Biostratigraphy of Yazdanshahr No.2 section in Kerman area, Central Iran, based on conodont communities

Bioestratigrafía de la sección Yazdanshahr No.2 en el área de Kerman, Irán central, con base en comunidades de conodontos

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ABSTRACT

Yazdanshahr No.2 section, which consists mostly of Bahram and Sibzar formations is located in the Zarand city, northern Kerman province (Central Iran). Five biozones have been identified based on the conodont community. The first biozone, which includes Padehat (15 meter) and Sibzar formations (75 meter), was distinguished based on genera *Bipennatus* and *Icriodus* and the probable corresponding age was considered to span Emsian to Eifelian. The second biozone is recognized by the first appearance of index taxon *Polygnathus varcus* (*varcus* Zone: early to middle Givetian). The third biozone starts with the firth appearance of the index genus *Icriodus expansus* (*expansus* zone: middle Givetian). The base of the Fourth biozone is recognized by the first appearance of the genus *I. subterminus* (*subterminus* Zone: middle to late Givetian) and the last biozone was distinguished with the first appearance of genera *Ancyrodella* and *Polygnathus incompletes* in the Givetain-Frasnian boundary (*falsiovalis* to *crepida* Zone?: Frasnian to Famenian?). Bahram Formation (94 meter) consists of Fossiliferous limestone (*varcus* to *subterminus* Zone) at the lower part, and alternation of dolomite and sandstone (*falsiovalis* to *crepida* Zone?) at the upper part. Sibzar Formation consists of Middle Devonian dolomite and limy dolomite containing intercalation of sandstone and limestone layers.

Keywords: Icriodus, Polygnathus, biozones, Bahram Formation, Devonian, Kerman, Iran.

RESUMEN

La sección Yazdanshahr No.2, que consiste en su mayor parte de las formaciones Bahram y Sibzar, se localiza en la ciudad de Zarand, provincial del norte de Kerman (Irán central). Cinco biozonas han sido identificadas con base en comunidades de conodontos. La primera biozona, que incluye a las formaciones Padehat (15 metros) y Sibzar (75 metros), se distingue con base en la presencia de los géneros Bipennatus and Icriodus, y la edad probable fue considerada en el rango del Emsiano al Eifeliano. La segunda biozona es reconocida por la primera aparición del la especie índice Polygnathus varcus (Zona varcus: Givetiano temprano a medio). La tercer biozona comienza con la primera aparición de la especie índice Icriodus expansus (Zona expansus: Givetiano medio). La base de la cuarta biozona es reconocida por la primera aparición de la especie Icriodus subterminus (Zona subterminus: Givetiano medio a tardío), y la última biozona fue reconocida con la primera aparición de los taxa Ancyrodella y Polygnathus incompletes, en el límite Givetaino-Frasniano (Zona? falsiovalis a crepida: Frasniano a Fameniano?). La Formación Bahram (94 metros) consiste en una caliza fosilífera (Zona varcus a subterminus) en su porción inferior, y de una alternancia de dolomita y arenisca (Zona? falsiovalis a crepida), en su porción superior. La Formación Sibzar consiste de una dolomita de edad Devónico Medio y una dolomita limosa, que contiene una intercalación de capas de arenisca y caliza.

Palabras clave: Icriodus, Polygnathus, biozonas, Formación Bahram, Devónico, Kerman, Irán.

1. Introduction

The presence of Devonian and Lower Carboniferous deposits in Iran were first reported by Viquesnel (1850) and Loftus (1855), but the first stratigraphical studies of these sediments were carried out by Huckriede *et al.* (1962) in central Iran (Kerman area). These deposits have been known as red sandstone, dolomite, and fossiliferous limestone, and have been described as Jeirud Formation in the Central Alborz (Gaetani 1965; Assereto, 1963), Khoshyeilagh Formation in the northeastern Alborz (Bozorgnia, 1973), Moli and Ilanqareh formations (unofficial name?) in West Azerbaijan and Maku region in western Alborz (Alavi-Naini, 1993), Padeha, Sibzar and Bahram formations in Central Iran (Ruttner *et al.*, 1968). Parts of these sediments located in the east of Central Iran have been named Padeha, Sibzar, Bahram and Shishtu formations (Ruttner *et al.*, 1968; Stöcklin *et al.*, 1965). The name of the Padeha Formation was given to an unfossiliferous sandstone, dolomite and gypsum unit in the Ozbak-Kuh mountains, which overlays thick fossiliferous, mainly carbonatic Niur Formation, and was overlain by the lead-bearing dolomitic Sibzar Formation comprising the age of Early to Middle Devonian. Type section of the Sibzar Formation is named after the Sibzar mine in Ozbak-kuh mountain (Eastern Iran). The name has been proposed for the dolomite unit containing the important lead deposits of Ozbak-kuh in Iran (Ruttner *et al.*, 1968; Stöcklin, 1971). The contact between the overlying Bahram Formation and overlain Sibzar Formation is transitional (Ruttner *et al.*, 1968; Stöcklin *et al.*, 1965). The name of the Bahram Formation has been derived from Sar-Takhat-e-Bahram, a mountain located in the south of Ozbak-Kuh in East Central Iran (Ruttner *et al.*, 1968; Stöcklin *et al.*, 1965), and was applied to thick limestone unit in the Ozbak-Kuh mountain. The Bahram Formation itself, is predominantly overlain by alternation of shaly and sandy rocks of the Shishtu Formation (Ruttner *et al.*, 1968; Stöcklin *et al.*, 1965). This formation, the Bahram, can be correlated with the Jeirud Formation (Gaetani 1965; Assereto, 1963) in Central

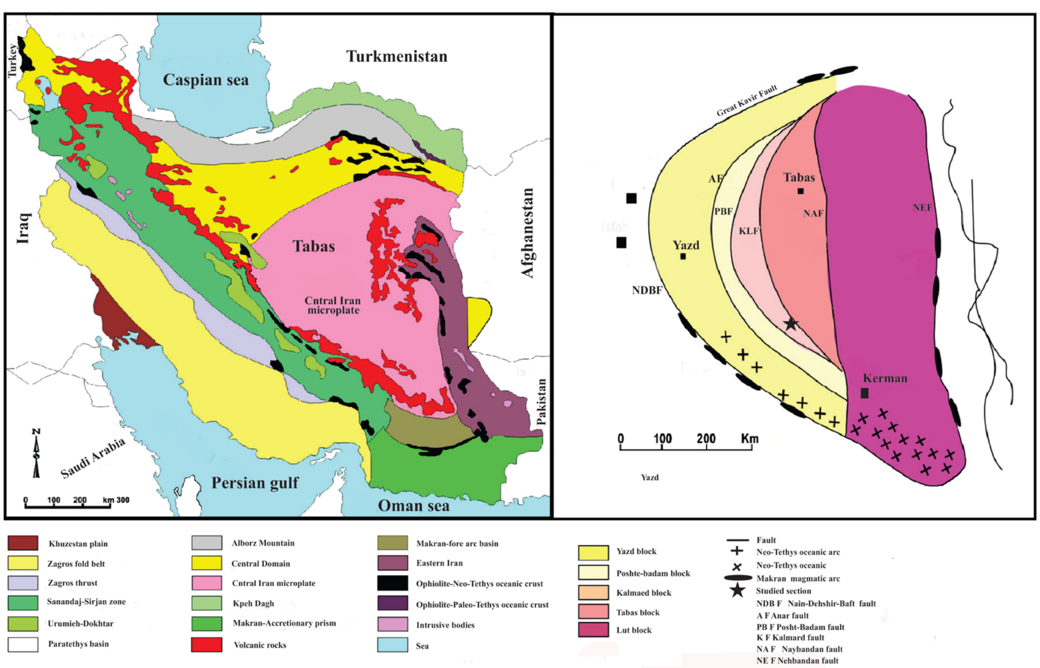

Figure 1 Structural units of Iran with location of the Yazdanshahr No.2 section (after Königshof *et al.*, 2017; Bahrami *et al.*, 2020).

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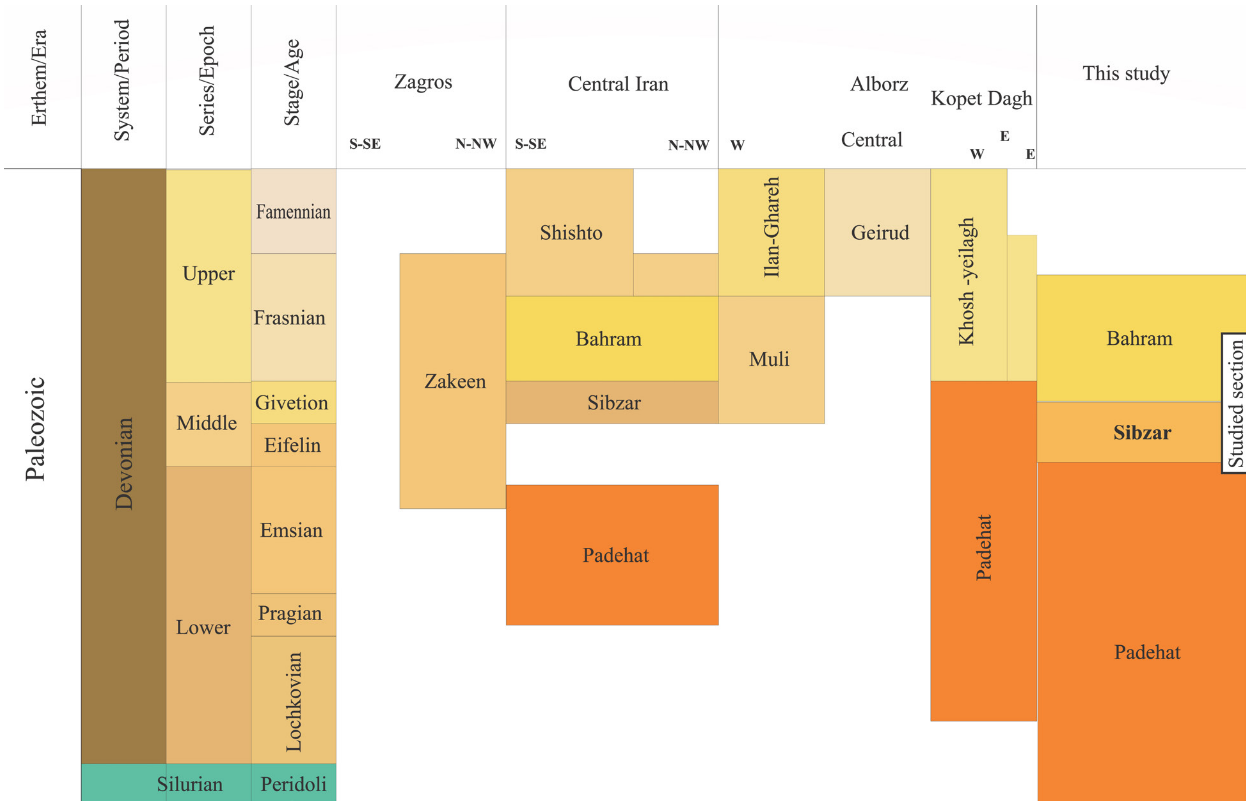

Figure 2 Devonian stratigraphic correlation in Iran (After Nasehi, 2018).

Alborz, the Khoshyeilagh Formation (Bozorgnia, 1973) in northeast of Alborz, the Zakeen Formation (Ghavidel Syooki, 1997) in Zagros, the Moli and Ilangareh formations (Alavi-Naini, 1993) in the Northwest of Alborz (Figure 2). In Iran, the most biostratigraphic research on Devonian sediments have been carried out based on Brachiopoda (Dastanpour 1996, 1998, 1999, Ahmadzadeh Heravi, 1971, 1975, Brice *et al.*, 1999; Brice and Kebriaei, 2000), crinoids (Webster *et al.*, 2003), 3vertebrate micro-remains (Hamdi and Janvier, 1981; Hairapetian *et al.*, 2000), Palynomorph (Hashemi, 1998; Ghavidel-Syooki, 2001) and conodonts (Walliser, 1966; Ahmadzadeh Heravi, 1971, 1975, Weddige, 1984; Ashouri, 1990, 2004, 2006; Yazdi, 1999; Hairapetian and Yazdi, 2003; Wendt *et al.*, 2005; Najjarzadeh *et al.*, 2020; Gholamalian, 2005, 2007; Gholamalian and Kebriaer, 2008; Boncheva *et al.*, 2007; Ahmadi *et al.*, 2012; Bahrami *et al.*, 2011a, 2011b, 2013, 2014, 2015, 2018; Nasehi, 2018; Bahrami *et al.*, 2019, 2020, Zamani *et al.*, 2020). The studied section is located in the southern margin of Kalmard Block (Fig 1), which has been formed during the Assyntic Orogeny to Early Cimerian Orogeny. Bahram Formation mostly consists of dark to light gray limestone rich in macrofossils such as brachiopods, corals and vertebrate micro and macro remains. (Figure 5). This Formation overlays carbonate sediments (mainly dolomite) of Middle Devonian Sibzar Formation, which itself overlays the evaporitic and detritic sediments of Lower Devonian Padeha Formation, and is overlain by light gray dolomite and limestone (probably Jamal Formation). In this research, more than 80 rock specimens (each 4kg) were sampled. via laboratory studies, 6 genera, 37 species and 9 subspecies of conodonts were recognized.

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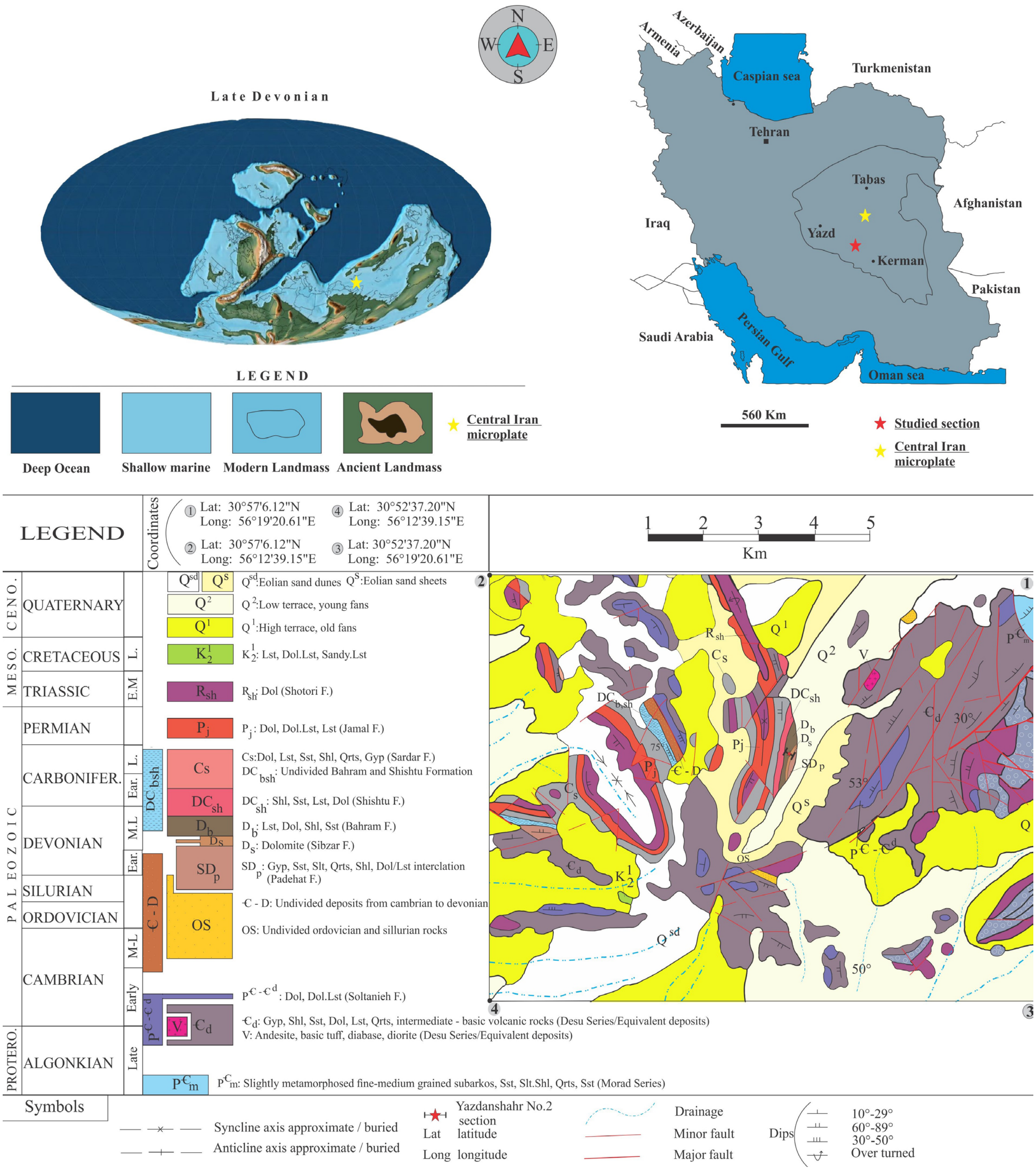

Figure 3 Central Iran microplate position in the Late Devonian (After Scotese, 2014; Salehi *et al*., 2020) with Geological map of studied area (After Vahdati-Daneshmand *et al*., 1995). Abbreviations: M-L: Middle to Late, Ear.: Early, L: Late, Meso.: Mesozoice, Ceno.: Cenozoic, Lst: Limestone, Dol: Dolomite, Sst: Sandstone, Slt: Siltstone, F: Formation, Shl: Shale, Qrts: Quartzite, Gyp: Gypsum.

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Figure 4 Representative examples of fossiliferous limestone fauna of Bahram Formation; (1) Coral (2) Cyrtospirifer (3) Fish teeth.

2. Geological setting

From a geographical point of view, Yazdanshahr no.2 section is located 47 kilometer north of Davaran village, located in Kerman province, central Iran, at the coordinates of 30°54′44.74″N and 56°16′30.82″E, but from a tectonics point of view, it belongs to Kalmard block constituting the Central Iran micro plate (Figure1). The investigated area is presented in figure 3, which illustrates the exact position of studied section (Yazdanshahr No2), and the distribution of stratigraphic units surrounding the section. These units ranging from Proterozoic (late Algonkian) to Cenozoic (Quaternary). this paper will investigate the Yazdanshahr No.2 section which have a thickness of 182 meter of Devonian sediments consisting of Padehat, Sibzar and Bahram formations. The base of the Yazdanshahr No.2 section starts with red Sandstone of Lower to Middle Devonian Padehat Formation (15 meter), which is overlain by dolomite and limy dolomite of Middle Devonian Sibzar Formation containing intercalation of sandstone and limestone layers. End of the section is recognized by Middle to Upper Devonian Bahram Formation, which starts mostly with fossiliferous limestone including brachiopods, vertebrate micro-remains, corals and conodonts to the alternation of dolomite and sandstone at the end of the section. This paper will concentrate on the biostratigraphy of Middle and Upper Devonian sediments of Yazdanshahr No.2 section, which mostly belongs to Bahram Formation. It is noteworthy that the Yazdanshahr No.1 section, which contains Padehat Formation was discussed in previous paper (2018).

3. Methods of work

In order to determine the biostratigraphical aspects of the area under careful investigation, field sampling along with length measurements were undertaken systematically wherever a change in lithology was identified. In some cases, more than one sample was taken from the corresponding layer. The samples underwent the following preparation steps: crushing (in dimensions of three centimeters), acid treatment (acetic acid 10%), washing, sieving (sieve of 75,125,250 and 710 mesh), picking (with needle utilizing a microscope) and photography (with electron microscope); following which were carefully studied, and eventually, lead to identification of 6 genera, 37 species, and 9 subspecies. In order to determine the related biozones, the conodont biofacies models presented in following work were applied: Klapper and Ziegler (1979), Clausen *et al.* (1993), Narkiewicz and Bultynck (2007, 2010), Bultynck and Gouwy (2008), Narkiewicz (2011) and Bahrami *et al.* (2019).

4. Biozonation of Yazdanshahr No.2 section

Conodont taxa of the Yazdanshahr No.2 section include 6 genera, 37 species, and 9 subspecies

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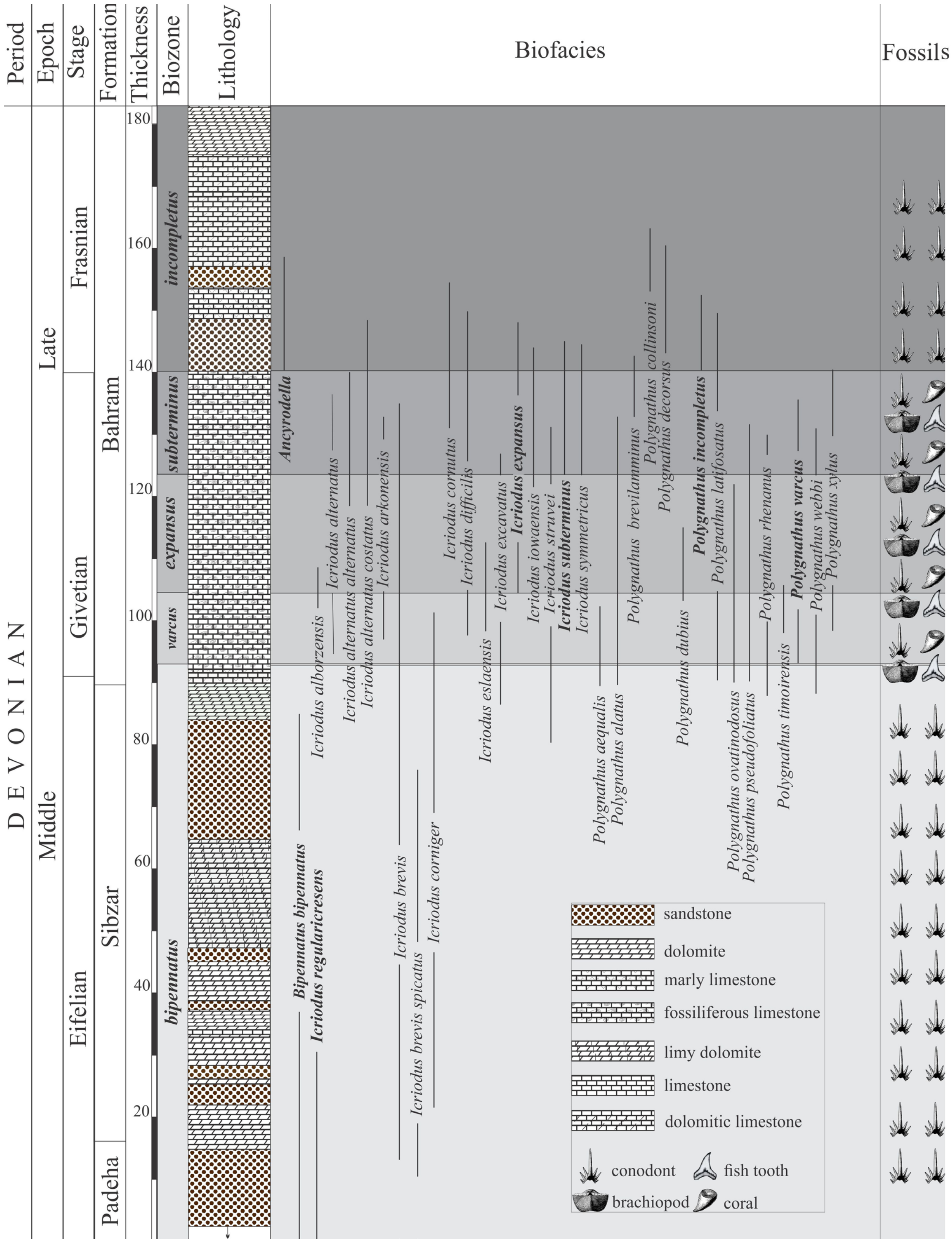

Figure 5 Biostratigraphic column of Yazdanshahr No.2 section.

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Table 1. Distribution of conodont species in studied section (Yazdanshahr No.2).

Taxa/ Sample no	12	16	20	24	28	32	36	38	40	44	48	50	52	54	56	58	60	64	68	72	76	total
Ancyrodella																		1	3	2		6
Bipennatus bipennatus	9	5	7																			21
Icriodus sp.	6	1	3	2	2	5	3	2	5	3	6	5	2	2	4	5	2	4	1	4	2	69
Icriodus alborzensis				3	2			1	1													4
Icriodus alternatus					3	2		2			2		2			1	1	1	2	2		13
Icriodus alternatus alternatus							1									2			2			2
Icriodus alternatus costatus									1		1								1			2
Icriodus alternatus curvirostatus	1	1	1	1		1		1	1	1												7
Icriodus alternatus elegantulus								1	1		1		1									3
Icriodus arkonensis			1		4	2	4	3	5	4	2	2			6	1						28
Icriodus arkonensis walliseranus				1	1																	0
Icriodus brevis	1	2	2	2	3	2	5	4	2	3	1	5	2		3	4	5	6				50
Icriodus brevis brevis			2	1	3	2			2	2												12
Icriodus brevis spicatus	2	3	3																			8
Icriodus corniger	1	3	4																			8
Icriodus difficilis			2	1						1		2	1	2	1		1		1			10
Icriodus eslaensis				2		2	3	2	2		1	1	2	2	1	2	1					20
Icriodus excavates					2	1			3	2	1		1		2	1	1	1				15
Icriodus expansus			1	2	3	2	2	3			1	4	4	3	4	2	3	4	2	2		42
Icriodus iowaensis						2	2					1	1			2	2					10
Icriodus norfordi									1	2	2			1	2	3	2	2	2			15
Icriodus regularicresens		1	1	2																		4
Icriodus struwei	2	3	1	1																		7
Icriodus symmetricus					1	2		2	1				2	3	3	2	1					15
Icriodus symmetricus symmetricus							1			1		2	1									3
Icriodus symmetricus expansus				1			1		2	1		1										3
Icriodus subterminus				2				2	3	4	4	2	3	4	2	1	3	1	1			26
Polygnathus					2	3	4	1	3	3	2	2	1	1	4	1	2	2	2	2		35
Polygnathus aequalis								1				1				1						3
Polygnathus alatus						1			1	1		1										2
Polygnathus brevilamminus										1	1		1	1								2
Polygnathus collinsoni																			1	2	1	4
Polygnathus decorsus						1		1	1	1												2
Polygnathus dubius					1				1	2	1											2
Polygnathus incompletus																				1	1	2
Polygnathus latifosatus			1			2		1		2		3		1	1	1	1					8
Polygnathus ovatinodosus					1		1		1	1	2	1	1									4
Polygnathus politus					1							1			1	1	1	1				4
Polygnathus pseudofoliatus				1	2	3		2	2	2		3	3	3	1	1	1	1				21

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(Figure 5), which dominated by genera *Bipinnatus* and *Icriodus* in Eifelian, and Genera *Icriodus* and *Polygnathus* in Givetian, and genera *Icriodus, Polygnathus* and *Ancyrodella* in Frasnian belonging to the families *Polygnathodontidae, Icriodontidae* and *Eugenathodontidae*, and mostly consisting the shallow marine inner platform environment. According to conodont taxa and prevailing shallow-water setting of Yazdanshahr No.2 section, an alternatinve conodont zonation was applied for the middle to late Givetian (*expansus* and *subterminus* zone) based on different authors as follow: Narkiewicz and Bultynck (2007, 2010), Bultynck and Gouwy (2008), Narkiewicz (2011) and Bahrami *et al*. (2019). Other biozones were distinguished based on conventional biofacies model presented by Klapper and Ziegler (1979), Clausen *et al*. (1993). it is noteworthy to say that biozones are distinguished in the stratigraphical order, which means that the first biozone is the oldest, and the last one is the youngest.

4.1. SEROTINUS? / COSTATUS ZONE TO VARCUS ZONE (*BIPENNATUS, ICRIODUS REGULARICRESENS* ASSEMBLAGE ZONE)

First zone is recognized based on assemblage of bipinnatus and regularicresens species, which continues to the varcus Zone. lack of adequate index taxa made it impossible to correlate the findings with old global biofacies presented by Klapper and Ziegler (1979), Clausen *et al*. (1993). As such, the age of this biozone is Emsian? to Eifelian.

The elements collected in this part are related to *Eugenathodontidae* and *Icriodontidae*, and include the following genera: *Bipennatus* sp. (Philip, 1965), *Bipennatus bipennatus* (Bischoff and Ziegler, 1957), *Bipennatus bipennatus bipennatus* (Bischoff and Ziegler, 1957), *Icriodus regularicresens* (Bultynck, 1970), *Icriodus struvei* (Weddige, 1977), *Icriodus brevis* (Stauffer, 1940), *Icriodus brevis* brevis Stauffer, 1940, *Icriodus brevis spicatus* (Youngquist and Peterson, 1947).

4.2. *VARCUS* ZONE

Second zone is recognized by the first appearance of index taxon *Polygnathus varcus*, and ends with the first appearance of the *Icriodus expansus*, which belongs to the following zone.

Lithology of this biozone is gray brachiopod limestone, and abundant varieties of fossils that consist of brachiopoda, trilobites, coral, tentaculites and fish teeth.

The collected elements in this part are related to *Polygnathodontidae* and *Icriodontidae*, and include the following genera: *Icriodus* (Branson and Mehl, 1934), *Icriodus alternatus* (Branson and Mehl, 1934), *Icriodus alternatus cymbiformis* (Branson and Mehl, 1938), *Icriodus brevis* (Stauffer, 1940), *Icriodus brevis* brevis (Stauffer, 1940), *Icriodus brevis darbyensis* (Klapper, 1958), *Icriodus incrassatus* (Youngquist and Peterson, 1947), *Icriodus incrassatus incrassatus* (Youngquist and Peterson, 1947), *Icriodus arkonensis* (Stauffer, 1948), , *Icriodus symmetricus* (Branson and Mehl, 1934), *Icriodus symmetricus* expansus (Branson and Mehl, 1938), *Polygnathus sp* . (Hinde, 1879), *Polygnathus varcus* (Stauffer, 1940), *Polygnathus rhenaus* (Klapper *et al*., 1970), *Polygnathus pseudofoliatus* (Wittekind, 1966), *Polygnathus xylus* (Stauffer, 1940), *Polygnathus latifosatus* (Wirth, 1967), *Polygnatus ovatinodosus* (Ziegler and Klapper, 1976), based on the conodonts collected, the age of this biozone is determined early to middle Givetian.

4.3. *EXPANSUS* ZONE (MIDDLE GIVETIAN)

This biozone starts with the firth appearance of the index genus *Icriodus expansus* (Narkiewicz and Bultynck, 2010; Bahrami *et al*., 2019), and continues to the base of the following zone which is recognized by the first appearance of the *Icriodus subterminus* (Sandberg and Dreesen, 1984; Narkiewicz and Bultynck, 2007; 2010; Bultynck and Gouwy 2008; Bahrami *et al*., 2019). Lithology of this biozone is gray brachiopod limestone, and abundant varieties of fossils that consist of brachiopoda, trilobites, coral, tetaculites and fish teeth. The collected elements in this part are related to *Polygnathodontidae* and *Icriodontidae*, and include the following genera: *Icriodus* (Branson and Mehl, 1934), *Icriodus alternatus* (Branson and Mehl, 1934), *Icriodus alternatus cymbiformis* (Branson and Mehl, 1938), *Icriodus brevis* (Stauffer, 1940),

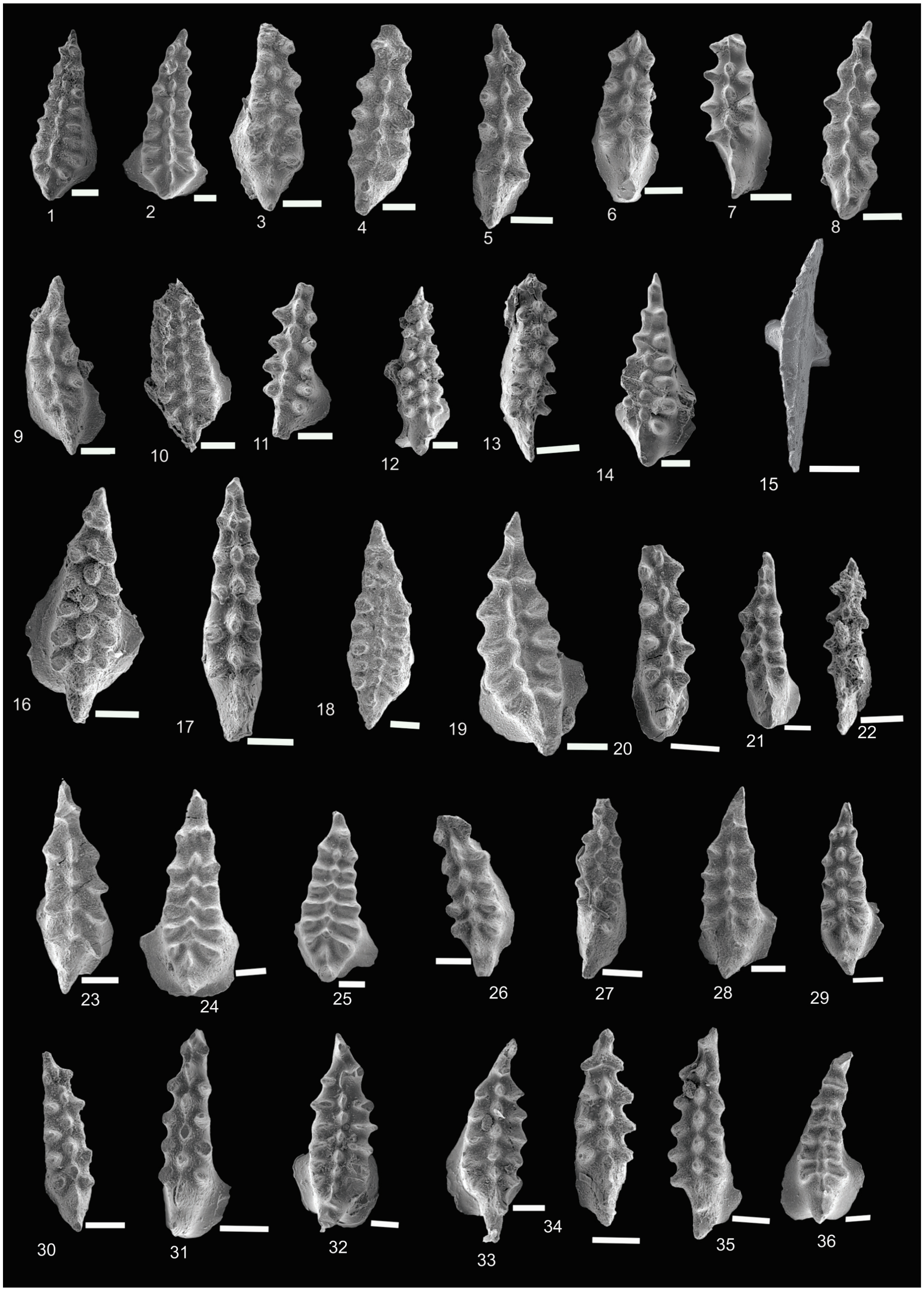

Figure 6 **Conodonts from Yazdanshahr No.2 section and** *sample numbers*, **respectively. 1, 2, 10, 25,** *Icriodus symmetricus symmetricus 55, 52, 34, 45*; **3, 4, 6, 8,** *I. eslaensis 37, 34, 25*; **5, 13, 35,** *I. alternatus costatus 29, 33, 28*; **7, 11, 21, 22,** *I. brevis 22, 29, 26, 25*; **9,** *Icriodus sp.* **38; 12,** *Icriodus* **cf.** *eslaensis 38*; **14,** *I. subterminus 22*; **15,** *Bipennatus bipennatus 18*; **16. I.** *alborzensis 24*; **17, 20, 31,** *I. alternatus alternatus 56, 36, 39;* **18, 24, 32,** *I. arkonensis 30*, **21, 21; 19, 23, 26, 29, 33,** *I. expansus 22, 20, 29, 33, 20*; **27, 30,** *I. alternatus 47, 45*; **28,** *I. symmetricus 61*; **34,** *I. brevis brevis 56*; **36,** *Icriodus corniger 25*. **Scale bars = 100 µ**

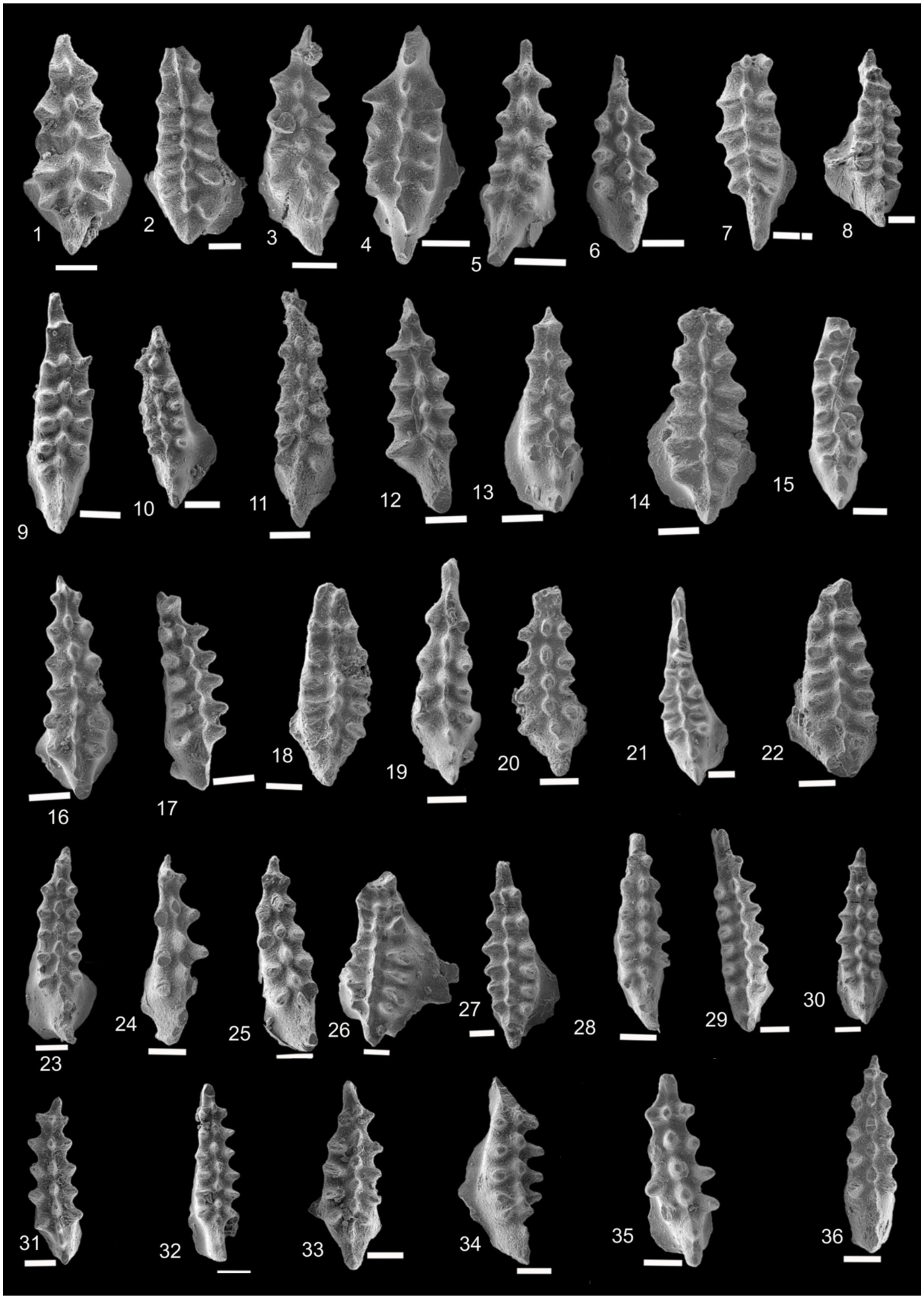

Figure 7 **Conodonts from Yazdanshahr No2.section and sample numbers, respectively. 1, 3, 34,** *Icriodus expansus 28, 29, 59*; **2, 14, 18,** *I. arkonensis 28, 25, 46*; **4,** *I. cedarensis 33*; **5, 6, 13, 17, 21, 20, 24, 25,** *I. brevis 24, 34, 25, 22, 52, 22, 25, 46*; **7,** *Icriodus sp. 50*; **8, 27, 29,** *I. symmetricus 42, 47, 38*; **9,** *I. alternatus 29*; **10, 35,** *I. brevis spicatus 21, 25*; **11, 15, 30,** *I. alternatus alternatus 26, 36, 38*; **12, 16,** *I. alternatus costatus 33, 25*; **19, 31, 33, 28,** *I. brevis brevis 33, 26, 46, 52*; **22,** *I. symmetricus symmetricus 28*; **23,** *I. alternatus curvirostatus 24*; **26,** *I. iowaensis 40*; **32,** *I. altternatus cymbiformis 27*; **36, 37,** *I. eslaensis 35, 42*. **Scale bars = 100 µ.**

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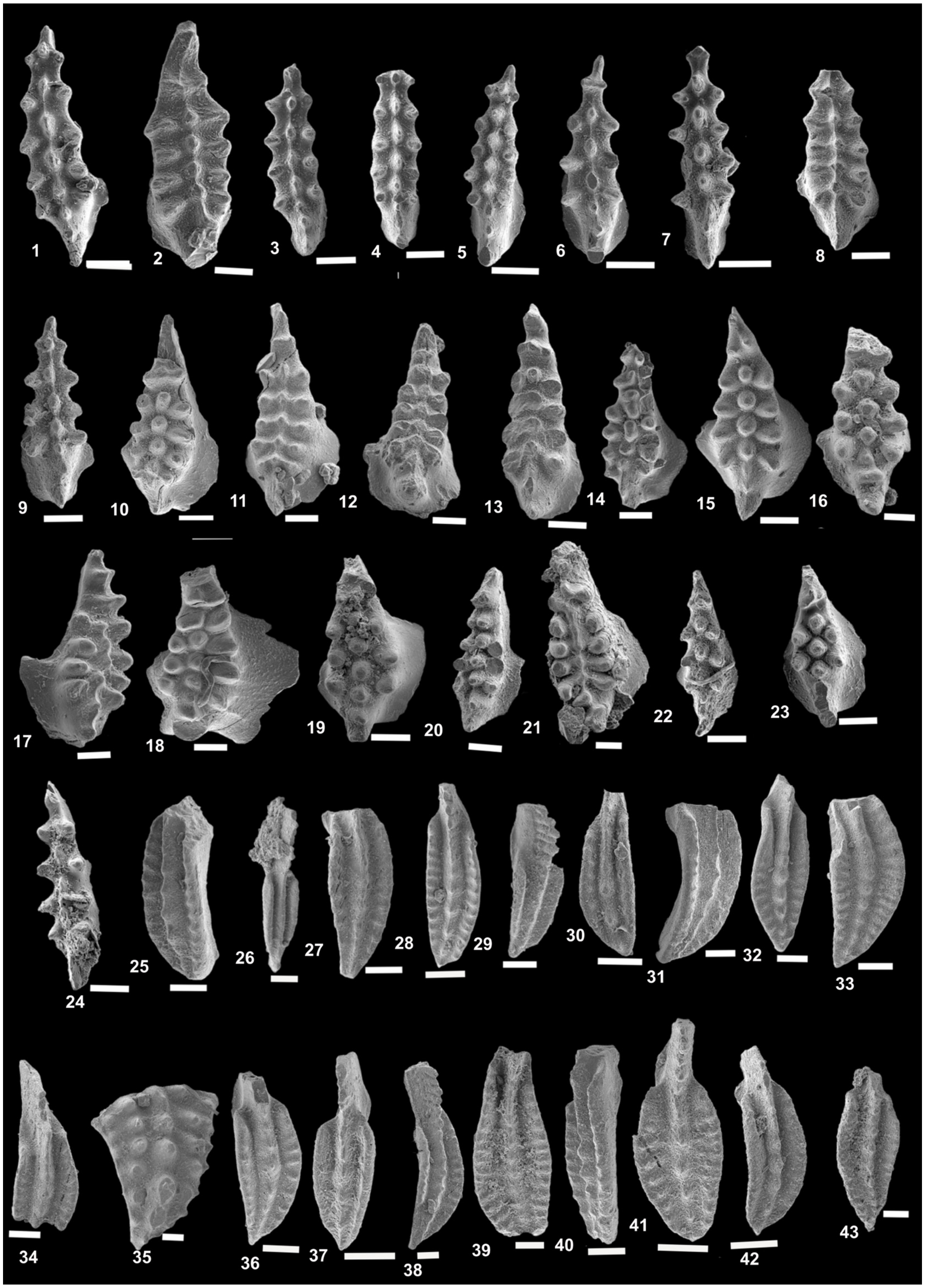

Figure 8 Conodonts from Yazdanshahr No2.section and sample numbers, respectively. 1, *Icriodus eslaensis 26*; **2, 8,** *I. arkonensis 45, 45;* **3, 5, 24,** *I. alternatus costatus 24, 38, 55*; **4,** *I. alternatus alternatus 46*; **6,** *I. brevis 45*; **7, 30,** *I. alternatus 28, 38*; **9,** *I. brevis spicatus 34*; **10, 12, 20, 21, 23,** *I. subterminus 56, 22, 25, 26, 33*; **11,** *I. expansus 58*; **13,** *I. difficilis 22*; **14,** *I. orri 22*; **15, 18, 19,** *I. excavatus 27, 36, 36*; **16,** *I. alborzensis 26*; **17, 22,** *Icriodus sp. 25, 45*; **25, 42,** *Polygnathus sp. 36,36*; **26,** *P. brevilamminus 33*; **27, 31, 34, 36,** *P. webbi 24, 22, 44, 55*; **28, 33,** *P. politus 26, 34*; **29, 38, 40,** *P. xylus 22, 22, 44*; **39, 43,** *P. pseudofoliatus 22, 26*; **32,** *P. dubius 26*; **35,** *Ancyrodella sp. 66*; **37,** *Polygnathus alatus 22;* **41,** *P. ovatinodosus 36*.**Scale bars = 100 µ.**

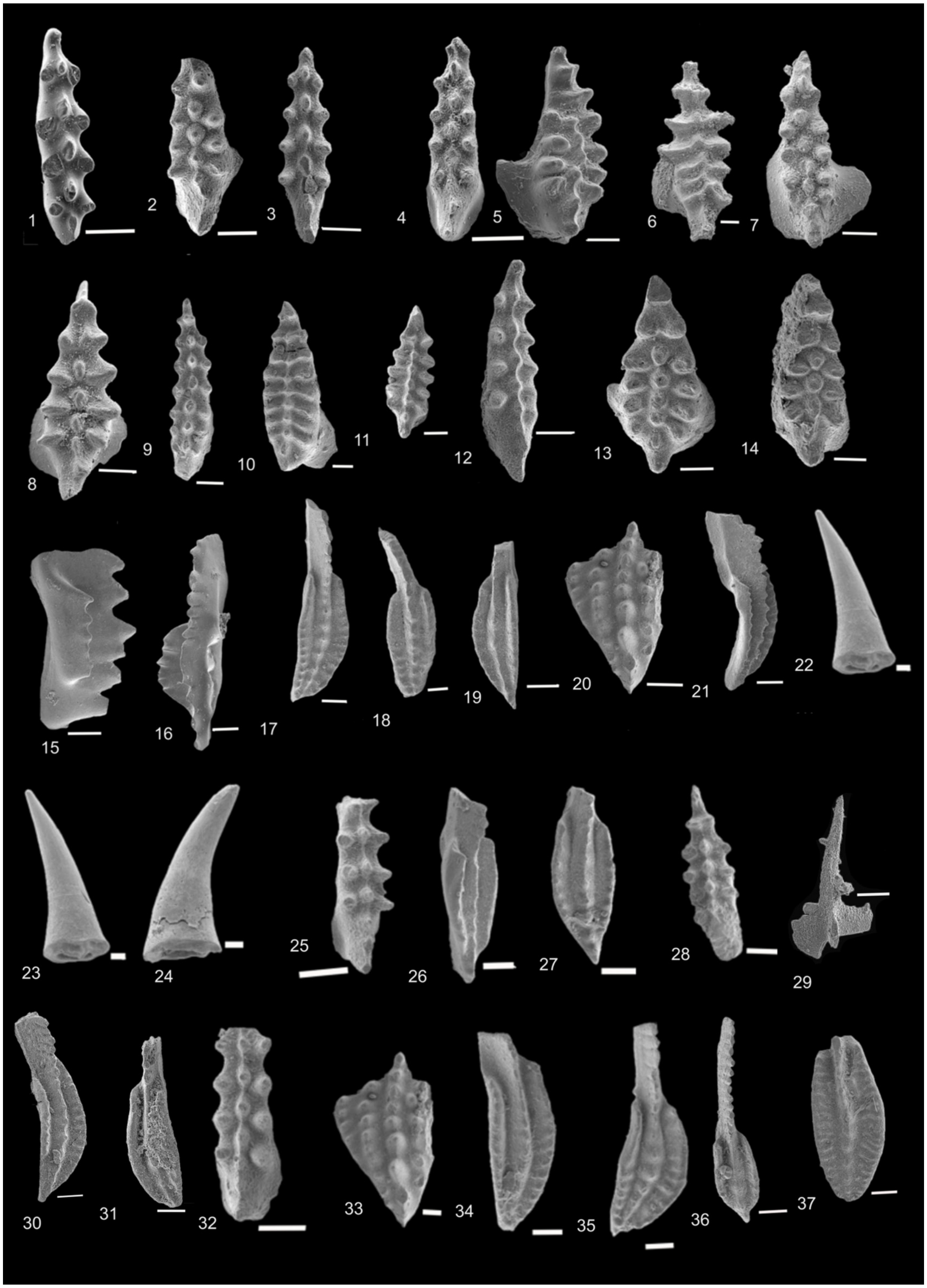

Figure 9 **Conodonts from Yazdanshahr No2.section and sample numbers, respectively. 1, 4, 9, I***criodus alternatus alternatus 46, 56, 46*; **2, 7, 13, 14,** *I. subterminus 45, 30, 24*; **3,** *I. alternatus costatus 46*; **5, 12, 25, 28, 32,** *Icriodus sp. 36, 26, 28 22, 26*; **6, 8,** *I. iowaensis 30, 36*; **15, 16** *Polygnathus berevilamminus 42, 44*;**17, 34, 35, 37,** *P. webbi 36, 42, 44, 38*; **18,** *P. politus 28*; **19, 20, 26, 31,** *P. decorsus 28, 34, 42, 48*; **20, 33,** *Ancyrodella sp. 68, 66*; **21, 30,** *Polygnathus xylus 48, 50;* **22, 23, 24, Fish teeth** *22, 22, 26*; **27,** *Polygnathus sp* **26; 29,** *Trichonodella sp. 50*; **36,** *Polygnathus varcus 26.* **Scale bars = 100 μ.**

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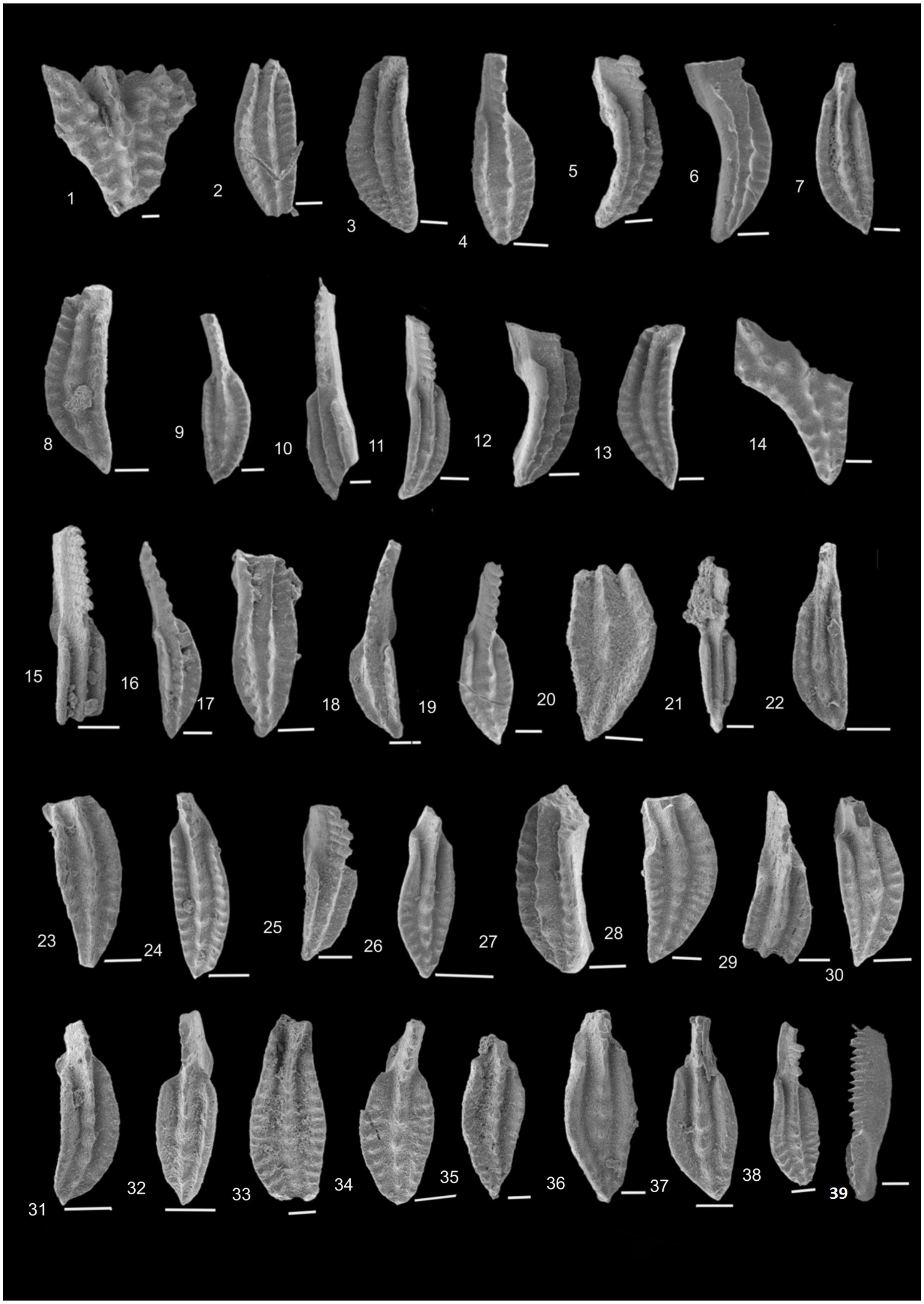

Figure 10 **Conodonts from Yazdanshahr No2. section and sample numbers, respectively. 1, 14,** *Ancyrodella sp. 68, 66*; **2, 3, 9, 12, 23, 29, 30, 38,** *Polygnathus webbi 36, 26, 40, 26, 32, 22, 46, 28*; **4, 19,** *P. decorsus 40, 34*; **5, 6, 8, 10, 13, 15, 25,** *P. xylus 25, 36, 36, 28, 22, 33, 26*; **7, 33,** *P. dubius 24, 26*; **11, 16, 24, 28,** *P. politus 28, 36, 40, 40*; **17, 20, 36, 37,** *P. aequalis 44, 26, 42, 36;* **18,** *P. timoirensis 44*; **21,** *P. brevilamminus 22;* **22, 26, 32,** *P. alatus 30, 22, 43*; **27, 31,** *Polygnathus sp. 28, 36*; **4,** *P. ovatinodosus 44*; **35,** *P. pseudofoliatus 46*; **39,** *P. varcus 24*. **Scale bars = 100 µ.**

Icriodus brevis brevis (Stauffer, 1940), *Icriodus brevis darbyensis* (Klapper, 1958), *Icriodus incrassatus* (Youngquist and Peterson, 1947), *Icriodus incrassatus incrassatus* (Youngquist and Peterson, 1947), *Icriodus arkonensis* (Stauffer, 1948), *Icriodus expansus* (Branson and Mehl, 1938), *Icriodus symmetricus* (Branson and Mehl, 1934), *Icriodus symmetricus expansus* (Branson and Mehl, 1938), *Polygnathus sp.* (Hinde, 1879), P*olygnathus varcus* (Stauffer, 1940), *Polygnathus rhenaus* (Klapper *et al*., 1970), *Polygnathus pseudofoliatus* (Wittekind, 1966), *Polygnathus xylus* (Stauffer, 1940), Polygnathus latifosatus (Wirth, 1967), *Polygnatus ovatinodosus* (Ziegler and Klapper, 1976).

4.4. *SUBTERMINUS* ZONE (MIDDLE TO LATE GIVETIAN)

The base of this zone is recognized by the first appearance of the *Icriodus subterminus*. This zone continues through the Givetian, and ends at the Givetian-Frasnian boundry, where the following zone starts with the first appearance of index genus *Ancyrodella*. Lithology of this biozone is gray to dark brachiopoda limestone. The elements collected in this biozone are the following genera: *Icriodus alternatus* (Branson and Mehl, 1934), *Icriodus alternatus cymbiformis* (Branson and Mehl, 1938), *Icriodus brevis* (Stauffer, 1940), *Icriodus brevis brevis* (Stauffer, 1940), *Icriodus brevis darbyensis* (Klapper, 1958), *Icriodus incrassatus* (Youngquist and Peterson, 1947), *Icriodus incrassatus incrassatus* (Youngquist and Peterson, 1947), *Icriodus arkonensis* (Stauffer, 1940), *Icriodus expansus* (Branson and Mehl, 1938), *Icriodus symmetricus* (Branson and Mehl, 1934), *Icriodus symmetricus expansus* (Branson and Mehl, 1938), *Polygnathus sp.* (Hinde, 1879), *Polygnathus varcus* (Stauffer, 1940), *Polygnathus rhenaus* (Klapper *et al*., 1970), *Polygnathus pseudofoliatus* (Wittekind, 1966), *Polygnathus xylus* (Stauffer, 1940), Polygnathus latifosatus (Wirth, 1967), *Polygnatus ovatinodosus* (Ziegler and Klapper, 1976).

4. 5. *FALSIOVALIS* TO *CREPIDA* ZONE? *(ANCYRODELLA, POLYGNATHUS INCOMPLETUS ASSEMBLAGE ZONE*)

This zone is recognized based on the assemblage of the index taxa *Ancyrodella* and *Polygnathus incompletus*, but the lower limit is marked by index genus *Ancyrodella* at the Frasnian-Famenian boundry. Lithology of this biozone is soft argillaceous red sandstone with marly limestone. The elements collected in this part include the followings genera: *Polygnathus incompletus* (Uyeno, 1967), *Icriodus brevis* (Stauffer, 1940), *Ancyrodella routondiloba* (Bryant, 1921), *Polygnathus varcus* (Stauffer, 1940), *Icriodus alternatus alternatus* (Branson and Mehl, 1934). Age of this biozone is Givetian (*falsovalis* Zone) to Frasnian? (*crepida* Zone?).

5. Conclusion

The studied section, Yazdanshahr No.2, is located in the northwest of Kerman; south of Central Iranian plate. Central Iran Plate belonged to the northern margin of Gondwana Until Early Carboniferous, and then has been separated from Gondwana, and joined Lurazia in the Late Triassic. Lower Devonian sediments in Yazdanshahr section (mostly section No.1) consist of continental evaporitic and detritic sediments (gypsum and red sandstone) with rare intercalation of carbonate layers (Padehat Formation). These facies have been deposited in a supratidal environment, and the age of the sediment (Padehat Formation in *5* specified. the upper limit of Padehat Formation was determined by The beginning point of transitional zone (Sandstone to Dolomite), which started with Sibzar Dolomite, and was considered as The boundary between Padehat and Sibzar formations, which can also be recognised by *Bipennatus* and *Icriodus* bearing transgrative deposits at the base of the Sibzar Formation. Nonetheless, based on previous study (Nasehi, 2018) and field information obtained from present study, the probable age of Padehat Formation can be considered from Emsian to Eifelian. The Sibzar Formation which overlay the Padehat Formation, mostly consists of middle devonian dolomite and limy dolomite with intercalation of sandstone and limestone layers, which has been overlain by fossiliferous carbonate deposits of The Bahram Formation. Due to the assemblages of Genus *Bipennatus bipennatus* and the family *Icriodontidae* including *Icriodus regularicresens,* *Icriodus brevis* and *Icriodus brevis spicatus*, the age of the Sibzar Formation is considered to be Eifelian (*serotinus?/costatus* Zone to *varcus* Zone (*Bipennatus, Icriodus regularicresens* Assemblage Zone). Bahram Formation mostly consists of fossiliferous limestone and intercalation of sandstone and dolomitic limestone. Four biozone were distinguished in Bahram Formation in Yazdanshahr No. 2 section. The first biozone starts with genus *Polygnathus varcus* (*varcus* Zone), which starts at lower Givetian, and ends at middle Givetian where *Icriodus expansus* is appeared in sediments. Second biozone starts with the first appearance of I*criodus expansus (expansus* Zone), which starts at the middle Givetian and ends at the base of the upper Givetian, where *Icriodus subterminus* is appeared in sediments. Third biozone is distinguished with the first appearance of *Icriodus subterminus (subterminus* Zone) at the base of upper Givetian, and continues to the base of lower Frasnian where genus *Ancyrodella* appeared in the sediments. Last biozone, which continues to the end of the section recognized by the first appearance of genus *Ancyrodella* and *Polygnathus incompletus*. Consequently, the age of Bahram Formation is considered to be the span of Givetian to Frasnian in Yazdanshahr No.2 section.

Contribution of authors

First author (E. Nasehi): writing of the original manuscript, financing, analysis, fieldwork, technical development and interpretation. Second author (M. A. Nasehi): writing of the corrected and edited manuscript, analysis, interpretation, graphic design.

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Conflicts of interests

The authors declare that they have no conflict of interest.

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