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GIVETIAN-FRASNIAN BOUNDARY CONODONTS FROM KERMAN PROVINCE, CENTRAL IRAN

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Key words: Iran, Devonian, Givetian - Frasnian boundary, conodonts, biostratigraphy.

Abstract. The Middle - Late Devonian boundary is investigated based on twenty-two conodont species and subspecies from three sections in the north and west of Kerman, southeastern central Iran. Upper Givetian - lower Frasnian carbonates of the basal part of the Bahram Formation transgressively overlie the sandstone beds of the top of (?) Early - Middle Devonian Padeha Formation. These massive skeletal limestones encompass the G-F boundary. The base of Frasnian is identified by the appearance of early forms of *Ancyrodella rotundiloba*. It helps to compare our biozones to those of global stratotype in southern France. A new species, *Polygnathus hojedki* n. sp. is described here. New range is suggested for *P. praepolitus*.

Riassunto. Il limite Devoniano Medio - Devoniano Superiore viene studiato sulla base di 22 specie e sottospecie di conodonti ottenute da tre sezioni stratigrafiche situate a nord e a ovest di of Kerman, nell'Iran centrale, parte sudorientale. I carbonati di età tardo Givetiano-Frasniano basale, riferibili alla parte basale della Formazione Bahram ricoprono in discordanza i livelli arenacei sommitali della Formazione Padeha di età (?)Devoniano Inferiore - Medio. Questi calcari bioclastici massicci contengono il limite G-F. La base del Frasniano viene identificata con la comparsa delle forme più primitive di *Ancyrodella rotundiloba*. Questo fatto aiuta a confrontare le nostre biozone con quelle dello stratotipo globale nel sud della Francia. Viene descritta la nuova specie *Polygnathus hojedki* n. sp. E viene proposta una nuova distribuzione per *P. praepolitus*.

Introduction

The Global Stratotype Section and Point (GSSP) of the Givetian - Frasnian boundary is located in the Col du Puech de la Suque section E of Montagne Noire, southern France (Feist & Klapper 1985; Klapper et al. 1987). This boundary is designated at the base of bed 42a′ in which early forms of *Ancyrodella rotundiloba* appear and mark the base of the Lower *asymmetricus* Zone, the base of Late Devonian in the scheme of Ziegler (1962) (Klapper 1985; Kirchgasser 1994). A few years later, Klapper (1989) and Ziegler & Sandberg (1990) presented separated new zonation schemes for the Late Devonian based on the pelagic genera. Klapper (1985; 2000); Feist & Klapper (1985) and Klapper et al. (1987) endorsed the SDS decision for the base of Frasnian at the first occurrence of *Ancyrodella rotundiloba*. Whereas Sandberg et al. (1989) and Ziegler & Sandberg (1996; 2000) rejected the GSSP definition of the Givetian - Frasnian boundary, by stating that "*Ancyrodella rotundiloba* is a shallow water species with unknown ancestor". Consequently they proposed to substitute the first occurrences of two other species, *An. pristina* and *An. soluta* (instead of *An. rotundiloba*) as biomarkers for the base of Frasnian.

Despite the stratotype section in Montagne Noire, recent studies on the Middle - Late Devonian boundary have been performed in some regions in North Africa, Europe, North America and East Asia (Aboussalam & Becker 2007; Gouwy et al. 2007; Narkiewicz & Bultynck 2007). Miller (2007) studied the

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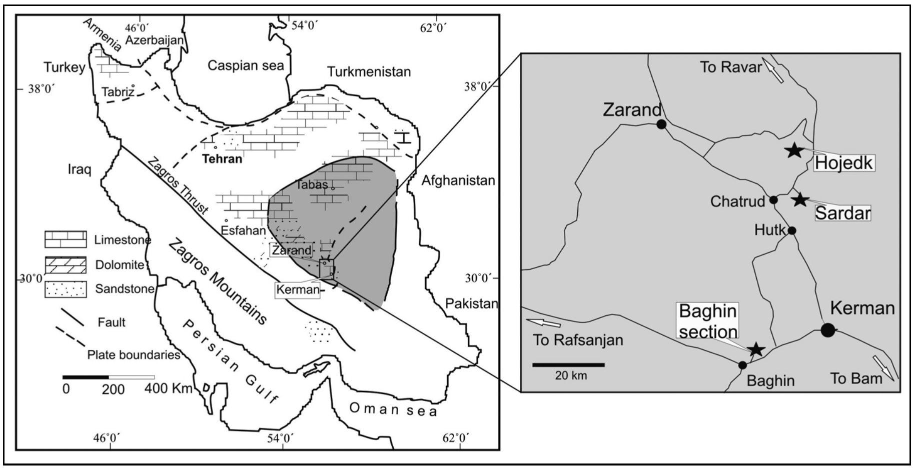

Fig. 1 - Palaeogeographic map of Iran (redrawn from Wendt et al. 2005), showing the roads and locations of the studied sections in the Kerman area, southeastern central Iran. The shaded area is the east-central Iran microplate.

ontogenic lineage of some index conodont species in Sub-Polar areas of Russia. Devleeschouwer et al. (2010) have examined the parastratotype of the G-F boundary in Belgium by means of magnetic susceptibility. Kirchgasser (1994) and Kralick (1994) analyzed the *Ancyrodella* species occurrence in some Middle - Late Devonian boundary successions of New York (USA). Hou et al. (1986) documented dacryconarids and conodonts of the boundary interval in China. Until now, there was no precise diagnostic investigation on the Givetian - Frasnian boundary interval in the Middle-East, except for some limited information from Iran such as Ashouri (2004, 2006).

In the present paper, we examined several conodont collections and their biostratigraphic implications on the exact position of the G-F boundary in the Hojedk, Baghin and Sardar localities in the North and West part of Kerman district, in the southeastern sector of East-Central Iran.

All of studied samples are stored in the Department of Geology, Faculty of Sciences, Hormozgan University, Bandar Abbas.

Geographic position

The Hojedk section is located in 65 km North of Kerman, 4 km West of Heruz village (next to Kerman - Ravar road) at N30°43′45.5″, E57°00′54″ (Fig. 1). The base of Baghin section, 25 km west of Kerman (5 km northeast of Baghin city) is studied at: N30°13′9.8″, E56°51′7.7” (Figs 1, 2). The Sardar section is located at N30°38′8.77″, E56°59′54.1″ in 45 km north of Kerman. The best way to this section is a sidetrack that separates from the main road near the Khorasani cervix (Figs 1, 2).

Palaeogeography

East-central Iran microplate including its southeastern sector, Kerman region, constituted a part of the Peri-Gondawana shallow shelf margin in the Devonian (e.g. Sengör 1990; Stampfli 2000; Torsvik & Cocks 2004; Wendt et al. 2005; Muttoni et al. 2009). Biogeographic data on Late Devonian biotas (e.g. brachiopods, Brock & Yazdi 2000) in accordance with earlier data, display strong affinities to those on other neighbor Middle Eastern Peri-Gondwanan terranes at 30-45°S palaeolatitude.

Stratigraphic setting

Four lithostratigraphic units have been recognized in the Devonian strata of central Iran: the Padeha, Sibzar, Bahram and Shishtu formations. Because of the very scarce palaeontological information, the age of the Padeha Formation is based on its stratigraphic position in the general succession and it is not well known in the most parts of Iran. Stöcklin & Setudehnia (1991) placed this formation in the Early Devonian. Nasehi (1997) studied this formation in the Shabjereh section near Zarand (Kerman Province) and based on conodonts, he attributed it to an Emsian - Givetian interval. The age of unfossiliferous dolostones of Sibzar Formation can only be estimated on the basis of its stratigraphic position in the all succession. This formation is absent in the most parts of the Kerman area; such as Hojedk, Hutk, Baghin, Sardar sections and etc. In these areas, the Bahram Formation limestones directly cover the sandstones and shales of the Padeha Formation in the mentioned areas. So the Sibzar Formation dolostones seem to be the lateral equivalent of limestones of the lower part of the Bahram Formation in the most parts of Kerman area, except for the Gerik section (Wendt et al. 2002). Analysis of the Bahram Formation stratotype in Ozbak-Kuh (N Tabas) and its equivalent successions in the Esfahan and Kerman regions shows that this formation is diachronous. It is Eifelian in the Zefreh section in NE Esfahan (Brice et al. 2006), Givetian in the Soh section in N Esfahan (Adhamian 2003), late Givetian - early Frasnian in the Ozbak-Kuh section (Khaksar et al. 2006),

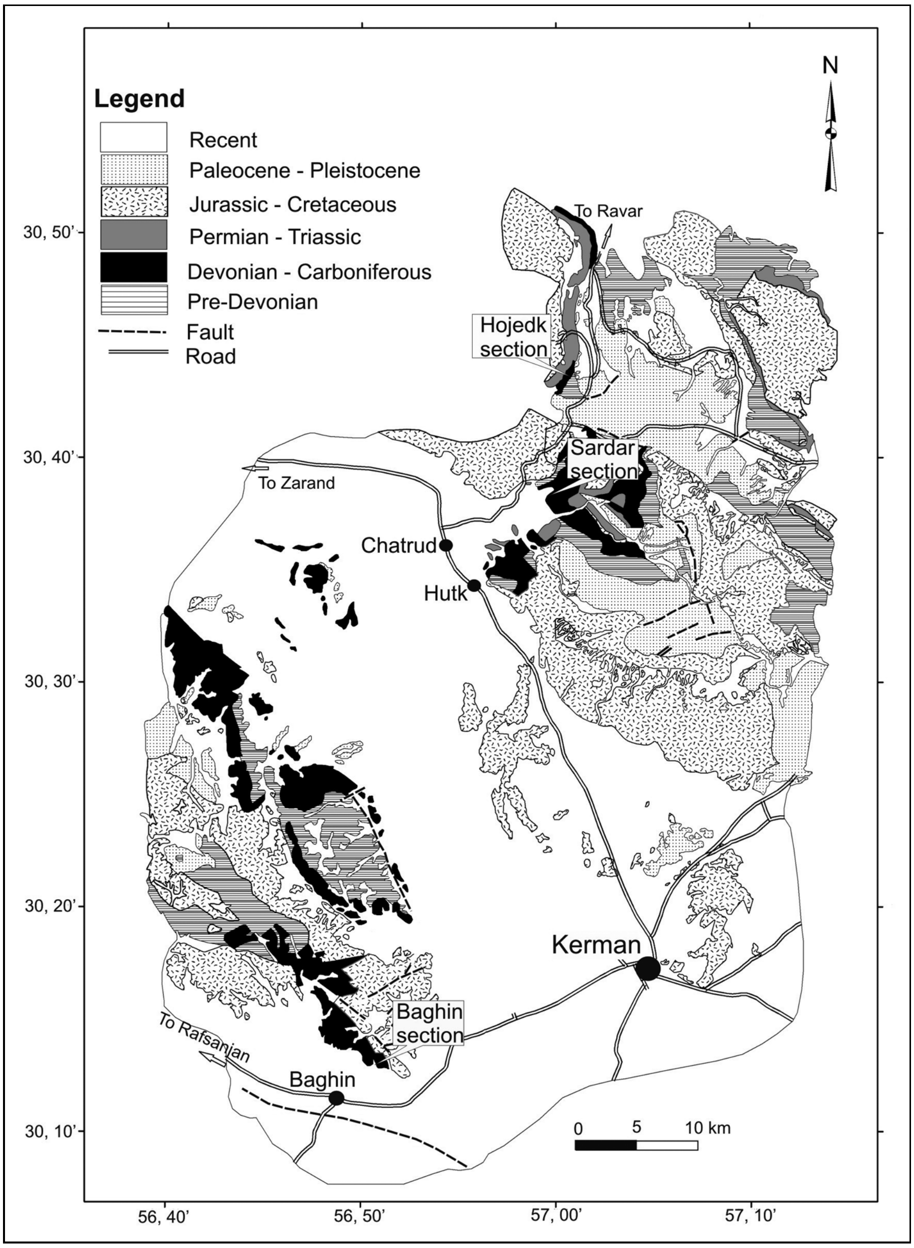

Fig. 2 - Simplified geological map of Kerman area (compiled from Sahandy 1991 and Zohrehbakhsh et al. 1992).

late Givetian - early Famennian in the Hojedk section (Gholamalian & Kebriaei 2008) and late Frasnian - early Famennian in the Shams Abad section, W Kerman (Bahrami et al. 2011a). The boundary between the Bahram and the overlying Shishtu Formation is not described or cannot be easily observed in the most of sections; so Wendt et al. (2002; 2005) would prefer to use the name of Bahram Formation for all of Middle to Late Devonian carbonate successions. Despite the recent works on the Late Devonian of central Iran, it seems that a comprehensive and precise conodont research on the Early to Middle Devonian deposits is really needed.

History of the G-F boundary studies in Iran

Among recent studies on central Iran, there are some papers on the Devonian strata e.g. Yazdi (1999), Ashouri (2002), Gholamalian (2007), Gholamalian et al. (2009), Bahrami et al. (2011a, 2011b); but only a few of authors refer to the Middle Devonian (Adhamian 2003; Brice et al. 2006; Wendt et al. 2002, 2005). The G-F boundary was studied by Ashouri (2004, 2006) who identified it in the bed S241 in the middle part of the Member 3 of the Khoshyeilaq Formation (Eastern Alborz, northern Iran) on the basis of presence of *Ancyrodella pristina* and *An. binodosa.* Wendt et al. (2002; 2005) recognized this boundary in the lower part of the Bahram Formation in several sections of Central Iran (e.g. Howz-e-dorah, Anarak, Hutk, Hojedk and Gerik), and in the Khoshyeilaq Formation in northern Iran (Khoshyeilaq and Mighan). Identification was generally based on scarce paleontological data from poor conodont samples.

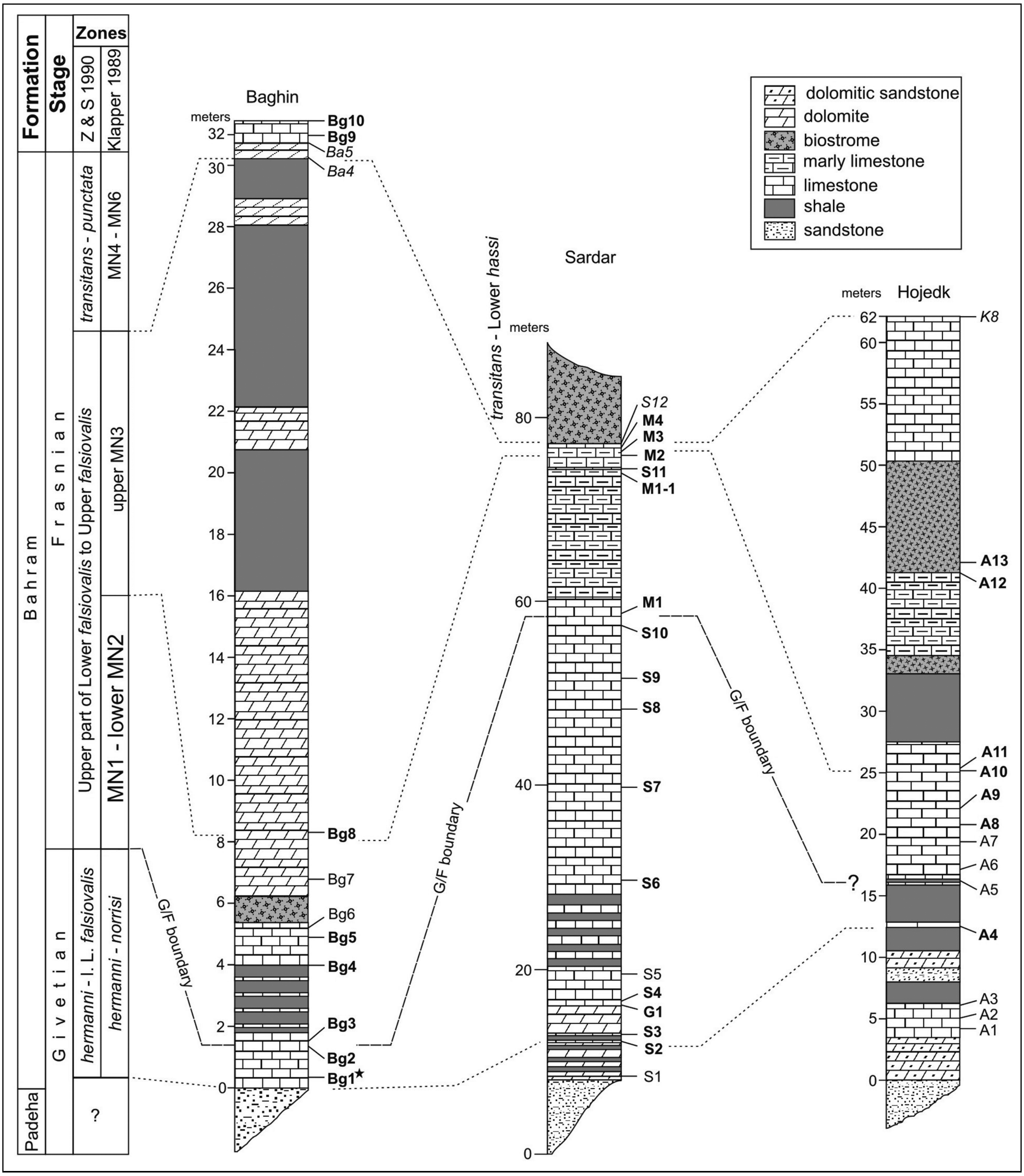

Fig. 3 - Lithostratigraphic columns with localization of the investigated samples and correlation of the G-F boundary studied successions in the Kerman Province, SE Iran. l.-L. *falsiovalis* = lower part of Lower *falsiovalis*. ★ B1 - *hermanni* Zone. Productive samples are shown in bold, and italic ones are studied by Gholamalian et al. (2011) and Gholamalian & Kebriaei (2008).

Studied successions

Hojedk section (Figs 3, 4)

Conodont biostratigraphy and lithology of the Bahram Formation succession in the Hojedk area were described by Gholamalian & Kebriaei (2008). The lowermost part of this section is reassessed in this work for a more precise positioning of G-F boundary. The base of the measured succession begins with 3.4 m of dolomitic sandstone above the top of the Padeha Formation and continues by 2.75 m thin bedded limestone and 13.85 m shale, sandstone, dolomite and nodular lime-

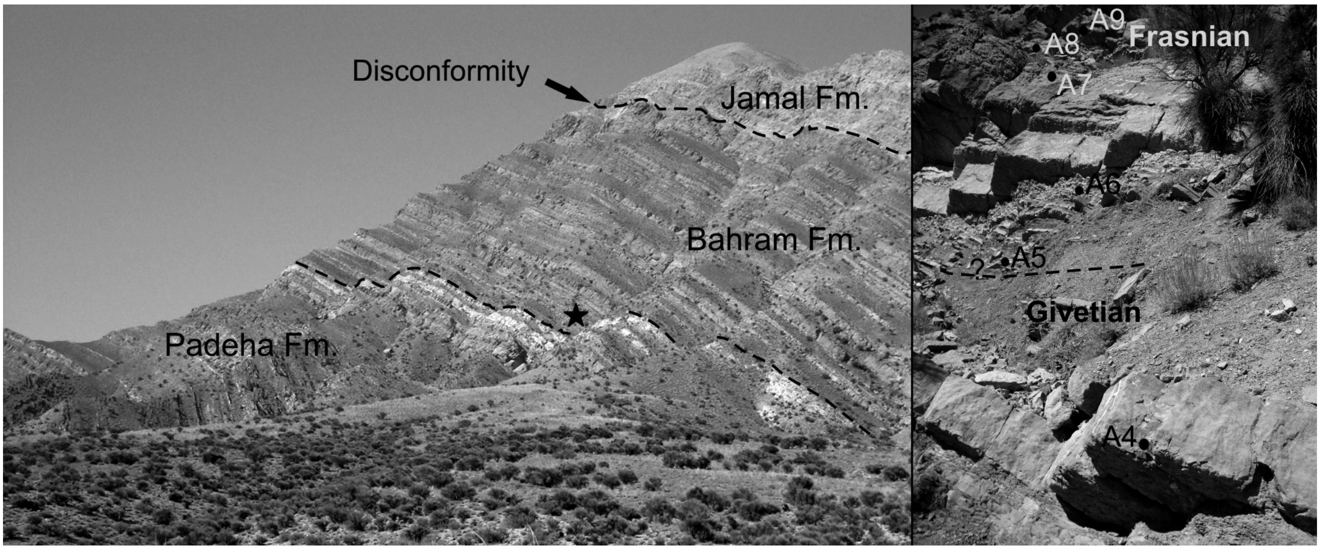

Fig. 4 - General view of the Hojedk section with close up of G-F boundary. Asterisk shows the sampled interval.

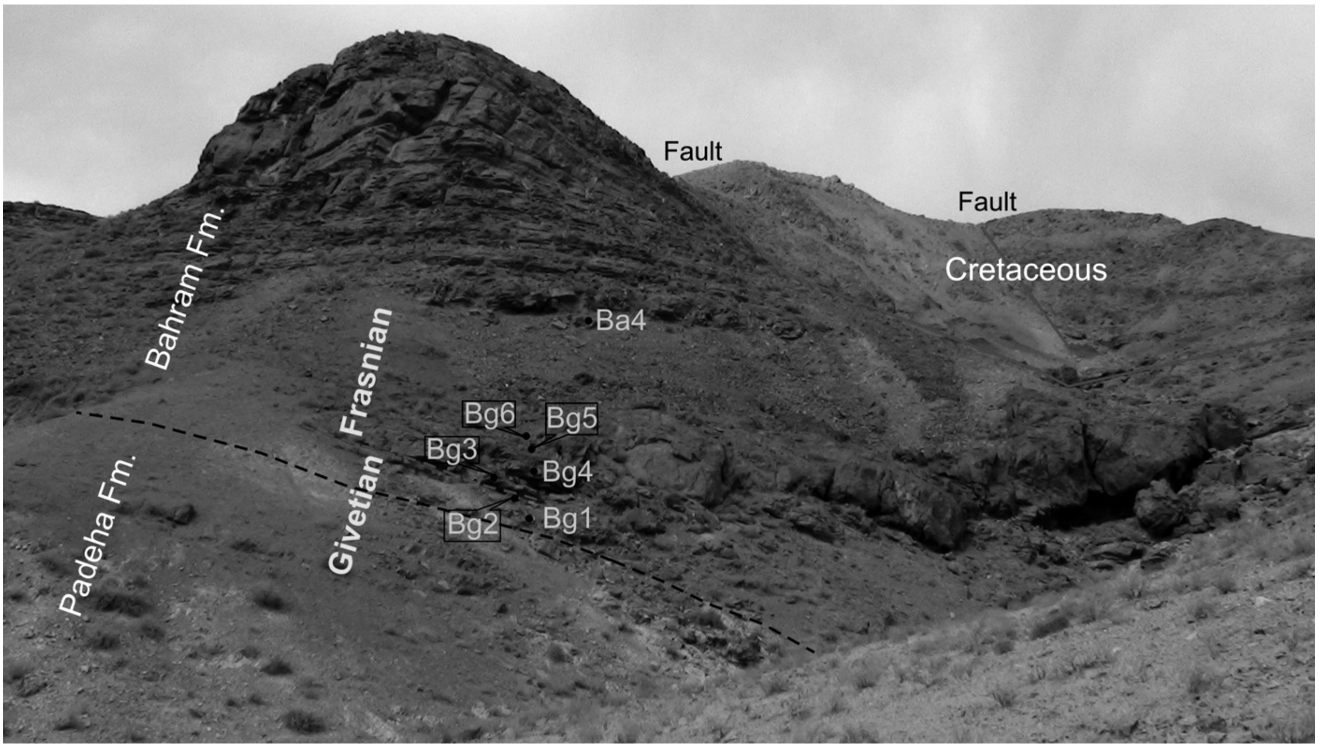

Fig. 5 - Lithostratigraphic units and sampled beds near the G-F boundary in the Baghin section.

stone. The overlying 11.15 m red to grey massive skeletal packstone contains abundant brachiopod shells. The sequence continues upwards with limestones, shales and sandstones (mostly in the lower half of the section). Two biostromes (rugose and tabulate corals and bryozoa) occur here. Gholamalian & Kebriaei (2008, p. 175) thoroughly discussed the age of these diachronic biostromes in the Kerman area and other parts of central Iran.

Baghin section (Figs 3, 5)

This section consists of 102.5 meters of shale, limestone and sandstone; and was recently studied by Gholamalian et al. (2011). The lowermost quartzarenite (16.8 m) of the top of Padeha Formation is conformably covered by a 1.8 m of thin bedded skeletal limestone defining the base of the Bahram Formation. These beds are overlain by 1.35 m of medium bedded skeletal limestones. A coral bed of 0.85 m thick underlies 24.5 m of early Frasnian dolostones and shales (Gholamalian et al. 2011). The rest of the succession is mostly composed of middle to late Frasnian medium and thick bedded limestones.

Sardar section (Figs 3, 6)

The carbonates of the basal part of the Bahram Formation transgressively overlie 5.4 m key quartzarenite of the Padeha Formation. The contact between

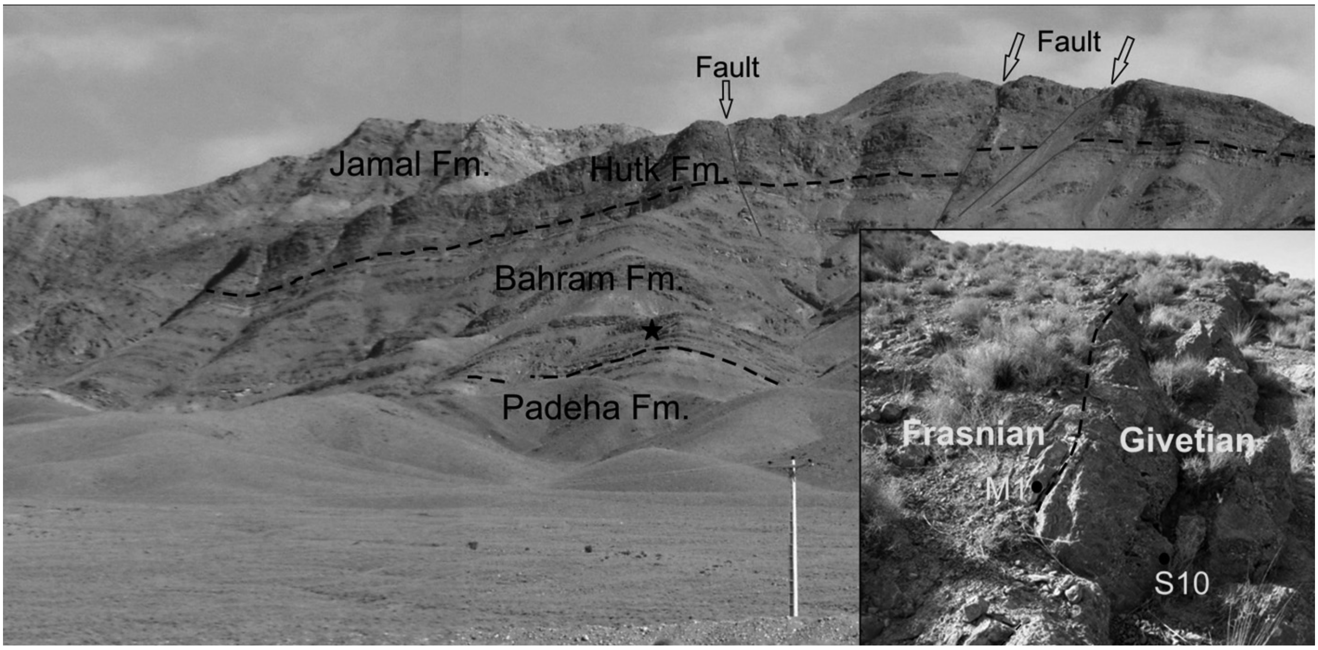

Fig. 6 - General view and close up of G-F boundary in the Sardar section. Asterisk shows the sampled interval.

the Padeha and Bahram formations is obviously sharp and the Sibzar Dolomite Formation is missing in this area. The base of the Bahram Formation begins with a 3.6 m alternation of dolostones and shales and continues with 15.8 m of thin bedded limestone, dolostone and an alternation of limestone and shale. A thickness of 32 m of thin bedded limestones and 16.4 m marly limestones overlie the mentioned beds. These beds underlie a coral and bryozoan dominated biostrome reef. The top of the Bahram Formation is referred to the Famennian (Molaahmadi et al. 2012). It is disconformably overlain by the Early Carboniferous grey limestones and massive dolostones of the Hutk Formation (Molaahmadi et al. 2012).

Biostratigraphy

This work is based on 28 productive out of 39 acid-leached samples taken from three sections (Tabs 1-3). Positions of these samples are shown on the Fig. 3. Six samples: Ba4, Ba5, Bg9, Bg10 (Baghin section), K8 (Hojedk section) and S12 (Sardar section) belong to the MN4 Zone (*transitans* Zone) or are even younger according to earlier studies (Gholamalian & Kebriaei 2008; Gholamalian et al. 2011). Twenty-two species and subspecies belonging to five genera enabled us to use the global zonations of Klapper (1989), Klapper & Johnson (1990) and Ziegler & Sandberg (1990) (in some cases). The presence of the early form of *An. rotundi-*

Zones	*hermanni* - lower MN1	upper MN1 - upper MN2			upper MN3		
Species \ Sample	A4	A8	A9	A10	A11	A12	A13
An. rotundiloba early form		9	25	4			
An. africana					1	1	
An. binodosa		6	6	1			
I. aff. *subterminus*	5	12	1	6	1		
I. excavatus	6	5	16	14			
I. xenium			1				
I. sp.		2					
P. praepolitus			6				
P. hojedki n. sp.	1	2	1	4			
P. aff. *dubius*	24						
P. dubius	50	2	6	3			1
P. alatus	2	1	5	3	5		1
P. aff. *xylus*	127	6	3	11			
P. denisbriceae			1				
P. pollocki				1			
P. sp. A			1				
P. sp. B				1			
T. aff. *weddigei*				4			

Tab. 1 - Range chart of conodonts in the Hojedk section; L. = Lower, U. = Upper, *herm.* = *hermanni*, *fals.* = *falsiovalis*.

Tab. 2 - Range chart of conodonts in the Baghin section; the age of sample Bg1 is *hermanni* Zone.

Zones	*hermanni - norrisi*		MN1 - lower MN2			upper MN3
Species	Bg1	Bg2	Bg3	Bg4	Bg5	Bg8
An. rotundiloba early form			1			
An. africana						1
I. excavatus			1	1		1
P. alatus		2				1
P. dubius	2					
P. praepolitus			1		2	
P. aff. *webbi*		1	1		1	2
P. xylus						1
P. linguiformis linguiformis	3					
Gen. et sp. indet.			1			

loba, the index species for the base of the Late Devonian is an important discovery that allows us to correlate our biozones with those of the GSSP in the Montagne Noire, France (Fig. 3). Abbreviations used here are: *An. = Ancyrodella*, *T. = Tortodus*, *I. = Icriodus*, *P. = Polygnathus*, *Schm. = Schmidtognathus.*

Hojedk section

• *hermanni* - lower MN1 zones (A4 to A7):

The age of this interval is based on the first appearance of *Polygnathus dubius* that first occurs at the base of the Lower *hermanni* Zone (Narkiewicz & Bultynck 2010) and the age of the next interval (upper MN1 - MN2).

Other associated species are: *Polygnathus alatus*, *P.* aff. *dubius*, *P.* aff. *xylus, P. hojedki* n. sp., *Icriodus excavatus* and *I.* aff. *subterminus.*

Polygnathus alatus that was assumed to be restricted to the Frasnian, is recently reported from the *ansatus* Zone (Klapper & Johnson 1980, Tab. 10; Narkiewicz & Bultynck 2007).

• Upper MN1- upper MN2 zones (A8 - A10)

This interval is characterized by the total range of *Ancyrodella binodosa* (Narkiewicz & Bultynck, 2010). The presence of *Ancyrodella rotundiloba* early form is also important here, being the index for the base of Frasnian (Klapper et al. 1987; Klapper 1985, 1989).

Other associated species are: *Polygnathus praepolitus, P. alatus, P. hojedki* n. sp., *P. dubius, P. denisbriceae, P. pollocki, P.* sp. A, *P.* sp. B, *Icriodus vitabilis, I. xenium, I. excavatus, I.* sp., and *Tortodus* aff. *weddigei.*

Polygnathus praepolitus that had previously known from Upper *falsiovalis* - Lower *rhenana* zones (MN3 - MN11) (Ovnatanova & Kononova 2001, 2008), appears in this interval, so we suggest new range; MN1-MN11.

• Upper MN3 Zone (A11-A13)

The base of this interval is defined by the first appearance of *An. africana* ranging from the upper MN3 to MN6 zones. The top is limited by the presence of *P. aequalis* in the sample K8 (see Gholamalian & Kebriaei 2008). According to Ji & Ziegler (1993), this species appears at the base of *transitans* Zone (MN4).

Other associated species are*: Icriodus* aff. *subterminus, P. alatus, P. dubius.*

Zones	*hermanni* to *norrisi*									MN1 - lower MN2				upper MN3	
Species	S2	S3	G1	S4	S6	S7	S8	S9	S10	M1	M1-1	S11	M2	M3	M4
An. rotundiloba early form										1		3			
An. africana														1	
An. binodosa											1				
I. aff. *subterminus*	3	29	6		4	13		4	8	14	22	30	2		2
I. excavatus		3			1	2		35	2	15	7	4			
P. praepolitus										8	19	6	1		10
P. aff. *webbi*									2	7	6	6			8
P. hojedki n. sp.		1									1				
P. aff. *dubius*	2					2							1		
P. dubius	2			1	1							2			
P. alatus						7	10	5	5	37	34	27	1	8	5
P. xylus	5	24	24	4	9	11		11	6	11	10	6			
P. denisbriceae	1														
P. sp. A	3	4													
P. sp. B												2			
P. sp. C											1				
T. aff. *weddigei*						1									

Tab. 3 - Range chart of conodonts in the Sardar section.

Sardar section

• *hermanni - norrisi* zones (S2-S10)

The base and top of this interval are recognized due to presence of *P. dubius* and the age of the next interval (MN1 - MN2).

Other associated species are: *Polygnathus alatus, P. dubius, P.* aff. *dubius, P.* aff. *webbi, P. xylus, P. denisbriceae, P. hojedki* n. sp., *P.* sp. A, *Tortodus* aff. *weddigei, Icriodus excavatus* and *I.* aff. *subterminus*.

• MN1 - lower MN2 zones (samples M1 - M2)

The age of the interval is based on the first occurrence of *Ancyrodella rotundiloba* early form in sample M1 (Tab. 3).

Other associated species are: *Ancyrodella binodosa*, *Polygnathus alatus, P. dubius, P.* aff. *dubius, P.* aff. *webbi, P. praepolitus, P. xylus, Icriodus excavatus* and *I.* aff. *subterminus*.

• Upper MN3 Zone

The lower limit can be defined by the entrance of *Ancyrodella africana*, the top by the first appearance of *P. aequalis* in the sample S12 (Gholamalian et al. in prep.).

Other associated species are: *P. praepolitus, P.* aff. *webbi, P. alatus, I.* aff. *subterminus*.

Baghin section

• *hermanni - norrisi* zones (Bg1 and Bg2)

The age of *hermanni* Zone for sample Bg1 is proved, based on the first appearance of *P. dubius* and the last occurrence of *P. linguiformis linguiformis* (Narkiewicz and Bultynck 2007: 425-427, 2010). The age of sample Bg2 with no index species is *hermanni - norrisi* zones on the basis of its stratigraphic position.

• MN1 - lower MN2 zones (Bg3)

The base of this interval is recognized by the first appearance of *An. rotundiloba* early form. The top is coincident with the base of the next zone.

Other associated species are: *Polygnathus praepolitus, P.* aff. *webbi* and *Icriodus excavatus.*

• Upper MN3 Zone (Bg8)

The lower limit of this zone is indicated by the entrance of *An. africana*; the upper one by the presence of *P. aequalis* at the base of the next zone in the sample Ba4 (Gholamalian et al. 2011).

Systematic palaeontology

Order **Ozarkodinida** Dzik, 1976

Family Polygnathidae Bassler, 1925

Genus *Polygnathus* Hinde, 1879

Type species: *Polygnathus dubius* Hinde, 1879

Polygnathus hojedki n. sp.

Pl. 3, Figs 8-13

Holotype: HUIC532, sample A4, Hojedk section, Pl. 3, Figs 10-12.

Paratype: HUIC530, sample A10, Hojedk section, Pl. 3, Figs 8-9.

Material: One specimens from sample A4, 2 from A8, 1 from A9, 4 from A10 (Hojedk section); one from S3 and 1 from M1-1 (Sardar section).

Etymology: This species is named after the Hojedk village where the first specimens were found.

Diagnosis: This polygnathid species is characterized by an asymmetric platform with nodes that are arranged in short transverse ridges and a high carina reaching the posterior end. Adcarinal troughs are deep and extend to the platform posterior end. The inner margin of platform is straight and parallel to the carina. The outer part of the platform is triangular. Its outer margin is straight and longer from the anterior geniculation point to the angle of refraction, that is rounded and straight to slightly concave and shorter from the angle to the posterior end.

Description. This species is characterized by an asymmetric triangular platform. The platform is constricted in the anterior part, widest in the middle part, and progressively narrowing in the posterior part. The posterior end is semi-rounded to weekly sharp. Coarse separate nodes are arranged in longitudinal rows. These nodes can be connected forming short transversal ridges which do not reach the carina. The high carina reaches the posterior end. It is smooth in the anterior half and is composed of separate denticles in the posterior half. Adcarinal troughs are deep and extend to the posterior end. The free blade is composed of 9 to 10 isometric denticles and equal to one third of the total length of the unit. A small basal cavity is located beneath the anterior third of the platform. The keel is distinct.

Remarks. *Polygnathus hojedki* can be distinguished from *P. webbi* by having longitudinal rows of nodes in addition to short transversal ridges. Other recently defined species, *Polygnathus vachiki* Gholamalian, can be recognized from *P. hojedki* by complete lack of longitudinal rows of nodes and disappearance of deep adcarinal troughs in the mid-platform. *Poygnathus hojedki* can be discriminated from *P. nodocostatus* by having transversal ridges on the surface and deeper adcarinal troughs and from *P. strictus* by separated denticles on the anterior half of platform, shorter blade and very short adcarinal troughs.

Range. *hermanni* - upper MN2 zones, according to associated species (Tabs 1, 3).

Conclusions

The presence of the early form of *Ancyrodella rotundiloba* as key biomarker for the base of Late Devonian enabled us to define the G-F boundary in southeast Iran and correlate it to the GSSP in Montagne Noire (France). The following biozones are recognized: *hermanni*; *hermanni - norrisi*; MN1 - MN2; and MN3. In all studied sections, characterized by shallow marine faunas, the base of Bahram Formation belongs to a late Givetian - early Frasnian time interval. A new late Givetian - early Frasnian conodont species, *Polygnathus hojedki* n. sp. is described. A new range, from MN1 to MN11 (Ovnatanova & Kononova 2008) zones is proposed for *P. praepolitus*.

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PLATE 1

Figs 1-2 - *Ancyrodella rotundiloba* (Bryant, 1921) early form, HUIC418, sample S11, Sardar section, x 30.

Figs. 3-4 - *Ancyrodella rotundiloba* (Bryant, 1921) early form, HUIC461, sample A9, Hojedk section, upper and lower views, x 30.

Fig. 5 - *Ancyrodella rotundiloba* (Bryant, 1921) early form, HUIC463, sample A9, Hojedk section, upper view, x 30.

Figs 6-7 - *Ancyrodella rotundiloba* (Bryant, 1921) early form, HUIC465, sample A9, Hojedk section, upper and lower views, x 41.

Figs 8-9 - *Ancyrodella rotundiloba* (Bryant, 1921) early form, HUIC468, sample A8, Hojedk section, upper view, x 31.

Figs 10-11 - *Ancyrodella rotundiloba* (Bryant, 1921) early form, HUIC472, sample A8, Hojedk section, upper and lower views, x 34.

Figs 12-13 - *Ancyrodella rotundiloba* (Bryant, 1921) early form, HUIC480, sample A9, Hojedk section, upper and lower views, x 35.

Figs 14-15 - *Ancyrodella binodosa* Uyeno, 1967, HUIC474, sample A8, Hojedk section, upper and lower views, x 53.

Figs 16-17 - *Ancyrodella binodosa* Uyeno, 1967, HUIC478, sample A9, Hojedk section, upper and lower views, x 45.

Figs 18-19 - *Ancyrodella binodosa* Uyeno, 1967, HUIC482, sample A9 Hojedk section, upper and lower views, x 31.

Figs 20-21 - *Ancyrodella africana* García-López, 1981, HUIC484, sample A11, Hojedk section, upper and lower views, x 44.

PLATE 2

Figs 1 - Gen. et sp. indet., HUIC560, sample Bg3, Baghin section, upper view, x 30.

Figs 2, 4, 6-8 - *Icriodus excavatus* Weddige, 1984. 2) HUIC486 sample A4, Hojedk section, upper view, x 49; 4) HUIC487 sample A8, Hojedk section, upper view, x 61; 6) HUIC490, sample A9, Hojedk section, upper view, x 60; 7) HUIC488 sample A10, Hojedk section, upper view, x 48; 8) HUIC547, sample M1-1, Sardar section, upper view, x 51.

Figs 3 - *Icriodus* aff. *subterminus* Youngquist, 1947, HUIC542, sample S3, Sardar section, upper view, x 61.

Fig. 5 - *Icriodus xenium* Nazarova, 1997, HUIC489, sample A9, Hojedk section, upper view, x 47.

Fig. 9 - *Icriodus* sp. HUIC491, sample A8, Hojedk section, upper view, x 53.

Figs 10-13, 15 - *Polygnathus* aff. *dubius* Hinde, 1879. 10-11) HUIC492, sample A4, Hojedk section, upper and lateral views, x 45; 12-13) HUIC511, sample A4, Hojedk section, upper and lower views, x 30; 15) HUIC512, sample A4, Hojedk section, upper view, x 42.

Figs 14, 16-17 - *Polygnathus dubius* Hinde, 1879. 14) HUIC515, sample A4, Hojedk section, upper view, x 31; 16-17) HUIC503, sample A4, Hojedk section, upper and lower views, x 40.

Fig. 18 - *Polygnaths pollocki* Druce, 1976, HUIC507, sample A10, Hojedk section, upper view, x 36.

Figs. 19-22 - *Polygnaths* aff. *xylus* Stauffer, 1940. 19) HUIC500 sample A4, Hojedk section, upper view, x 49; 20-21) HUIC575, sample S3, Sardar section, upper and lower views, x 50; 22) HUIC576, sample A4, Hojedk section, upper view, x 48.

Figs 23-26 - *Polygnathus alatus* Huddle, 1934. 23) HUIC571, sample M1, Sardar section, upper view, Sardar section, upper view, x30; 24) HUIC559, sample M2, Sardar section, upper view, x 35; 25) HUIC577, sample M1-1, Sardar section, upper view, x 33; 26) HUIC578, sample M1, Sardar section, upper view, x 31.

PLATE 3

Figs 1, 2, 6, 7- *Polygnathus praepolitus* Kononova, Alekseev, Barskov and Reimers, 1996. 1) HUIC550, sample M1-1, Sardar section, upper view, x 43; 2) HUIC551, sample M1-1, Sardar section, upper view, x 56; 6) HUIC552, sample S11, Sardar section, upper view, x 52; 7) HUIC525, Sample A11, hojedk section, upper view, x 52.

Figs 3-5 - *Polygnathus alatus* Huddle 1934. 3) HUIC555, sample S9, Sardar section, upper view, x 40; 4) HUIC561, sample Bg8, Baghin section, upper view, x 40; 5) HUIC553, sample S8, upper view, x 38.

Figs 8-13 - *Polygnathus hojedki* n. sp. 8-9) HUIC530, sample A10, Hojedk section, upper and lower views, x 40; 10-12) HUIC532, sample A4, Hojedk section, upper, lower and lateral views, x 35; 13) HUIC574, sample S3, Sardar section, upper view, x 33.

Fig. 14 - *Polygnathus* sp. C, HUIC562, sample M1-1, Sardar section, upper view, x 40.

Figs 15-16 - *Polygnathus alatus* Huddle, 1934, HUIC498, sample A4, Hojedk section, upper and lower views, x 33.

Figs 17-18 - *Polygnathus* aff. *webbi* Branson & Mehl, 1934, 17) HUIC563, sample M1-1, Sardar section, upper view, x 40; 18) HUIC564, sample M1-1, Sardar section, upper view, x 40.

Fig. 19 - *Polygnathus linguiformis linguiformis* Hinde, 1879, HUIC565, Sample Bg1, Baghin section, upper view, x 35.

Fig. 20 - *Polygnathus* sp. A, HUIC534, sample A9, Hojedk section, upper view, x 32.

Fig. 21 - *Polygnathus denisbriceae* Bultynck, 1979, HUIC535, sample A9, Hojedk section, upper view, x 45.

Figs 22-26 - *Tortodus* aff. *weddigei* Aboussalam, 2003. 22) HUIC536, sample A10, Hojedk section, upper view, x 39; 23-24) HUIC537, sample A10, Hojedk section, upper and lateral views, x 40; 25-26) HUIC538, sample A10, Hojedk section, upper and lower views, x 33.

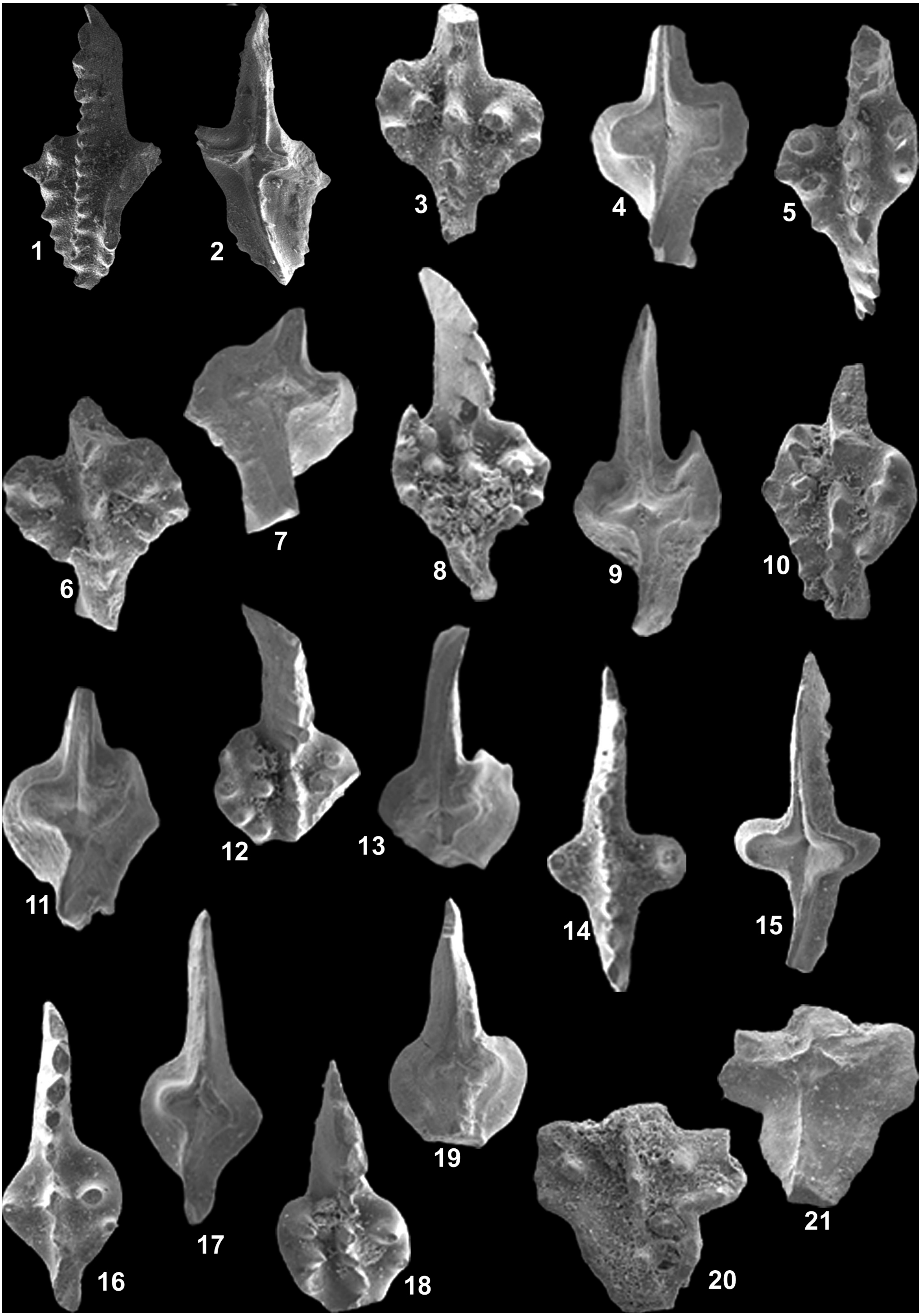

PLATE 1

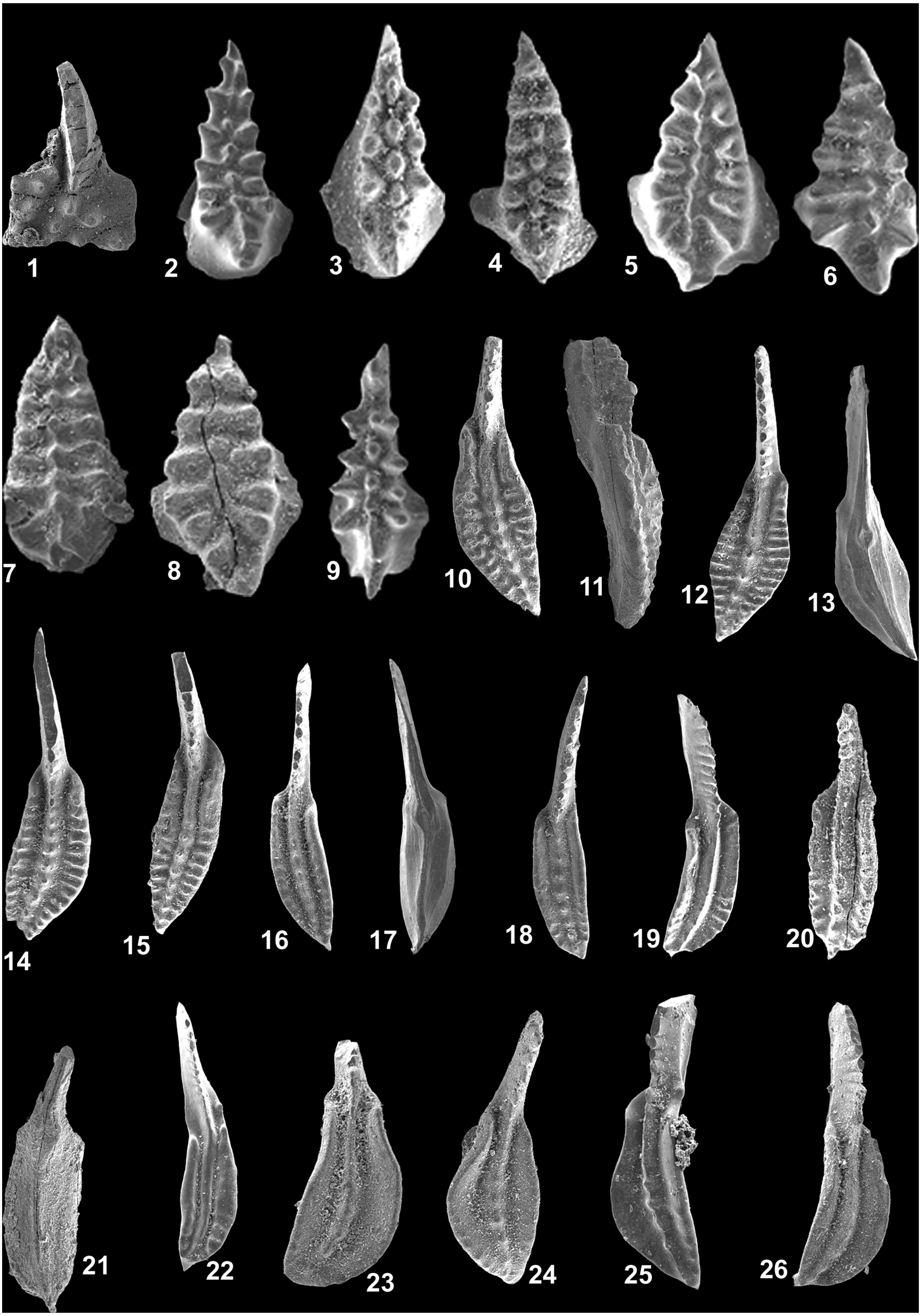

PLATE 2

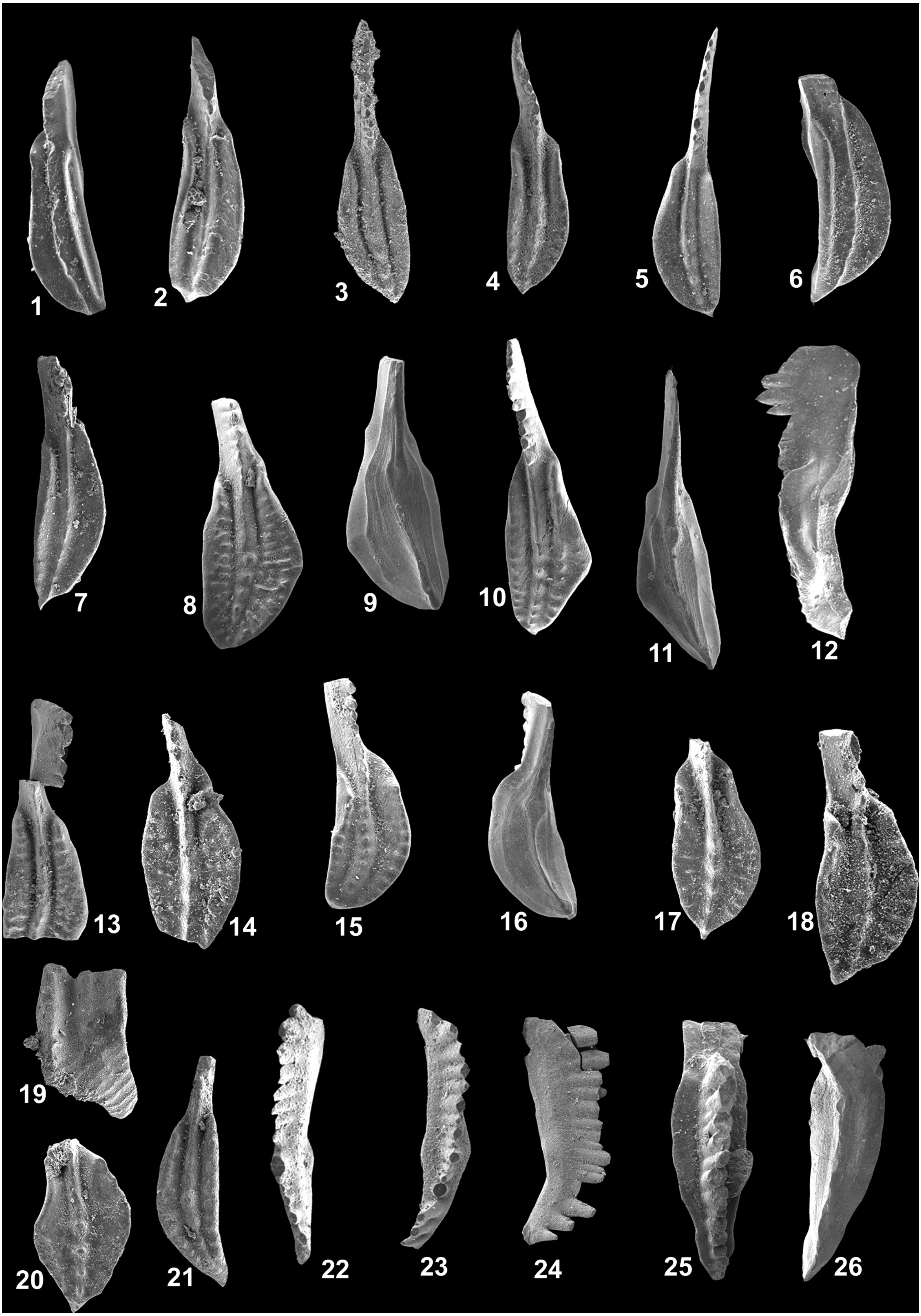

PLATE 3