

Conodont biostratigraphy of the upper Frasnian–lower Famennian transitional deposits in the Shotori Range, Tabas area, Central-East Iran Microplate

ALI BAHRAMI, CARLO CORRADINI, D. JEFFREY OVER & MEHDI YAZDI



A rich and diverse conodont fauna from upper Frasnian and lower-middle Famennian strata in three sections – Ghale-kalaghu, Howz-e-dorah 1 and Howz-e-dorah 2 – in the southern Shotori Range of central Iran contains forty-five taxa belonging to eight genera, dominated by icriodids and polygnathids, from the Lower *rhenana* Zone to the *velifer* Zone (= Uppermost *marginifera* Zone). A hiatus is documented across the Frasnian/Famennian boundary that possibly includes the Upper *rhenana* to the Middle *triangularis* Zone. • Key words: conodonts, Shotori Range, Iran, Devonian, Frasnian, Famennian.

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The Shotori Range is part of a north-south oriented mountain system, which separates the Lut Desert of eastern Iran from the central Iranian desert depression in the northern part of the “Central-East Iran Microplate”. The investigated area belongs to the “Jamal Mountains” and is located near the village of Sorond and the Chiruk Silicic Sand mine, approximately 75 km southeast of Tabas (Fig. 1).

Iran is a structural collage of several microplates that was situated at the northern margin of Gondwana during the Palaeozoic along with a small area in the north-east, the Kope-Dagh, which was part of Laurussia (Berberian & King 1981, Scotese 2001). The Gondwanan part was located about 20°–25° south of the equator (Golonka *et al.* 1994) and was covered by a large shelf sea during the Palaeozoic (Wendt *et al.* 2002).

In the Shotori Range a sedimentary sequence about 5000 meters thick, ranging from the Lower Devonian to the Paleogene, is exposed. Devonian strata are represented by thick sequences of shallow water sediments. Several sections were measured by various authors to describe the stratigraphy of the region, but never in detail. A disconformity at the Frasnian/Famennian boundary has been noted (*i.e.* Yazdi 1999, Ashouri 2004, Wendt *et al.* 2005, Gholamalian *et al.* 2009, Gholamalian 2007,

Bahrami *et al.* 2011b), but the duration of the hiatus was equivocal due to the lack of precise biostratigraphic data.

This report provides detailed conodont stratigraphy across the Frasnian/Famennian Boundary based on close sampling of three sections in the southern part of the Shotori Range, and is part of a detailed study of the stratigraphy of the Upper Devonian and Lower Carboniferous in the Tabas area. The study is connected to a wider project on the Upper Devonian and Lower Carboniferous of Iran, studying in detail some selected sections in various parts of the country, in order to achieve an understanding of the evolution of the depositional environments of this part of North Gondwana. In this respect, papers on the Devonian/Carboniferous boundary in the Tabas area (Bahrami *et al.* 2011a) and on the Upper Devonian of Kerman province (Bahrami *et al.* 2011b) were recently published.

Geological settings

The base of the Devonian sequence in the Shotori Range is marked by several tens of meters of red sandstone of the Padeha Formation. Fossils are rare in this unit and the Early-Middle Devonian age is inferred on the basis of

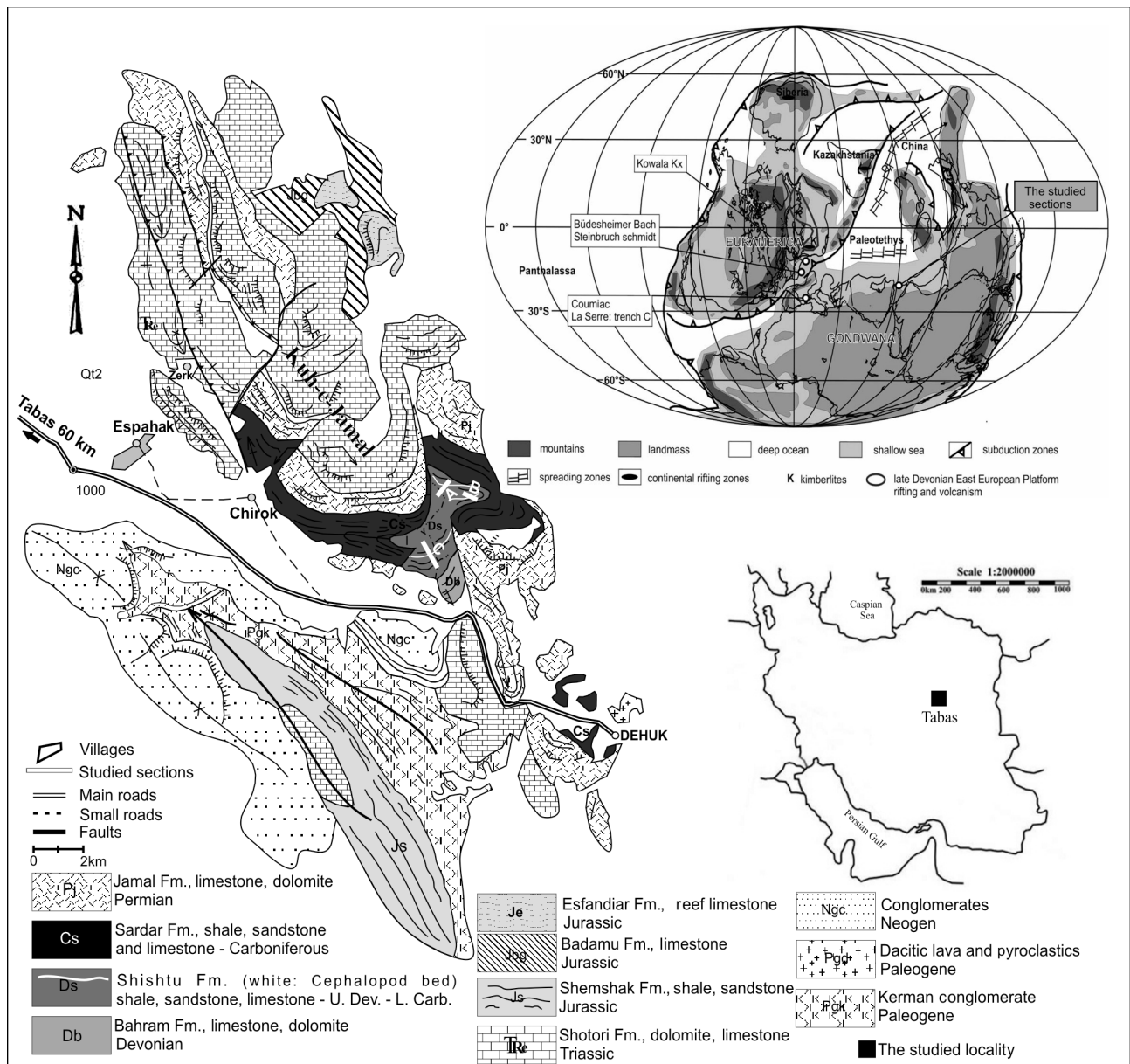


Figure 1. Geological map of the area around the Espahak village, Tabas Province, east central Iran, with indication of the studied sections (redrawn and simplified after Stocklin & Nabavi 1971). Paleogeographic reconstruction map (modified after Scotese & McKerrow 1990) showing the location of the investigated area, location of ocean spreading zones and continental rifting zones Racki (1998) in the Late Devonian, as well as some key European Frasnian/Famennian boundary sections modified after Pujol (2005).

adjacent units (Wendt *et al.* 2002). The sequence continues with the Sizbar Formation, composed primarily of dolostones with rare calcareous intercalations. Wendt *et al.* (2002) suggested a shallow subtidal to supratidal depositional environment, and defined a Givetian age on the basis of conodonts from Kalshaneh, in the southern part of the Central-East Iran Microplate.

The sequence continues upward with the Bahram Formation, up to 500 m thick, which consists of thick bedded dark grey limestone in the lower part and massive brown dolomite with minor green shale intercalations in the upper

part. The limestones are very fossiliferous, and contain conodonts, brachiopods, tentaculitids, crinoids, bryozoans, rugose and tabulate corals, stromatoporoids, trilobites, and rare mollusks (Wendt *et al.* 2002). The age of the Bahram Formation in the Shotori Range is limited to the early Frasnian, whereas in other parts of Iran it includes Famennian strata (Wendt *et al.* 2005, Bahrami *et al.* 2011b).

The Bahram Formation is conformably overlain by the Shishtu Formation, a carbonate and clastic unit (Stocklin & Nabavi 1971) that is informally subdivided into two sub-formations: “Shishtu-1” and “Shishtu-2”.

Ghale-kalaghu section

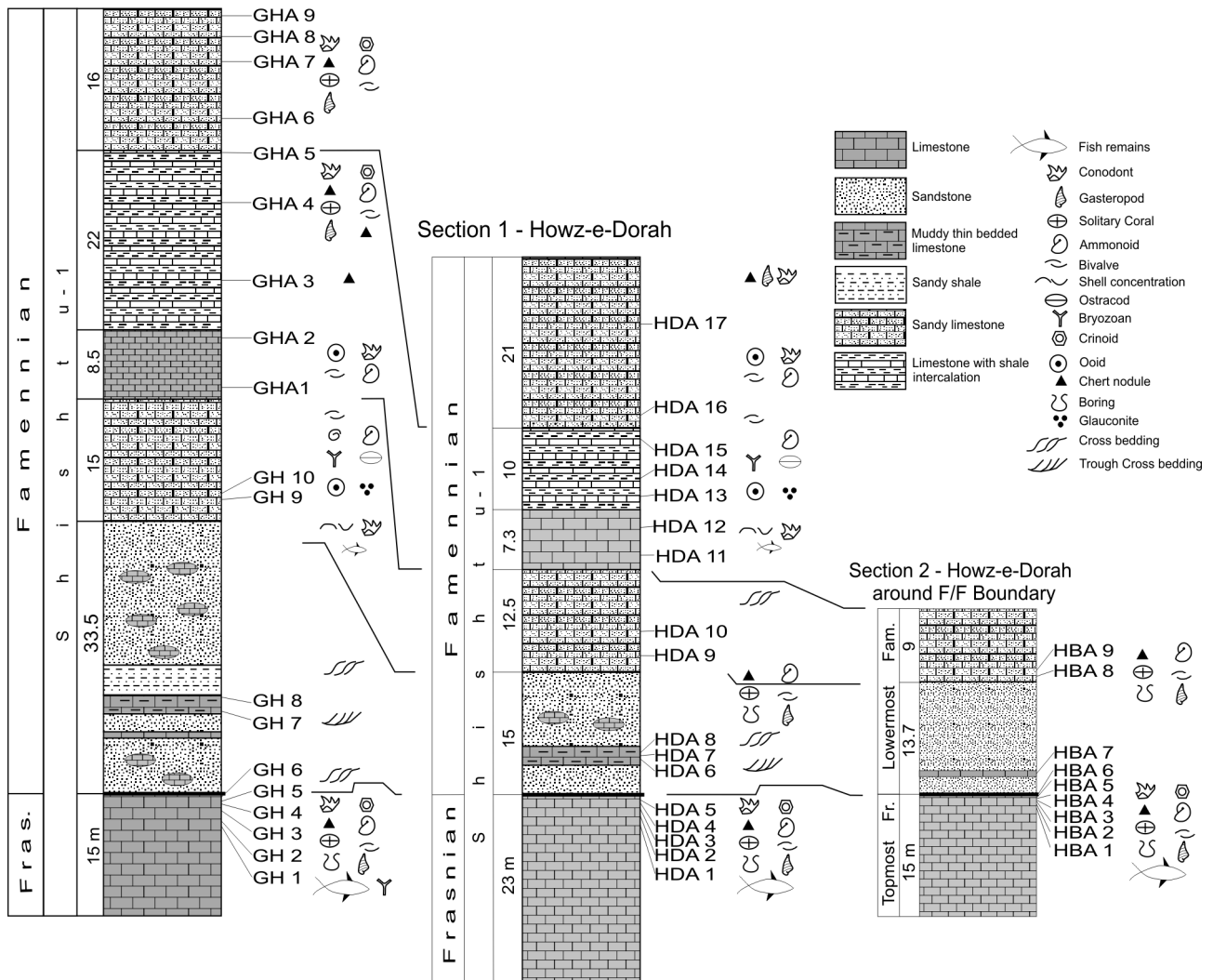


Figure 2. Stratigraphic log, samples position, fossil content and sedimentary features of the Ghale-kalaghu, Howz-e-dorah 1 and 2 sections.

The Shishtu 1 subformation is more than 300 m thick, consisting of dark green shale interbedded with quartzitic sandstones and intercalations of fossiliferous limestone; the topmost 28 m (beds 23–26 of Stocklin *et al.* 1965) are represented by highly fossiliferous shale, sandstone, oolitic limestone, and iron oolites, which have been named the “Cephalopod Bed” (Stocklin *et al.* 1965). It ranges from the middle Frasnian to the late Famennian. The base of the “Cephalopod Bed” is diachronous, and ranges from late Frasnian in Kale-sardar to Famennian in Howz-e-dorah (Wendt *et al.* 1997, 2005; Yazdi 1999). The Shishtu 2 subformation is about 250 m thick and consists of interbedded limestone and shale. The base is marked by the “Mush Horizon”, a dark grey shale with an intercalation of strongly gypsiferous pink shale, and a thin brachiopod-rich limestone layer which indicates the start of the Tournaisian.

The Shishtu Formation as a whole ranges from middle Frasnian to Viséan. The Frasnian/Famennian boundary falls within the top unit of Shishtu 1 subformation at the base of the White Sandstone Beds (WSB) marker between “Placoderm beds” and “Cephalopod-bearing beds” (Fig. 3A–E). The Devonian/Carboniferous boundary can be traced between the “Cephalopod Bed” and the “Mush Horizon” at the boundary between the Shishtu-1 and Shishtu-2 subformations (Bahrami *et al.* 2011a).

The Frasnian/Famennian boundary in Iran

Beside the Shotori Range, upper Frasnian and lower Famennian rocks are relatively widespread in Iran, as they are documented in several parts of the country. However, the boundary is often missing, because of hiatuses and/or

unconformities between the two stages, or difficult to locate precisely, due to lacking of biostratigraphically relevant fauna.

In the central Alborz Mountains, north Iran, Upper Devonian rocks belongs to the Geirud Formation (Assereto 1963), a huge sequence of shales, quartzites, sandstones, conglomerates and sandy limestones deposited in a fluvial deltaic to shallow marine environment (Ueno *et al.* 1997, Wendt *et al.* 2005, Habibi *et al.* 2008 and reference therein). The fossils content is in general scarce and is mainly represented by brachiopods and palynomorphs, that allow to date the unit to a late Middle Devonian to Early Carboniferous, but are not sufficient to precisely locate the F/F boundary in any section.

In the eastern Alborz Mountains this time frame is occupied by the Khoshyeilagh Formation (Bozorgnia 1973), a thick sequence of limestones, dolostones, sandstones, siltstones and shales. Fossils are always abundant: brachiopods, tentaculitids, crinoids, rugose and tabulate corals, gastropods and trilobites. Wendt *et al.* (2005) subdivided the unit into three lithologically characterized members: a lower carbonate, a siliciclastic and an upper carbonate member. These authors locate the Frasnian/Famennian boundary in the lower part of the upper carbonate member in the Khoshyeilagh and Mighan sections on the basis of brachiopod and tentaculite fauna.

In the Kerman Province (southern part of the Central-East Iran microplate) Upper Devonian rocks belong to the Bahram Formation that in some places spans the whole Famennian. However, due to tectonics and the level of erosion connected with the pre-Permian emersion often it is not exposed completely (Wendt *et al.* 2002). The unit, deposited in a shallow water sedimentary environment, is always very fossiliferous, but biostratigraphically relevant fossil groups are not abundant. Thus the precise position of the F/F boundary can be often only inferred or approximated (*i.e.* Shams Abad section, Bahrami *et al.* 2011b).

In central-west Iran (provinces of Isfahan and Yazd) Upper Devonian rocks are referred to the Bahram Fm. (Wendt *et al.* 2005) or to an “equivalent of the Shishtu Fm.” (Hairapetian & Yazdi 2003). In these areas a precise position of the F/F boundary has never been established, too.

The studied sections

Three sections were measured in the southern part of the Shotori Range, approximately 75 km southeast of Tabas,

close to the village of Sorond and the Chiruk Silicic Sand mine (Fig. 1). The area is accessible by an unpaved track off the Tabas-Dihuk road.

Ghale-kalaghu section

The Ghale-kalaghu section (Figs 1, 2, 3a, 4) is located about 1 km south of the Chiruk mine, at coordinates: base 33°20′ 40.86″ N – 57°20′ 09.72″ E and top: 33°20′ 49.19″ N – 57°20′ 05.84″ E.

The section exposes about 105 m of the Upper Devonian Shishtu 1 subformation and includes (from top to base):

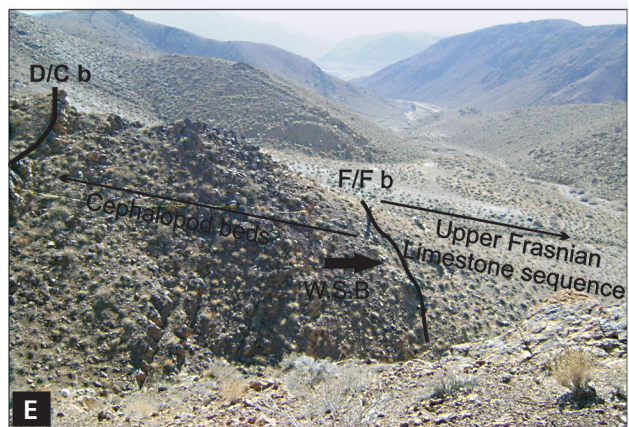
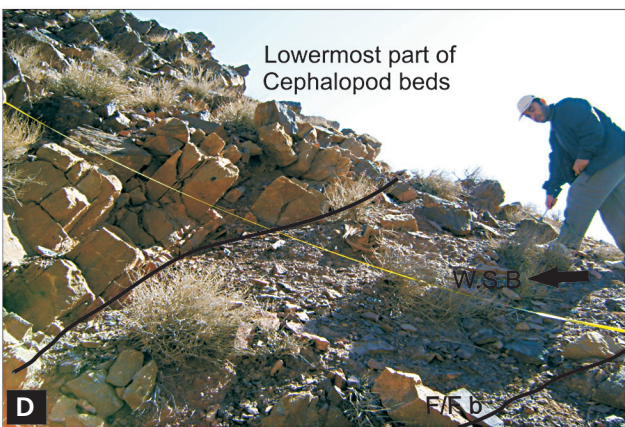
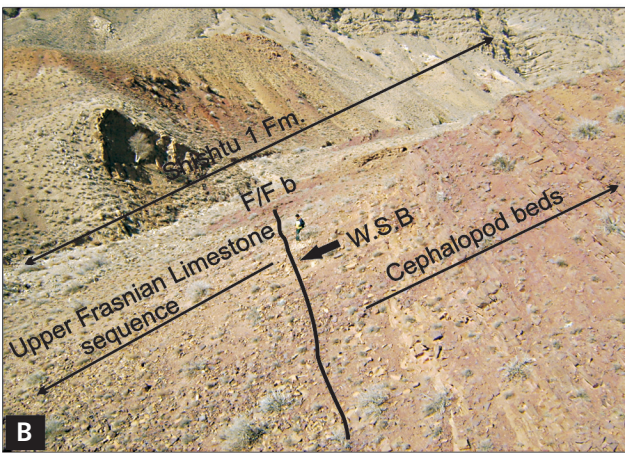
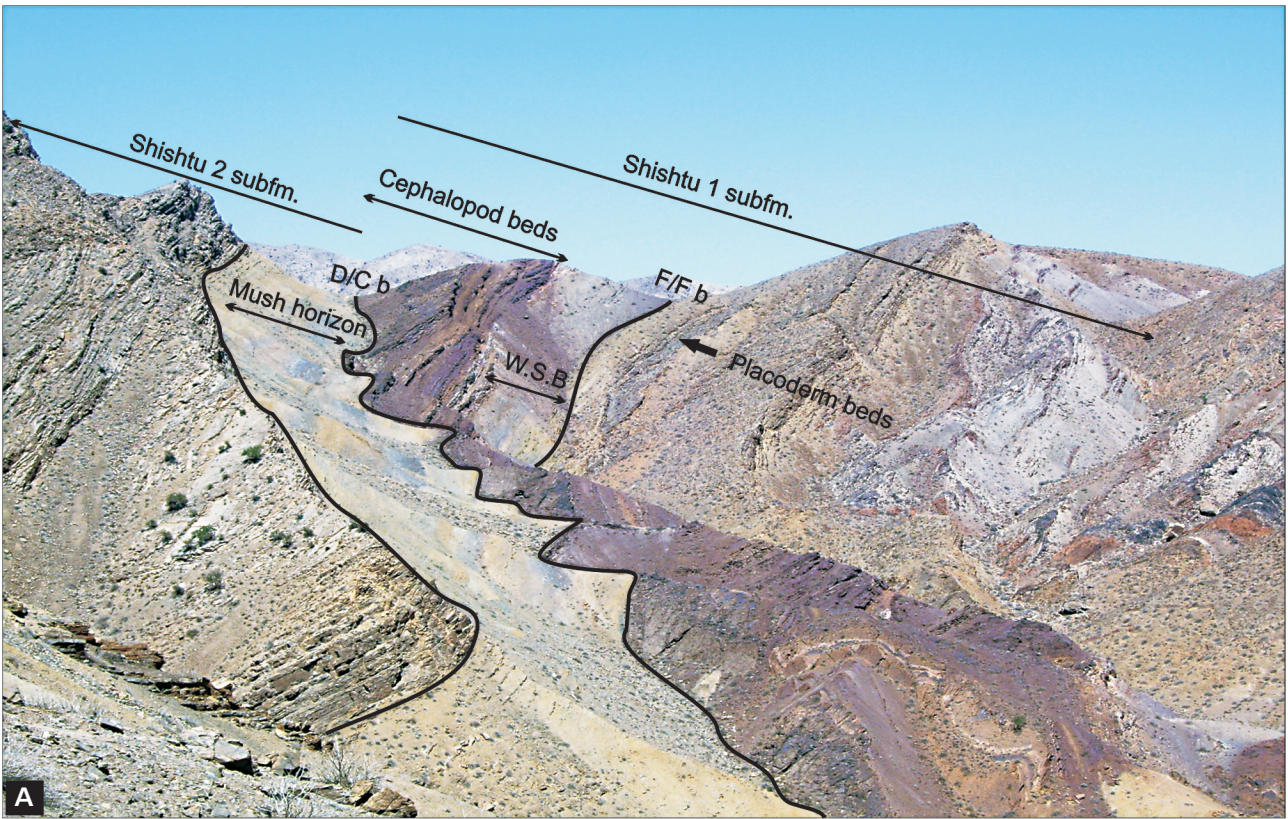
- 16 m of pink to red/brown sandy oolitic limestone with cherts. Fossil content represented by conodonts, bivalves, gastropods, and rare goniatites and crinoid stems;
- 22 m of brown to pink, thin bedded limestone with shale and marl intercalations. Fossils: gastropods, bivalves, crinoid stems, rare solitary corals, and conodonts;
- 8.5 m of yellow thin bedded limestone with crushed macrofauna (mainly bivalves and goniatites) and conodonts;
- 15 m of yellow to pink, and dark brown oolitic sandy limestone with brachiopods, bivalves, ostracodes, conodonts, and rare goniatites;
- 33.5 m of white to brown sandstone with ferruginous fine grained sandstones at the base with grey to dark sandy shale and sandstones, and a few thin bedded sandy limestones. The base of this unit is a disconformity;
- 25 m of nodular grey to brown limestone with alternation of grey to brown mudstone. Fossil content includes conodonts, rare goniatites, placoderm remains, crinoid stems, small solitary corals, and bryozoans. This unit is informally named the “placoderm-bearing beds”.

Howz-e-dorah 1 section

The Howz-e-dorah 1 section (Figs 1, 2, 3C, E, 5) is located about 500 m northeast of the Chiruk mine, at coordinates: base 33°22′ 21.07″ N – 57°20′ 22.85″ E and top: 33°22′ 26.64″ N – 57°20′ 29″ E.

The section comprising 88.8 m of limestone, sandstone, and shale was studied by Yazdi (1999) and Wendt *et al.* (1997, 2005), who gave a general age, but did not sampled in detail. The lithostratigraphy and fossil content are similar to the Ghale-kalaghu section.

Figure 3. Selected views of the studied sections. • A – the western face of the Ghale-kalaghu section, with indication of the lithostratigraphic units: Mush horizon, Cephalopod beds, White Sandstone Beds (W.S.B.), position of the Frasnian/Famennian and the Devonian/Carboniferous boundaries. • B – view of the sequence across the Frasnian/Famennian boundary in Howz-e-dorah 2 section. • C, D – close view of the upper contact between the White Sandstone Beds and the Cephalopod beds at the Howz-e-dorah 1 (c) and Howz-e-dorah 2 (d) sections. • E – general view of Howz-e-dorah 1 section.



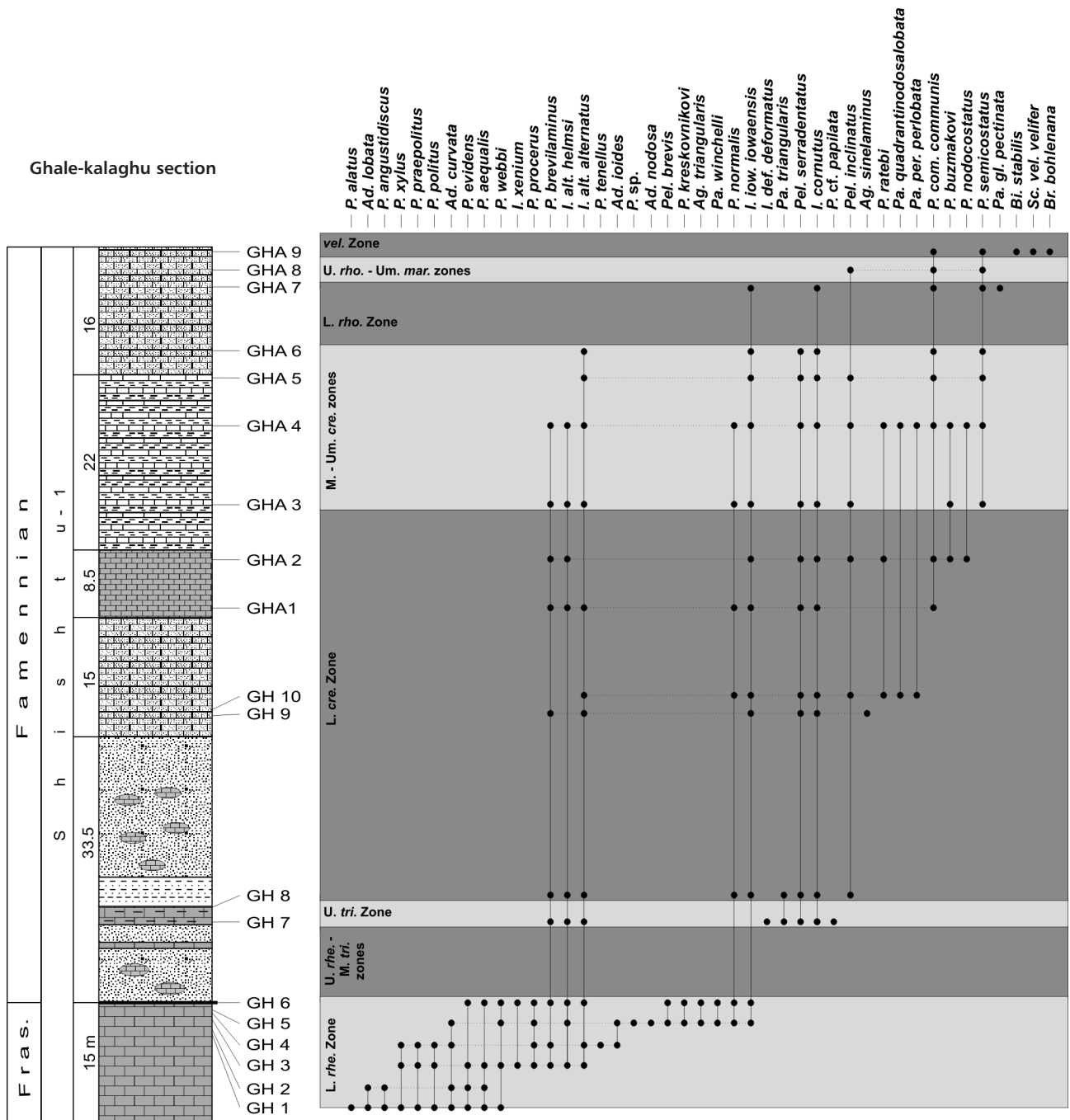


Figure 4. Conodont occurrences and biozonation of the Ghale-kalaghu section. Abbreviations: *Ad.* – *Ancyrodella*, *Ag.* – *Ancyrognathus*, *Bi.* – *Bispathodus*, *I.* – *Icriodus*, *Pal.* – *Palmatolepis*, *Pel.* – *Pelekysgnathus*, *P.* – *Polygnathus*, *Sc.* – *Scaphignathus*, *L. rhe.* – Lower rhenana, *M. tri.* – Middle triangularis, *U. tri.* – Upper triangularis, *L. cre.* – Lower crepida, *M.-Um. cre.* – Middle to Uppermost crepida, *L. rho.* – Lower rhomboidea, *U. rho.* – Upper rhomboidea, *U. mar.* – Upper marginifera, *vel.* – *velifer*.

Howz-e-dorah 2 section

The Howz-e-dorah 2 section (Figs 1, 2, 3b, d, 6) is located close to section Howz-e-dorah 1 in the same flank of the hill, at coordinates: base 33°22′ 16.67″ N – 57°20′ 23″ E and top: 33°22′ 26.24″ N – 57°20′ 25.48″ E.

The Howz-e-dorah 2 section was measured across the Frasnian/Famennian boundary. It includes 15 m of the uppermost Frasnian limestone, 13.7 m of white to brown sandstone, and 9 m of sandy oolitic limestone, which represents the lowermost part of the “Cephalopod bed”.

Table 1. Range chart of conodont species in the Ghale-kalaghu section. For abbreviation of conodont genera see the caption of Fig. 4.

GHALE-KALAGHU	GH 1	GH 2	GH 3	GH 4	GH 5	GH 6	GH 7	GH 8	GH 9	GH 10	GHA 1	GHA 2	GHA 3	GHA 4	GHA 5	GHA 6	GHA 7	GHA 8	GHA 9	Σ		
<i>Ad. curvata</i>	1	2		1	1															5		
<i>Ad. ioides</i>				2	1																3	
<i>Ad. lobata</i>	1	1																			2	
<i>Ad. nodosa</i>					1																1	
<i>Ag. sinelaminus</i>									1												1	
<i>Ag. triangularis</i>				3	2																5	
<i>Bi. bohlenana</i>																				1	1	
<i>Bi. stabilis</i>																				2	2	
<i>I. al. alternatus</i>			3	5		6	15	3	16	5	11		5	22	9	2					102	
<i>I. al. helmsi</i>			5		3	1	3	2			3	1	3	11							32	
<i>I. cornutus</i>							7	6	8	13	17	5	10	6	7	4	17				100	
<i>I. def. deformatus</i>							1														1	
<i>I. iow. iowaensis</i>					7	15	1	12	11	6	27	5	2	9	22	10	12				139	
<i>I. xenium</i>			1			2															3	
<i>P. aequalis</i>	3	2	2			1															8	
<i>P. alatus</i>	1																				1	
<i>P. angustidiscus</i>	2	1																			3	
<i>P. brevilaminus</i>			3	2		3	1	2	3		1	5	3	1							24	
<i>P. buzmakovi</i>												3	2	1							6	
<i>P. cf. papilata</i>							1														1	
<i>P. com. communis</i>											5	3		2	7	4	2	8	2		33	
<i>P. evidens</i>	1	1	1			2															5	
<i>P. kreskovnikovi</i>					1	1															2	
<i>P. nodocostatus</i>												1		1							2	
<i>P. normalis</i>					1	2		1		2	1		2	3							12	
<i>P. politus</i>	1		5	3																	9	
<i>P. praepolitus</i>	2		1	2																	5	
<i>P. procerus</i>	1		1	1	2	2															7	
<i>P. ratebi</i>										2		1		1							4	
<i>P. semicostatus</i>													15	17	12	26	48	11	19		148	
<i>P. tenellus</i>				1																	1	
<i>P. webbi</i>	8		7		7	12															34	
<i>P. xylus</i>	2		2	1																	5	
<i>P. sp.</i>					1																1	
<i>Pa. gl. pectinata</i>																		1			1	
<i>Pa. per. perlobata</i>										2				2							4	
<i>Pa. quadrantinosalobata</i>										1				1							2	
<i>Pa. triangularis</i>							3	2													5	
<i>Pa. winchelli</i>					1	1															2	
<i>Pel. brevis</i>					1	1															2	
<i>Pel. inclinatus</i>								2		2		1	2	3	2				2		14	
<i>Pel. serradentatus</i>							3	7	5	2	1	1	5	1	4	3					32	
<i>Sc. vel. velifer</i>																					17	17
Unassigned elements	18	11	8	27	19	54	5	29	42	8	35	8	58	68	95	61	23	41	14		624	
TOTAL	41	18	39	45	49	105	40	66	86	43	101	34	107	149	158	110	103	62	55		1411	

Table 2. Range chart of conodont species in the Howz-e-dorah 1 section. For abbreviation of conodont genera see the caption of Fig. 4.

HOWZ-E-DORAH 1	HAD 1	HDA 2	HDA 3	HDA 4	HDA 5	HDA 6	HDA 7	HDA 8	HDA 9	HDA 10	HDA 11	HDA 12	HDA 13	HDA 14	HDA 15	HDA 16	HDA 17	Σ
<i>Ad. curvata</i>	1	3			1													5
<i>Ad. ioides</i>			2	3	2													7
<i>Ad. lobata</i>	1																	1
<i>Ad. nodosa</i>				1	1													2
<i>Ag. sinelaminus</i>										1								1
<i>Ag. triangularis</i>				7	3													10
<i>I. al. alternatus</i>		7	12			19		41	13			7		23		12		134
<i>I. al. helmsi</i>		5			3		5				2	1	2	8				26
<i>I. cornutus</i>						11	16	24	27				12			27	31	148
<i>I. def. deformatus</i>						4												4
<i>I. iow. iowaensis</i>									18	7		14			23	8	29	99
<i>I. xenium</i>		2			2													4
<i>P. aequalis</i>	4	3	7		3													17
<i>P. alatus</i>	1																	1
<i>P. angustidiscus</i>	2	1																3
<i>P. brevilaminus</i>		2	2	5	2	1	5	4	1			3	1	4				30
<i>P. buzmakovi</i>													2	1				3
<i>P. com. communis</i>												5		7		3	7	22
<i>P. evidens</i>	2	1			2													5
<i>P. kreskovnikovi</i>				1	1													2
<i>P. normalis</i>				2	3		3			1	2	1	2	1				15
<i>P. politus</i>		3		8														11
<i>P. praepolitus</i>	1		2															3
<i>P. procerus</i>				1														1
<i>P. ratebi</i>									2					1				3
<i>P. semicostatus</i>														18	43	12	5	78
<i>P. tenellus</i>				1														1
<i>P. webbi</i>	16	9	32		14													71
<i>P. xylus</i>	1	2	1															4
<i>Pa. gl. pectinata</i>																	1	1
<i>Pa. per. perlobata</i>															2	1		3
<i>Pa. quadrantinodosalobata</i>												1						1
<i>Pa. triangularis</i>						3	3			1				1				8
<i>Pa. winchelli</i>				1	1													2
<i>Pel. brevis</i>				1	1													2
<i>Pel. inclinatus</i>										4	1	2						7
<i>Pel. serradentatus</i>						7			4		5					3		19
Unassigned elements	87	34	28	16	69	11	37	89	24	45	8	13	5	43	64	5	38	616
TOTAL	116	72	86	47	108	56	69	158	87	61	18	47	24	107	132	71	111	1370

Conodont data

Forty-seven conodont samples (3–4 kg each) were collected: 19 samples from the Ghale-kalaghu section, 17 samples from the Howz-e-dorah 1 section, and 11 samples from the Howz-e-dorah 2 section. The samples were pro-

cessed with the conventional acetic and/or formic acid technique. All samples yielded conodonts varying in abundance and state of preservation.

About 2400 conodont elements were collected (Tables 1, 2, 3). Conodonts are not abundant, only a few samples yielded more than a dozen elements/kg; in general

Table 3. Range chart of conodont species in the Howz-e-dorah 2 section. For abbreviation of conodont genera see the caption of Fig. 4.

HOWZ-E-DORAH 2	HBA1	HBA2	HBA3	HBA4	HBA5	HBA6	HBA7	HBA8	HBA9	HBA10	HBA11	TOTAL
<i>Ad. curvata</i>	2	1	1			1						5
<i>Ad. ioides</i>				2	1	1						4
<i>Ad. lobata</i>	1	1										2
<i>Ad. nodosa</i>					1	1						2
<i>Ag. triangularis</i>					3	3						6
<i>I. al. alternatus</i>			3	8			7		14		9	41
<i>I. al. helmsi</i>			2			5		2		2	3	14
<i>I. cornutus</i>							9	9	19	28		65
<i>I. def. deformatus</i>							1					1
<i>I. iow. iowaensis</i>							9	5	19		8	41
<i>I. xenium</i>			2	1	1	1						5
<i>P. aequalis</i>	3	5										8
<i>P. alatus</i>	1	1										2
<i>P. angustidiscus</i>	2	2	1									5
<i>P. brevilaminus</i>			2	1	1	2	1	3	1		1	12
<i>P. buzmakovi</i>										2	1	3
<i>P. com. communis</i>											7	7
<i>P. evidens</i>	2	1	2			2						7
<i>P. normalis</i>					1	2		2		2	1	8
<i>P. politus</i>			8		4							12
<i>P. praepolitus</i>	1	1		1								3
<i>P. procerus</i>					1							1
<i>P. tenellus</i>					1							1
<i>P. semicostatus</i>											9	9
<i>P. sp. A</i>									1			1
<i>P. sp. B</i>											2	2
<i>P. webbi</i>	9	14	11	24		12						70
<i>P. xylus</i>	1	2	1	2								6
<i>Pa. triangularis</i>							2	1				3
<i>Pa. winchelli</i>					1	1						2
<i>Pel. brevis</i>					1	1						2
<i>Pel. inclinatus</i>								2				2
<i>Pel. serradentatus</i>							5		3			8
Unassigned elements	43	12	27	5	27	13	37	12	39	18	16	249
TOTAL	65	40	60	44	43	45	71	36	96	52	57	609

higher yields occurred in the upper part of the studied interval.

The state of preservation of the conodonts is generally excellent in the upper Frasnian, where many specimens are complete without contamination. In the lower Famennian the preservation is good, but some specimens are broken and/or coated by an iron hematite crust. The color of conodonts is dark black (C.A.I. 5) in the upper Frasnian, then gradually turns to brown (C.A.I. 3) in the upper part of the sections.

Forty-five species and subspecies belonging to eight

genera: *Ancyrodella*, *Ancyrognathus*, *Bispathodus*, *Icriodus*, *Polygnathus*, *Palmatolepis*, *Pelekysgnathus* and *Scaphignathus* were discriminated (Tables 1, 2, 3). The association is dominated by the shallow water genera *Icriodus* and *Polygnathus*; palmatolepids are scarce in all sampled horizons.

The collection is stored in the Department of Geology of the Isfahan University under acronym EUIC. Repository numbers of the figured specimens (Figs 7, 8, 9) can be obtained from the figures captions.

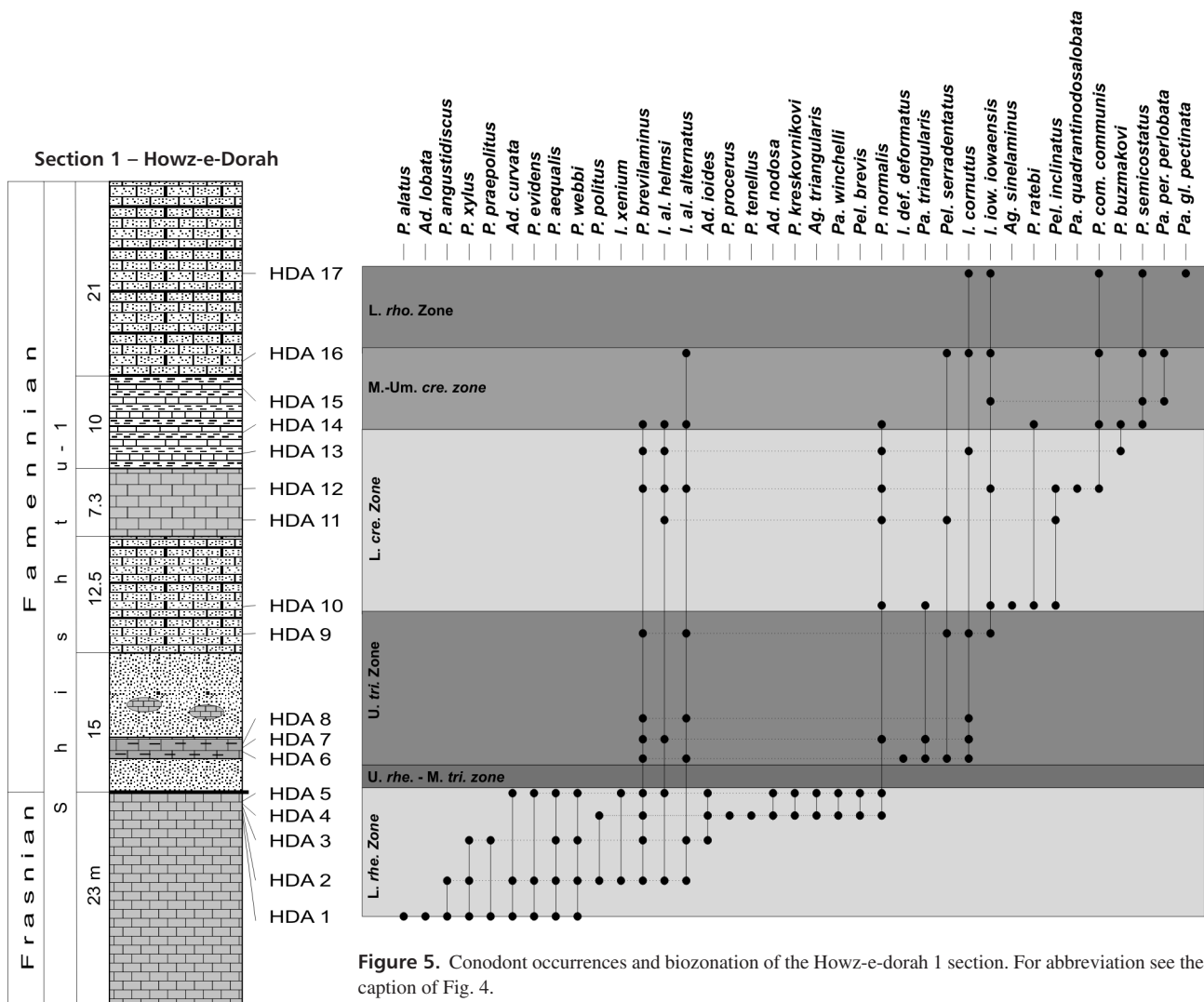


Figure 5. Conodont occurrences and biozonation of the Howz-e-dorah 1 section. For abbreviation see the caption of Fig. 4.

Biostratigraphy

The “Late Devonian standard conodont zonation” (Ziegler & Sandberg 1990) is one of two widely used conodont zonation schemes in use in the Late Devonian. It is based on pelagic index species, mainly of the genus *Palmatolepis* that are rare in the relatively shallow water sediments of the Tabas area. Therefore we also utilize icriodids and polygnathids to identify the zonal boundaries. As a result, it is not possible to recognize all the zones, but sometimes only longer biostratigraphic intervals that group some adjacent zones.

Eight biointervals, from late Frasnian to middle Famennian were discriminated.

Lower *rhenana* Zone

The Lower *rhenana* Zone is discriminated in the limestone unit at the base of the sections (GH 1–6, HDA 1–5, HBA 1–6) by the co-occurrence of *Polygnathus aequalis*,

P. praepolitus, and *P. politus*. The first two species became extinct within this interval (Ji & Ziegler 1993, Ovnatanova & Kononova 2001), while *P. politus* enters within this zone (Ovnatanova & Kononova 2001). This interval is characterized by an abundant and well-preserved conodont fauna, and its top is marked by the unconformity between the limestone and the sandstone units.

Upper *rhenana*–Middle *triangularis* zones

This interval has not been documented, due to the lack of recovered fauna and the unconformity between the limestone and the sandstone units.

Upper *triangularis* Zone

The Upper *triangularis* Zone is identified in the lower part of the mainly sandy unit (samples GH 7, HDA 6–10,

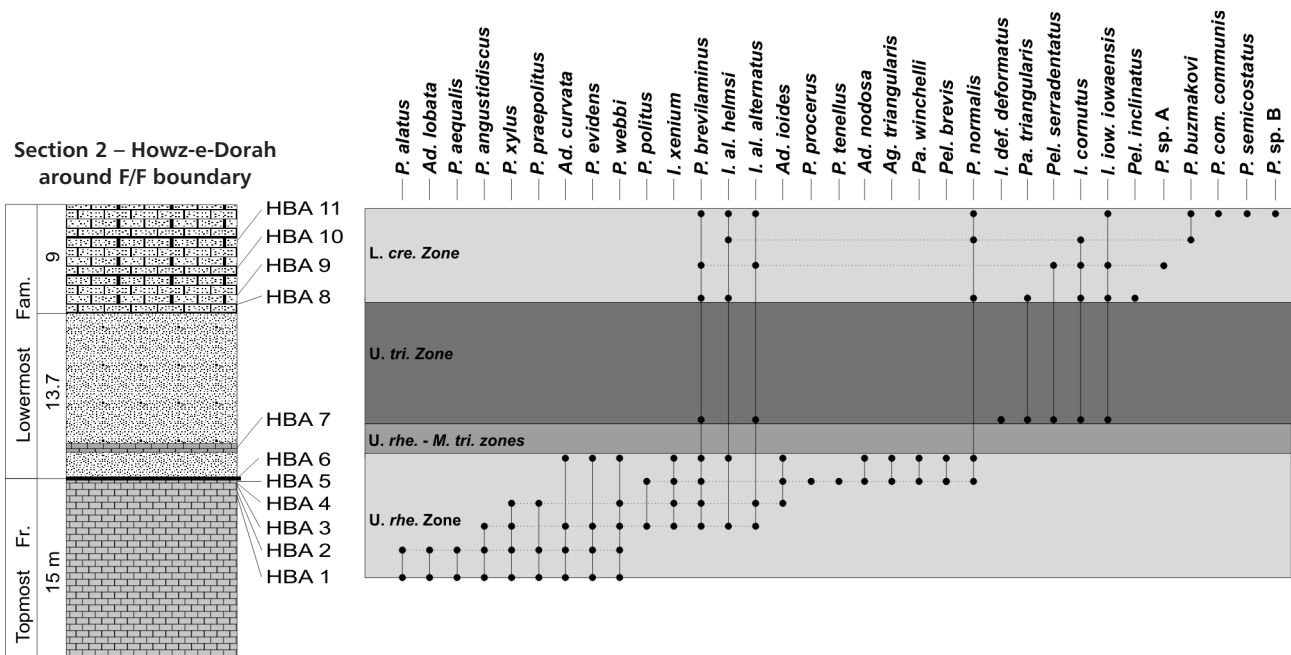


Figure 6. Conodont occurrences and biozonation of the Howz-e-dorah 2 section. For abbreviation see the caption of Fig. 4.

HBA 7) by the occurrence of *Icriodus cornutus*, which, according to Bultynck (2003) has its first appearance datum within this zone. The upper boundary is marked by the first occurrence of *Pelekysgnathus inclinatus*. Icriodids are dominant in this interval; polygnathids are also common.

Lower *crepida* Zone

The lower *crepida* Zone is discriminated in samples GH 8–GHA 3, HDA 11–13 and HBA 8–11. The entrance of *Pelekysgnathus inclinatus*, which has its FAD at the base of the Lower *crepida* Zone (Sandberg & Dreesen 1984, Bultynck 2003), allows recognition of the lower boundary. The upper boundary is marked by the first occurrence of *Polygnathus semicostatus*. Icriodids are dominant in this interval.

Middle-uppermost *crepida* zones

An undifferentiated interval is discriminated in the Ghale-kalaghu (samples GH 4–6) and Howz-e-dorah 1 (samples HD 14–16) sections. The lower boundary is recognized by the first occurrence of *Polygnathus semicostatus*, which ranges from the Middle *crepida* to the Upper *expansa* zones (Ji & Ziegler 1993). The upper limit is identified by the last occurrence of *Icriodus alt. alternatus*, which ranges from the Lower *rhenana* to the Uppermost *crepida* Zone (Bultynck 2003).

Lower *rhomboidea* Zone

The Lower *rhomboidea* Zone is recognized in the upper part of the Ghale-kalaghu (sample GHA 7) and Howz-e-dorah 1 (samples HD 17) sections, as the interval between the last occurrence of *Icriodus alt. alternatus* and the last occurrence of *I. iow. iowaensis*, that became extinct at the top of this zone (Bultynck 2003).

Upper *rhomboidea* to Upper *marginifera* zones

A thin interval corresponding to an undifferentiated Upper *rhomboidea* to Upper *marginifera* zones is discriminated in the upper part of the Ghale-kalaghu section, as the interval between the last occurrence of *I. iow. iowaensis* and the first occurrence of *Scaphignathus vel. velifer*. *Polygnathus semicostatus* and *Po. c. communis* are dominant in this interval.

velifer Zone

This zone is identified at the top of the Ghale-kalaghu section by the entrance of *Scaphignathus vel. velifer* in sample GHA 9. This zone is equivalent to the Uppermost *marginifera* Zone by Ziegler & Sandberg (1984) and named after the nominate taxon by Corradini (2008). *Bispathodus stabilis* and *Branmehla bohlenana* enter in this interval.

Systematic palaeontology

Since most of the taxa collected in the Howz-e-dorah 1, Howz-e-dorah 2 and Ghale-kalaghu sections are well known in literature, systematic notes are restricted to necessary taxonomic and/or biostratigraphic remarks. Taxonomy is focused only on P1 elements. For suprageneric classification, the scheme proposed by Sweet (1988) is followed.

Class Conodonta Pander, 1856
Order Ozarkodinida Dzik, 1976
Family Cavusgnathidae Austin & Rhodes, 1981

Genus *Scaphignathus* Helms, 1959

Type species. – *Scaphignathus velifera* Helms, 1959.

Scaphignathus velifer velifer Helms, 1959

Figure 9KK

- 1959 *Scaphignathus velifera* Ziegler (*sic*); Helms, p. 655, pl. 2, fig. 19; pl. 5, figs 20, 28.
- 1971 *Scaphignathus velifer* Helms. – Beinert *et al.*, p. 83, pl. 2, figs 1–6, 8, 9, 11 (*cum syn.*).
- 1984 *Scaphignathus velifer velifer* Helms. – Ziegler & Sandberg, p. 188.
- 2003 *Scaphignathus velifer velifer* Helms. – Corradini, pp. 76, 77, pl. 10, fig. 7.

Studied material. – 17 specimens from the upper part of the Ghale-kalaghu section.

Remarks. – According to Ziegler & Sandberg (1984), representatives of *Sc. velifer velifer* have a well-developed trough in the anterior part of the platform and a blade on the right side, but rare specimens may have a central blade.

All the studied specimens have an evident short trough in the anterior part of the platform, small nodes aligned in the posterior part, the free blade attached on the right side of the platform; in lateral view the platform is slightly arched to nearly flat, and the free blade is very high.

Stratigraphic range. – From the *velifer* Zone (= Uppermost *marginifera* Zone of Ziegler & Sandberg, 1984) to the Upper *trachytera* Zone (Ziegler & Sandberg 1984).

Family Polygnathidae Bassler, 1925

Genus *Polygnathus* Hinde, 1879

Type species. – *Polygnathus dubius* Hinde, 1879.

Polygnathus ratebi Yazdi, 1999

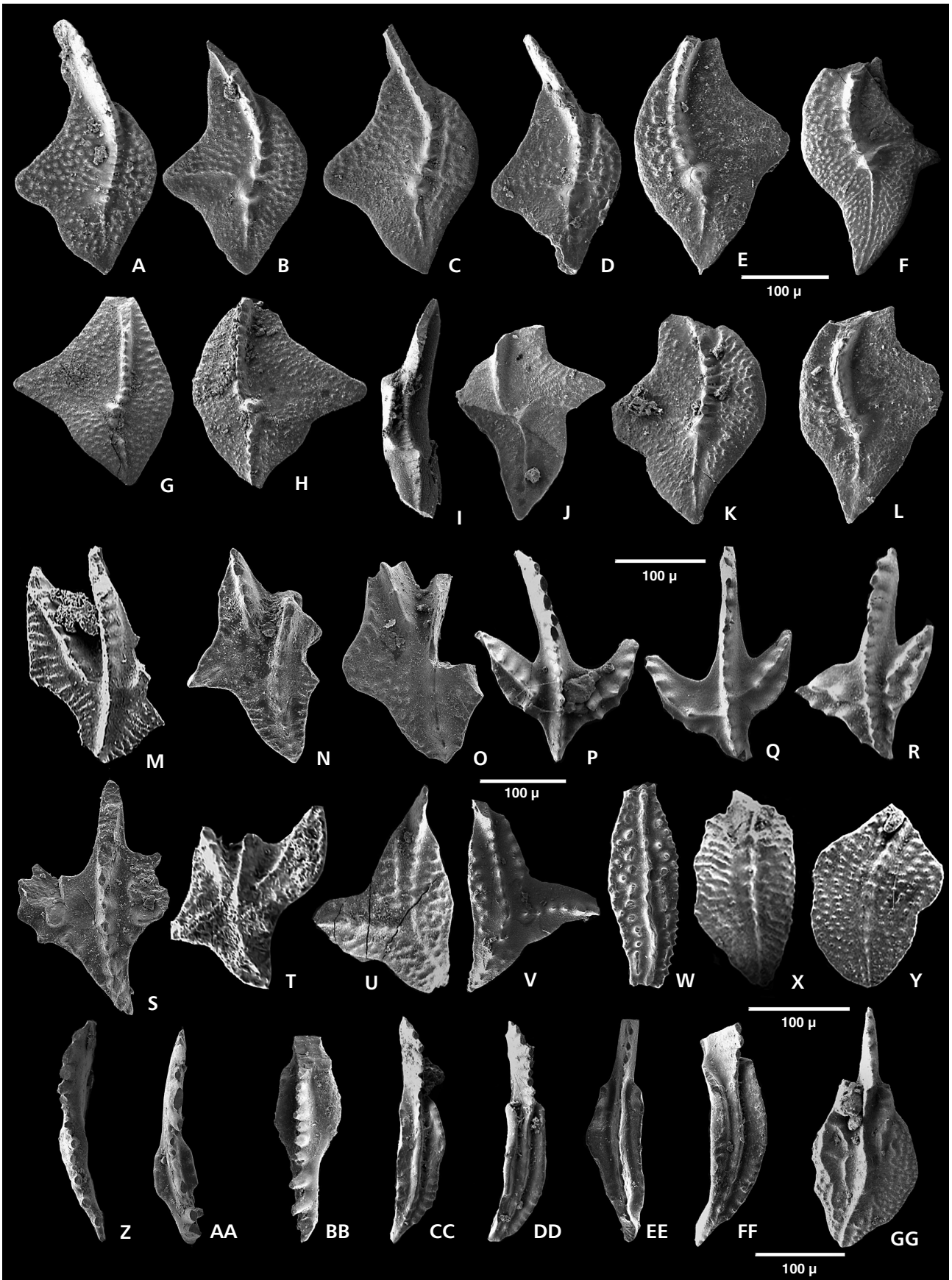
Figure 8II, AAA

- 1999 *Polygnathus ratebi*; Yazdi; pp. 197, 198, pl. 9, figs 1–5.

Material. – 7 specimens.

Remarks. – *Polygnathus ratebi* is characterized by a carina limited to the anterior part of the platform, deep adcarinal troughs and posterior part of the platform are covered by

Figure 7. Conodonts from the Ghale-kalaghu, Howz-e-dorah 1 and 2 sections. • A–E – *Palmatolepis triangularis* Sannemann, 1955b; A – upper view of EUIC 10001, sample GH 7 (Upper *triangularis* Zone), B – upper view of EUIC 10002, sample GH 8 (Lower *crepida* Zone), C – upper view of EUIC 10003, sample HDA 6 (Upper *triangularis* Zone), D – upper view of EUIC 10004, sample HDA 10 (Lower *crepida* Zone), E – upper view of EUIC 10005, sample HBA 8 (Lower *crepida* Zone). • F, J – *Palmatolepis perlobata perlobata* Ziegler, 1960; F – upper view of EUIC 10006, sample GH 10 (Lower *crepida* Zone), J – upper view of EUIC 10007, sample GHA 4 (Middle to Uppermost *crepida* zones). • G, H – *Palmatolepis winchelli* (Stauffer, 1938); G – upper view of EUIC 10008, sample GH 6 (Lower *rhenana* Zone), H – upper view of EUIC 10009, sample HDA 4 (Lower *rhenana* Zone). • I – *Palmatolepis glabra pectinata* Ziegler, 1962; upper view of EUIC 10010, sample HDA 17 (Lower *rhomboidea* Zone). • K, L – *Palmatolepis quadrantinosalobata* Sanneman, 1955b; K – upper view of EUIC 10011, sample HDA 14 (Middle to Uppermost *crepida* zones), L – upper view of EUIC 10012, sample GH 10 (Lower *crepida* Zone). • M, O – *Ancyrodella lobata* (Branson & Mehl, 1934) M2; M – upper view of EUIC 10013, sample GH 2 (Lower *rhenana* Zone), O – upper view of EUIC 10014, sample HDA 1 (Lower *rhenana* Zone). • N, T – *Ancyrodella curvata* (Branson & Mehl, 1934) M2; N – upper view of EUIC 10016, sample GH 2 (Lower *rhenana* Zone), T – upper view of EUIC 10015, sample HBA 1 (Lower *rhenana* Zone). • P–R – *Ancyrodella ioides* Ziegler, 1959; P – upper view of EUIC 10017, sample GH 4 (Lower *rhenana* Zone), Q – upper view of EUIC 10018, sample GH 5 (Lower *rhenana* Zone), R – upper view of EUIC 10019, sample HDA 4 (Lower *rhenana* Zone). • S – *Ancyrodella nodosa* Ulrich & Bassler, 1926; upper view of EUIC 10020, sample HDA 5 (Lower *rhenana* Zone). • U, V – *Ancyrognathus triangularis* Youngquist, 1945; U – upper view of EUIC 10021, sample GH 5 (Lower *rhenana* Zone), V – upper view of EUIC 10022, sample HDA 4 (Lower *rhenana* Zone). • W – *Ancyrognathus sinelaminus* Branson & Mehl, 1934; upper view of EUIC 10023, sample GH 9 (Lower *crepida* Zone). • Fig. X – *Polygnathus cf. papilata* Youngquist & Peterson, 1947; upper view of EUIC 10024, sample GH 7 (Upper *triangularis* Zone). • Y – *Polygnathus nodocostatus nodocostatus* Branson & Mehl, 1934; upper view of EUIC 10025, sample GHA 2 (Lower *crepida* Zone). • Z, AA, BB – *Polygnathus angustidiscus* Youngquist, 1945; Z – upper view of EUIC 10026, sample GH 2 (Lower *rhenana* Zone), AA – upper view of EUIC 10027, sample HDA 2 (Lower *rhenana* Zone), BB – upper view of EUIC 10028, sample HBA 2 (Lower *rhenana* Zone). • CC–FF – *Polygnathus xylus* Stauffer, 1938; CC – upper view of EUIC 10029, sample GH 3 (Lower *rhenana* Zone), DD – upper view of EUIC 10030, sample GH 4 (Lower *rhenana* Zone), EE – upper view of EUIC 10031, sample HDA 2 (Lower *rhenana* Zone), FF – upper view of EUIC 10032, sample HDA 3 (Lower *rhenana* Zone). • GG – *Polygnathus* sp. Upper view of EUIC 10034, sample GH 5 (Lower *rhenana* Zone).



transverse ridges. Compared to the types figured by Yazdi (1999), our specimens are very similar and fit well in the description of the species, even if one specimen (Fig. 8II) has a more evident ornamentation on the anterior margins of the platform.

Stratigraphic range. – The species was reported from the Upper *triangularis* Zone to the Upper *crepida* Zone (Yazdi 1999). Our material suggests a possible occurrence up to the Uppermost *crepida* Zone.

***Polygnathus semicostatus* Branson & Mehl, 1934**

Figure 9LL

- 1934 *Polygnathus semicostatus* Branson & Mehl; p. 247, pl. 21, figs 1, 2.
- 1974 *Polygnathus semicostatus* Branson & Mehl. – Dreesen & Orchard, p. 3, pl. 1, figs 1–8, pl. 2, figs 1–25.
- 1975 *Polygnathus semicostatus* Branson & Mehl. – Klapper in Ziegler (ed.), p. 317, pl. *Polygnathus*-5, fig. 6 (cum syn.).

Material. – 235 specimens.

Remarks. – *P. semicostatus* displays wide variability of

morphological features. Dreesen & Orchard (1974) recognized eight evolutionary morphological trends on the basis of increasing number of transversal ridges, progressive arching of the platform, and development of deep adcarinal grooves and a wide tongue. In the studied material the species shows a wide variability, and two morphotypes can be discriminated: some specimens have a narrow and elongate platform with strongly upturned margins and short ridges in the anterior part; others are wider in anterior part of the platform and narrow in the posterior part.

Range. – From the Middle *crepida* Zone to the Upper *expansa* Zone (Ji & Ziegler 1993).

Family Spathognathodontidae Hass, 1959

Genus *Ancyrodella* Ulrich & Bassler, 1926

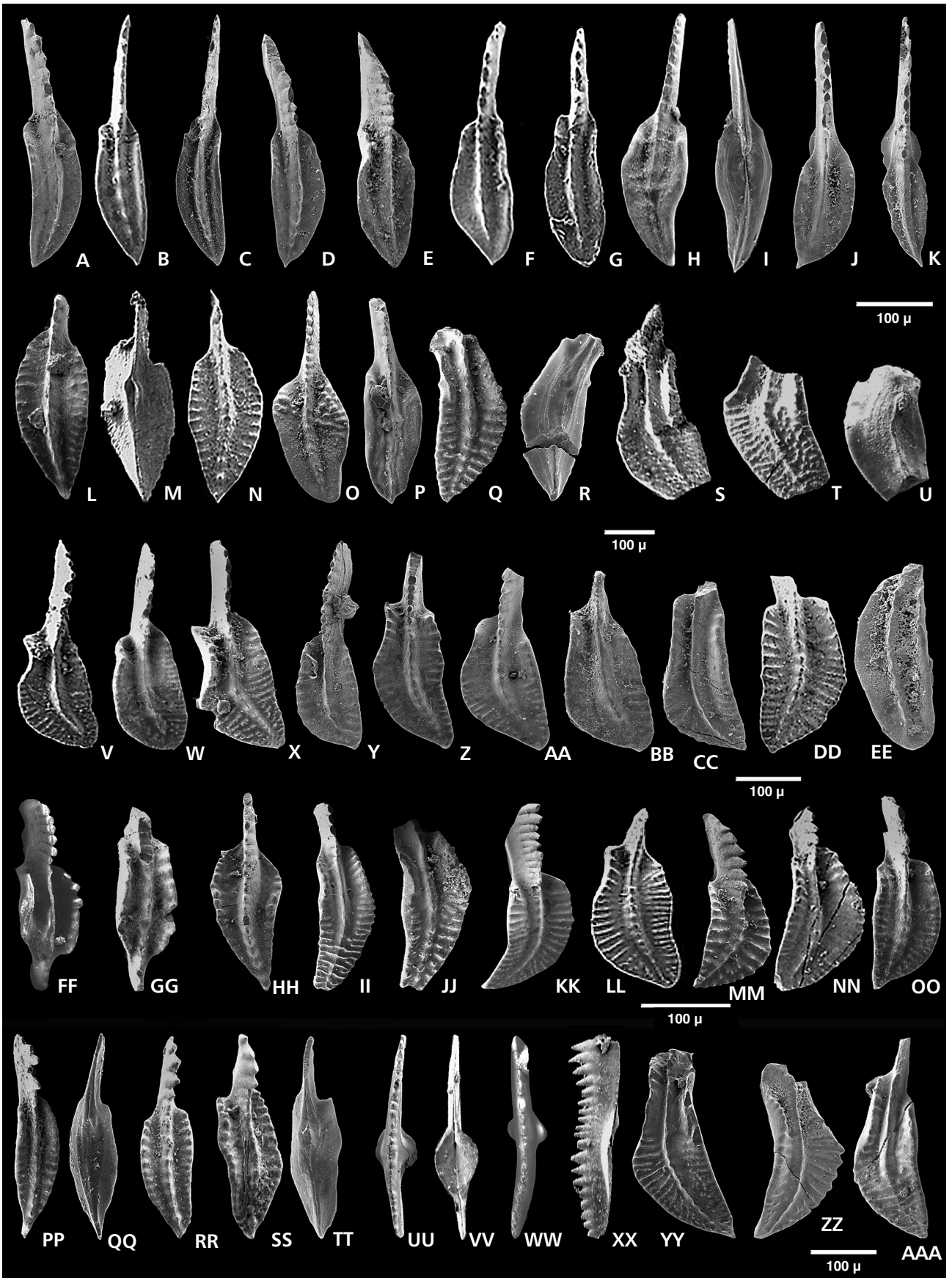
Type species. – *Ancyrodella nodosa* Ulrich & Bassler, 1926.

***Ancyrodella curvata* (Branson & Mehl, 1934)**

Figure 7N, T

- 1934a *Ancyrognathus curvata*; Branson & Mehl, p. 241, pl. 19, figs 6, 11.

Figure 8. Conodonts from the Ghale-kalaghu, Howz-e-dorah 1 and 2 sections. • A–D – *Polygnathus politus* Ovnatanova, 1969; A – upper view of EUIC 10035, sample GH 1 (Lower *rhenana* Zone), B – upper view of EUIC 10036, sample GH 4 (Lower *rhenana* Zone), C – upper view of EUIC 10037, sample HDA 2 (Lower *rhenana* Zone), D – upper view of EUIC 10038, sample HDA 4 (Lower *rhenana* Zone). • E–G – *Polygnathus praepolitus* Kononova et al., 1996; E – upper view of EUIC 10039, sample GH 4 (Lower *rhenana* Zone), F – upper view of EUIC 10040, sample GH 4 (Lower *rhenana* Zone), G – upper view of EUIC 10041, sample HDA 1 (Lower *rhenana* Zone). • H–K, P – *Polygnathus communis communis* Branson & Mehl, 1934; H – upper and I – lower views of EUIC 10042, sample GHA 7 (Upper *rhomboidea* to Upper *marginifera* zones), J – upper view of EUIC 10043, sample HDA 17 (Lower *rhomboidea* Zone), K – upper view of EUIC 10044, sample GHA 8 (Upper *rhomboidea* to Upper *marginifera* zones), P – upper view of EUIC 10044, sample GHA 8 (Upper *rhomboidea* to Upper *marginifera* zones). • L–N – *Polygnathus* sp. B; L – upper view of EUIC 10045, sample HBA 11 (Lower *crepida* Zone), M – lower and upper (N) views of EUIC 10046, sample HBA 11 (Lower *crepida* Zone). • O – *Polygnathus* sp. A; upper view of EUIC 10047; sample HBA 9 (Lower *crepida* Zone). • Q–R, JJ – *Polygnathus buzmakovi* Kuzmin, 1990; Q – upper and lower (R) views of EUIC 10048, sample GHA 4 (Middle to Uppermost *crepida* zones), JJ – upper view of EUIC 10068, sample GHA 3 (Middle to Uppermost *crepida* zones). • S–U – *Polygnathus evidens* Klapper & Lane, 1985; S – upper view of EUIC 10049, sample GH 1 (Lower *rhenana* Zone), T – upper and lower (U) views of EUIC 10050, sample GH 2 (Lower *rhenana* Zone). • V–Y, KK, MM, NN – *Polygnathus webbi* Stauffer, 1938; V – upper view of EUIC 10051, sample GH 1 (Lower *rhenana* Zone), W – upper view of EUIC 10052, sample GH 5 (Lower *rhenana* Zone), X – upper view of EUIC 10053, sample GH 6 (Lower *rhenana* Zone), Y – upper view of EUIC 10054, sample HDA 1 (Lower *rhenana* Zone), KK – upper view of EUIC 10055, sample HDA 2 (Lower *rhenana* Zone), MM – upper view of EUIC 10056, sample HDA 3 (Lower *rhenana* Zone), NN – upper view of EUIC 10057, sample HBA 4 (Lower *rhenana* Zone). • Z–CC, LL – *Polygnathus aequalis* Klapper & Lane, 1985; Z – upper view of EUIC 10058, sample HBA 1 (Lower *rhenana* Zone), AA – upper view of EUIC 10059, sample HBA 2 (Lower *rhenana* Zone), BB – upper view of EUIC 10060, sample HDA 2 (Lower *rhenana* Zone), CC – upper view of EUIC 10061, sample HDA 4 (Lower *rhenana* Zone), LL – upper view of EUIC 10062, sample HDA 5 (Lower *rhenana* Zone). • EE – *Polygnathus alatus* Huddle, 1934; upper view of EUIC 10063, sample GH 1 (Lower *rhenana* Zone). • FF, GG, PP, QQ – *Polygnathus brevilaminus* Branson & Mehl, 1934; FF – upper view of EUIC 10064, sample GHA 1 (Lower *crepida* Zone), GG – upper view of EUIC 10065, sample GHA 4 (Middle to Uppermost *crepida* zones), PP – upper and lower (QQ) views of EUIC 10070, sample HDA 12 (Lower *crepida* Zone). • HH, RR – *Polygnathus tenellus* Ji & Ziegler, 1993; HH – upper view of EUIC 10066, sample HDA 4 (Lower *rhenana* Zone), RR – upper view of EUIC 10066, sample GH 5 (Lower *rhenana* Zone). • II, AAA – *Polygnathus ratebi* Yazdi, 1999; II – upper view of EUIC 10067, sample GH 9 (Lower *crepida* Zone), AAA – upper view of EUIC 10078, sample GHA 4 (Middle to Uppermost *crepida* zones). • OO – *Polygnathus procerus* Sannemann, 1955b; upper view of EUIC 10069, sample GH 4 (Lower *rhenana* Zone). • SS, TT – *Polygnathus* sp.; upper (SS) and lower (TT) views of EUIC 10072, sample HBA 7 (Upper *triangularis* Zone). • UU, VV, XX – *Bispathodus stabilis* (Branson & Mehl, 1934); upper (UU) and lower (VV) views of EUIC 10073, sample GHA 9 (*velifer* Zone), XX – lateral view of EUIC 10074, sample GHA 9 (*velifer* Zone). • WW – *Branmehla bohlenana* (Helms, 1959); upper view of EUIC 10075, sample GHA 9 (*velifer* Zone). • YY, ZZ – *Polygnathus krestovnikovii* Ovnatanova, 1969; YY – upper view of EUIC 10076, sample HDA 2 (Lower *rhenana* Zone), ZZ – upper view of EUIC 10077, sample HDA 4 (Lower *rhenana* Zone).



- 1966 *Ancyrodella curvata* (Branson & Mehl). – Glenister & Klapper, p. 789, pl. 86, fig. 13–15.
 1993 *Ancyrodella curvata* (Branson & Mehl). – Ji & Ziegler, pp. 51, 52, pl. 2, figs 4, 5, 10.
 1999 *Ancyrodella curvata* (Branson & Mehl). – Yazdi, p. 183, pl. 4, figs 12–15.
 2007 *Ancyrodella curvata* (Branson & Mehl). – Gholamalian, p. 466, fig. 9c.

Material. – 14 specimens.

Remarks. – A broadly triangular conodont element with pointed lobe developed on the inner margin and two pointed lobes developed on the outer margin, one pointing anteriorly and the second postero-laterally. The free blade extends as a carina to the posterior margin. Although the Iranian materials are mostly broken, they can be referred to *Ancyrodella curvata* by the shape of the lobes.

Stratigraphic range. – From the Lower *hassi* to the top-most *linguiformis* zones (Ji & Ziegler 1993).

Order Prioniodontida Dzik, 1976
 Family Icriodontidae Müller & Müller, 1957

Genus *Icriodus* Branson & Mehl, 1938

Type species. – *Icriodus expansus* Branson & Mehl, 1938.

Icriodus alternatus alternatus Barnson & Mehl, 1934

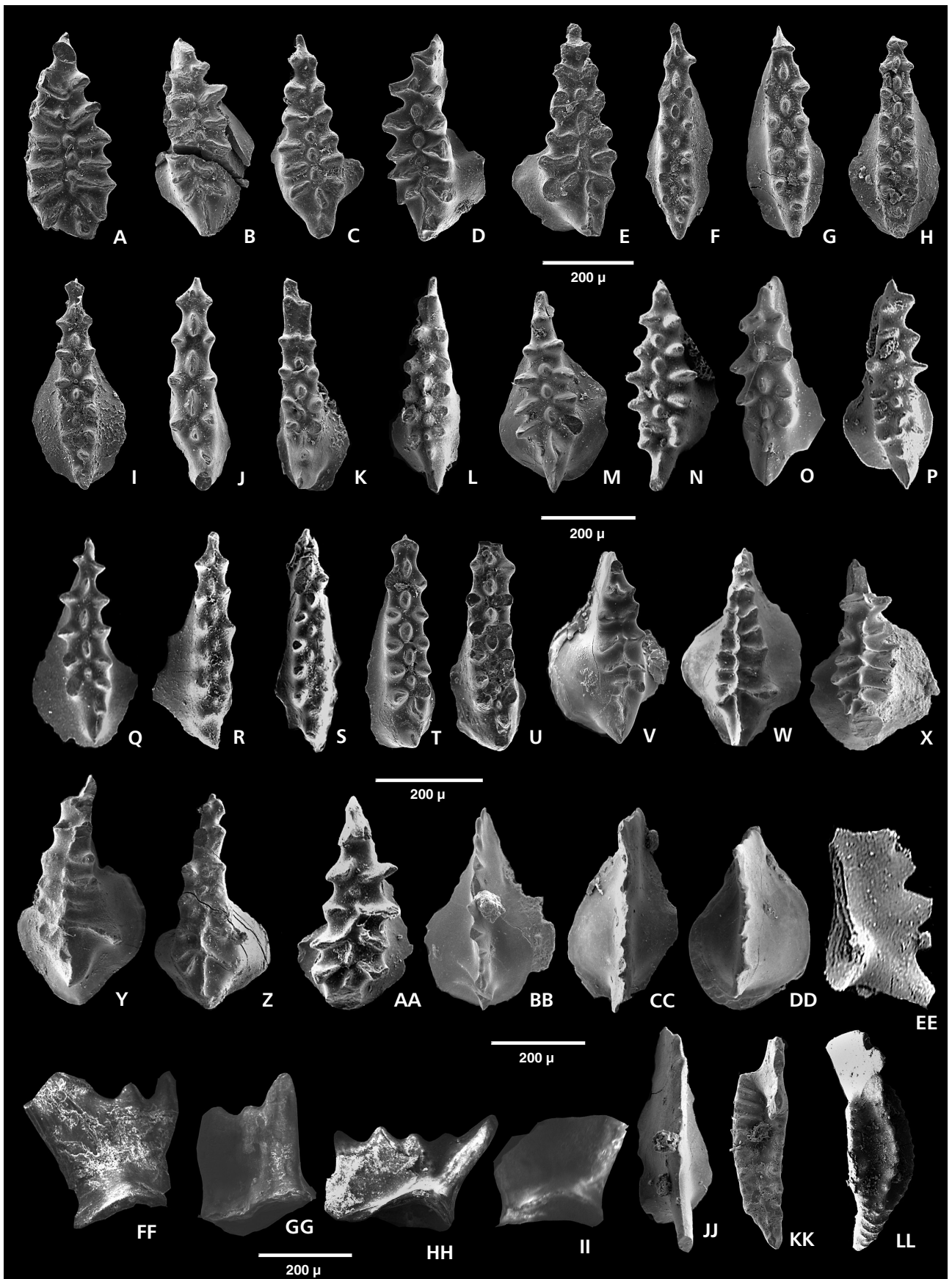
Figure 9F–K

- 1934 *Icriodus alternatus*; Branson & Mehl, p. 225, pl. 13, figs 4–6.
 1975 *Icriodus alternatus* Branson & Mehl. – Klapper in Ziegler (ed.), p. 69, *Icriodus* – pl. 3, figs 5, 6 (*cum syn.*).
 1984 *Icriodus alternatus alternatus* Branson & Mehl. – Sandberg & Dreesen, p. 158, pl. 2, figs 5, 11 (*cum syn.*).
 2003 *Icriodus alternatus alternatus* Branson & Mehl. – Corradini, p. 92, pl. 2, figs 9–12.

Studied material. – 277 specimens.

Remarks. – Sandberg & Dreesen (1984) proposed two morphotypes for *I. alt. alternatus*, according to the cross section of denticles of the medial row that may be rounded or laterally compressed. They reported also that the two morphotypes have the same stratigraphic distribution and that (p. 151) “in some faunas both morphotypes are present, whereas in other faunas one or the other morphotype is dominant or occurs exclusively”. In the studied material both the morphologies are present, even if a majority of specimens have elongated denticles; furthermore a few specimens alternate elongated and rounded denticles in the median row. Therefore, considering that the two proposed morphotypes have no apparent utility, they are not accepted in this paper.

Figure 9. Conodonts from the Ghale-kalaghu, Howz-e-dorah 1 and 2 sections. • A–E – *Icriodus xenium* Nazarova, 1997; A – upper view of EUIC 10079, sample GH 3 (Lower *rhenana* Zone), B – upper view of EUIC 10080, sample GH 6 (Lower *rhenana* Zone), C – upper view of EUIC 10081, sample HDA 5 (Lower *rhenana* Zone), D – upper view of EUIC 10082, sample HDA 5 (Lower *rhenana* Zone), E – upper view of EUIC 10083, sample HDA 2 (Lower *rhenana* Zone). • F–K – *Icriodus alternatus alternatus* Sandberg & Dreesen, 1984; F – upper view of EUIC 10084, sample GHA 5 (Middle to Uppermost *crepida* zones), G – upper view of EUIC 10085, sample GHA 1 (Lower *crepida* Zone), H – upper view of EUIC 10086, sample GH 6 (Lower *crepida* Zone), I – upper view of EUIC 10087, sample HDA 16 (Lower *rhomboidea* Zone), J – upper view of EUIC 10088, sample HDA 12 (Lower *crepida* Zone), K – upper view of EUIC 10089, sample HDA 3 (Lower *rhenana* Zone). • L–P – *Icriodus cornutus* Sannemann, 1955a; L – upper view of EUIC 10090, sample HDA 13 (Lower *crepida* Zone), M – upper view of EUIC 10091, sample HDA 16 (Lower *rhomboidea* Zone), N – upper view of EUIC 10092, sample HDA 17 (Lower *rhomboidea* Zone), O – upper view of EUIC 10093, sample GH 7 (Upper *triangularis* Zone), P – upper view of EUIC 10094, sample GH 8 (Upper *triangularis* Zone). • Q–U – *Icriodus alternatus helmsi* Sandberg & Dreesen, 1984; Q – upper view of EUIC 10095, sample GHA 1 (Lower *crepida* Zone), R – upper view of EUIC 10096, sample GHA 4 (Middle to Uppermost *crepida* zones), S – upper view of EUIC 10097, sample HDA 7 (Upper *triangularis* Zone), T – upper view of EUIC 10098, sample HDA 11 (Lower *crepida* Zone), U – upper view of EUIC 10099, sample HBA 8 (Lower *crepida* Zone). • V–Z – *Icriodus iowaensis iowaensis* Youngquist & Peterson, 1947; V – upper view of EUIC 10100, sample GHA 5 (Middle to Uppermost *crepida* zones), W – upper view of EUIC 10101, sample GHA 5 (Middle to Uppermost *crepida* zones), X – upper view of EUIC 10102, sample HDA 17 (Lower *rhomboidea* Zone), Y – upper view of EUIC 10103, sample HDA 9 (Upper *triangularis* Zone), Z – upper view of EUIC 10104, sample HBA 7 (Upper *triangularis* Zone). • AA – *Icriodus deformatus deformatus* Han, 1987; upper view of EUIC 10105, sample HDA 6 (Upper *triangularis* Zone). • BB–EE – *Pelekysgnathus serradentatus* Capkinoglu, 1991; BB – upper view of EUIC 10106, sample GH 7 (Upper *triangularis* Zone), CC – upper view of EUIC 10107, sample GHA 5 (Middle to Uppermost *crepida* zones), DD – upper view of EUIC 10108, sample HDA 9 (Upper *triangularis* Zone). • EE, FF, HH, JJ – *Pelekysgnathus inclinatus* Thomas, 1949; EE – lateral view of EUIC 10109, sample HDA 11 (Lower *crepida* Zone), FF – lateral view of EUIC 10110, sample HDA 12 (Lower *crepida* Zone), HH – lateral view of EUIC 10111, sample GHA 5 (Middle to Uppermost *crepida* zones), JJ – upper view of EUIC 10112, sample HBA 8 (Lower *crepida* Zone). • GG, II – *Pelekysgnathus brevis* Sandberg & Dreesen, 1984; GG – lateral view of EUIC 10113, sample GH 5 (Lower *rhenana* Zone), II – lateral view of EUIC 10114, sample HDA 4 (Lower *rhenana* Zone). • KK – *Scaphignathus velifer velifer* Helms, 1959; upper view of EUIC 10115, sample GHA 9 (*velifer* Zone). • LL – *Polygnathus semicostatus* Branson & Mehl, 1934; upper view of EUIC 10116, sample GHA 4 (Middle to Uppermost *crepida* zones).



Stratigraphic range – From the Lower *rhenana* Zone to the Uppermost *crepida* Zone (Bultynck 2003).

Icriodus iowaensis iowaensis

Youngquist & Peterson, 1947

Figure 9V–Z

- 1984 *Icriodus iowaensis iowaensis*; Youngquist & Peterson, p. 247, pl. 37, figs 22–24, 27–29.
- 1984 *Icriodus iowaensis iowaensis* Youngquist & Peterson. – Sandberg & Dressen, pp. 159, 160, pl. 1, figs 7–11 (*cum syn.*).
- 1985 *Icriodus iowaensis iowaensis* Youngquist & Peterson. – Klapper & Lane, p. 920, figs 11.7–11.10.
- 1991 *Icriodus iowaensis iowaensis* Youngquist & Peterson. – Johnston & Chatterton, pl. 3, figs 21–24.
- 1992 *Icriodus iowaensis iowaensis* Youngquist & Peterson. – Savage, p. 280, figs 2.1–2.6.

Studied material. – 279 specimens.

Remarks. – *I. iowaensis iowaensis* is characterized by having a low cusp and conspicuous ridges connecting denticles. The ridges connect at least some of the medial-row denticles and join many lateral-row denticles to those of the medial row. In lateral view has the posterior cusp and all or most denticles are of about equal height. Sandberg & Dressen (1984) report on variability of the size of the platform, from broad platform and widely expanded basal cavity to narrow specimens.

In the studied material all the specimens have an expanded basal cavity and a broad platform.

Stratigraphic range. – According to Bultynck (2003) *Icriodus iowaensis iowaensis* ranges from the *linguiformis* Zone to the Lower *rhomboidea* Zone. Ziegler & Sandberg (1990, p. 21) report the occurrence of early forms in the upper part of Upper *rhenana* Zone. In the Ghale-kalaghu section the species occur also in the uppermost part of the Lower *rhenana* Zone

Genus *Pelekysgnathus* Thomas, 1949

Type species. – *Pelekysgnathus inclinatus* Thomas, 1949.

***Pelekysgnathus serradentatus* Capkinoglu, 1991**

Figures 9BB–DD

- 1991 *Pelekysgnathus serradentatus*; Capkinoglu, pp. 351, 352, pl. 1, figs 1–3.
- 2000 *Pelekysgnathus serradentatus* Capkinoglu. – Capkinoglu & Gedik, p. 78, pl. 1, figs 1–3.

2007 *Pelekysgnathus serradentatus* Capkinoglu. – Gholamalian, p. 468, figs 10E, F.

Material. – 59 specimens.

Remarks. – *Pelekysgnathus serradentatus* is characterized by lacking a prominent posterior cusp, by a very broad, expanded basal cavity and by a peculiar irregular shape of denticles that are somehow irregularly laterally expanded. Our material fit well in the original diagnosis of the species (Capkinoglu 1991). Bahrami *et al.* (2011b) described as *Pel. cf. serradentatus* a few specimens from southern Iran, with shape similar to the holotype (Capkinoglu 1991, pl. 1, fig. 1), but differing by a laterally compressed denticulation. This material comes from a slightly younger stratigraphic level, and indicates a possible evolutionary trend from a laterally expanded to a laterally compressed denticulation. *Pelekysgnathus serradentatus* seems to have a limited geographical distribution, being documented up to now only from Turkey and Iran.

Stratigraphic range. – The species was reported from the Middle *triangularis* Zone to the lower part of an undifferentiated *crepida* Zone (Capkinoglu & Gedik 2000). The studied material comes from the Upper *triangularis* to the Uppermost *crepida* Zone.

Conclusions

The conodont fauna from three sections in the Shotori range allows detailed biostratigraphy across the Frasnian-Famennian boundary in the area. A hiatus spanning from the Upper *rhenana* into the Middle *triangularis* Zone is documented. The older Famennian strata are represented by white sandstones/quartzites with subordinate minor limestone lenses, deposited in a shallow water environment. More to the North, in the northern part of the Shotori Range Gholamalian *et al.* (2009) reported a similar hiatus characterized by a more diverse pelagic fauna (Kale-sardar section) and inferred a generally deeper water environment. Therefore different sedimentary environments occurred in the northern part and in the southern part of the Shotori Range during the Late Devonian, characterized by deeper and shallower water, respectively.

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