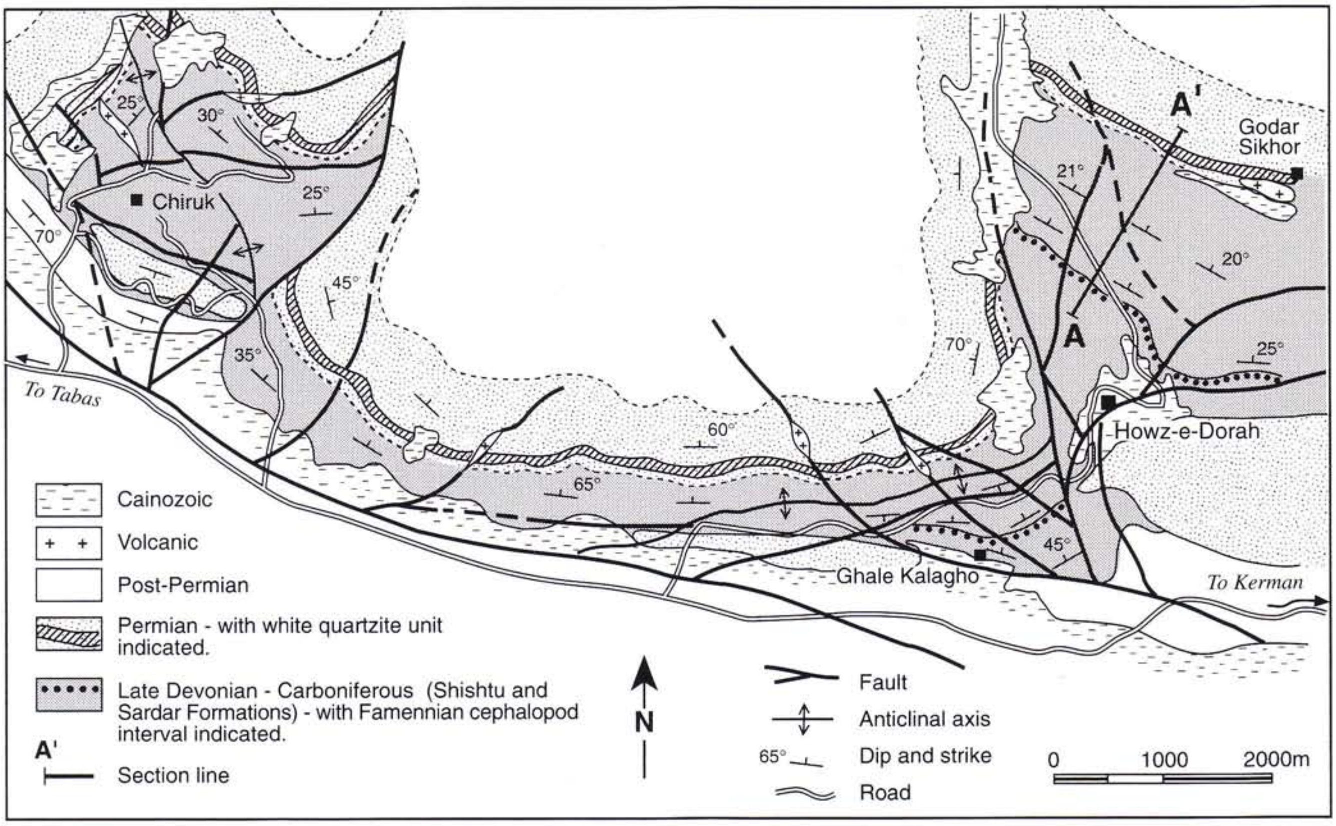


Fig. 2 - Howz-e-Dorah area showing simplified geology and the location of the Howz-e-Dorah section, A to A1.

synsedimentary faults. The type sections for the Shishtu Formation and Sardar Formation selected by Stöcklin *et al.* (1965, p. 11-19) at Howz-e-Dorah and the Sardar River area are interrupted by a number of hiatuses and locally show changes in thickness. For this study a more complete section passing through both formations was sought. The section selected is approximately 2.5 km to the north of the section documented by Stöcklin *et al.* (1965) at Howz-E-Dorah (Fig. 2, 4). It commences in the topmost horizon of the Bahram Formation (Early Frasnian), passes through the Shishtu Formation (Frasnian, Famennian and Early Carboniferous), the Sardar Formation (Carboniferous), including the Sardar conglomerate (post Namurian) and into the Jamal Formation (Early Permian). The Jamal Formation continues into the Late Permian (Figs. 2, 4, 5). At Kale Sardar a number of short sections (Figs. 3, 6) have been collected to supplement data from the Howz-e-Dorah section.

A. Howz-E-Dorah Section (Fig. 2).

Co-ordinates for base of section: Long. 57°20'28"E, Lat. 33°22'50"N.

Co-ordinates of top of section: Long. 57°20'45"E, Lat. 33°23'15"N.

(From Deh-e-Shahzadeh'Ali 1:50,000 Iran sheet, N1-40-11 (7456I) K753.

It is located between Howz-e-Mohammad Ghasem and Sorond village, approximately 75 km southeast of Tabas (Fig. 1, 2). The base of the section commences 700 m northwest of Howz-e-Dorah at the boundary between the Bahram Formation and Shishtu Formation and continues through the Sardar Formation to the Jamal Formation (Permian). Limestone horizons were sampled for conodonts and macrofauna along the section line.

1. Shishtu Formation.

The lowest horizon of the Shishtu Formation (A-A[1] on Fig. 2, 4) occurs above a brown, siliceous dolomitic horizon that marks the top of the Bahram Formation. A second locality in the Shotori Range where the Bahram Formation crops out and the base of the Shishtu Formation is exposed is in the vicinity of the area approximately 2 km northwest of Howz-e-Mohammad Ghasem on the Tabas-Kerman road, about 80 km southeast of the city of Tabas; here the top of the Bahram Formation and the base of the Shishtu Formation are not clear.

2. Shishtu Formation and Sardar Formation Boundary.

The boundary between the Shishtu Formation (= top of Shishtu 2 of Stöcklin *et al.* 1965, 1991, p. 18-20) and the Sardar Formation occurs between a 2-3 m hori-

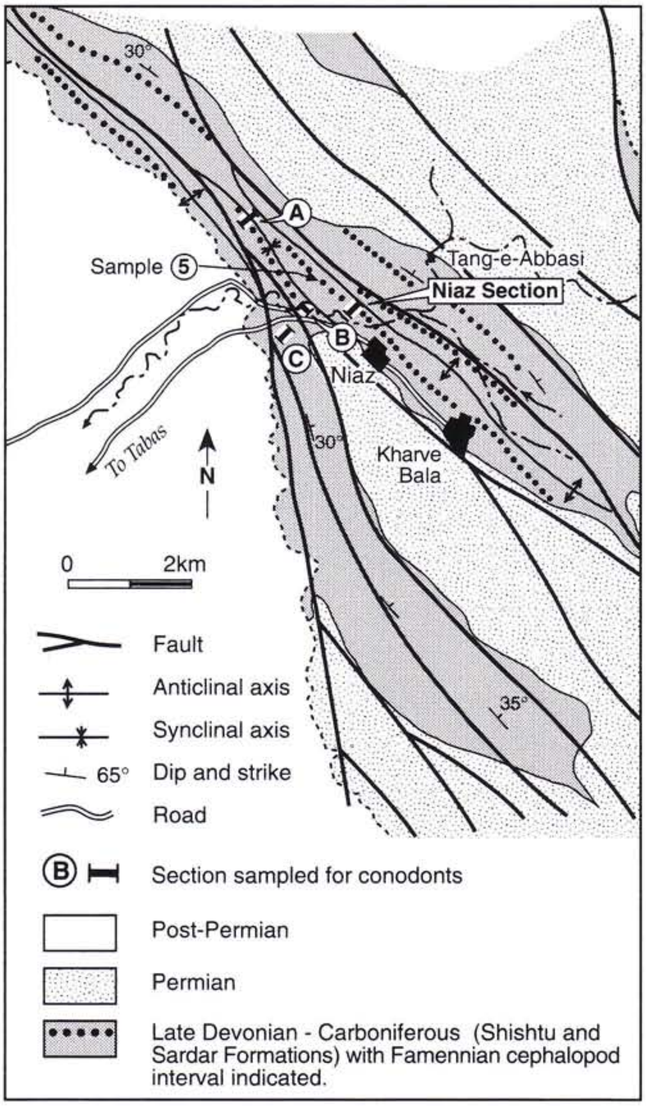


Fig. 3 - Kale Sadar area showing simplified geology and location of the Niaz section, Section A, Section B and Section C.

zon of sandy crinoidal limestone grading to a muddy, sandy limestone with an influx of fine sediment and a coarse-grained sandy horizon, the base of which is rough and uneven suggesting a possible erosional event. Stöcklin *et al.* (1965 p. 18-20) reported that a conglomeratic sequence overlies the Shishtu Formation, but at Howz-e-Dorah this is represented by a coarse-grained sandstone that grades into a sandstone horizon containing small, rounded cherty pebbles.

3. Sardar Formation.

Stöcklin *et al.* (1965, p. 16) in choosing the type section for the Sardar Formation, a locality south of the Sardar River at Kale Sardar, stated that "this is not an ideal section because the lowermost part of the Formation and its contact with older rocks is not exposed". The section at Howz-e-Dorah described herein provides a more complete record of the Sardar Formation than the type section.

4. Permian.

The Jamal Formation as defined by Stöcklin *et al.* (1965, p. 21-22) consists of from 500 m to 800 m of Permian sediments. Not included in the formation as originally defined is a white unit of siliceous sand, the result of a transgressive event at the base of the Permian. Partow Azar (1992) included this sequence within the Permian naming it the Baghe Vang Member. This siliciclastic sequence is thought to be related to the post-glacial event of Gondwana (Husseini, 1992, p. 423). The siliceous sand, commonly referred to as "white quartzite", varies in thickness from 40 m to 60 m, and clearly overlies the uppermost horizons of the Carboniferous. Contrary to Stöcklin *et al.* (1965, p. 20), the unit is not part of a continuous sedimentary sequence as conodonts have shown there to be a substantial gap in the sequence coinciding with the upper part of the Late Carboniferous (see discussion below).

B. Sections at Kale Sardar (Fig. 3, 6).

The Kale Sardar area is located 25-28 km east of Tabas, in the foothills of the Shotori Range (Fig. 1) in an area of several northwest-southeast trending Late Palaeozoic and Mesozoic sedimentary sequences (Fig. 3). Palaeogene and Neogene-Quaternary volcanic sediments cover the topographically lower areas.

In order to supplement information gleaned from the study of the Howz-e-Dorah section, four additional sections were sampled at Kale Sardar. Of especial interest was the Sardar conglomerate; limestone clasts collected from the conglomerate were individually processed for conodonts in order to obtain a minimum age for the date of its deposition. Stratigraphic information obtained in the vicinity of Kale Sardar will assist in the elucidation of the structural complexities of the area.

1. NIAZ section (Fig. 3, 6).

Co-ordinates for base of the section: Long. 57°8'38"E, Lat. 33°39'30"N.

Based on Kharv-e-Pain 1:50,000 sheet, Iran. 7457III, K753.

The age of the Sardar conglomerate at Niaz village, thought by Stöcklin *et al.* (1965, 1991, p. 16, 56) to represent an unconformity between the Shishtu and Sardar formations and, accordingly, argued by them to be Early Carboniferous in age, is shown herein to be no older than *sinuatus-corrugatus-sulcatus* Zone (early Late Carboniferous, Namurian).

Stöcklin *et al.* (1965, 1991, p. 56) suggested that the Sardar conglomerate resulted from epeirogenetic movements commencing in the Late Devonian and continuing into the Permian. The presence of more than 20 m of Sardar conglomerate at Kale Sardar (Fig. 6) indica-

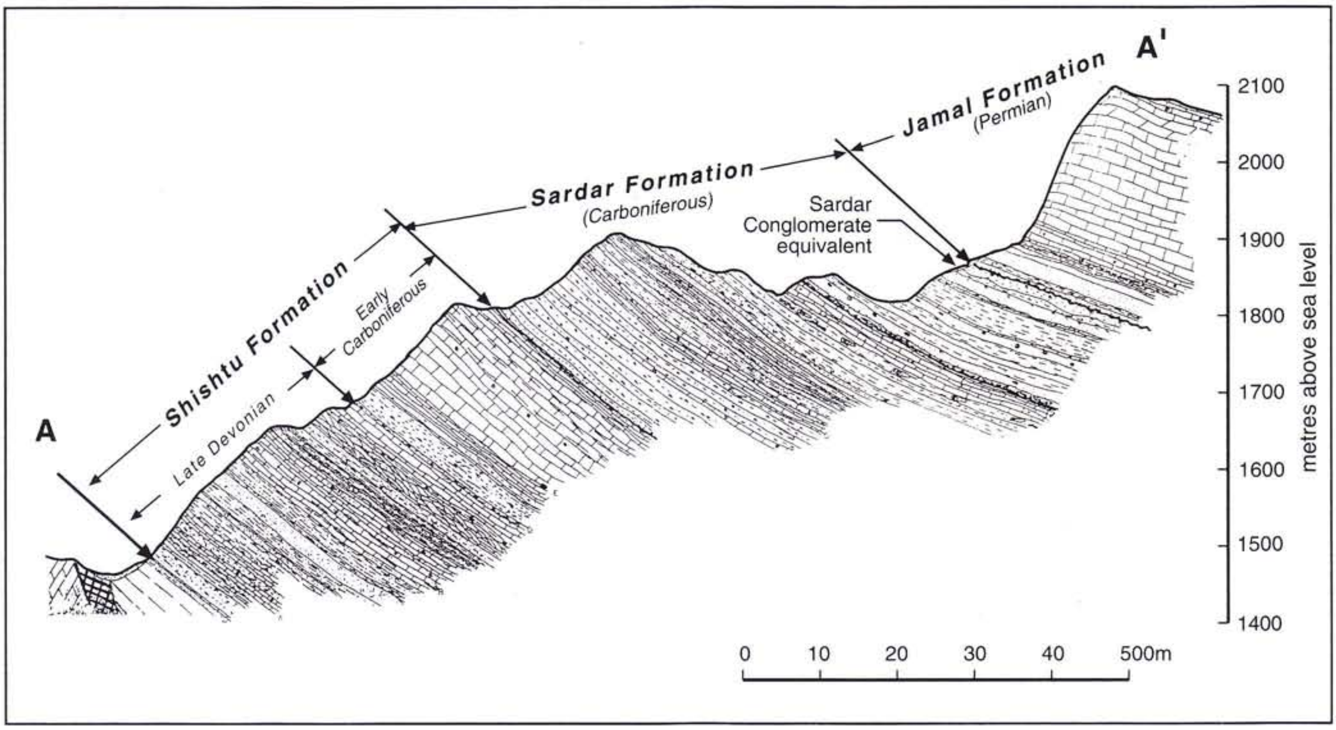


Fig. 4 - Diagrammatic geological section of the Howz-e-Dorah section, A to A1, indicating the approximate boundaries of the Shishtu Formation, the Sardar Formation and the Jamal Formation. See Fig. 2 for location of section .

tes that the structural history of the Kale Sardar area differs from that of the Howz-e-Dorah area where it is represented by an erosional surface (Fig. 5).

2. Section A, 2 km NW from Tang-e-Abbasi, near Tabas (Fig. 3, 6).

Co-ordinates for base of the section: Long. 57°7'0"E, Lat. 33°40'30"N.

Based on Kharv-e-Pain 1:50,000 sheet, Iran. 7457III, K753.

The section (Fig. 3) commences with a series of oolitic limestones alternating with muddy limestones containing cephalopods. From 11 m the fossiliferous limestones become red to brown in colour. Conodonts from sample 6, at 15 m, are consistent with an Early or Middle *expansa* age (Famennian, Late Devonian). The horizon can be correlated with the interval from 339 m to 343 m in the Howz-e-Dorah section, both having a similarly high number of cephalopods and other macrofauna including species of orthoceratids, goniatites, and gastropods in common.

At 19 m there is an erosional surface after which the limestone becomes white with some nodular horizons and an occasional grey or green shaley limestone bed. A fauna of the Frasnian (Late Devonian) species, *Beloceras tenuistriatum* from nodules at 21 m indicates that the erosional surface at 19 m marks a fault boundary. At 37 m, the sequence again changes abruptly to a series of green shales and sandy shales. Lithologically, the shales appear to correlate with those of the Sardar Formation cropping out around 590 m to 730 m in the Howz-e-Dorah section.

3. Section B, at Kale Sardar, near Tabas (Fig. 3, 6).

Co-ordinates for base of the section: Long. 57°7'40"E, Lat. 33°39'15"N.

Based on Kharv-e-Pain 1:50,000 sheet, Iran. 7457III, K753.

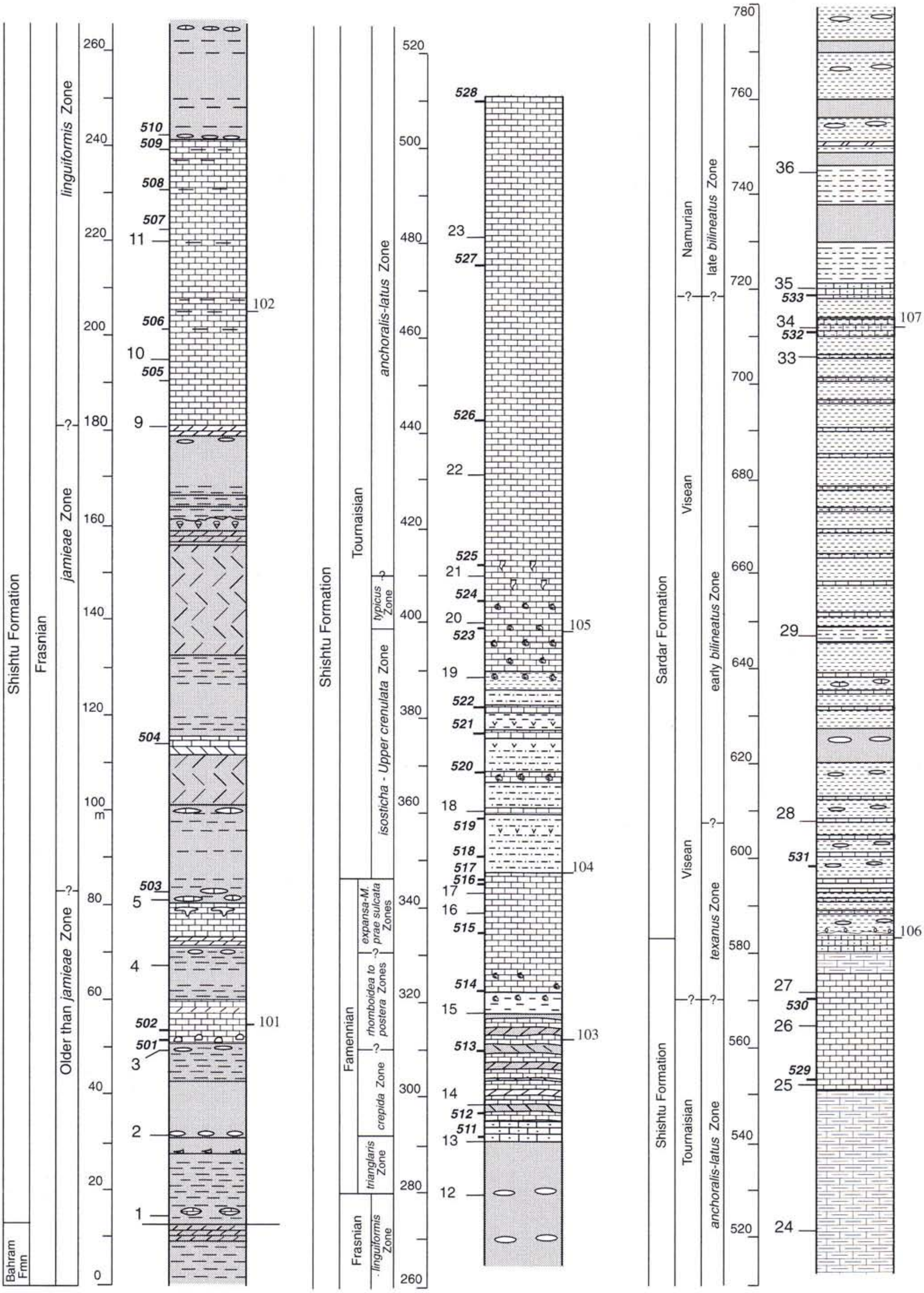
The section (Fig. 3) commences in a green, sandy shale and muddy sandstone sequence. Although there is no apparent erosional surface at the top of the shale-sandstone sequence, there may be some loss of section at this point as the ensuing series of three horizons have their equivalent in the Howz-e-Dorah section whereas the shale-sandstone sequence is not represented in the more complete section.

From 37 m, thin-bedded limestones alternate with colour-banded horizons of striped chert. From sample 14 at 38 m, conodonts indicative of the *anchoralis-latus* Zone (late Tournaisian, Early Carboniferous) were recovered. This sequence can be correlated with that from 510 m to 550 m above the base of the section at at Howz-e-Dorah.

4. Section C, at Kale Sardar, near Tabas (Fig. 3, 6).

Co-ordinates for base of the section: Long. 57°7'30"E, Lat. 33°39'8"N.

Based on Kharv-e-Pain 1:50,000 sheet, Iran. 7457III, K753.


Bahram Fmn
Shishtu Formation
Frasnian
Older than jamieae Zone
jamieae Zone
linguiformis Zone
0
20
40
60
80
100 m
120
140
160
180
200
220
240
260
1
2
3
4
5
9
10
11
501
502
503
504
505
506
507
508
509
510
101
102
Shishtu Formation
Frasnian
Famennian
Tournaisian
linguiformis Zone
triangularis Zone
crepida Zone
rhomboidea to postera Zones
expansa-M. prae sulcata Zones
isosticha - Upper crenulata Zone
typicus Zone
anchoralis-latus Zone
260
280
300
320
340
360
380
400
420
440
460
480
500
520
12
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16
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522
523
524
525
526
527
528
103
104
105
Shishtu Formation
Tournaisian
Sardar Formation
Visean
Visean
Namurian
anchoralis-latus Zone
texanus Zone
early bilineatus Zone
late bilineatus Zone
520
540
560
580
600
620
640
660
680
700
720
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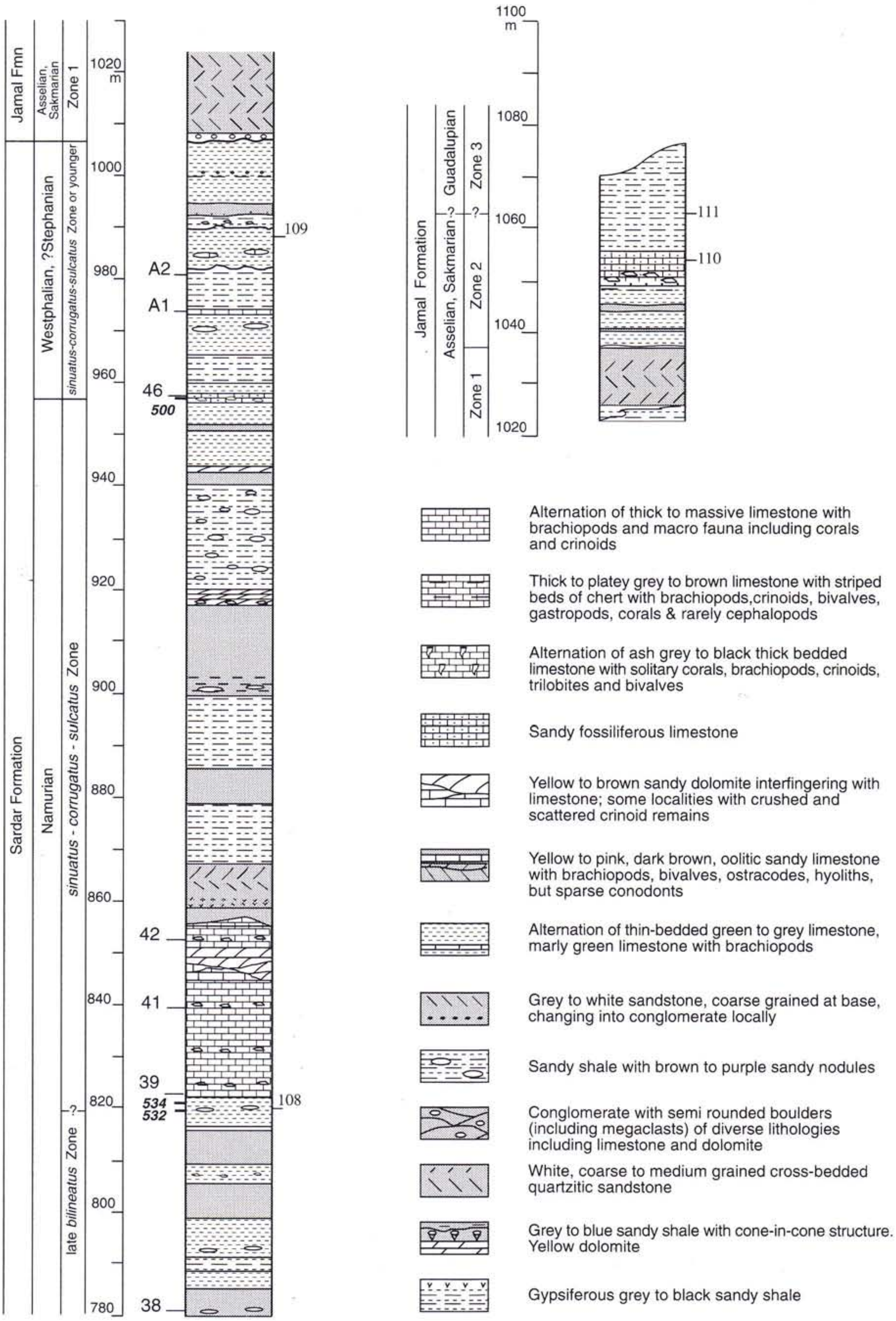


Fig. 5 - Stratigraphic section at Howz-e-Dorah. As the section was sampled on 3 occasions (in 1991, 1992 and 1994), each series of samples were numbered independently. The 3 series of sample numbers appearing adjacent to the section column are printed in 3 font sizes to differentiate the 3 collections.

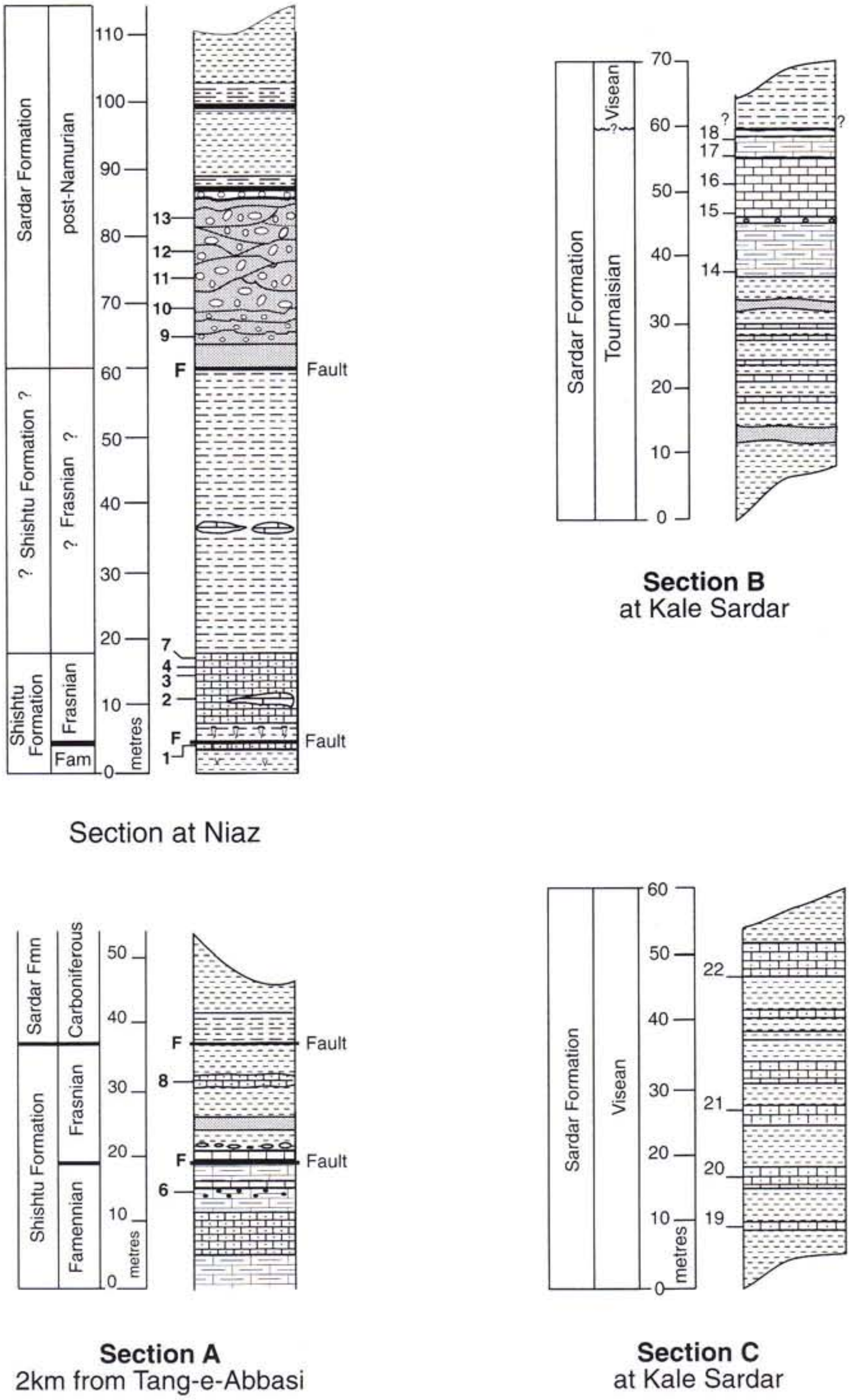


Fig. 6 - Stratigraphic sections at Kale Sardar: Niaz, Section A, Section B, Section C. For legend see Fig. 5; for locality of sections see Fig. 3.

This section (Fig. 3) is the only section sampled at Kale Sardar that did not yield conodonts. Biostratigraphy, therefore, is based on macrofauna. Lithological correlation to the Howz-e-Dorah section is possible as at 47 m, a horizon of 5 to 7 m thick black sandy fossiliferous limestone with an abundant fauna of brachiopods dated as Visean indicates this sequence to be younger than Section B.

Conodont data and age inferences.

Late Devonian and Carboniferous conodont sequences discussed herein is based on the evaluation of 85 conodont species/subspecies (Tables 1-3, Plates 1-13) and a number of macrofauna collected from the Shotori Range. For the Late Devonian, the most commonly accepted conodont zonation is based on the distribution of the pelagic species *Palmatolepis* (Ziegler & Sandberg, 1990). According to Sandberg & Dreesen (1984, p. 150) and Savoy & Harris (1993, p. 2416) *Palmatolepis* species lived mostly in a pelagic and basin habitat. That species of *Palmatolepis* are rare in the Late Devonian of the Shotori Range indicates that most of the sediments of the area may have been deposited in shallow water. It should be noted, however, that although palmatolepids are not common in the Shotori Range sections, an attempt has been made to tie the occurrences of polygnathids and icriodontids to the palmatolepid-based zonation. For the Carboniferous, zonation and conodont occurrences documented by Brenckle & Manger [eds] (1991), for example, Conil *et al.* (1991) and Perret & Weyant (1994) have been used.

Based on conodont occurrences from the section measured in the Shotori Range at Howz-e-Dorah through 1070 m of outcrop and minor sections at Kale Sardar, conodont zones from mid Frasnian through the Carboniferous represented in the area are as follows:

1. Older than late Early *hassi* Zone.

In the Howz-e-Dorah section, two biostromal beds at 52 m and 82 m above the base of the section and below the first horizon yielding biostratigraphically useful for conodonts, were found to contain *Hexagonaria* sp., *Cyphopterorhynchus arpaensis* (Abramian) and *C. koraghensis interpositus* Sartenaer, a fauna also reported by

Meters above base of section		54	83.5	114	181	191	195	202	205	220	223	231	239	243	–	279	292	297	298	310	313	318	323	335	339	343	345
Sample number		502	503	504	9	505	10	506	102	11	507	508	509	510	Gha-Ka	12	511	512	14	513	103	15	514	515	16	17	516
Conodont taxa / Sample Wt. (kg)		2	3	3	4	3	4	4	4	4	4	4	4	4	1	4	4	4	4	4	4	4	4	4	4	4	4
Polygnathus aspelundi	Pa		1																								
P. capollocki n. sp.	Pa		1		2	3	1		34			1	2	1													
Icriodus alternatus alternatus	Pa			1				1	2	?1																	
I. alternatus morph II	Pa			6					2	3	1	1	2	2			7				167						
I. sp. B	Pa			1																							
Ancyrodella nodosa	Pa			1					1						2												
P. evidens	Pa			1					3		1	1	1	1		2											
I. expansus	Pa				1				1																		
I. cf. *I. iowaensis*	I								1																		
Ad. curvata	Pa								5	3				2		1											
	Sb								1																		
P. aequalis	Pa								2		1																
P. webbi	Pa								1					2													
P. planarius	Pa									2					5				1		3						
P. aff. *P. angustidiscus*	Pa											2	1		2												
P. bervicarina	Pa													4	3												
I. iowaensis iowaensis	Pa														1			1			23	1					
I. aff. *I. iowaensis iowaensis*	Ca																2										
	Ka																	1									
Ancyrognathus sinelamina	Pa																2				?1						
P. cf. *aculatus*	Pa																2				3						
I. cornutus	Pa																2										
Pelekysgnathus inclinatus	Pa																	3									
P. cf. *papilata*	Pa																		1								
I. alternatus mawsonae n. subsp.	Pa																				15						
I. cf. *I* sp. aff. *I. cornutus*	Pa																				22						
P. rabeti n. sp.	Pa																				8						
P. n. sp. A	Pa																				1						
Palmatolepis minuta minuta	Pa																				1						
Pal. quadrantinodosalobata	Pa																				1						
Pal. subperlobata	Pa																				2						
Pal. tenuipunctata	Pa																				5						
Pal. cf. *tenuipunctata*	Pa																				3						
P. communis communis	Pa																						1	1	3	1	1
P. semicostatus	Pa																							1	6	1	15
I. costatus darbyensis	Pa																								10		
Mehlina spp.	Pa																								2	2	1
P. perplexus	Pa																								6		
P. n. sp. B	Pa																								1		
Pal. sp. C	Pa																								1		
P. cf. *experplexus*	Pa																									1	
Clydagnathus ormistoni	Pa																									3	1
Polylophodonta confluens	Pa																										1
Unassigned elements		1	5	33	6	5	3	5	72	80	10	17	12	60	84	12		16	17	3	456	9			37	35	50

Tab. 1 - Distribution of conodont elements from the Howz-e-Dorah section (A--A1) for the Devonian portion of the Shishtu Formation.

Sartenaer (1966) and dated broadly as Frasnian. On the basis of conodont data, the fauna can now be restricted to the lower half of the Frasnian, late Early *hassi* Zone or older.

2. Late Early *hassi* Zone.

Eighty four metres above the base of the Howz-e-Dorah section, the incoming of *Polygnathus aspelundi* suggests that this level is no older than late in the Early *hassi* Zone and is no younger than *jamieae* Zone. This is based on the age and range of *P. aspelundi* given by Klapper (1997). In their discussion of the zonation of the Lali Section, South China, Ji & Ziegler (1993, p. 18, 19) include *P. aspelundi* in their discussion of the *punctata* Zone, grouping beds 21-28 from the Lali section in this zone. In the description of the individual beds of the Lali Section, however, Ji & Ziegler (1993, p. 12) show that *P. aspelundi* first occurs within Bed 25 suggesting the possibility that this bed could represent the commencement of the Early *hassi* Zone.

3. *jamieae* Zone.

Based on ranges suggested by Klapper (1997), the occurrence of *Ad. nodosa*, *P. evidens* and *I. alternatus alternatus*, 114 m above the base of the section are consistent with an age of *jamieae* Zone.

Note: Apart from the occurrence of dolomite beds at various levels, the section from the commencement of the *jamieae* Zone appears to be continuous. Conodont data available for the next 195 m of section do not allow the various zones from Early *rhenana* (= Lower *gigas* Zone) to Early *triangularis* (= immediately above the Frasnian--Famennian boundary) to be clearly defined. Conodonts occurring within this interval include: *Icriodus alternatus alternatus*, *I. expansus*, *I.* cf. I. *iowaensis iowaensis*, *Polygnathus aequalis*, *P.* aff. P. *angustidiscus*, *P. brevicarina*, *P. evidens*, *P. planarius*, *P. capollocki* n. sp. and *P. webbi*. At 205 m above the base of the section, *P. webbi* and a single specimen of an orthoceratid were recovered. The bed also contained a Frasnian brachiopod fauna identified by Sartenaer (in Stöcklin *et al.*, 1991, p. 12) that included: *Hypothyridina* cf. *cuboides*

Meters above base of section		347	348	351	359	361	368	377	383	389	398	399	400	405	410	413	432	511	554	565	570	584	609	646	706	710	711	712	718	720	745	820	987
Sample number		517	104	518	519	18	520	521	522	19	105	523	20	524	21	525	22	528	529	26	530	106	28	29	33	532	34	107	533	35	36	108	109
Sample Wt. (kg) / Conodont taxa		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Polygnathus inornatus	Pa	1	36	8		2																											
Undet. spathognathodids	Pa		1	1		1				1	2				1	2	1		1														
P. communis communis	Pa		2	1	2	1						18	6	3																			
Siphonodella isosticha	Pa		3																														
Si. cf. obsoleta	Pa		2																														
Pseudopolygnathus multistriatus	Pa										1		2	6	1	1			1														
cf. *Idioprioniodus* sp.	Pa										2	2			2			1	2					1				6	3				
Dollymae boukaerti	Pa											1																					
Ps. pinnatus	Pa											?1			1																		
Gnathodus delicatus	Pa											4																					
Gn. semiglaber	Pa												1		4		1	1	1		1	1	2										
Gn. typicus	Pa																	1										4					
Gn. pseudosemiglaber	Pa																				2			6								4	
Gn. girtyi girtyi	Pa																						1			1		23	6		14	3	
Idioprioniodus ssp.	Pa																							2				10			3		
Gn. girtyi intermdius	Pa																							1				13			4		
Gn. girtyi simplex	Pa																							14	?2	1		1				5	
Idiognathoides sp.	Pa																											1					
Lochriea commutata	Pa																															6	
Rhachistognathus muricatus	Pa																															3	
Declinognathodus noduliferus	Pa																															12	
Idiognathodus sinuatus	Pa																															4	
Neognathodus cf. *medadultimus*	Pa																															2	
Neogondolella cf. *clarki*	Pa																																1
Unassigned elements		13	189	30	10	7	1	7	1	6	7	72	39	69	19	14	16	7	27	2	2	13	8	93	4	15	4	143	24	9	31	45	

Tab. 2 - Distribution of conodont elements from the Howz-e-Dorah section (A--A1) for the Carboniferous portion of the Shishtu Formation, the Sardar Formation and the lowermost Jamal Formation (Permian).

(Sowerby), *Schizophoria* cf. *striatula* (Schlotheim), *Strophonella* sp., *Atrypa* cf. *reticularis* (Linné), *Strophonella* cf. *productoides* (Murchison), *Cyrtospirifer* of the group *verneuili* (Murchison), and *Athyris* cf. *communis* (Gosselet). Because of the constraints of the conodont fauna, a late Frasnian age (no older than *jamieae* Zone) can now be attributed to this fauna.

4. *linguiformis* Zone (?Frasnian-Famennian boundary).

At 279 m above the base of the Howz-e-Dorah section, the last occurrence of *Ancyrodella curvata* late form and *Ad. nodosa* suggests a level close to the top of the *linguiformis* Zone. Ziegler & Sandberg (1990) suggest both these species became extinct at the end of Frasnian. The last element related to the *Ad. curvata* late form from sample 12, 279 m above the base of the section came from a limey white to brown sandstone bed from within a sandy sequence below a sequence of beds rich in cephalopods, referred to by Stöcklin *et al.* (1965, 1991) and herein as the "Cephalopod beds". Although the dark rich shales usually associated with the Kellwasser Event are not represented in the Howz-e-Dorah section, the bed containing *Ad. curvata* within the sandy sequence may possibly be correlated with the Kellwasser Event found elsewhere globally. The Frasnian/Famennian boundary may have occurred with within sample 12, 279 m above the base of the section, or very close to this level.

Cephalopod specimens collected from a white sandy oolitic limestone at Kale Sardar (Niaz section, sample 7, 18 m above the base of the section [= top of bed 17 of Stöcklin *et al.*, 1991, p. 15] have been identified by Prof. M. House as: *Beloceras tenuistriatum* var. nov. (pers. commun., June 1995). This is the first report of this species from the Shotori Range. As *Ad. curvata* late form and *Pal. winchelli* were recovered from the same horizon (Table 3), *Beloceras tenuistriatum* at Kale Sardar can not be younger than late Frasnian (from Late *rhenana* Zone to the end of the *linguiformis* Zone). At Kale Sardar, the white, sandy oolitic limestone varies in thickness from outcrop to outcrop and at times intertongues with green shale. This is contrary to Stöcklin *et al.* (1991, p. 16-18) who documented all green shales as belonging to the Sardar Formation and dated as Late Carboniferous in age. As outlined above, conodonts interpreted as Late Frasnian in age, suggest a date for at least portion of the green shales that inter-tongue with the white, sandy oolitic limestones.

5. Late *triangularis* Zone or Early crepida Zone.

At 291 m above the base of the Howz-e-Dorah section, a series of red, richly fossiliferous, sometimes oolitic limestones commence. These beds, as mentioned above, are generally referred to as the "Cephalopod beds". The basal bed, sample 13, a red sandy oolitic limestone, normally indicative of well oxygenated warm water, yielded no conodonts possibly because of the high oolitic content. However, as the macrofauna and vertebrate microremains from the sample have either been changed to or are covered by chamosite, the envi-

Section		NIAZ											A		B			
Sample number		1	2	3	4	7	5	9	10	11	12	13	6	8	14	15	16	17
Meters above base of section		4.50	11.50	14.80	19.60	18.00	selective	pebble	pebble	pebble	pebble	pebble	15.00	32.00	38.00	48.00	52.00	57.00
Sample Wt. (kg) / Conodont taxa		1	3	3	3	4	1	4	4	4	4	4	3	3	4	4	4	4
Icriodus alternatus s.s	Pa					13				1								
I. alternatus alternatus	Pa		1	1		3	1			4								
I. cf. *I. alternatus*	Pa									1								
I. cf. *I.* aff. *I. cornutus*	Pa		2	1														
I. expansus	Pa					6												
Icriodus sp. A	Pa									1								
Pelekysgnathus inclinatus	Pa	2																
Idioprionoids ssp.	Pa															5		
cf. *Idioprionoids* sp.	Pa							1								5		
Scaliognathus anchoralis europensis	Pa															6		
Ancyrodella curvata	Pa		6	7		35												
Ad. nodosa	Pa		1			4												
Bispathodus stabilis	Pa												1					
Lochriea commutata	Pa											2						
Mehlina sp.	Pa	7																
Pseudopolygnathus controversus	Pa						?1						1					
cf. *Ps. triangularis inequalis*	Pa															1		
Ps. pinnatus	Pa						1					?2				1		
Scaphignathus velifer velifer	Pa	3																
Sc. velifer leptus	Pa	1																
Polygnathus communis communis	Pa	2											1					
P. communis collinsoni	Pa												2					
P. evidens	Pa					37												
P. longiposticus	Pa							2										
P. nodocostatus	Pa	1											1					
P. experplexus	Pa												1					
P. perplexus	Pa												1					
P. planarius	Pa				1													
P. semicostatus	Pa	2											1					
cf. *P. symmetricus*	Pa										2					2		
P. capollocki n. sp.	Pa			3														
P. n. sp. A	Pa									1								
cf. *P. uncornis*	Pa					?				2								
P. webbi	Pa			3														
Palmatolepis glabra pectinata	Pa	2																
Pal. kapperi	Pa	1																
Pal. minuta minuta	Pa	4								2								
	M	2																
Pal. schindwolfi	Pa	1																
Pal. perlobata sigmoida	Pa	2																
Pal. quadrantinodosalobata	Pa									2								
Pal. sp. A	Pa			1														
Pal. sp. B	Pa						1											
Pal. sp. D	Pa		1															
cf. *Pal. winchelli*	Pa					2												
Pal. wolskae	Pb	4																
Alterognathodus sp.	Pa				2													
Gnathodus pseudosemiglaber	Pa							6	1		5	10			3	4	1	2
Gn. semiglaber	Pa														1			2
Gn. typicus	Pa							5	1			1			1	5		
Gn. bilineatus	Pa											1						
Gnathodus sp.	Pa											1						
Declinognathodus noduliferous	Pa											7						
Idiognathoides sinuatus	Pa											3						
Hindeodella segaformis	Pa														1			
Unassigned elements		125	24	16	7	154	6	10	10	11	8	2	6	5	134	3		

Tab. 3 - Distribution of conodont elements from sections in the Kale Sardar area: Niaz Section, Section A and Section B.

ronment must have been one of a restricted area where reducing conditions could be combined with periodic rough water conditions as suggested by Odin (1988, p. 24-25) in his explanation of the Swiss Jurassic ironstones. It is possible that the beginning of the Early *triangularis* Zone might be represented in sample 13 in this environment obviously hostile to conodonts.

At 292 m above the base of the section in the lower part of the "Cephalopod beds", *P. acutatus* occurs with *An. sinelaminus*. According to Khalymbadzha et al. (1992, p. 75) the age the faunas from southern Kazakhstan associated with *P. actuatus*, including *An. sinelaminus* and *I. iowaensis*, "may perhaps correspond to the Early Famennian *Palmatolepis crepida* Zone". Alternatively, it could dated as Middle or Late *triangularis* Zone as, apart from *P. acutatus*, the associated fauna are represented in these zones.

At 313 m above the base of the Howz-e-Dorah section, in sample 103, the numbers of icriodontids represented in the fauna increases rapidly also indicative of very shallow water. A 4 kg sample yielded more than 700 conodont elements and approximately 900 vertebrate micro remains.

This time interval is also recognised at Kale Sardar where a clast from the Sardar conglomerate, sample 11, yielded a similar fauna. Important species represented in the Shishtu Formation at both localities for this time interval include: *Icriodus alternatus alternatus*, *I.* cf. *I.* sp. aff. *I. cornutus*, *I. iowaensis iowaensis*, *Polygnathus* cf. *P. papilata*, *P. ratebi* n. sp. *P.* n. sp. *A*, *Palmatolepis minuta minuta*, *Pal. quadrantinodosolobata*, *Pal. subperlobata*, *Pal. tenuipunctata*, and *Pal.* cf. *tenuipunctata.*

6. Middle *crepida* Zone.

On the age attributed to *P. semicostatus* by Dreesen & Dusar (1974), the incoming of this species in sample 515, 335 m above the base of the Howz-e-Dorah section, indicates an age no older than Middle *crepida* Zone. This age is in accordance with Ji & Ziegler (1993) who also give the age of *Polygnathus semicostatus* as from within Middle *crepida* Zone into the Late *expansa* Zone.

7. Latest *marginifera* Zone.

At Kale Sardar in sample 1, 4.5 m above the base of the Niaz section, the conodont fauna included a zonal species, *Scaphignathus velifer velifer*, as well as *Sc. ve-*

lifer leptus, *Pelekysgnathus* sp., *Mehlina* sp., *Polygnathus communis communis*, *P. semicostatus*, *P. nodocostatus*, *Palmatolepis glabra pectinata*, *Pal. marginifera marginifera*, *Pal. minuta minuta*, *Pal. schindewolfi*, and *Pal. perlobata sigmoida*. Although it is recognised that *Pal.* g. *pectinata* is normally restricted to horizons no younger than Late *marginifera* Zone, Ji & Ziegler (1993, p. 15) record it as occurring in the Latest *marginifera* Zone. Sample 1 at Kale Sardar also has a diverse fauna of Famennian cephalopods including numerous species of *Platyclymenia*.

No samples have been processed from between 335 m and 339 m above the base of the section at Howz-e-Dorah, an interval that might be of the same age. As no platyclymeniids have been collected from the section at Howz-e-Dorah, there is the possibility of there being a hiatus for this time interval at Howz-e-Dorah.

8. Early *expansa* Zone.

The incoming of *I. costatus darbyensis* in sample 16, 339 m above the base of the Howz-e-Dorah section is indicative of the Early *expansa* Zone. The presence of faunal elements such as *P. perplexus* is consistent with this age. Approximately 1 m above sample 16, crushed and scattered pieces of orthoceratids were collected. According to House (1981, p. 30), all ammonoids with the exception of the Prionoceratidae and Bactritina became extinct at the end of the Late Devonian, approximately 95% of the entire group disappeared. Where previously in the Howz-e-Dorah section some beds consisted almost entirely of orthoceratids, the number of these fossils after sample 16 were reduced so far as to constitute less than 5% in beds close to the top of Famennian.

At 343 m above the base of the section in sample 17, *P. experplexus* and *Clydagnathus ormistoni* appear, two forms also consistent with an Early *expansa* age. At Kale Sardar, in section A, sample 6 yielded a vast fauna of diverse cephalopods including numerous Famennian orthoceratids. The Early *expansa* conodont fauna includes: *Bispathodus stabilis*, *Pseudopolygnathus controversus*, *Polygnathus communis communis*, *P. communis collinsoni*, and *P. semicostatus*. The associated cephalopod fauna identified by Prof. Michael House (pers. comm. 1995) includes: *Cyrtoclymenia* cf. *inflata* (Münster), and *Platyclymenia richteri* Wedeking Group, the latter being typical of Famennian IV. Precise dating of the conodont fauna from this horizon would align this with Early *expansa* Zone.

Note: The Howz-e-Dorah section appears to have a considerable hiatus at this level with the following zones not represented with certainty: Middle and Late *expansa* zones, Early, Middle and Late *praesulcata* zones, *sulcata* Zone, Lower and Upper *duplicata* zones and *sandbergi* Zone. Such a hiatus can be observed worldwide due to a global regression. Compare, for example, the history of the Michigan Basin documented by Gutschick & Sandberg (1991) where a hiatus occurs from within the *praesulcata* Zone to the beginning of the *crenulata* Zone.

9. Early *crenulata* Zone.

The first appearance of *Si. isosticha* is in sample 104, 384 m above the base of the Howz-e-Dorah section occurring in the bed lying unconformably immediately above the topmost unit of the "Cephalopod beds". This species first appears in the upper part of the *crenulata* Zone. The dominant conodont occurring with *Si. isosticha* is the long-ranging *Polygnathus inornatus*.

10. *isosticha*-Upper *crenulata* Zone.

Sample 521, 377 m above the base of the Howz-e-Dorah section, yielded a specimen of *Pseudopolygnathus multistriatus* that, according to Lane *et al.* (1980) occurs in beds no older than *isosticha*-Late *crenulata* Zone.

11. *typicus* Zone (= *communis carina* Zone).

This zone is represented with certainty in the Howz-e-Dorah section with the occurrence of *Dollymae bouckaerti* in sample 523, 380 m above the base of the section (Conil et al., 1991; Sweet, 1988). Other elements

PLATE 1

Fig. 14, 15 x70; figs 1-9, 11, 12, 16 x100; fig. 10 x150; fig. 13 x200.

Fig. 1-4 - *Icriodus iowaensis iowaensis* Youngquist & Peterson, 1947: 1) upper view, EUIC 1821; 103 Howz-e-Dorah; 2) upper view, EUIC 1822; 103 Howz-e-Dorah: 3) upper view, EUIC 1823; 103 Howz-e-Dorah; 4) lower view, EUIC 1823; 103 Howz-e-Dorah.

Fig. 5 - *Icriodus iowaensis iowaensis* Youngquist & Peterson, 1947: narrow form, lateral view, EUIC 1824; 511 Howz-e-Dorah.

Fig. 6-9 - *Icriodus iowaensis iowaensis* Youngquist & Peterson, 1947: 6) upper view, EUIC 1825; 103 Howz-e-Dorah; 7) upper view, EUIC 1826; 103 Howz-e-Dorah: 8) upper view, EUIC 1827; 103 Howz-e-Dorah; 9) upper view, EUIC 1828; 103 Howz-e-Dorah.

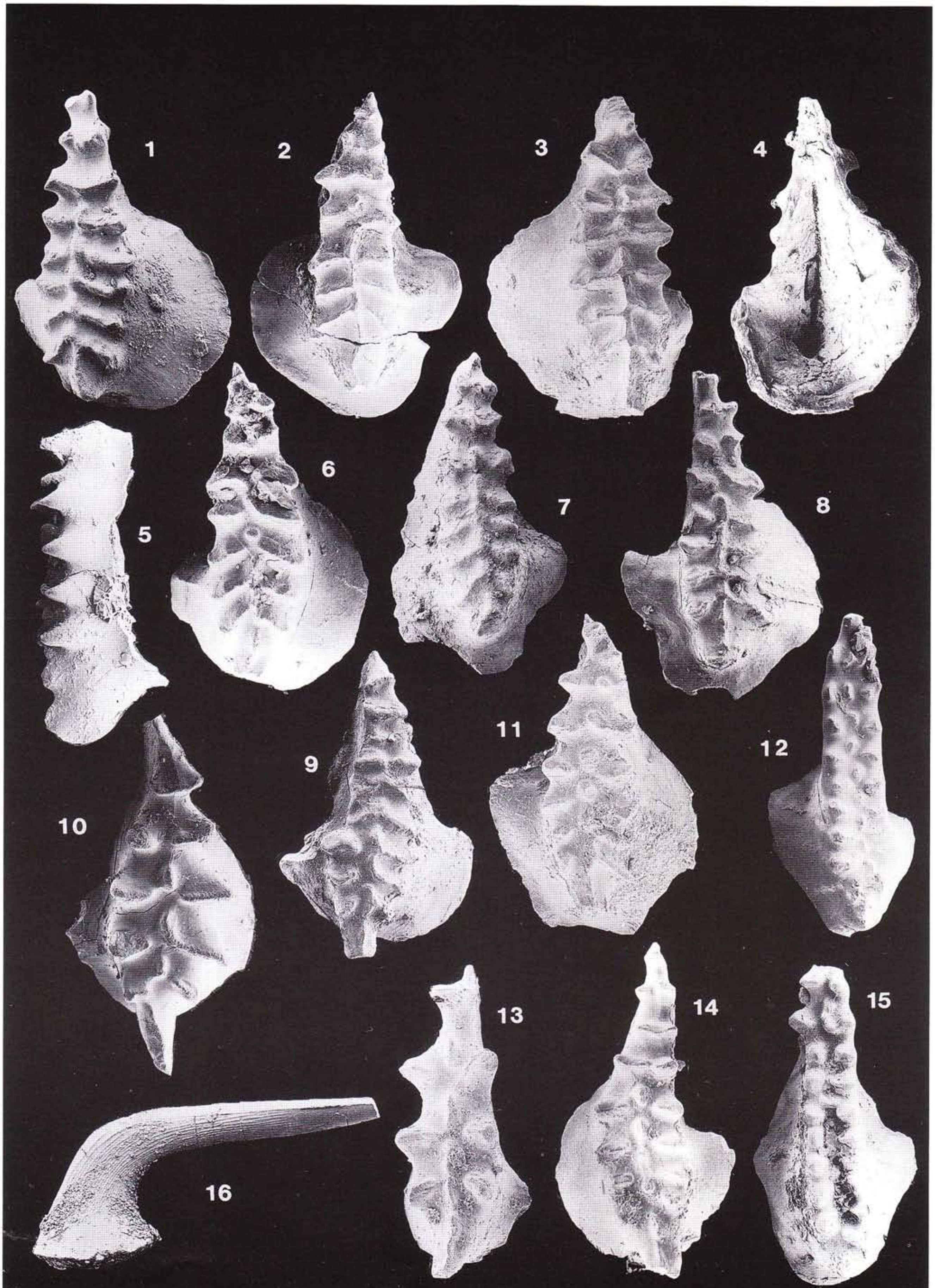
Fig. 10 - *Icriodus* cf. *I. iowaensis iowaensis* Youngquist & Peterson, 1947: upper view, EUIC 1829; 102 Howz-e-Dorah.

Fig. 11,13,14-*Icriodus alternatus* Morphotype II Dreesen & Houlleberghs, 1980: 11) upper view, EUIC 1830; 103 Howz-e-Dorah; 13) upper view, EUIC 1832; 102 Howz-e-Dorah; 14) upper view, EUIC 1833; 103 Howz-e-Dorah.

Fig. 12 - *Icriodus* cf. *I.* sp. aff. *I. cornutus* Sanneman, Clausen, Korn & Luppold, 1991: upper view, EUIC 1831; 103 Howz-e-Dorah.

Fig. 15 - *Icriodus alternatus mawsonae* n. subsp.: upper view, EUIC 1834; 103 Howz-e-Dorah.

Fig. 16 - *Icriodus* aff. *I. iowaensis* Youngquist & Peterson, 1947: Ka element lateral view, EUIC 1835; 512 Howz-e-Dorah.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associated with this species are: *Polygnathus communis communis*, *Idioprioniodus* sp. and *Gnathodus delicatus*.

Sample 9, a clast from the Sardar conglomerate at Kale Sardar, yielded *Ps. pinnatus*, *P. longiposticus*, *Gn. pseudosemiglaber* and *Gn. typicus* indicating a fauna of *typicus* age.

12. *anchoralis-latus* Zone.

The uppermost part of the *anchoralis-latus* Zone can be recognised in sample 14, 38 m above the base of section B at Kale Sardar by the co-occurrence of *Gnathodus pseudosemiglaber*, *Gn. typicus* and *Gn. semiglaber*. In sample 15, 10 m above sample 14 in the same section, *Sc. anchoralis europensis* occurs *inter alia* with *Gn. pseudosemiglaber* and *Gn. typicus* and *P. symmetricus*. Based on ranges given in Belka & Groessens (1986), the last occurrence *Sc. anchoralis europensis* and the first occurrence of *Gn. pseudosemiglaber* are close to the end of the *anchoralis-latus* Zone, in other words, samples 14 and 15 in section B at Kale Sardar are very close to the Tournaisian-Visean boundary.

In the Howz-e-Dorah section, *anchoralis-latus* Zone cannot be defined with precision but as the section is continuous and there is no sign of any hiatus between the beds identified as belonging to the *typicus* Zone below and the *texanus* Zone above, further sampling between these should yield diagnostic forms of *anchoralis-latus* age.

Note: From the *anchoralis-latus* Zone to Carboniferous-Permian boundary, conodont zonation is problematic as discussed in detail in Brenckle & Manger [eds] (1991), for example in Webster & Groessens (1991). Indicative of the inherent problems, for the period above the *texanus* Zone and below the *naviculus* Zone, Sweet (1988)

PLATE 2

Figs 3, 4, 9 x60; fig. 10, 17 x80; fig. 1, 2, 8, 11, 12, 15, 18-20, x100; fig. 5-7, 13, 14 x200; fig. 16 x250.

Fig. 1 - *Icriodus* sp. B.: 1) upper view, EUIC 1836; 504 Howz-e-Dorah; 2) lower view, EUIC 1836; 504 Howz-e-Dorah.
Fig. 3, 4 - *Icriodus alternatus mawsonae* n. subsp. 3) upper view, EUIC 1837; 103 Howz-e-Dorah; 4) upper view, EUIC 1838; 103 Howz-e-Dorah.
Fig. 5-10 - *Icriodus alternatus alternatus* Branson & Mehl, 1934a: 5) upper view, EUIC 1839; 504 Howz-e-Dorah; 6) upper view, EUIC 1840; 7 Niaz Section, Kale Sardar; 7) upper view, EUIC 1841; 11 Niaz Section, Kale Sardar; 8) upper view, EUIC 1842; 103 Howz-e-Dorah; 9) upper view, EUIC 1843; 103 Howz-e-Dorah; 10) upper view, EUIC 1844; 11 Niaz Section, Kale Sardar.
Fig. 11, 12 - *Icriodus expansus* Branson & Mehl, 1938: 11) upper view, EUIC 1845; 7 Kale Sardar; 12) upper view, EUIC 1856; 7 Kale Sardar.
Fig. 13 - *Icriodus* sp. A: upper view, EUIC 1847; 11 Niaz Section, Kale Sardar
Fig. 14 - *Icriodus cornutus* Sannemann, 1955: upper view, EUIC 1848; 518 Howz-e-Dorah.
Fig. 15 - *Icriodus costatus darbyensis* Klapper, 1958: upper view, EUIC 1849; 16 Howz-e-Dorah.
Fig. 16, 17 - *Pelekysgnathus inclinatus* Thomas, 1949: 16) lateral view, EUIC 1850; 1 Niaz Section, Kale Sardar; 17) lateral view, EUIC 1851; 1 Niaz Section, Kale Sardar.
Fig. 18, 19 - *Idioprioniodus* spp.: 18) lateral view, EUIC 1852; 107 Howz-e-Dorah; 19) lateral view, EUIC 1853; 107 Howz-e-Dorah.
Fig. 20 - cf. *Idioprioniodus* sp.: lateral view, EUIC 1854; 524 Howz-e-Dorah.

PLATE 3

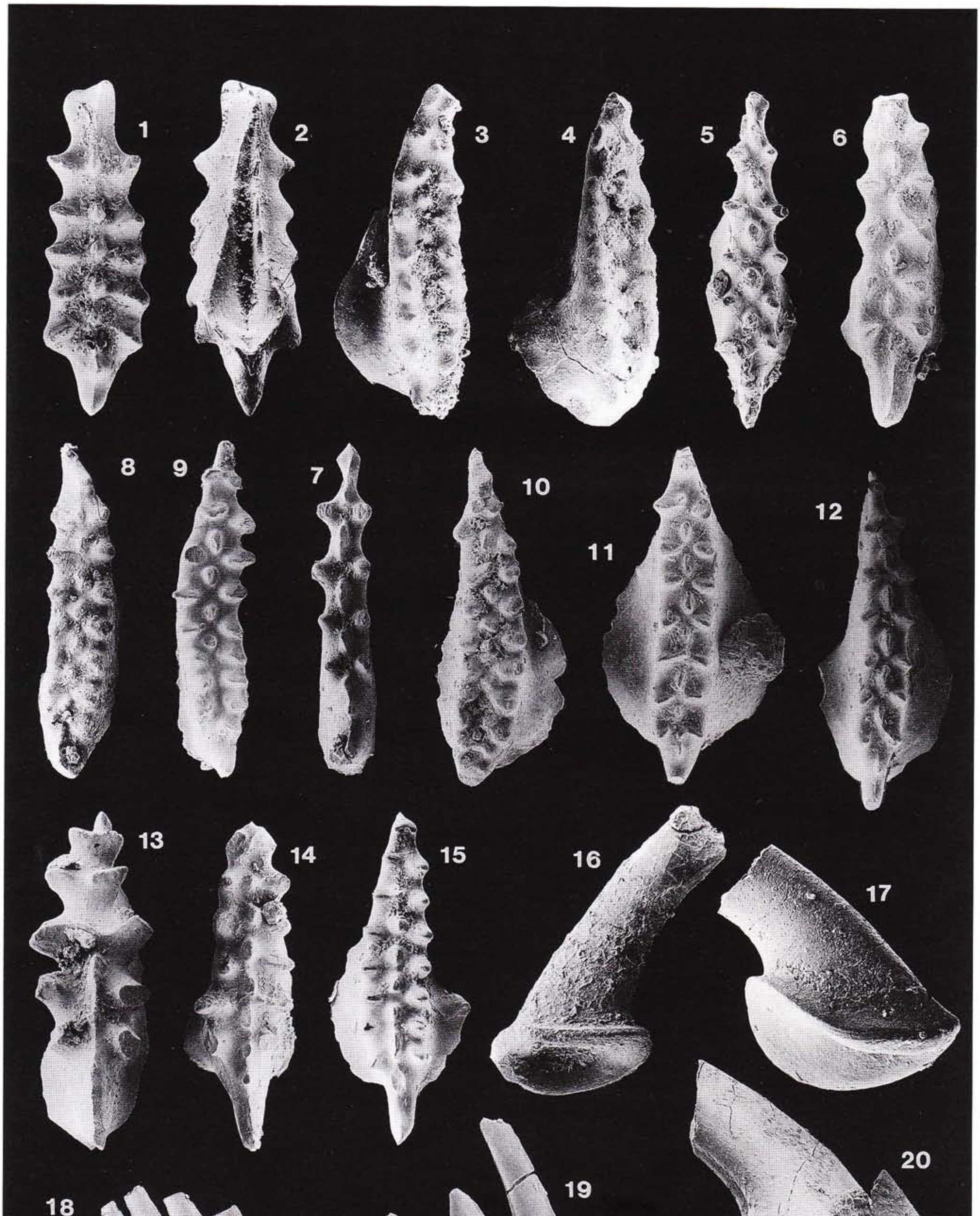
Fig. 14, 15 x60; fig. 2, 3, x80; fig. 1, 4-8, 12, 16 x100; fig. 9, 11, x120; fig. 10 x200; fig. 13 x550.

Fig. 1, 2 - *Idioprioniodus* spp.: 1) lateral view, EUIC 1855; 107 Howz-e-Dorah; 2) lateral view, EUIC 1856; 107 Howz-e-Dorah.
Fig. 3-8 - cf. *Idioprioniodus* sp.: 3) lateral view, EUIC 1857; 533 Howz-e-Dorah; 4) lateral view, EUIC 1858; 15 Niaz Section, Kale Sardar; 5) lateral view, EUIC 1859; 107 Howz-e-Dorah; 6) lateral view, EUIC 1860; 107 Howz-e-Dorah; 7) lateral view, EUIC 1861; 528 Howz-e-Dorah; 8) lateral view, EUIC 1862; 107 Howz-e-Dorah.
Fig. 9-13 - *Lochriea commutata* (Branson & Mehl, 1941): 9) upper view, EUIC 1863; 108 Howz-e-Dorah; 10) upper view, EUIC 1864; 108 Howz-e-Dorah; 11) upper view, EUIC 1865; 108 Howz-e-Dorah; 12) upper view, EUIC 1866; 108 Howz-e-Dorah; 13) enlargment of microstructure on the central blade of EUIC 1865; 108 Howz-e-Dorah.
Fig. 14-15 - *Dollymae boukaerti* Groessens, 1971: 14) upper view, EUIC 1867; 523 Howz-e-Dorah; 15) lower view, EUIC 1867; 523 Howz-e-Dorah.
Fig. 16 - *Neogondolella* cf. *clarki* (Koike, 1967) upper view, EUIC 1868; 109 Howz-e-Dorah.

PLATE 4

Fig. 1, 2, 4, 5, 9, 12-14, x60; fig. 3, 6-8, 10, 11 x80; fig. 15 x100.

Fig. 1-5 - *Scaliognathus anchoralis europensis* Lane & Ziegler, 1983: 1) upper view, EUIC 1869; 15 Niaz Section, Kale Sardar; 2) lower view, EUIC 1869; 15 Niaz Section, Kale Sardar; 3) upper view, EUIC 1870; 15 Niaz Section, Kale Sardar; 4) upper view, EUIC 1871; 15 Niaz Section, Kale Sardar; 5) lower view, EUIC 1871; 15 Niaz Section, Kale Sardar.
Fig. 6-11 - *Ancyrodella nodosa* Ulrich & Bassler, 1926: 6) lower view, EUIC 1872; 504 Howz-e-Dorah; 7) upper view, EUIC 1872; 504 Howz-e-Dorah; 8) upper view, EUIC 1873; Ghale Kalagho; 9) upper view, EUIC 1874; Ghale Kalagho; 10) upper view, EUIC 1875; 102 Howz-e-Dorah; 11) lower view, EUIC 1875; 102 Howz-e-Dorah.
Fig. 12-15 - *Ancyrodella curvata* (Branson & Mehl, 1934a): 12) lower view, EUIC 1876; 102 Howz-e-Dorah; 13) upper view, EUIC 1876; 102 Howz-e-Dorah; 14) upper view, EUIC 1877; 7 Niaz Section, Kale Sardar; 15) lateral view of Sb element, EUIC 1878; 102 Howz-e-Dorah.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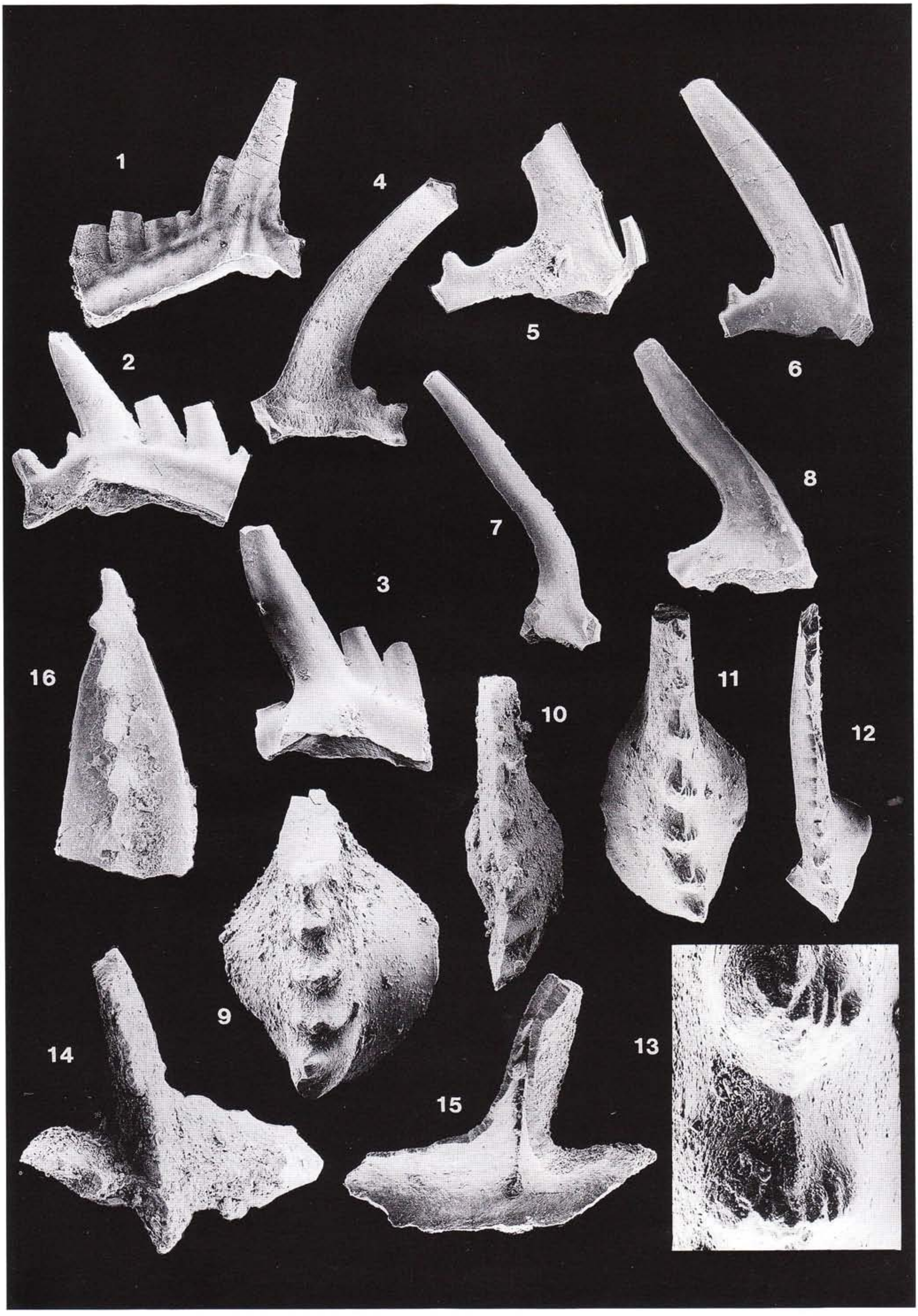
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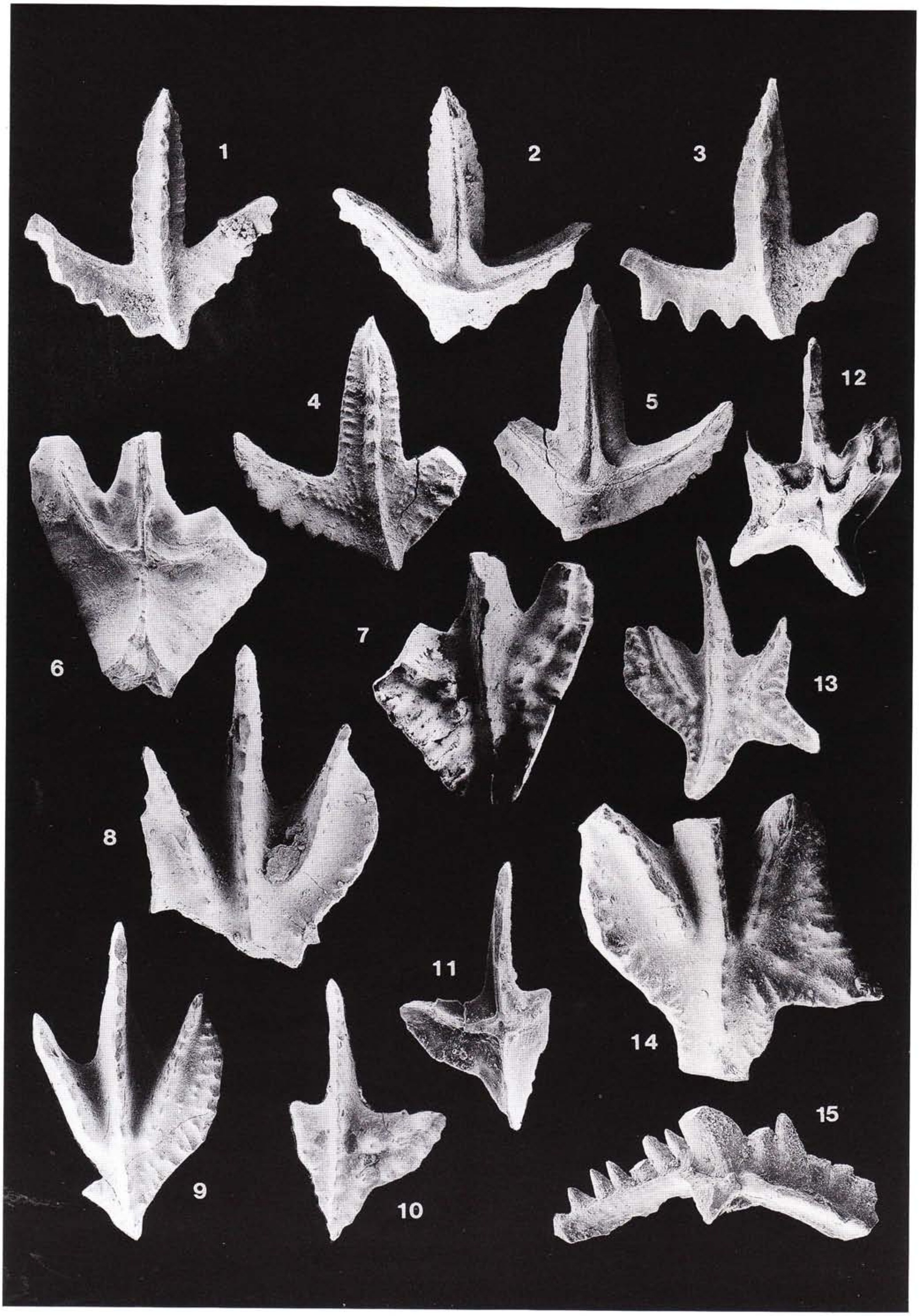
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labels the interval as one of "no widely recognised Zones". Zones given in Conil *et al.* (1991) are used herein.

13a. "Early" *bilineatus* Zone (Visean).

According to the zonation of Groessens (in Conil *et al.*, 1991, Fig. 2), there appears to be a dearth of conodonts between the *texanus* Zone and the *bilineatus* Zone they show as the *Taphrognathodus transatlanticus* Zone. The occurrence of *Gn. girtyi girtyi*, in sample 28, 609 m above the base of the Howz-e-Dorah section, indicates a *bilineatus* age. Also occurring in this sample is *Gn. semiglaber*, a species that, according to Ziegler (in Ziegler [ed.], 1981, p. 147) may overlap with the occurrence of *Gn. bilineatus*, the zonal form for this zone.

PLATE 5

Fig. 15, 16 x30; fig. 13, 14 x40; fig. 3-6, 9-12, x60; fig. 7, 8 x80; fig. 1, 2 x100.

Fig. 1-2 - *Pseudopolygnathus controversus* Sandberg & Ziegler, 1979: 1) lower view, EUIC 1879; 6 Niaz Section, Kale Sardar; 2) upper view, EUIC 1879; 6 Niaz Section, Kale Sardar.

Fig. 3-12 - *Pseudopolygnathus multistriatus* Mehl & Thomas, 1947: 3) upper view, EUIC 1880; 524 Howz-e-Dorah; 4) lower view, EUIC 1880; 524 Howz-e-Dorah; 5) lower view, EUIC 1881; 529 Howz-e-Dorah; 6) upper view, EUIC 1881; 529 Howz-e-Dorah; 7) upper view, EUIC 1882; 524 Howz-e-Dorah; 8) lower view, EUIC 1882; 524 Howz-e-Dorah; 9) lower view, EUIC 1883; 20 Howz-e-Dorah; 10) upper view, EUIC 1883; 20 Howz-e-Dorah; 11) upper view, EUIC 1884; 524 Howz-e-Dorah; 12) lower view, EUIC 1884; 524 Howz-e-dorah.

Fig. 13-16 - *Pseudopolygnathus pinnatus* Voges, 1959: 13) lower view of Morphotype I, EUIC 1885; 9 Niaz Section, Kale Sardar; 14) upper view of Morphotype I, EUIC 1885; 9 Niaz Section, Kale Sardar; 15) upper view of Morphotype II, EUIC 1886; 21 Howz-e-Dorah; 16) lower view of Morphotype II, EUIC 1886; 21 Howz-e-Dorah.

PLATE 6

Fig. 14, 15 x40; fig. 1, 3, 4, x60; fig. 2, 18-22 x80; fig. 5-13, 16, 17, 23 x100.

Fig. 1 - *Pseudopolygnathus pinnatus* Voges, 1965: upper view, EUIC 1887; 15 Niaz Section, Kale Sardar.

Fig. 2 - *Pseudopolygnathus* cf. *triangulus inaequalis* Voges, 1959: upper view, EUIC 1888; 15 Niaz Section, Kale Sardar.

Fig. 3-4 - *Ancyrognathus sinelaminus* (Branson & Mehl, 1934a): 3) upper view, EUIC 1889; 511 Howz-e-Dorah; 4) upper view, EUIC 1890; 511 Howz-e-Dorah.

Fig. 5 - *Scaphignathus velifer leptus* Ziegler & Sandberg, 1984: upper view, EUIC 1891; 1 Niaz Section, Kale Sardar.

Fig. 6-7 - *Scaphignathus velifer velifer* Helms, 1959: 6) upper view, EUIC 1892; 1 Niaz Section, Kale Sardar; 7) upper view, EUIC 1893; 1 Niaz Section, Kale Sardar.

Fig. 8-11 - *Rhachistognathus muricatus* (Dunn, 1965); 8) upper view, EUIC 1894; 108 Howz-e-Dorah; 9) lower view, EUIC 1894; 108 Howz-e-Dorah; 10) upper view, EUIC 1895; 108 Howz-e-Dorah; 11) lower view, EUIC 1895; 108 Howz-e-Dorah.

Fig. 12-13 - *Polygnathus aspelundi* Savage & Funai, 1980: 12) upper view, EUIC 1896; 503 Howz-e-Dorah; 13) lower view, EUIC 1896; 503 Howz-e-Dorah.

Fig. 14-15 - *Polygnathus brevicarina* Klapper & Lane, 1985: 14) upper view, EUIC 1897; 510 Howz-e-Dorah; 15) lower view, EUIC 1897; 510 Howz-e-Dorah.

Fig. 16, 23 - *Polygnathus aequalis* Klapper & Lane, 1985: 16) upper view, EUIC 1898; 102 Howz-e-Dorah; 23) upper view, EUIC 1994; 507 Howz-e-Dorah.

Fig. 17 - *Polygnathus* cf. *acutatus* Khalymbadzha, Shinkarov & Gatovsky, 1992: upper view, EUIC 1899; 511 Howz-e-Dorah.

Fig. 18-19 - *Bispathodus stabilis* (Branson & Mehl, 1934a): 18) lower view, EUIC 1900; 6 Niaz Section, Kale Sardar; 19) upper view, EUIC 1900; 6 Niaz Section, Kale Sardar.

Fig. 20 - *Spathognathodid* sp.: upper view, EUIC 1901; 525 Howz-e-Dorah.

Fig. 21-22 - *Mehlina* spp.: 21) lateral view, EUIC 1902; 17 Howz-e-Dorah; 22) lateral view, EUIC 1903; 16 Howz-e-Dorah.

PLATE 7

Fig. 1-5, 11, 12, 17-20 x60; fig. 7 x70; fig. 6, 16, 21, 22 x100; fig. 9, 10, 14, 15 x120; fig. 8, 13 x150.

Figs 1-2 - *Polygnathus* aff. *P. angustidiscus* Youngquist, 1945: 1) upper view, EUIC 1905; 509 Howz-e-Dorah; 2) upper view, EUIC 1906; 509 Howz-e-Dorah.

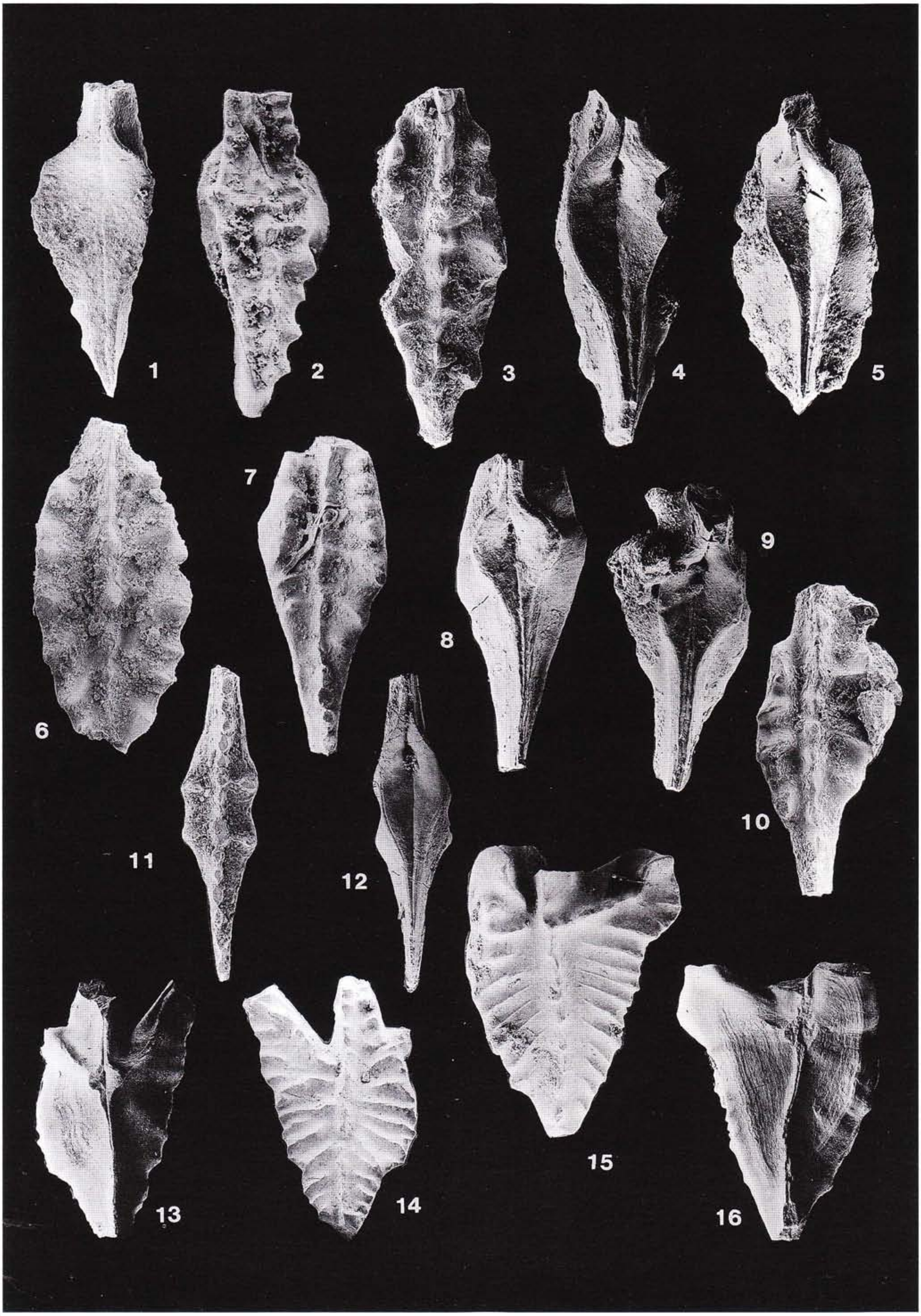
Figs 3-6 - *Polygnathus evidens* Klapper & Lane, 1985: 3) upper view, EUIC 1907; 510 Howz-e-Dorah; 4) upper view, EUIC 1908; 7 Niaz Section, Kale Sardar; 5) lower view, EUIC 1909; 7 Niaz Section, Kale Sardar; 6) upper view, EUIC 1910; 102 Howz-e-Dorah.

Fig. 7-13,15- *Polygnathus communis communis* Branson & Mehl, 1934a: 7) upper view, EUIC 1911; 104 Howz-e-Dorah; 8) upper view, EUIC 1912; 523 Howz-e-Dorah; 9) lower view, EUIC 1912; 523 Howz-e-Dorah; 10) upper view, EUIC 1913; 524 Howz-e-Dorah; 11) lower view, EUIC 1913; 525 Howz-e-Dorah; 12) upper view, EUIC 1914; 16 Howz-e-Dorah; 13) upper view, EUIC 1915; 104 Howz-e-Dorah; 15) lower view, EUIC 1917; 20 Howz-e-Dorah.

Fig. 14, 16 - *Polygnathus* cf. *P. communis collinsoni* Druce, 1966: 14) upper view, EUIC 1916; 6 Niaz Section, Kale Sardar; 16) upper view, EUIC 1918; 6 Niaz Section, Kale Sardar.

Fig. 17-20 - *Polygnathus planarius* Klapper & Lane, 1985; 17) upper view, EUIC 1919; Ghale Kalagho, Howz-e-Dorah; 18) upper view, EUIC 1920; Ghale Kalagho, Howz-e-Dorah; 19) upper view, EUIC 1921; Ghale Kalagho, Howz-e-Dorah; 20) lower view, EUIC 1921; Ghale Kalagho, Howz-e-Dorah.

Fig. 21-22 - *Polygnathus* cf. *experplexus* Sandberg & Ziegler, 1979: 21) upper view, EUIC 1922; 17 Howz-e-Dorah; 22) lower view, EUIC 1922; 17 Howz-e-Dorah.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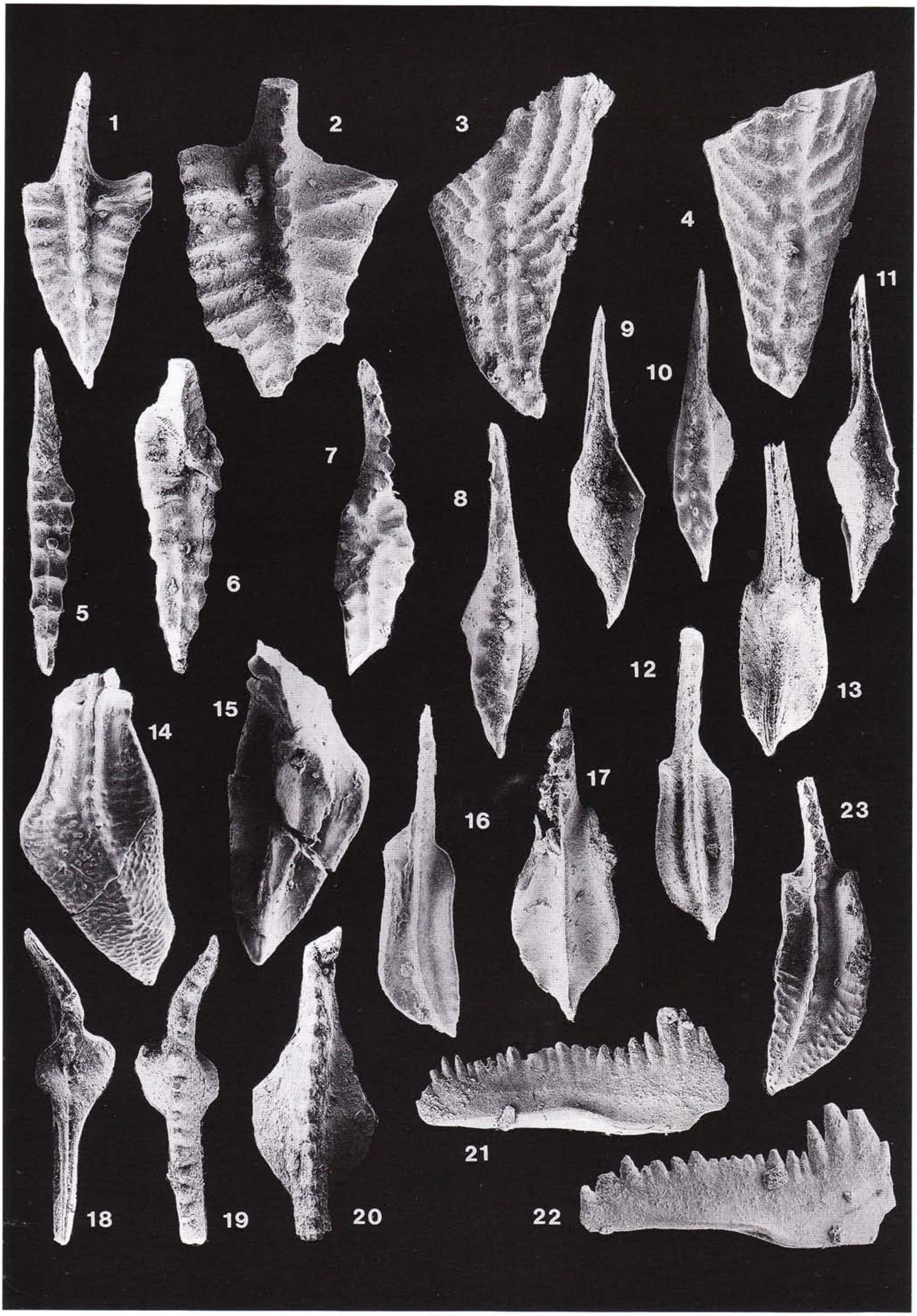
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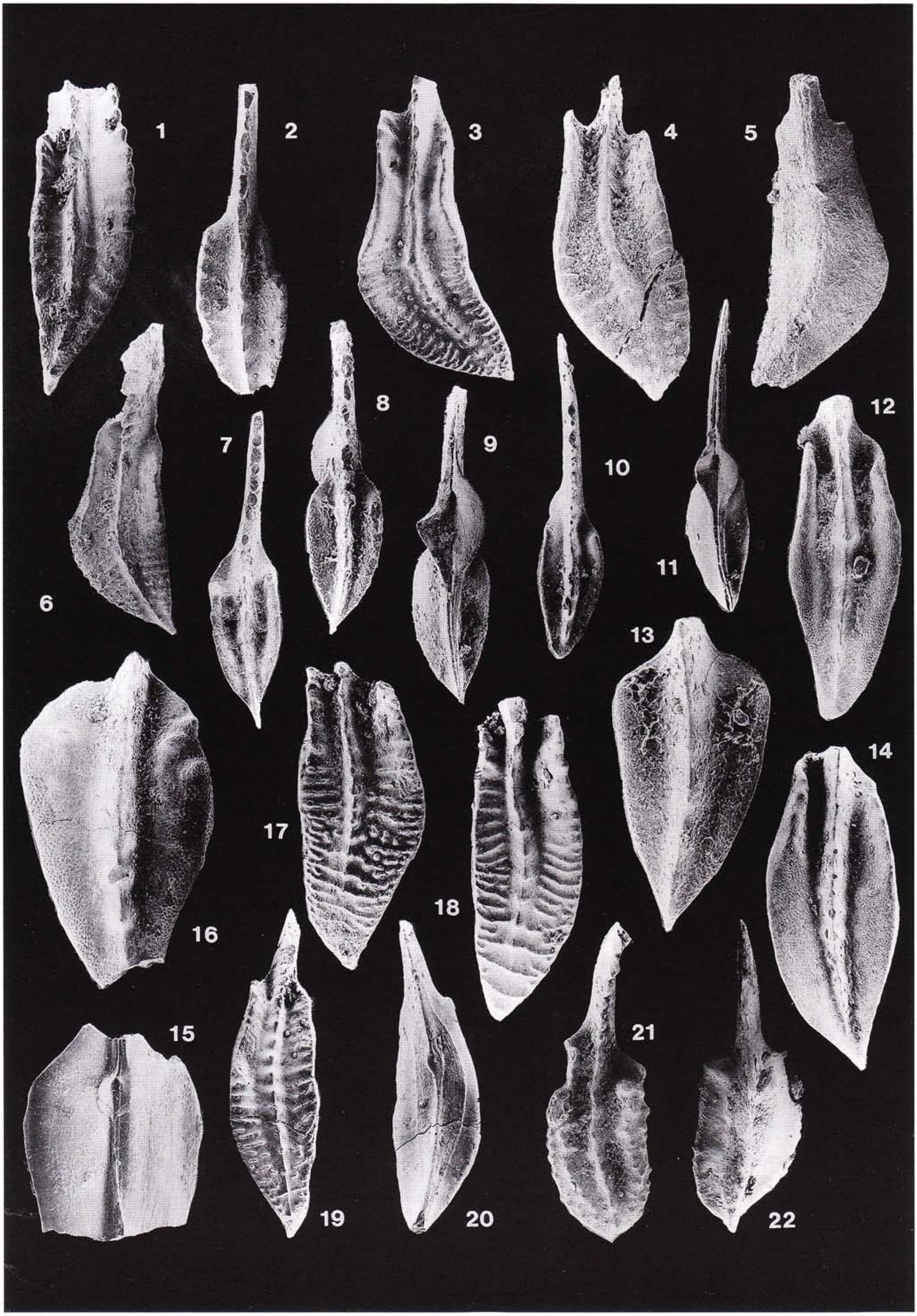
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13b. "Late" *bilineatus* Zone (Namurian).

This informal subdivision of the *bilineatus* Zone equates with the base of the *girtyi simplex* Zone first recognised by Webster (1969) in sequences in southwestern Nevada and later applied to sections in England (Higgins, 1975, 1985). From sections in Arkansas and Oklahoma, the interval recognised by Webster (1969) on the grounds that the *girtyi simplex* Zone is represented by the *Cavusgnathus naviculus* and *C. unicornis* zones (Lane & Straka, 1974). The *naviculus* Zone of Sweet (1988) would, therefore, be the equivalent of the *bilineatus* Zone (Namurian) used herein and to the lower part of the *girtyi simplex* Zone as the occurrence of *Gn. girtyi simplex* is given by Higgins (1985) as from the base of the Namurian. Its occurrence with *Gn. girtyi intermedius* in sample 29, 646 m above the base of the Howz-e-Dorah section indicates the upper part of the *bilineatus* Zone or Late *bilineatus* Zone as used herein.

PLATE 8

Fig. 2, 7, 12-14 x60; fig. 1, 3-6, 8, 11, 15-20 x100; fig. 9, 10 x120.

Fig. 1-5 - *Polygnathus inornatus* E. R Branson, 1934: 1) upper view, EUIC 1923; 104 Howz-e-Dorah; 2) upper view, EUIC 1924; 518 Howz-e-Dorah; 3) lower view, EUIC 1925; 104 Howz-e-Dorah; 4) upper view, EUIC 1926; 104 Howz-e-Dorah; 5) lower view, EUIC 1927; 104 Howz-e-Dorah.

Fig. 6, 17 - *Polygnathus perplexus* Thomas, 1949: 6) upper view, EUIC 1928; 16 Howz-e-Dorah; 17) upper view, EUIC 1938; 16 Howz-e-Dorah.

Fig. 7 - *Polygnathus* cf. *papilata* Youngquist & Peterson, 1947: upper view, EUIC 1929; 14 Howz-e-Dorah.

Fig. 8-11 - *Polygnathus semicostatus* Branson & Mehl, 1934a: 8) upper view, EUIC 1930; 516 Howz-e-Dorah; 9) upper view, EUIC 1931; 516 Howz-e-Dorah; 10) upper view, EUIC 1932; 6 Niaz Section, Kale Sardar; 11) upper view, EUIC 1933; 516 Howz-e-Dorah.

Fig. 12 - *Polygnathus* cf. *unicornis* Müller & Müller, 1957: upper view, EUIC 1934; 510 Howz-e-Dorah.

Fig. 13, 14 - *Polygnathus* sp. A: 13: upper view, EUIC 1935; 11 Niaz Section, Kale Sardar; 14) upper view, EUIC 1936; 103 Howz-e-Dorah.

Fig. 15, 16 - *Polygnathus* sp. B: 15) upper view, EUIC 1937; 16 Howz-e-Dorah; 16) lower view, EUIC 1937; 16 Howz-e-Dorah.

Fig. 18 - *Polygnathus longiposticus* Branson & Mehl, 1934a: upper view, EUIC 1939; 9 Niaz Section, Kale Sardar.

Fig. 19-20 - *Polygnathus* cf. *symmetricus* Branson, 1934; 19) upper view, EUIC 1940; 15 Niaz Section, Kale Sardar; 20) lower view, EUIC 1940; 15 Niaz Section, Kale Sardar.

PLATE 9

Fig. 16 x50; fig. 3,-5, x60; figs 1, 2, 6-15, 17, 21 x100; fig. 20 x120; fig. 19 x150, fig. 18 x200

Fig. 1-5 - *Polygnathus ratebi* n. sp.: 1) upper view of paratype, EUIC 1941; 103 Howz-e-Dorah; 2) lower view of paratype, EUIC 1941; 103 Howz-e-Dorah; 3) upper view of holotўp, EUIC 1942; 103 Howz-e-Dorah; 4) lower view of holotype, EUIC 1942; 103 Howz-e-Dorah; 5) upper view of paratype, EUIC 1943; 103 Howz-e-Dorah.

Fig. 6-12 - *Polygnathus capollocki* n. sp.: 6) upper view of paratype, EUIC 1944; 102 Howz-e-Dorah; 7) upper view of paratype, EUIC 1945; 102 Howz-e-Dorah; 8) upper view of holotype, EUIC 1946; 102 Howz-e-Dorah; 9) lower view of holotype, EUIC 1946; 102 Howz-e-Dorah; 10) lateral view of paratype, EUIC 1947; 102 Howz-e-Dorah; 11) lateral view of paratype, EUIC 1948; 102 Howz-e-Dorah; 12) upper view of paratype, EUIC 1949; 102 Howz-e-Dorah.

Fig. 13-15 - *Polygnathus webbi* Stauffer, 1938: 3) upper view, EUIC 1950; 102 Howz-e-Dorah; 14) lower view, EUIC 1950; 102 Howz-e-Dorah; 15) upper view, EUIC 1951; 3 Niaz section, Kale Sardar.

Fig. 16 - *Polylophodonta confluens* (Ulrich & Bassler, 1926): upper view, EUIC 1952; 516 Howz-e-Dorah.

Fig. 17, 18 - *Palmatolepis minuta minuta* Branson & Mehl, 1934a: 17) upper view, EUIC 1953; 11 Niaz Section, Kale Sardar; 18) upper view, EUIC 1954; 103 Howz-e-Dorah.

Fig. 19 - *Palmatolepis marginifera marginifera* Helms, 1959: upper view, EUIC 1955; 1 Niaz Section, Kale Sardar.

Fig. 20, 21 - *Palmatolepis glabra pectinata* Ziegler, 1962: 20) upper view, EUIC 1956; 1 Niaz Section, Kale Sardar; 21) upper view, EUIC 1957; 1 Niaz Section, Kale Sardar.

PLATE 10

Fig. 16, 17, 18 x50; fig. 6, 7, 10-12, 14, x60; fig. 5, 13, 15, x80; fig. 1-4, 8, 9, x100.

Fig. 1-3 - *Palmatolepis minuta minuta* Branson & Mehl, 1934a: 1) upper view, EUIC 1958; 1 Niaz Section, Kale Sardar; 2) upper view, EUIC 1959; 1 Niaz Section, Kale Sardar; 3) upper view, EUIC 1960; 1 Niaz Section, Kale Sardar.

Fig. 4 - *Palmatolepis schindewolfi* Müller, 1956: upper view, EUIC 1961; 1 Niaz Section, Kale Sardar.

Fig. 5 - *Palmatolepis perlobata sigmoida.* Ziegler, 1962: upper view, EUIC 1962; 1 Niaz Section, Kale Sardar.

Fig. 6,7,14 - *Palmatolepis subperlobata* Branson & Mehl, 1934a: 6) upper view, EUIC 1963; 103 Howz-e-Dorah; 7) lower view, EUIC 1963; 103 Howz-e-Dorah; 14) upper view, EUIC 1969; 103 Howz-e-Dorah.

Fig 8, 9 - *Palmatolepis quadrantinodosalobata* Sannemann, 1955: 8) upper view, EUIC 1964; 11 Niaz Section, Kale Sardar; 9) upper view, EUIC 1965; 11 Niaz Section, Kale Sardar.

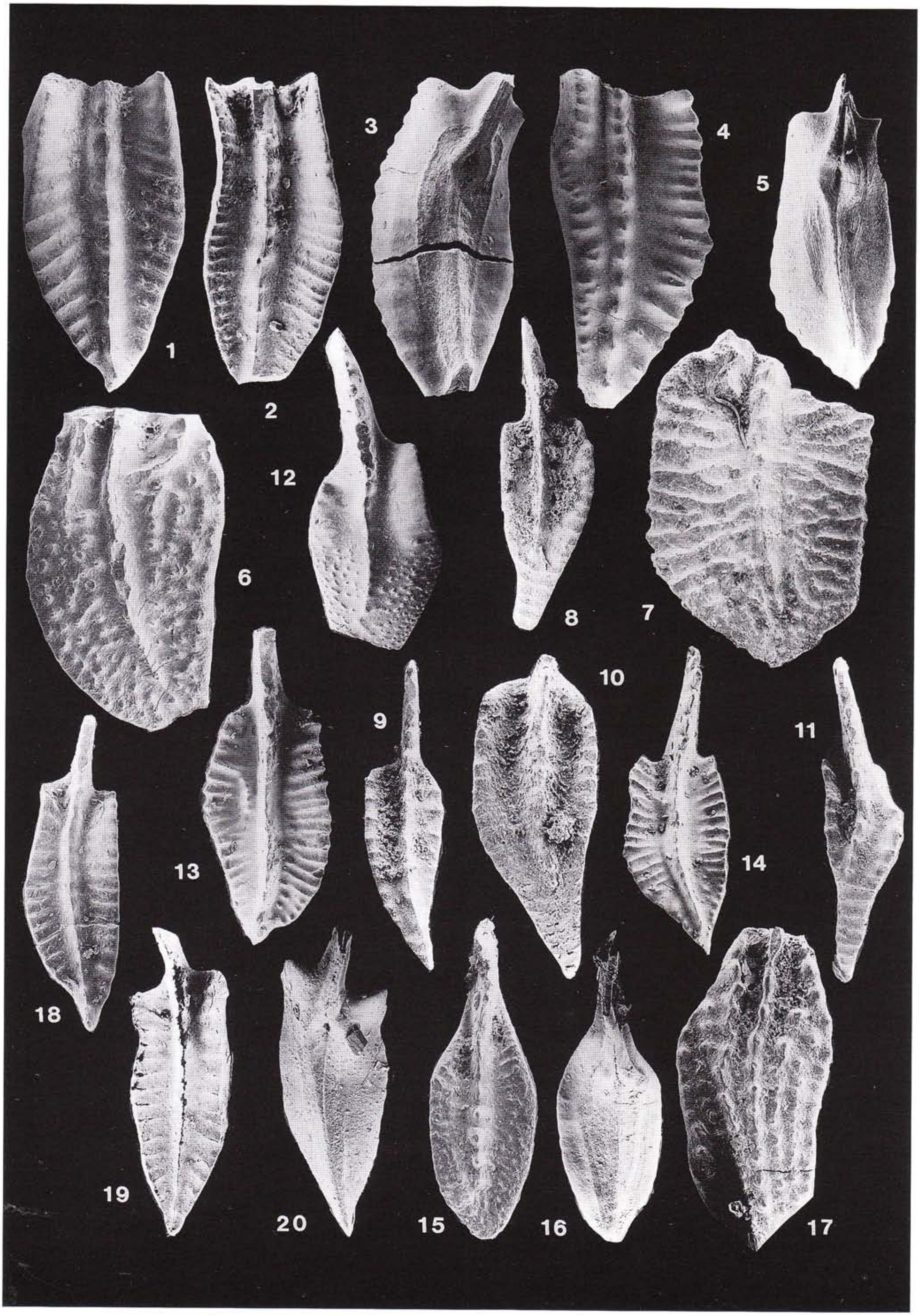
Fig. 10-12 - *Palmatolepis tenuipunctata* Sannemann, 1955: 10) upper view, EUIC 1966; 103 Howz-e-Dorah; 11) lower view, EUIC 1966; 103 Howz-e-Dorah; 12) upper view, EUIC 1867; 103 Howz-e-Dorah.

Fig. 13 - *Palmatolepis* cf. *tenuipunctata* Sannemann, 1955: upper view, EUIC 1968; 103 Howz-e-Dorah.

Fig. 15 - *Palmatolepis* sp. A: upper view, EUIC 1970; 3 Niaz Section, Kale Sardar.

Fig. 16, 17 - *Palmatolepis* sp. C: 16) upper view, EUIC 1971; 16 Howz-e-Dorah; 17) lower view, EUIC 1971; 16 Howz-e-Dorah.

Fig. 18 - *Palmatolepis* sp. B: upper view, EUIC 1972; 7 Niaz Section, Kale Sardar.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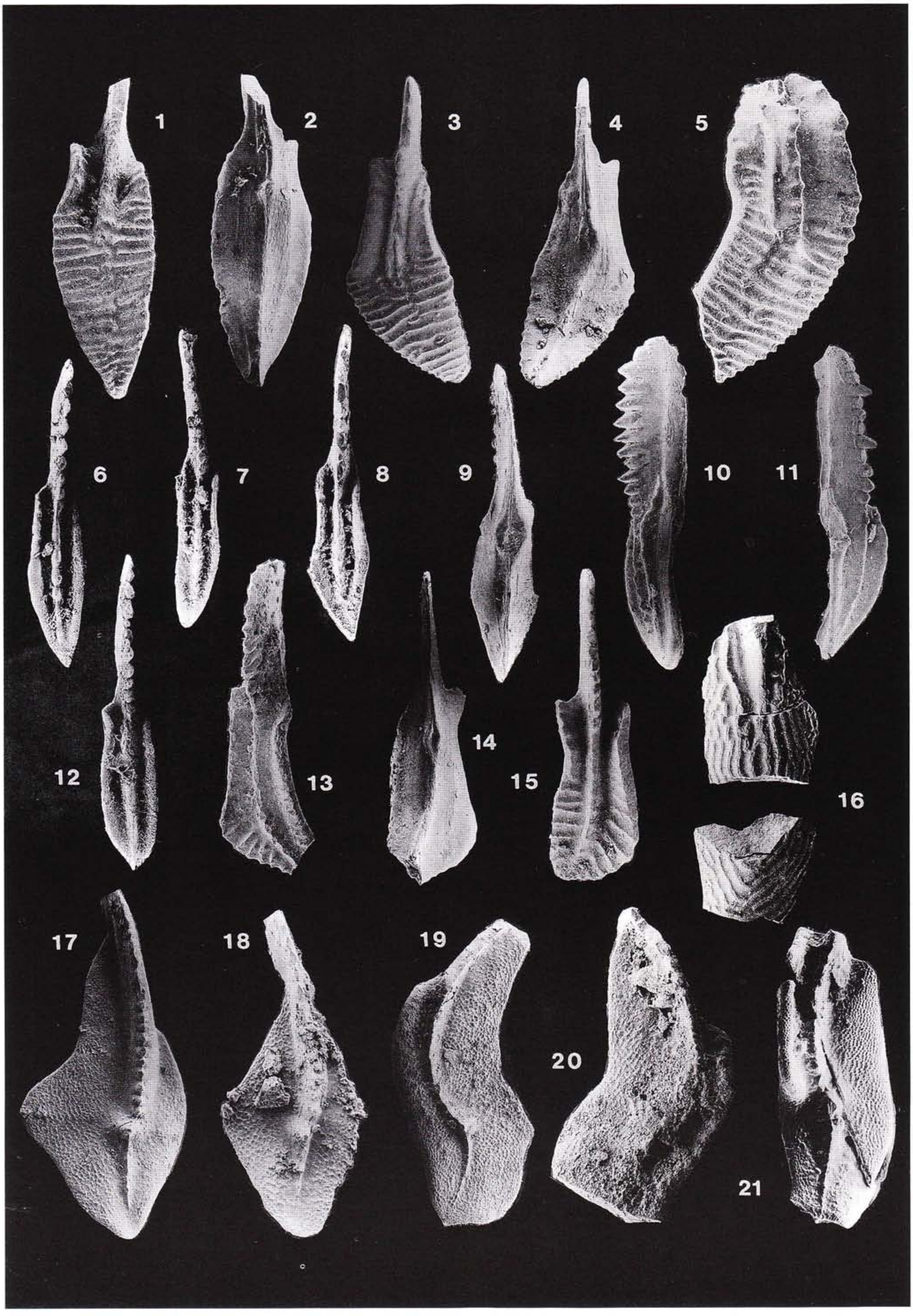
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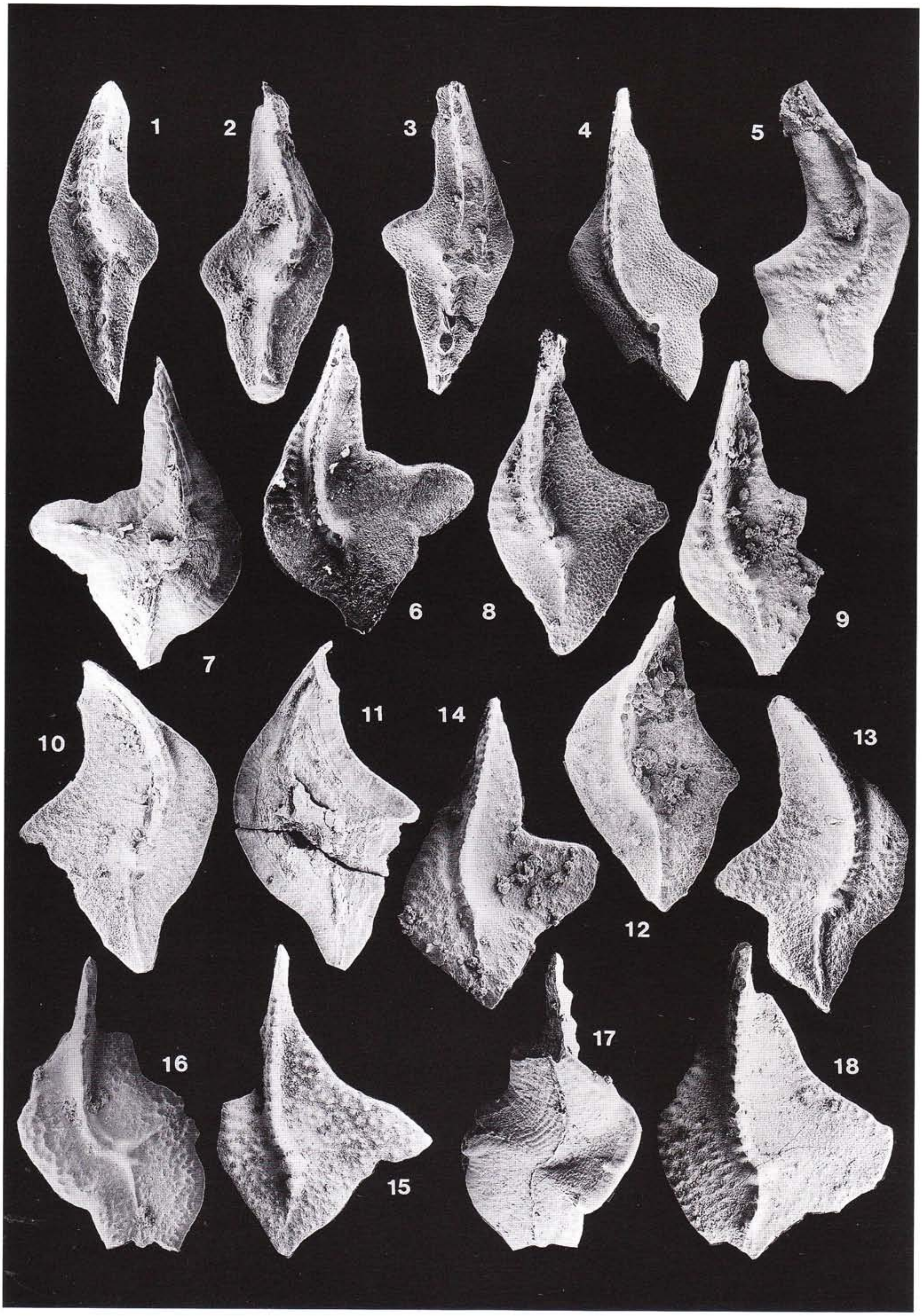
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Note: The *bollandensis* Zone is not clearly represented in the Howz-e-Dorah section. Although 7 productive horizons were processed in the 114 m between horizons of Late *bilineatus* age to those of *noduliferus* Zone, no diagnostic conodonts of *bollandensis* age were recovered.

14. *sinuatus-corrugatus-sulcatus* Zone or younger.

The presence of *Declinognathodus noduliferus*, *Idiognathoides sinuatus* and *Rhachistognathus muricatus* in the base of the crinoidal limestone in sample 108, 820 m above the base of the section at Howz-e-Dorah are indicative of an age no older than the *sinuatus-corru-*

PLATE 11

Fig. 3, 9 x60; fig. 1 x75; fig. 4-8, 10-15, 19, 20 x100; fig. 2, 16, 17, 18 x160.

Fig. 1 - *Palmatolepis winchelli* (Stauffer, 1938): upper view, EUIC 1973; 7 Niaz Section, Kale Sardar.

Fig. 2 - *Palmatolepis* sp. D: upper view, EUIC 1974; 2 Niaz Section, Kale Sardar.

Fig. 3, 4 - *Palmatolepis wolskae* Ovnatanova, 1969: 3) lateral view of Pb element, EUIC 1975; 1 Niaz Section, Kale Sardar; 4) lateral view of Pb element, EUIC 1976; 1 Niaz Section, Kale Sardar.

Fig. 5, 6 - *Alternognathus* cf. *regularis* Ziegler & Sandberg, 1984: 5) lower view, EUIC 1977; 4 Niaz Section, Kale Sardar; 6) upper view, EUIC 1977; 4 Niaz Section, Kale Sardar.

Fig. 7, 8 - *Siphonodella isosticha* (Cooper, 1939): 7) upper view, EUIC 1978; 104 Howz-e-Dorah; 8) upper view, EUIC 1979; 104 Howz-e-Dorah.

Fig. 9 - *Siphonodella* cf. *obsoleta* Hass, 1959: upper view, EUIC 1980; 104 Howz-e-Dorah.

Fig. 10-19 - *Gnathodus pseudosemiglaber* Thomson & Fellows, 1970: 10) upper view, EUIC 1981; 107 Howz-e-Dorah; 11) upper view, EUIC 1982; 15 Niaz Section, Kale Sardar; 12) upper view, EUIC 1983; 107 Howz-e-Dorah; 13) upper view, EUIC 1984; 15 Niaz Section, Kale Sardar; 14) lower view, EUIC 1983; 107 Howz-e-Dorah; 15) upper view, EUIC 1985; 13 Niaz Section, Kale Sardar; 16) upper view, EUIC 1986; 13 Niaz Section, Kale Sardar; 17) upper view of transtional form between *Gn. pseudosemiglaber* and *Gn. girtyi*, EUIC 1987; 108 Howz-e-Dorah; 18) upper view of transtional form between *Gn. pseudosemiglaber* and *Gn. girtyi*, EUIC 1988; 108 Howz-e-Dorah; 19) upper view of transtional form between *Gn. pseudosemiglaber* and *Gn. girtyi*, EUIC 1989; 108 Howz-e-Dorah.

Fig. 20 - *Gnathodus bilineatus* (Roundy, 1926): upper view, EUIC 1990; 13 Niaz Section, Kale Sardar.

PLATE 12

Fig. 8 x60; fig. 21, 22 x85; fig. 5 x95; fig. 1-4, 5-7, 9, 13, x100; fig. 18 x110; fig. 14, 15 x120; fig. 11, 12, 19, 20, 23 x130; fig. 10 x140; fig. 16, 17 x150.

Fig. 1-3, 5 - *Gnathodus girtyi intermedius* Globensky, 1967: 1) upper view, EUIC 1991; 36 Howz-e-Dorah; 2) upper view, EUIC 1992; 29 Howz-e-Dorah; 3) upper view, EUIC 1993; 532 Howz-e-Dorah; 5) upper view, EUIC 1995; 29 Howz-e-Dorah.

Fig. 4 - *Gnathodus pseudosemiglaber* Thompson & Fellows, 1970: upper view of transitional form between *Gn. pseudosemiglaber* and *Gn. girtyi*, EUIC 1994; 9 Niaz Section, Kale Sardar.

Fig. 6-8 - *Gnathodus semiglaber* Bischoff, 1957: 6) lower view, EUIC 1996; 107 Howz-e-Dorah; 7) upper view, EUIC 1996; 107 Howz-e-Dorah; 8) upper view, EUIC 1997; 14 Howz-e-Dorah.

Fig. 9,11,12- *Gnathodus girtyi girtyi* Hass, 1953: 9) upper view of early form, EUIC 1998; 108 Howz-e-Dorah; 11) upper view, EUIC 2000; 108 Howz-e-Dorah; 12) upper view, EUIC 2001; 108 Howz-e-Dorah.

Fig. 10 - *Gnathodus typicus* Roundy, 1926: upper view, EUIC 1999; 13 Niaz Section, Kale Sardar.

Fig. 13-18 - *Gnathodus girtyi simplex* Dunn, 1965: 13) upper view, EUIC 2002; 107 Howz-e-Dorah; 14) upper view, EUIC 2003; 108 Howz-e-Dorah; 15) lower view, EUIC 2003; 108 Howz-e-Dorah; 16) upper view, EUIC 2004; 108 Howz-e-Dorah; 17) lower view, EUIC 2004; 108 Howz-e-Dorah; 18) upper view, EUIC 2005; 108 Howz-e-Dorah.

Fig. 19, 20 - *Gnathodus delicatus* Branson & Mehl, 1938: 19) upper view, EUIC 2006; 523 Howz-e-Dorah; 20) lower view, EUIC 2006; 523 Howz-e-Dorah.

Fig. 21-23 - *Declinognathodus noduliferus noduliferus* (Ellison & Graves, 1941): 21) upper view, EUIC 2007; 108 Howz-e-Dorah; 22) lower view, EUIC 2007; 108 Howz-e-Dorah; 23) lower view, EUIC 2008; 108 Howz-e-Dorah.

PLATE 13

Fig. 3, 11, 14 x60; fig. 18 x65; fig. 4 x70; 14 x80; fig. 17 x85; fig. 1, 5, 7, 8, 10, 12, 16, 19 x100; fig. 2, 6, 9, x120; fig. 13, 15 x130.

Fig. 1-3 - *Declinognathodus noduliferus noduliferus* (Ellison & Graves, 1941): 1) upper view, EUIC 2009; 13 Niaz Section, Kale Sardar; 2) upper view, EUIC 2010; 13 Niaz Section, Kale Sardar; 3) upper view, EUIC 2011; 13 Niaz Section, Kale Sardar.

Fig. 4 - *Neognathodus* cf. *medadultimus*, Merrill, 1972: upper view, EUIC 2012; 108 Howz-e-Dorah.

Fig. 5-7 - *Idiognathoides sinuatus* Harris & Hollingsworth, 1933: 5) upper view of early form, EUIC 2013; 108 Howz-e-Dorah; 6) upper view, EUIC 2014; 9 Niaz Section, Kale Sardar; 7) upper view, EUIC 2015; 108 Howz-e-Dorah.

Fig. 8 - ?*Gnathodus* sp.: upper view, EUIC 2016; 13 Niaz Section, Kale Sardar.

Fig. 9, 10 - *Gnathodus* sp.: 9) upper view, EUIC 2017; 107 Howz-e-Dorah; 10) upper view, EUIC 2018; 107 Howz-e-Dorah.

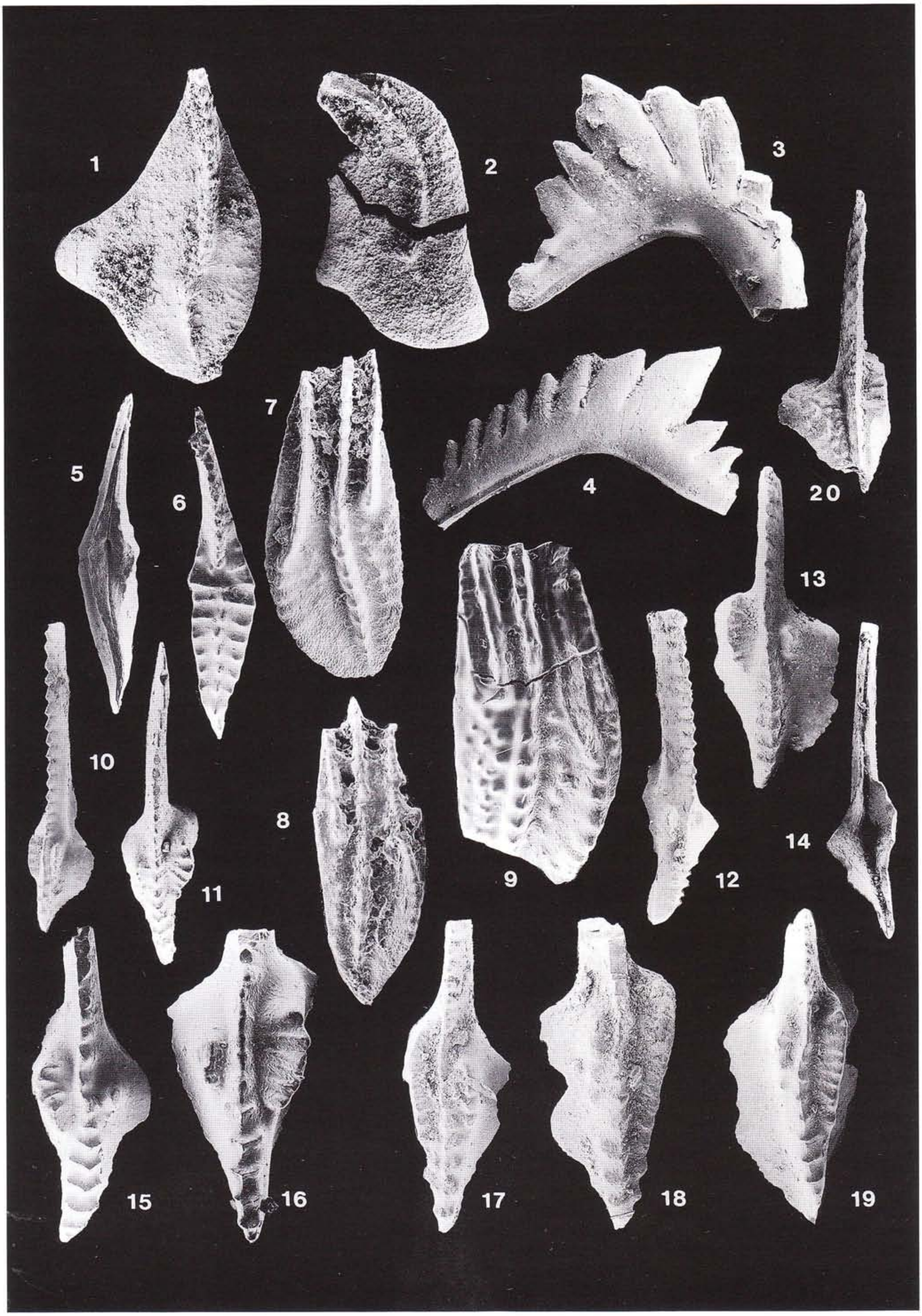
Fig. 11, 12 - *Clydagnathus ?ormistoni* Beinert, Klapper, Sandberg & Ziegler, 1971: 11) lateral view, EUIC 2019; 17 Howz-e-Dorah; 12) upper view, EUIC 2022; 17 Howz-e-Dorah.

Fig. 13 - *"Hindeodella" segaformis* Bischoff, 1957: lateral view, EUIC 2021; 15 Niaz Section, Kale Sardar.

Fig. 14-17 - Unassigned elements: 14) lateral view, EUIC 2022; 15 Niaz Section, Kale Sardar; 15) lateral view, EUIC 2023; 15 Niaz Section, Kale Sardar; 16) lateral view, EUIC 2024; 15 Niaz Section, Kale Sardar; 17) lateral view, EUIC 2025; 15 Niaz Section, Kale Sardar.

Fig. 18 - ?*Pseudopolygnathus* sp.: lateral view of Sb element, EUIC 2026; 516 Howz-e-Dorah.

Fig. 19 - *Idiognathoides* sp. lateral view of Sc element, EUIC 2027; 107 Howz-e-Dorah.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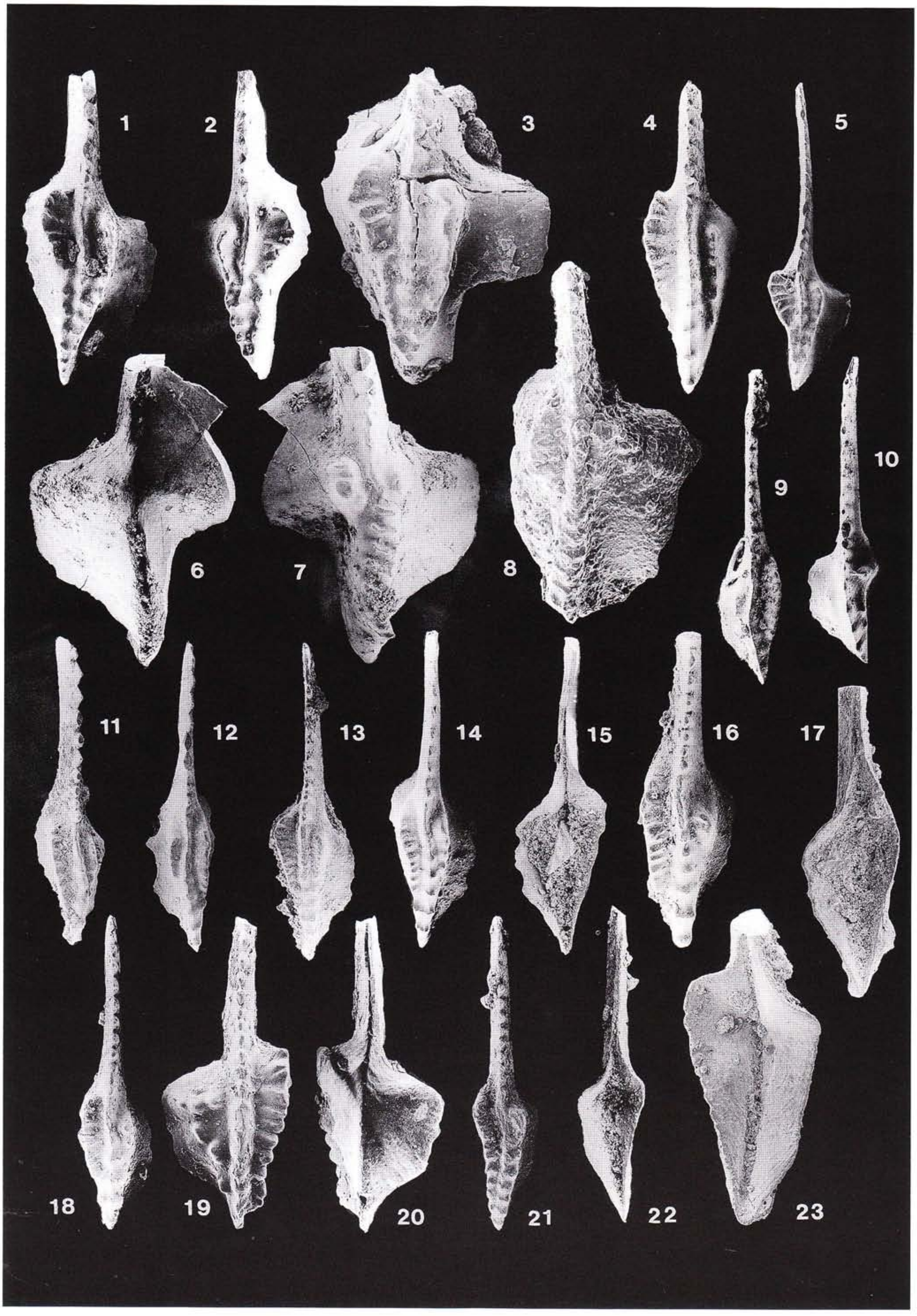
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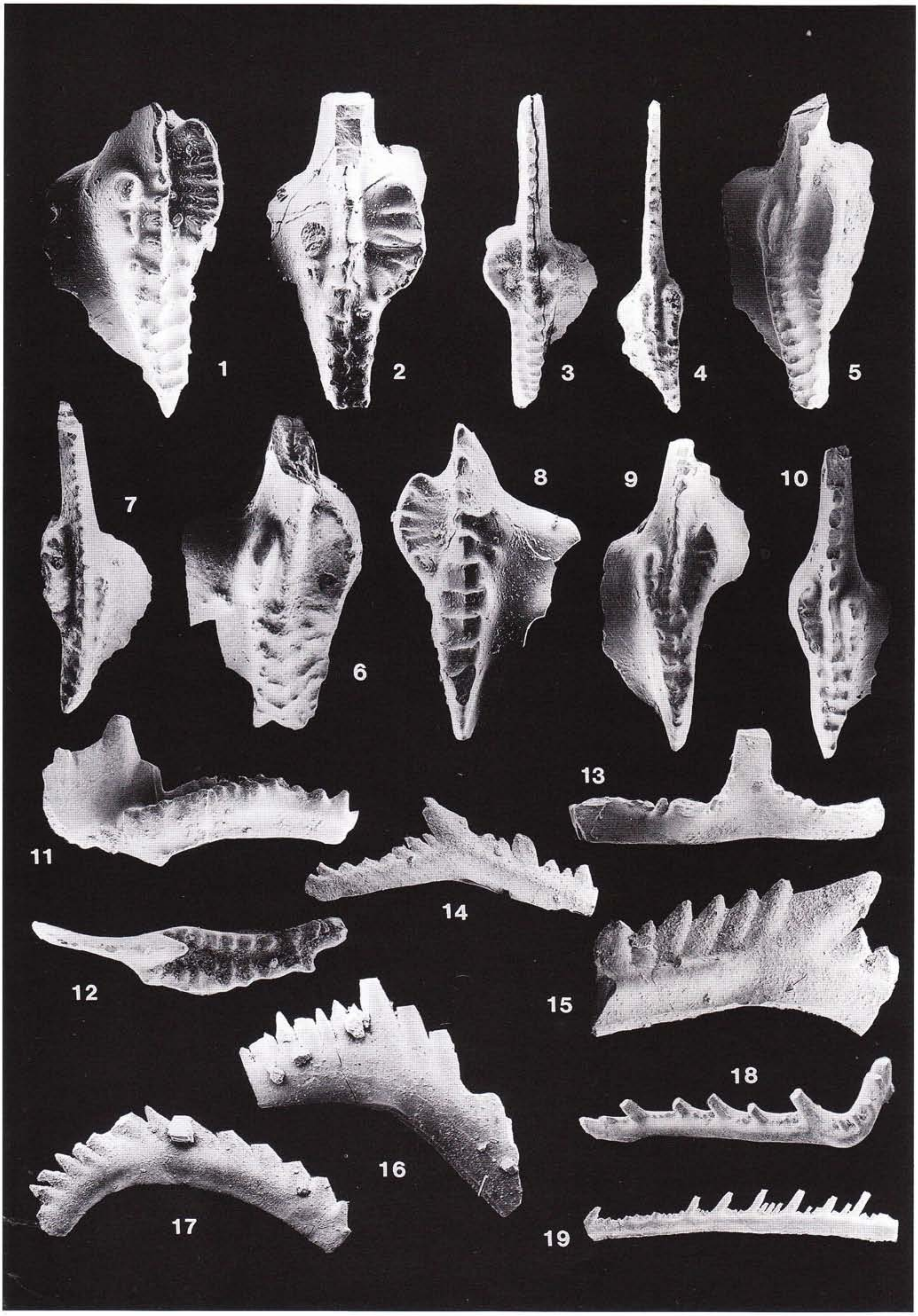
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gatus-sulcatus Zone. Although *Lochriea commutata*, another element in the fauna from sample 108, is generally thought to have its latest occurrence below this zone (e.g. Conil *et al.*, 1991), it has been reported to occur in the *sinuatus* Zone in the Pyrenees (Perret & Weyant, 1994). In a clast from the Sardar conglomerate, sample 13, at Kale Sardar, *Idiognathoides sinuatus* was recovered together with *Declinognathodus noduliferus*, *Lochriea commutata*, and *Gnathodus pseudosemiglaber* indicating the clast to be at least *sinuatus-corrugatus-sulcatus* in age. *Gn. bilineatus*, normally thought not to extend beyond the *noduliferus* Zone, is also present in the fauna; this is another form reported by Perret & Weyant (1994) to occur in the *sinuatus* Zone in the Pyrenees. Biogeographically, the Pyrenees and Iran, both situated on the northern margin of Gondwana, must have been in close juxtaposition at this time thus explaining the similar ranges for both *Lochriea commutata* and *Idiognathoides sinuatus.*

At least 5 goniatites identified as beyrichoceratids or reticuloceratids (Prof. M. House, pers. comm., 1993, 1995) were collected from sample 108 at Howz-e-Dorah. The cephalopods from sample 108 in the Howz-e-Dorah section occur with a fauna of conodonts dated as *sinuatus-corrugatus-sulcatus* Zone, an age consistent with the Namurian age for the genus *Reticuloceras*. Beyrichoceratids, however, are known to occur in older horizons. From eastern Australia, Campbell *et al.* (1983) reported four species of *Beyrichoceras* occurring in horizons that can be aligned with the upper part of the Visean (p. 77, Table 1 and 78, fig. 2) and Roberts *et al.* (1993) align the West European *Beyrichoceras* Zone with the late Visean. Lemosquest *et al.* (1985) reported the disappearance of Carboniferous goniatites including *Beyrichoceras* in the late part of Visean in North Africa. If further study of the goniatites prove the specimens from Howz-e-Dorah to be beyrichoceratids, this will extend their range into the Namurian. With the constraining age of the conodonts on this goniatite fauna, precise identification of the specimens will be useful for future correlations.

15. Upper part of the Namurian (= Westfalian).

No conodont data is available for the 138 m of section above sample 108 at Howz-e-Dorah. At 958 m above the base of the section in sample 500, specimens of *Gastrioceras* sp., a genus known to occur in the upper quarter of the Namurian (= Westfalian), were collected (identified by Prof. M. House, pers. comm., 1993, 1995). *Gastrioceras* sp., identified by O. Walliser, was also reported from Kale Sardar by Stöcklin *et al.* (1991) from his horizon 35 in the type section of the Sardar Formation.

The presence of *Gastrioceras* sp. in the Late Carboniferous allows correlation of the Sardar Formation at Kale Sardar and Howz-e-Dorah.

16. Late Namurian.

A single specimen of *Neogondolella clarki* was recovered from sample 109, 971 m above the base of the section at Howz-e-Dorah. According to Sweet (1988) *Neogondolella* first appears in the late Namurian (=Atokan). The bed yielding *Neogondolella clarki* contains a highly diverse fauna of brachiopods.

17. Age of the Sardar conglomerate

The age of the Sardar conglomerate is controversial (e.g. Stöcklin *et al.*, 1965, 1991; Husseini, 1992). In order to have more precise age control over the time of its deposition, 5 limestone clasts from the Niaz section at Kale Sardar were processed for conodonts. Faunas from the clasts are representative of 4 different zones: Late *triangularis* Zone or Early *crepida* Zone, *typicus* Zone, *anchoralis-latus* Zone and *sinuatus-corrugatus-sulcatus* Zone. From this data alone, the Sardar conglomerate must have been deposited some time after the *sinuatus-corrugatus-sulcatus* Zone.

18. Permian.

The siliclastics ("White Quartzite") cropping out between 1008 m and 1038 m above the base of the section at Howz-e-Dorah represent basal Permian (Asselian) (Partow Azar, 1992). Investigation of conodonts from this limestone was outside the scope of this study but macrofauna collected from sample 110 from 1055 m above the base of the section include numerous Permian species of *Fenestella*, *Bellerophon*, other gastropods, brachiopods, bivalves and crinoid remains.

Systematic palaeontology.

Acid leaching 110 samples collected from two localities in the Shotori Range, Eastern Iran produced 3445 conodonts representing 85 species/subspecies. Three of these are new and are described below. As recent synonymies are have been published for the other species (e.g. Ji & Ziegler, 1993; Mawson & Talent, 1997), the faunas are documented (Plates 1-13, Tables 1-3) but no taxonomic comment is given. All figured specimens from the area are deposited at the University of Esfahan, Iran, bearing the prefix EUIC.

Phylum **Conodonta** Pander, 1856

Order Conodontophorida Eichenberg, 1930

Family Icriodontidae Müller and Müller, 1957

Genus *Icriodus* Branson and Mehl, 1938

Type species. *Icriodus expansus* Branson and Mehl, 1938

Icriodus alternatus mawsonae n. subsp.

Pl. 1, Fig. 15; Pl. 2, Fig. 3, 4

1991 *Icriodus alternatus* n. subsp. Clausen, Korn and Luppold, pl. 8, fig. 4.

Derivation of name. In honour of Prof. Ruth Mawson, an Australian conodont researcher.

Holotype. EUIC 1834, the specimen illustrated on the Plate 1, fig. 15 from sample 103, 315 m above the base of the Howz-e-Dorah section.

Diagnosis. A subspecies of *Icriodus alternatus* with a row of very weakly expressed nodes located in a central trough between lateral rows of nodes. Basal cavity follows the shape of the spindle, expanding posteriorly.

Description. Between lateral rows of discrete nodes, a central row of poorly expressed nodes lies in a slight trough. Towards the anterior, one or two of the lateral nodes may be fused. The basal cavity flares considerably posteriorly and tapers evenly towards the anterior; a slight spur is developed along the outer margin.

Remarks. The specimen illustrated by Clausen *et al.* (1991, pl. 8, fig. 4), at first glance appears to be an aberrant form of *I. a. alternatus* with the central nodes poorly developed. However, as 15 specimens, all showing this characteristic, have been recovered from sample 103, a new subspecies, as suggested by Clausen *et al.* (1991), appears warranted. The central trough between the lateral rows of denticles bears tiny central nodes, most clearly visible towards the middle of the element. Anteriorly the nodes are fused. A second feature that identifies this as a separate subspecies is the basal cavity; it is larger than that of *I. alternatus sensu stricto*. The sample yielding the new subspecies also contains *Pal. tenuipunctata*, *Pal. minuta minuta*, and *I. iowaensis iowaensis* suggesting the age to range from the Late *triangularis* Zone to the Early *crepida* Zone. *I. alternatus mawsonae* occurs in horizons of similar age in a section at Kuragh Spur, Chitral, Pakistan (Mawson, pers. comm, 1997; Talent et al., 1999).

Occurrence. Fifteen I elements from sample 103 at Howz-e-Dorah.

Family Polygnathidae Bassler, 1925

Genus *Polygnathus* Hinde, 1879

Type species. *Polygnathus dubius* Hinde, 1879

Polygnathus capollocki n. sp.

Pl. 9, Fig. 6-12

1968 *Polygnathus* n. sp. A. Pollock, p. 436, pl. 62, fig. 32, 33, 38.
1995 *Polygnathus* cf. *xylus* Stauffer, Kuz'min, pl. 2, fig. 7.

Derivation of name. In honour of C.A. Pollock who, in 1968, recognised this form as a new species.

Holotype. EUIC1947, the specimen illustrated on Pl. 9, Figs. 8, 9 from sample 102, 205m above the base of the Howz-e-Dorah section.

Diagnosis. A species of *Polygnathus* with a long, very narrow and slightly curved platform that has a shagreen surface except for nodes along the upturned margins; deep adcarinal trough developed almost the entire length of the platform.

Description. A species of *Polygnathus* with a slender, arrow-shaped platform; the posterior end is very pointed. Platform surface is shagreen lacking ornament except for tiny and/or fused nodes that may develop along the margins in the anterior half of the platform. The carina is almost straight and does not reach the posterior end. The margins of the platform are sharply upturned forming two deep troughs on either side of the carina that run for more than three-quarters the length of the platform. The length of the free blade approaches that of the platform and is made up of eight to ten clear, sharp denticles.

Remarks. The specimens from Iran are similar to the specimens from Alberta, Canada, illustrated by Pollock (1968, pl. 62, Figs. 32, 33, 38). The polygnathid from the Timan Formation, Russian Platform illustrated by Kuz'min (1995, pl. 2, fig. 7) appears to be a specimen of *P. capollocki*. The Iranian material came from samples yielding *Ad. curvata* late form indicating that in Iran the age of this conodont can be said to be from late in the Early *hassi* Zone to the end of the *linguiformis* Zone (Ji & Ziegler, 1993). Its earlier appearance in Russia (Kuz'min, 1995) is indicative of an older age.

Occurrence. One Pa element from sample 503, two from sample 9, three from sample 505, one from sample 10, 34 from sample 102, one from sample 508, two from sample 509, and one from sample 510 at Howz-e-Dorah. Three Pa elements from sample 3 at Kale Sardar.

Polygnathus ratebi n. sp.

(Pl. 9, Figs. 1-5)

Derivation of name. In honour of Farajoalah Ratebi, a National Iranian Steel Company geologist, who spent most of his working life in exploration of coal and raw materials in Tabas and central Iran.

Holotype. EUIC1942, the specimen illustrated on Pl. 9, Figs. 3, 4 from sample 103, 312.50 m above the base of the Howz-e-Dorah section.

Diagnosis. A species of *Polygnathus* with short carina extending to half the length of the platform with strongly upturned, almost smooth platform margins forming deep adcarinal troughs. Linguloid posterior half of the platform is covered by complete or interrupted ridges.

Description. A species of *Polygnathus* with a carina made up of fused denticles extends to the midlength of the platform; the platform margins paralleling the carina are sharply upturned forming smooth, deep adcarinal troughs. The platform is very narrow at the anterior but widens gradually reaching maximum width at midlength of the platform. In the posterior half of the platform, parallel ridges, some complete and some discontinuous, cover the tongue. The ridges on the platform are parallel or semi-parallel, sometimes becoming weakly nodose especially close to the carina.

Remarks. *P. ratebi* n. sp. shows some similarities to *Polygnathus samueli* Klapper & Lane (1985, p. 943, fig. 17.13-18) but the platform shape and the form of basal cavity are different from *P. samueli* as *P. ratebi* has a tiny basal cavity, and a narrow platform with parallel upturned anterior margins. In their consideration of the phylogeny of the *semicostatus* group, Ji & Ziegler (1993, p. 43) suggest that there might be an intermediate form between *P. brevicarinus* and *P. semicostatus* (wide-platform morphotype). Such a transitional form, they conclude, might arise in the Early *triangularis* to the Early *crepida* interval. As it is found in association with other conodonts that can be dated as from the Late *triangularis* Zone to the Late *crepida* Zone, and because of its morphological characteristics, *P. ratebi* could possibly be the ancestor of *P. semicostatus*.

Occurrence. Eight Pa elements from sample 103 at Howz-e-Dorah.

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