NEW BIOSTRATIGRAPHICAL FINDINGS ON THE PADEHA FORMATION BASED ON CONODONT ACCUMULATION IN YAZDANSHAHR, KERMAN, CENTRAL IRAN

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Abstract. The aim of the study was the biostratigraphical evaluation of Padeha Formation based on conodont accumulation in Yazdanshahr. The section under study is located north of Yazdanshahr in northwestern Zarand County in Kerman, central Iran. After investigating several sections of the Padeha formation in the Kerman area, one fossiliferous section was chosen for study. In terms of lithology, the section is composed mainly of red-colored clastic and evaporative rock with carbonate intercalations. The conodont accumulations indicate two local biozones: the *Zieglerodina remscheidensis* and *Pandorinellina steinhornensis* assemblage zones and the Eugenathodontidae-Icriodus assemblage zone. Based on the abundance of Spathognathodontidae and similarities to global biozones, these biozones were found to be of the Late Silurian (Early Pridoli) age. No evidence of the *Icriodus* genus (especially *woschmidti* or post-*woschmidti* species) was observed in this assemblage. The latter biozones manifest the appearance of Eugenathodontidae *in* the Early Devonian; therefore, a sedimentary hiatus exists within the Late Silurian to the start of Early Devonian (Late Pridoli to Pragian). The sediment was deposited in a depositional environment ranging from lagoons to shallow waters (inner carbonate platform). The Yazdanshahr section was the most complete of the Padeha formation because conodonts were found in the lower, middle and upper parts of the section. This function will allow researchers to correlate their sections with these findings based on stratigraphic principles.
Keywords: *Icriodus, sedimentary environment, Silurian, Kerman, biozones*

Introduction

Devonian deposits in Iran were first reported on a geological map prepared by the National Iranian Oil Company. Located near Gush-Kamar in the Ozbak-Kuh mountains, the type section was studied by Ruttner et al. (1968), Stocklin (1971) and Stocklin et al. (1965, 1991). Late Silurian-Early Devonian sediment has been studied in Kerman province in Iran and reported according to stratigraphic principles (Huckriede et al., 1962). Most recent studies have been based on conodonts, fish remnants, brachiopods, corals and palynomorphs. The following authors have recently worked on conodonts: Ahmadi et al., 2012; Bahrami, 2011, 2013, 2014, 2015; Boncheva et al., 2007; Adhamian, 2003; Ashuri, 2004, 2006; Gholamalian, 2007; Gholamalian and Kebriaei, 2008; Gholamalian et al., 2009; Yazdi, 1999; Weddige, 1984.

Geologically speaking, Iran is divided into five structural units: the Zagros, Alborz, Sanandaj-Sirjan, Eastern Iran and Central Iran (Stocklin et al., 1965; Stocklin, 1968; Stocklin and Nabavi, 1971; Stocklin and Setudehnia, 1991; Heydari et al., 2008). In terms of structure, Central Iran is composed of five blocks: the Lut, Tabas, Kalmard, Posht-Badam, Anar and Dehshir (Alavi, 1991; Heydari et al., 2008; *Fig. 1*). Devonian sediment has been described in the Jeirud Formation in the Central Alborz (Assereto, 1963), the Khoshyeilagh formation in the northeastern Alborz (Bozorgnia, 1973), the Moli and Ilanqareh Formation (unofficial name) in West Azerbaijan and Maku (western

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Alborz) (Alavi-Naini and Bolourchi, 1973) and the Pedeha, Sibzar, Bahram and Shisto formations in Central Iran (Ruttner et al., 1968).

The type section of the Padeha formation is named after the village of Padeha in the Ozbak-Kuh mountains (Eastern Iran). Lithologically characterized by red sandstone, dolomite and gypsum at Ozbak-Kuh (eastern Central Iran), the Padeha formation overlies the fossiliferous carbonates of the Niur formation and underlies the Sibzar dolomites. This formation formed in the Early Devonian and exhibits shallow facies related to the Caledonian orogeny (Ruttner et al., 1968; Stocklin, 1971). The Padeha formation was deposited in an inner platform and extends across all of the Central Iran basin. Based on its stratigraphic position, this formation has been aged back to the Early Devonian.

Devonian deposits in Iran (Pedeha, Sibzar, etc.) are not well known and a large deal of uncertainty is associated with them. In general, Early Paleozoic Devonian deposits in Iran precipitated in separate geological units. Few studies have been done on the effect of sea level at the time the Late Silurian and Early Devonian rock formed. Evidence indicates the effect of Caledonian movement (Ruttner et al., 1968; Stocklin, 1971). Sea transgression covered most of Iran in the Middle and Late Devonian. In the present research, an attempt is made to determine the age of the sediment based on conodont accumulation.

Methodology and study area

The structural units of Iran were investigated and the Kalmard block was selected for study. The study area is located about 18 km from Zarand and 70 km to the northeast of Kerman. The measured section was delimited as 31º3′55″N and 30º2′40″N latitude and 56º17′ 5″E and 56º15′10″E longitude (*Fig. 1*).

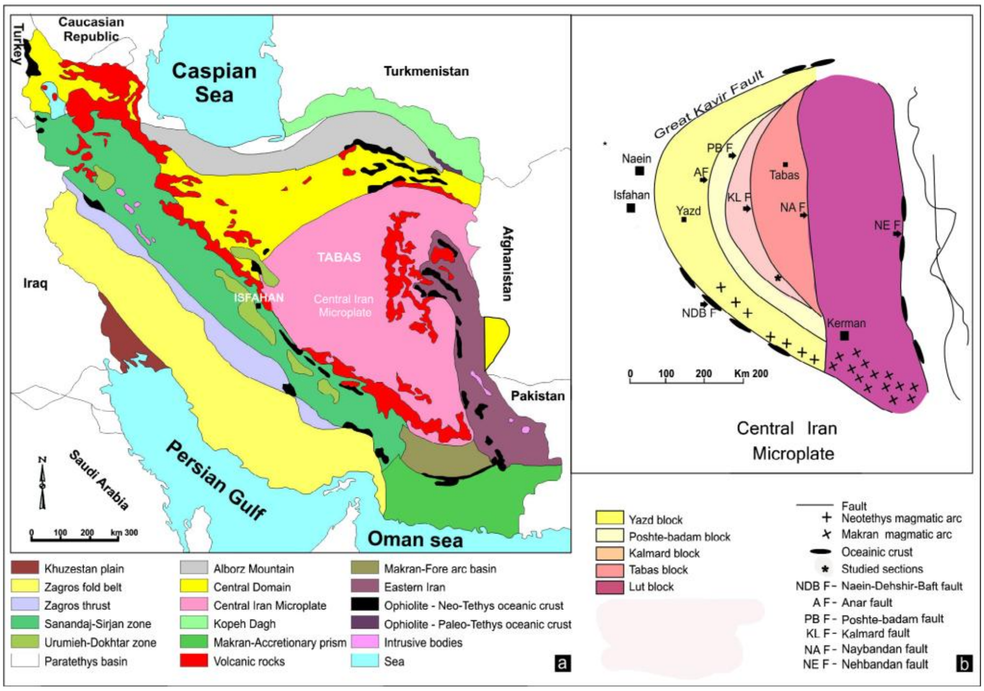

Figure 1. *Structural units of Iran located in the studied section*

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Field sampling and length measurements were undertaken systematically wherever a change in the lithology was identified to carefully investigate the biostratigraphy of the study area. If needed, more than one sample (+4 kg) was taken from the corresponding bedding. The samples were studied carefully after undergoing the following preparation steps: crushing (to dimensions of 3 cm), acid treatment (10% acetic acid), washing, sieving (75, 125, 250 and 710 mesh), picking (with a needle) and photography.

Discussion

An investigation on Late Silurian and Devonian deposits (Padeha, Sibzar, and Bahram) in the Central Iran microplate indicates that, during the Late Silurian, most of Central Iran was exposed out of water. The Devonian deposits in Central Iran formed in separate basins. Evidence indicates a radical variation in thickness even at short distances. For instance, the Hur section is 280 m thick (Ahmadi et al., 2012), the Varkamar section is 210 m thick and the Neqeleh section is about 200 m thick. The Nachf section is about 120 m thick and the Shomal-Tar section is about 200 m (near Isfahan) (Bahrami et al., 2015). The Shahmirzad section is 450 m thick (Heydari et al., 2008) and the Soh section is 88 m thick (Adhamian, 2003).

These radical changes in thickness can be attributed to horst and graben basins from the Caledonian and Hercynian epirogenic phases in Central Iran (Soffel and Forster, 1980; Weddige, 1984). The presence of gypsum as evaporative facies in the section base along with carbonate intercalations containing Spathognathodontidae indicate a lagoon on an inner carbonate platform (*Table 1*) (Sweet, 1988; Flugel, 2010). The presence of evaporative facies in the Late Silurian can be attributed to the Ardenian orogeny. The Early Devonian red-colored clastic facies with carbonate intercalations can be attributed to the Earian orogeny.

Lithostratigraphy of Yazdanshahr section

The study area is located in the northern Shabjereh mountains near Khorramabad (northeastern Kerman, Central Iran; *Fig. 2*). The local sedimentary rock were different types of clastic, colloidal carbonate and evaporative rock. The lower boundary is covered by alluvial deposits. The two local members were identified as follows:

Lower boundary (base): talus and fluvial (covered)

Member I

Lithozone I

1. 20 m of grey, reddish and white gypsum with clay or gypsum-bearing clay intercalations.
2. 6.8 m of olive green lime and the fresh grayish green colour (argillaceous micrite or sandy mudstone becoming pelmicrite or wackestone in the upper layers).
3. 58 m of white to red gypsum with grey-coloured shaley limestone intercalations.
4. 32.8 m of brick-coloured sandstone in alternation with limestone in fresh red color with layering thickness of 0.5-1 m. The penetration of ferrous compounds into the rocks caused their red appearance (sample 3).
5. 4.5 m of light grey and creamy light-grey limestone. This limestone encompasses gypsum beddings in the form of two 1-m thick hard beddings (sample 5).

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Table 1. *Distribution of conodont species in Yazdanshahr column*

Yazdan shahr																												
Taxa	18	19	20	21	22	23	24	25	40	42	49	50	51	53	61	62	67	69	70	73	74	76	80	89	90	91	###	Total
Bipennatus Philip, 1965									3	4	2	3	2	3	1	3	2	1	2	3								29
Bipennatus bipennatus Bischoff and Ziegler, 1957										2								3	21	2								28
B.bipennatus bipennatus Bischoff and Ziegler, 1957																												0
*Distomodus sp.*Branson and Mehl 1947		1	1																									2
Hindeodlla compressa Huddle, 1934									1													1					1	3
Hindeodella equidentata Rhodes, 1953								2																				2
Icriodus sp Branson and Mehl 1934									2	4												5	1					12
Icriodus brevis, Stauffer, 1940,									2		2													2	1			7
Icriodus brevis brevis Stauffer, 1940																									1			1
I. brevis spicatus Youngquist and Pelerson, 1947																								3	1			4
Icriodus.regularicresens Bultynck, 1970										1											2	1	1	2				7
I. struvei Weddig, 1977																					2	1						3
Ligonodina Ulrich and Bassler 1926			1		2	2	2	1																				8
Ligonodina elegans Walliser 1964																												0
Lonchodina Bassler, 1925		1	3	1	4	6	6	1																				22
Neopripniodus Rhodes and Muller , 1956		1	1	2	1	2	3	5																				15
Neopripniodus bicurvatus Branson and Mehl, 1933		1	3	2	2	1																						9
Ozarkodina Branson and Mehl, 1933		2	3	4	4	3	2																					18
Ozarkodina confluens Branson and Mehl, 1933		2	6	5	4	2	1																					20
Ozarkodina denckmanni Ziegler, 1956		2	1		2	1																						6
Ozarkodina media Walliser, 1957				1																								1
Ozarkodina typical Branson and Mehl, 1933			4	4	3	3	1																					15
Ozarkodina Ziegleri Walliser, 1964		1	2	3	3		1																					10
Panderodus simplex Branson and Mehl, 1933		1	2	2																								5
Pandorinellina exigua Philip, 1966		3	5	6	5	4	2																					25
Pandorinellina steinhornensis Ziegler, 1956		2	1	5	4	4	2																					18
Plectospathodus Branson and Mehl, 1933		2	3	3	1																							9
Trichonodella symetrica Branson and Mehl, 1933		1	3	4	6	5	2																					21
Wurmiella excavata Branson and Mehl, 1933			1	2	2																							5
Zieglerodina remscheidensis Ziegler, 1960		2	5	3	6	4	1																					21
Total		22	45	47	49	37	23	9	8	11	4	3	2	3	1	3	2	4	23	5	4	8	2	7	3	0	1	###

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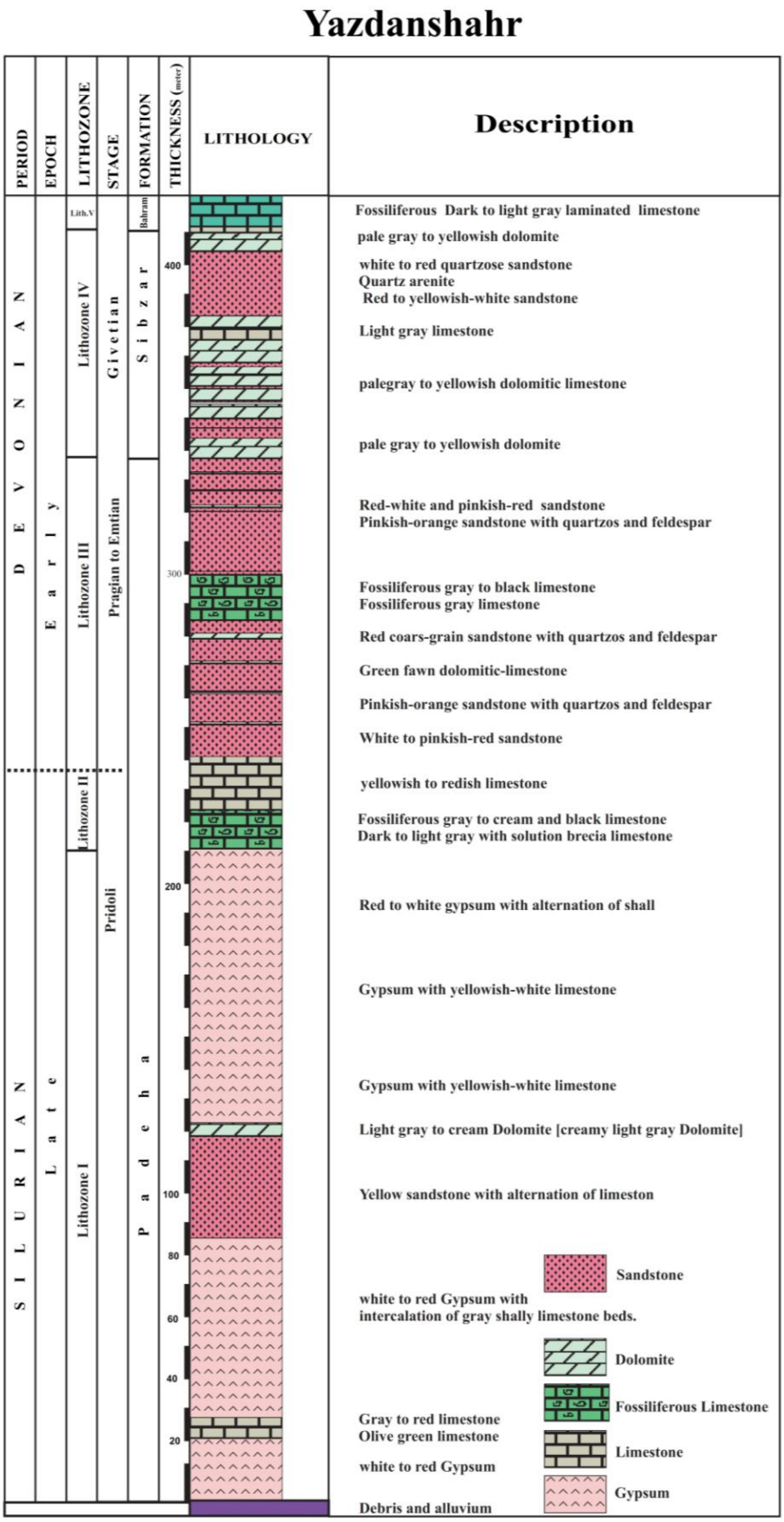

***Figure 2.** Lithostratigraphic section of Yadanshahr, Iran*

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6. 88.4 m of soft gypsum with thinly-bedded intercalations of pease-coloured limestone.

Lithozone II

7. 13 m of light- to dark-grey limestone together with shell fragments (sandy bioclast lime wackestone/pelbioclast lime wackestone or sandy biomicrite/pelbiomicrite (light- to dark-grey limestone)). Solution breccia from the dissolution of gypsum can be observed in the base of this rock unit. The identified conodonts include:
   a. *Ozarkodina confluens* (Branson and Mehl, 1933)
   b. *Spatognathodus primus* (Branson and Mehl, 1933)
   c. *Pandorinellina steinhornensis* (Ziegler, 1956)
   d. *O. confluens* (Branson and Mehl, 1933)
   e. *P. exigua* (Philip, 1966)
   f. *Zieglerodina remscheidensis* (Ziegler, 1960)
   g. *Distomodus* (Branson and Mehl, 1947)
   h. *Hindeodella equidentata* (Rhodes, 1953)
   i. *Ligonodina* (Ulrich and Bassler, 1926)
   j. *L. elegans* (Walliser, 1964)
   k. *Lonchodina* (Bassler, 1925)
   l. *Neopripniodus bicurvatus* (Branson and Mehl, 1933)
   m. *O. denckmanni* (Ziegler, 1956)
   n. *O. ziegleri* (Walliser, 1964)
   o. *Panderodus simplex* (Branson and Mehl, 1933)
   p. *Trichonodella symetrica* (Branson and Mehl, 1933)
8. 17.4 m of yellow to grey limestone, creamy with no fossil which gradually turns to red.

Member II

Lithozone III

9. 10.2 m of red-white-brick-coloured sandstone containing siliceous cement with quartz and feldspar.
10. 1 m of thinly-bedded red to white dolomitic sandy limestone (dolograinstone or sandy dolosparite).
11. 10 m of red sandstone with siliceous cement and abundant quartz and feldspar grains. It turns gradually to micrite and microsparite. The identified conodonts include:
   a. *I. struvie* (Weddige, 1977)
   b. *I. regularicresens* (Bultynck, 1970)
   c. *I. brevis* (Staulfer, 1940)
   d. *I. brivis spicatus* (Youngquist and Peterson, 1947)
   e. *Bipennatus bipennatus* (Bischoff and Ziegler, 1957)
12. 8.7 m of thinly bedded clay-bearing red sandstone containing trace fossils.
13. 1 m of gray marl limestone (micrite to microcrystalline matrix, laterally becoming bioclastic lime wackestone or biomicrite)
14. 7 m of coarse-grained red lime sandstone with weak carbonate cement and abundant clastic grains of quartz and feldspar
15. 2 m of light green dolomitic limestone (packstone-dolosparite) with sparicalcite cement and abundant rhombohedral calcite

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16. 4 m of red to white sandstone with medium to coarse grains of quartz and feldspar and siliceous cement

Lithozone IV (Sibzar formation)

17. 15 m of grey to dark limestone to dolostone with sparicalcite cement and abundant rhombohedra of dolomite. Organic remnants of crinoid debris, fish teeth and conodonts are as follows:
    a. *I. brevis* (Stauffer, 1940)
    b. *B. bipennatus sub sp*.
18. 20.2 m of red sandstone (quartz arenite), medium- to coarse-grained quartz along with nodules of iron oxide (opaque minerals, feldspar and siliceous cement)
19. 0.2 m of dark gray limestone (biosparite-grainstone) with sparicalsite cement and calcite rhombohedra. The only conodont is *Ozarkodina* sp.
20. 17 m of red sand with argillaceous matrix together with three light-grey dolostone beddings
21. 6.7 m of yellowish grey dolostone (dolograinstone-dolosparite). The identified conodonts include:
    a. *Icriodus sp., I. struvei* (Weddige, 1977)
    b. *I. brevis* (Stauffer, 1940)
    c. *I. brevis brevis* (Stauffer, 1940)
    d. *Bipennatus sp., B. bipennatus* (Bischol and Ziegler, 1957)
    e. *Ozarkodina* sp.
22. 4.5 m of white to red quartzose sandstone
23. 20.4 m of light-grey to yellow dolomite (dolosparite dolograinstone) with three layers of red sandstone.
24. 8 m of light grey to yellow dolostone with quartzose grains and sparit calcite cement. Identified conodonts include:
    a. *Icriodus sp., I. aff. regularicresens* (Bultynck, 1970)
    b. *Bippenatus sp 2*.
25. 20.63 m of white to red quartzose sandstone
26. 6 m of light-gray dolomite (dolograinstone dolosparite)
27. 2 m of marl containing trilobite, ostracoda, Ecinid spine and bryozoan

Bahram grey brachiopoda limestone (Bahram Formation)

Biozonation of Yazdanshahr section

The conodont collections in this section contain 15 genus, 20 species and 5 subspecies were identified (*Fig. 3*). Together, these identify two biozones as follows:

1. Zieglerodina remscheidensis, Pandorinellina steinhornensis assemblage zone. The elements collected in this part relate to *Spathognathodontidae* and include the following:
    - *O. confluence* (Branson and Mehl, 1933) (*Spathognathodus primus;* Branson and Mehl, 1933)
    - *Zieglerodina remscheidensis* (Ziegler, 1960) (*S. remscheidensis;* Ziegler,1960)
    - *Pandorinellina steinhornensis* (Ziegler, 1966) (*S. steinhornensis*, Ziegler, 1956)
    - *P. exiguus* philipi (Klapper, 1969)

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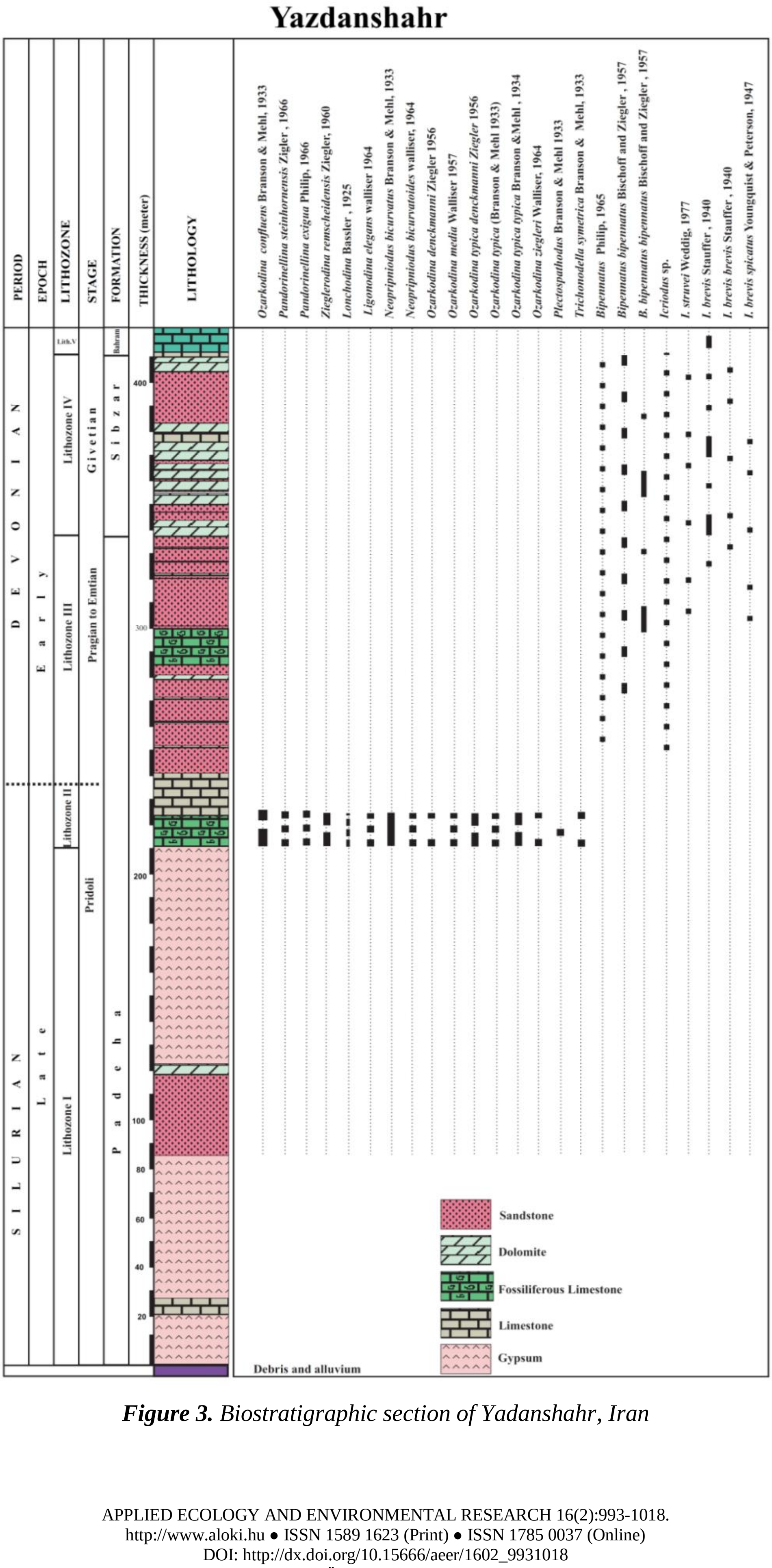

Figure 3. *Biostratigraphic section of Yadanshahr, Iran*

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The collected elements were comparable to the following:

- Murphy et al. (2004) (from Nevada, Spain, Germany and Czech Republic)
- Farrel (2004) (from Camelford limestone, Australia)
- Corradini et al. (2014) (from Cellon section)
- Corriga et al. (2011) (from Malinfier section, Italy)
- Mathieson et al. (2016) (from Cobra Supergroup in Western New South Wales, Australia)
- Drygant and Szaniawski (2012) (from Podolia, Ukraine)
- Corriga et al. (2014) (from Tafilalt, southeastern Morocco)
- Ziegler (1975, 1991)

As such, the age of this biozones is Pridoli.

2. *Eugenathodontidae-Icriodus* assemblage zone
   The elements collected in this part are related to *Eugenathodontidae* and include the followings genus:
   - *Bipennatus* (Philip, 1965)
   - *B. bipennatus* (Bischoff and Ziegler, 1957)
   - *B. bipennatus bipennatus* (Bischoff and Ziegler, 1957)
   - *Icriodus sp.*
   - *I. struvei* (Weddige, 1977)
   - *I. brevis* (Stauffer, 1940)
   - *I. brevis brevis* (Stauffer, 1940)
   - *I. brevis spicatus* (Youngquist and Peterson, 1947)

   As such, the age of this biozone is Pragian to Emsian with the collected elements being comparable to those in the following work:

   - Mathieson et al. (2016) (from Cobra Supergroup in Western New South Wales, Australia); Murphy (2005) (from Nevada)
   - Murphy (2005) (from Nevada)
   - Corriga et al. (2014) (from Podolia, Ukraine)
   - Clark et al. (1966) (from Nevada)
   - Nasehi (1996) (from Central Iran)
   - Ziegler (1975, 1991)

It is difficult to identify the contact between the Silurian and Devonian. The studied section exhibit a stratigraphic hiatus between the Late Pridoli and Early Pragian. Lochkovian deposits have not been observed in Iran; therefore, Central Iran was exposed out of water.

Conclusion

The studied section indicates that the Padeha Formation has two members across this area. The lower part (evaporative deposits with carbonate intercalations) has been aged back to the Late Silurian, while the upper part of Padeha Formation (clastic deposits

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with carbonate intercalations) is reported to be formed in the Early Devonian. The contact between the lower and upper parts exhibits a sedimentary hiatus (Late Pridoli to Late Emsian). Stratigraphists and geologists can correlate the stratigraphic column with this section. Using stratigraphic principles, it will be possible to solve the problem of age determination in Central Iran.

Within this time window, present-day Iran formed on the northern margin of the Gondwana Supercontinent, which later divided into separate structural units under the effect of Caledonian epirogenic movement (from faulting and formation of horst and graben basins). In the Late Silurian and Early Devonian, sea transgression and regression occurred, respectively. Note that the transgression at this time extended to limited parts of Iran. The evidence presented herein confirms the hypothesis of a horst and graben basin along the paleo faults in Central Iran in the Early Paleozoic.

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APPENDIX

Plate 1

1. *Bipennatus* Philip, 1965
2. *B. bipennatus bipennatus* Bischoff and Ziegler, 1957
3. *B. bipennatus bipennatus* Bischoff and Ziegler, 1957
4. *B. bipennatus bipennatus* Bischoff and Ziegler, 1957
5. *B. bipennatus bipennatus* Bischoff and Ziegler, 1957
6. *Bipennatus bipennatus* Bischoff and Ziegler, 1957
7. *Bipennatus bipennatus* Bischoff and Ziegler, 1957
8. *Bipennatus bipennatus* Bischoff and Ziegler, 1957
9. *Bipennatus* sp.aff *B. palethorpei* Telfond, 1975 (Plate 2: 4, 8)
10. *Bipennatus* Philip, 1965
11. *Bipennatus* Philip, 1965
12. *Bipennatus bipennatus* Bischoff and Ziegler, 1957
13. *Bipennatus bipennatus* Bischoff and Ziegler, 1957

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Plate 1

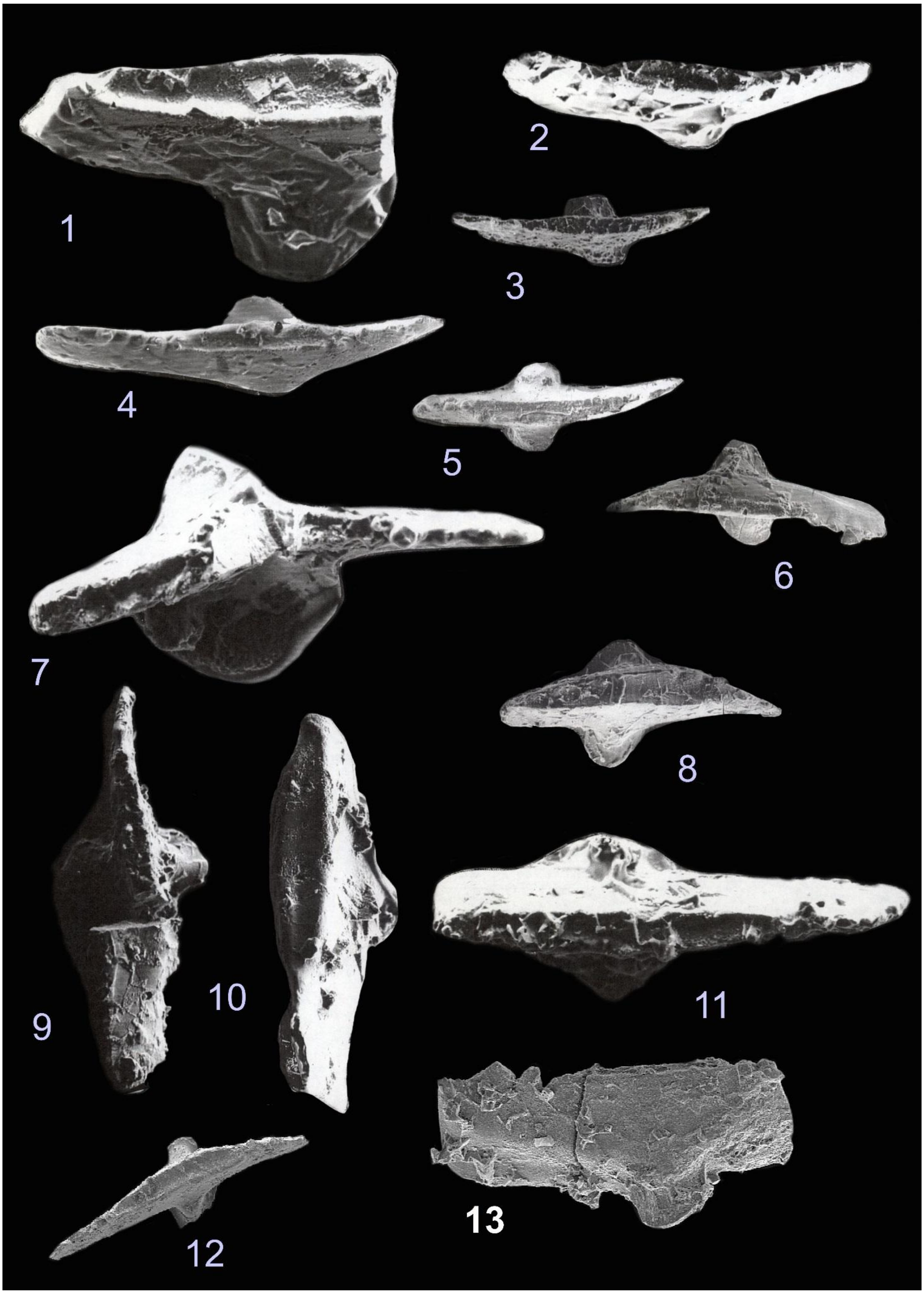

Plate 2

1. *Ozarkodina ziegleri* Walliser, 1964
2. *Ozarkodina ziegleri* Walliser, 1964
3. *Trichonodella symetrica* Branson and Mehl, 1933
4. *Ozarkodina ziegleri* Walliser, 1964
5. *Ozarkodina ziegleri* Walliser, 1964
6. *Ozarkodina* Branson and Mehl, 1933
7. *Ozarkodina ziegleri* Walliser, 1964
8. *Trichonodella symetrica* Branson and Mehl, 1933
9. *Ozarkodina* Branson and Mehl, 1933
10. *Trichonodella symetrica* Branson and Mehl, 1933
11. *Trichonodella symetrica* Branson and Mehl, 1933
12. *Trichonodella symetrica* Branson and Mehl, 1933
13. *Trichonodella symetrica pinnula* Philip, 1966
14. S element of ? *Ozarkodina* Branson and Mehl, 1933

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Plate 2

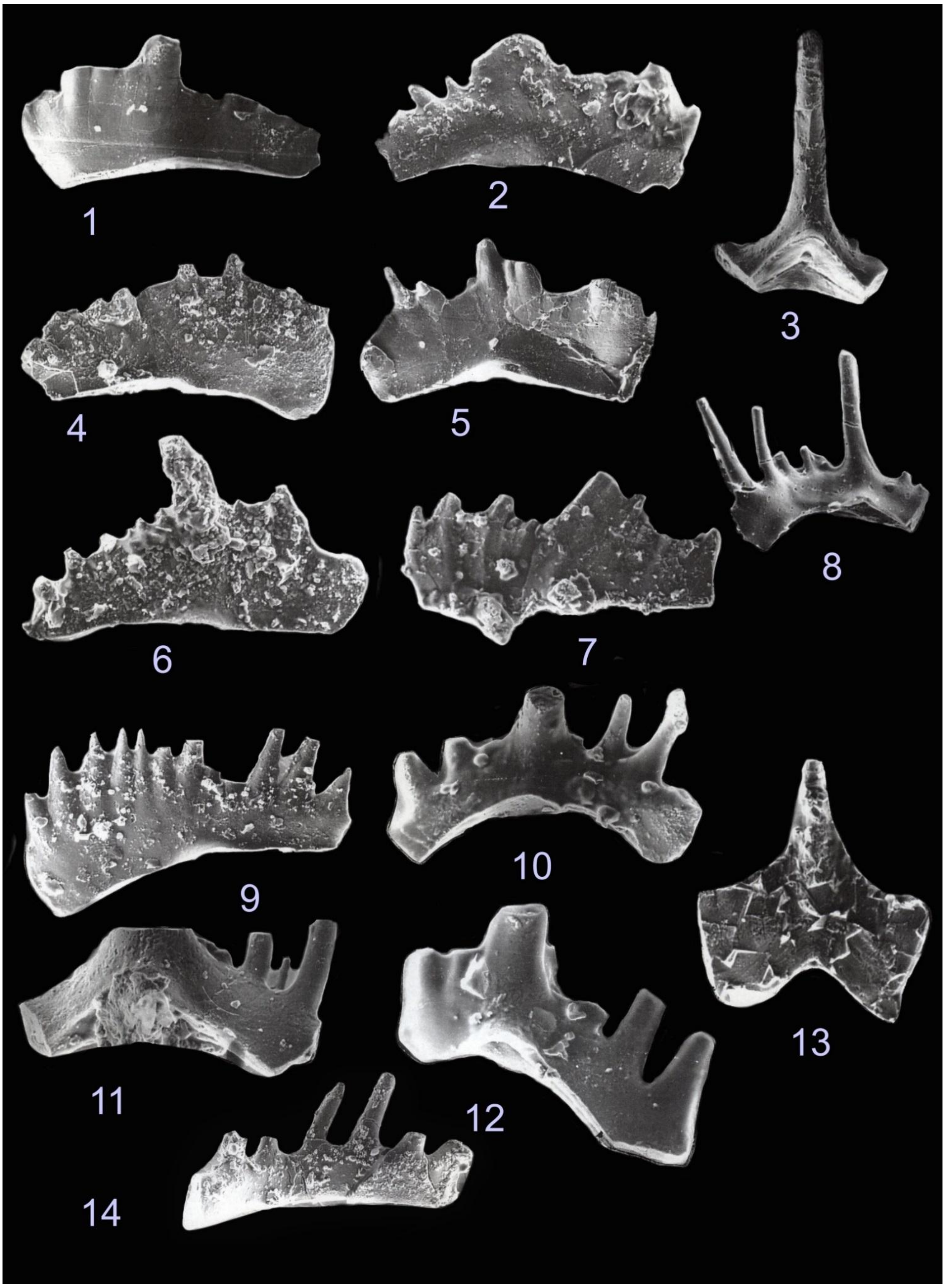

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Plate 3

1. *Ligonodina elegans* Walliser 1964
2. *Ligonodina* Bassler, 1925
3. *Distomodus* Branson and Mehl 1947
4. *Lonchodina* Bassler, 1925
5. *Hindeodella equidentata* Rhodes, 1953
6. Ozarkodina typica denckmanni Ziegler, 1956
7. *Ozarkodina denckmanni* Ziegler, 1956
8. *Ozarkodina denckmanni* Ziegler, 1956
9. *Lonchodina* Bassler, 1925
10. Ozarkodina typica denckmanni Ziegler, 1956
11. Ozarkodina typica denckmanni Ziegler, 1956
12. Ozarkodina typica denckmanni Ziegler, 1956
13. Ozarkodina typica denckmanni Ziegler, 1956
14. *Ozarkodina ziegleri* Walliser, 1964
15. Ozarkodina typica denckmanni Ziegler, 1956
16. Ozarkodina typica denckmanni Ziegler, 1956

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Plate 3

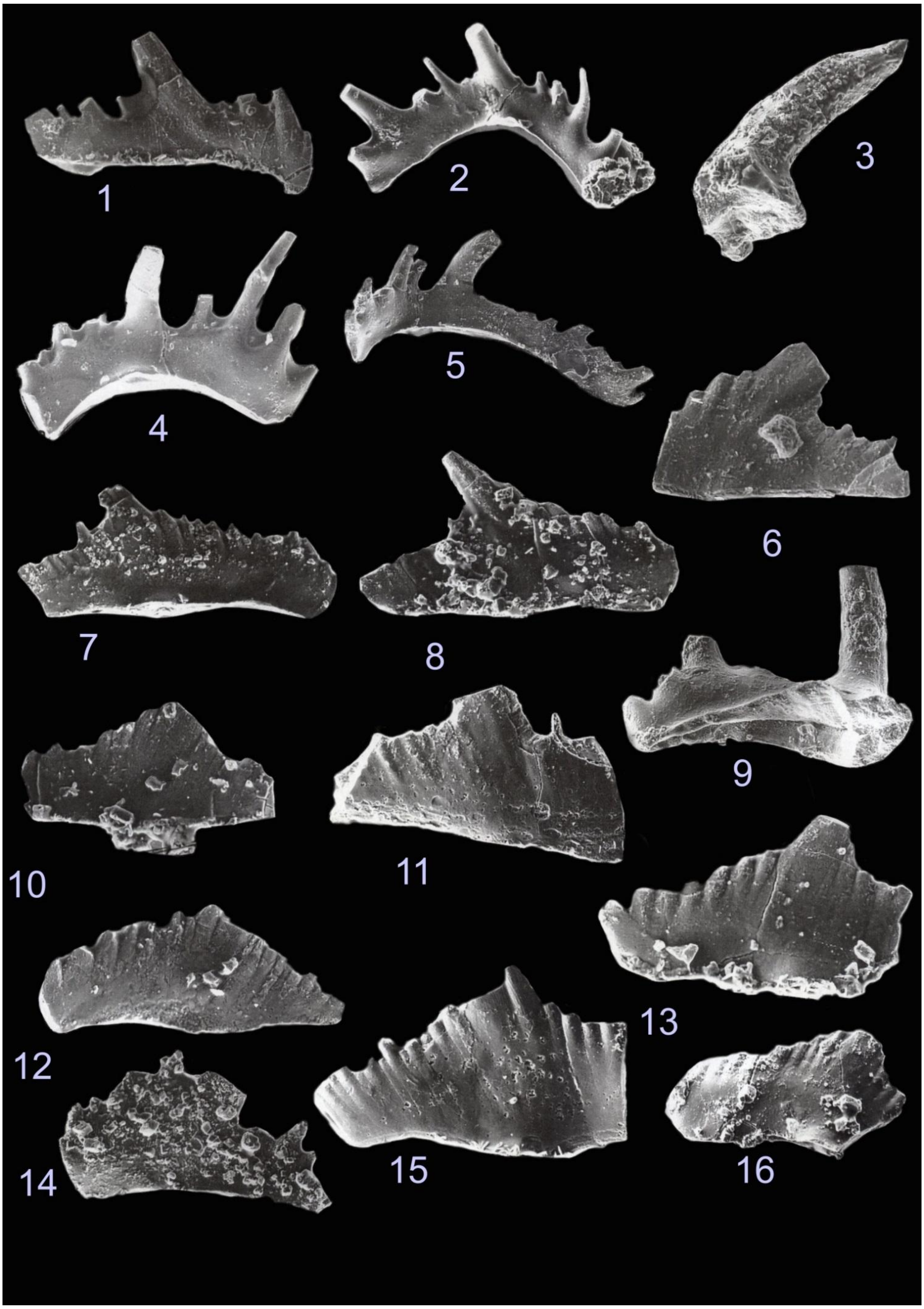

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Plate 4

1. *Hindeodella* subtillis N166
2. *Hindeodella equidentata* Rhodes, 1953 N22
3. *Wurmiella excavata* Branson and Mehl, 1933; *Neopripniodus excavatus* Branson and Mehl, 1933 N30
4. *Lonchodina* Bassler, 1925 N20
5. Ligonodina salopina Rhodes, 1953, N24
6. Ligonodina salopina Rhodes, 1953, N25
7. *Neopripniodus bicurvatus* Branson and Mehl, 1933 N30
8. Wurmiella *excavata* Branson and Mehl, 1933 *Neopripniodus excavatus* (Branson and Mehl)
9. *Wurmiella excavata* Branson and Mehl, 1933 *Neopripniodus excavatus* (Branson and Mehl) N
10. *Neopripniodus bicurvatoides* Walliser, 1964 N30
11. *Lonchodina* Bassler, 1925 N21
12. *Wurmiella excavata* Branson and Mehl, 1933; *Neopripniodus excavatus* (Branson and Mehl) N20
13. *Lonchodina* Bassler, 1925 N20
14. *Lonchodina* Bassler, 1925 N
15. *Wurmiella excavata* Branson and Mehl, 1933 *Neopripniodus excavatus* (Branson and Mehl) N20

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Plate 4

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Plate 5

1. *Ozarkodina confluens* Branson and Mehl, 1933 (*Spatognathodus primus primus* Branson and Mehl, 1933) N21
2. *Ozarkodina confluens* Branson and Mehl, 1933 (*Spatognathodus primus primus* Branson and Mehl, N19
3. *Zieglerodina remscheidensis* Ziegler, 1960 (Spathognathodus remscheidensis Ziegler,1960) N 22
4. *Zieglerodina remscheidensis* Ziegler, 1960 (*Spathognathodus remscheidensis* Ziegler, 1960) N25
5. *Zieglerodina remscheidensis* Ziegler, 1960 (*Spathognathodus remscheidensis* Ziegler, 1960) N19
6. *Zieglerodina remscheidensis* Ziegler, 1960 (*Spathognathodus remscheidensis* Ziegler, 1960) N25
7. *Ozarkodina confluens* Branson and Mehl, 1933 (*Spatognathodus primus* Branson and Mehl, 1933) N19
8. *Ozarkodina confluens* Branson and Mehl, 1933 (*Spatognathodus primus* Branson and Mehl, 1933) N24
9. *Pandorinellina exigua* Philip, 1966 (*Spathognathodus exiguous* Philip, 1966) N21
10. *Pandorinellina exigua* Philip, 1966 (*Spathognathodus exiguous* Philip, 1966) N21
11. *Pandorinellina exigua* Philip, 1966 (*Spathognathodus exiguous* Philip, 1966) N22
12. *Pandorinellina exigua* Philip, 1966 (*Spathognathodus exiguous* Philip, 1966) N21
13. *Pandorinellina exigua* Philip, 1966 (*Spathognathodus exiguous* Philip, 1966) N20
14. *Zieglerodina remscheidensis* Ziegler, 1960 (*Spathognathodus remscheidensis* Ziegler, 1960) N19
15. *Pandorinellina exigua* Philip, 1966 (*Spathognathodus exiguous* Philip, 1966) N21
16. *Pandorinellina cf exigua* Philip, 1966 (*Spathognathodus exiguous* Philip, 1966) N19
17. *Pandorinellina sp* Muller & Muller 1957
18. *Pandorinellina steinhornensis* Ziegler, 1966 (*Spathognathodus steinhornensis* Ziegler, 1956) N23
19. *Ozarkodina cf confluens* Branson and Mehl, 1933 (*Spatognathodus primus* Branson and Mehl, 1933) N25
20. *Zieglerodina cf remscheidensis* Ziegler, 1960 (*Spathognathodus remscheidensis* Ziegler, 1960) N21
21. *Pandorinellina cf steinhornensis* Ziegler, 1966 (*Spathognathodus steinhornensis* Ziegler, 1956) N19

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Plate 5

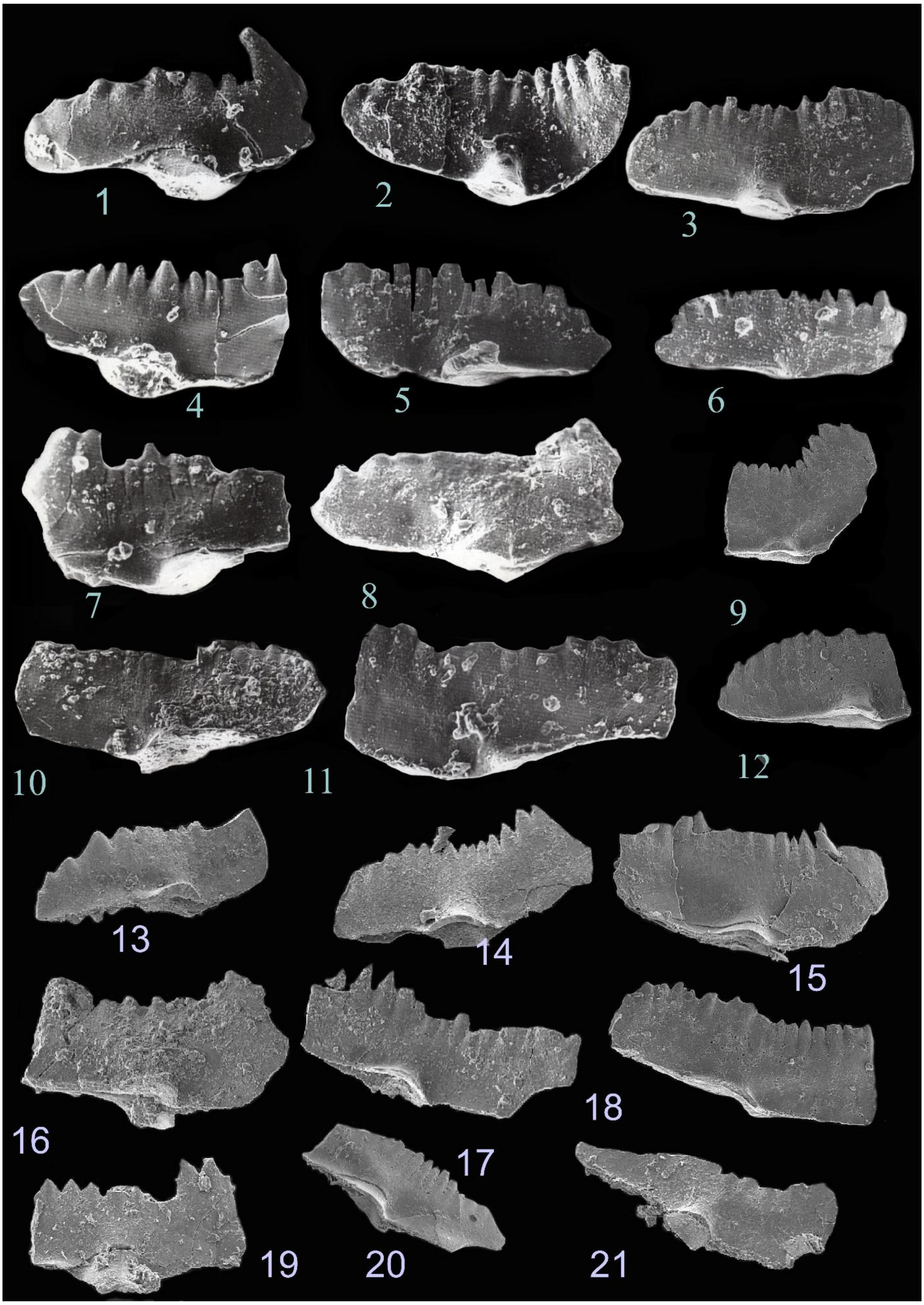

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Plate 6

1. *Zieglerodina remscheidensis* Ziegler, 1960 (*Spathognathodus remscheidensis* Ziegler, 1960) N26
2. *Ozarkodina confluens* Branson and Mehl, 1933 (*Spatognathodu*s *primus* Branson and Mehl, 1933) N25
3. *?Pandorinellina exigua* Philip, 1966 (*Spathognathodus exiguous* Philip, 1966)
4. *Zieglerodina remscheidensis* Ziegler, 1960 (*Spathognathodus remscheidensis* Ziegler, 1960) N24
5. *Ozarkodina confluens* Branson and Mehl, 1933 (S*patognathodus primus primus* Branson and Mehl, 1933) N26
6. *Pandorinellina steinhornensis* Ziegler, 1966 (*Spathognathodus steinhornensis* Ziegler, 1956) N18
7. *Pandorinellina steinhornensis* Ziegler, 1966 (*Spathognathodus steinhornensis* Ziegler, 1956) N24
8. *Ozarkodina confluens* Branson and Mehl, 1933 (*Spatognathodus primus primus* Branson and Mehl, 1933) N20
9. *Zieglerodina remscheidensis* Ziegler, 1960 (*Spathognathodus remscheidensis* Ziegler, 1960)
10. *Pandorinellina steinhornensis* Ziegler, 1966 (*Spathognathodus steinhornensis,* Ziegler, 1956) N20
11. *Pandorinellina exigua* Philip, 1966 (*Spathognathodus exiguous* Philip, 1966) N22
12. Pandorinellina exigua Philip, 1966 (*Spathognathodus exiguous* Philip, 1966) N22
13. *Pandorinellina steinhornensis* Ziegler, 1966 (*Spathognathodus steinhornensis* Ziegler, 1956) N26
14. *Pandorinellina exigua* Philip, 1966 (*Spathognathodus exiguous* Philip, 1966) N20
15. *Pandorinellina exigua* Philip, 1966 (*Spathognathodus exiguous* Philip, 1966) N22
16. *Pandorinellina steinhornensis* Ziegler, 1966 (*Spathognathodus steinhornensis* Ziegler, 1956) N19
17. *Pandorinellina steinhornensis* Ziegler, 1966 (*Spathognathodus steinhornensis* Ziegler, 1956)N26
18. *Ozarkodina confluens* Branson and Mehl, 1933 (*Spatognathodus primus* Branson and Mehl, 1933) N19
19. *Pandorinellina exigua* Philip, 1966 (*Spathognathodus exiguous* Philip, 1966) N20
20. *Pandorinellina steinhornensis* Ziegler, 1966 (*Spathognathodus steinhornensis* Ziegler, 1956) N21
21. *Ozarkodina confluens* Branson and Mehl, 1933 (*Spatognathodus primus* Branson and Mehl, 1933) N24
22. *Pandorinellina steinhornensis* Ziegler, 1966 (*Spathognathodus steinhornensis* Ziegler, 1956) N19

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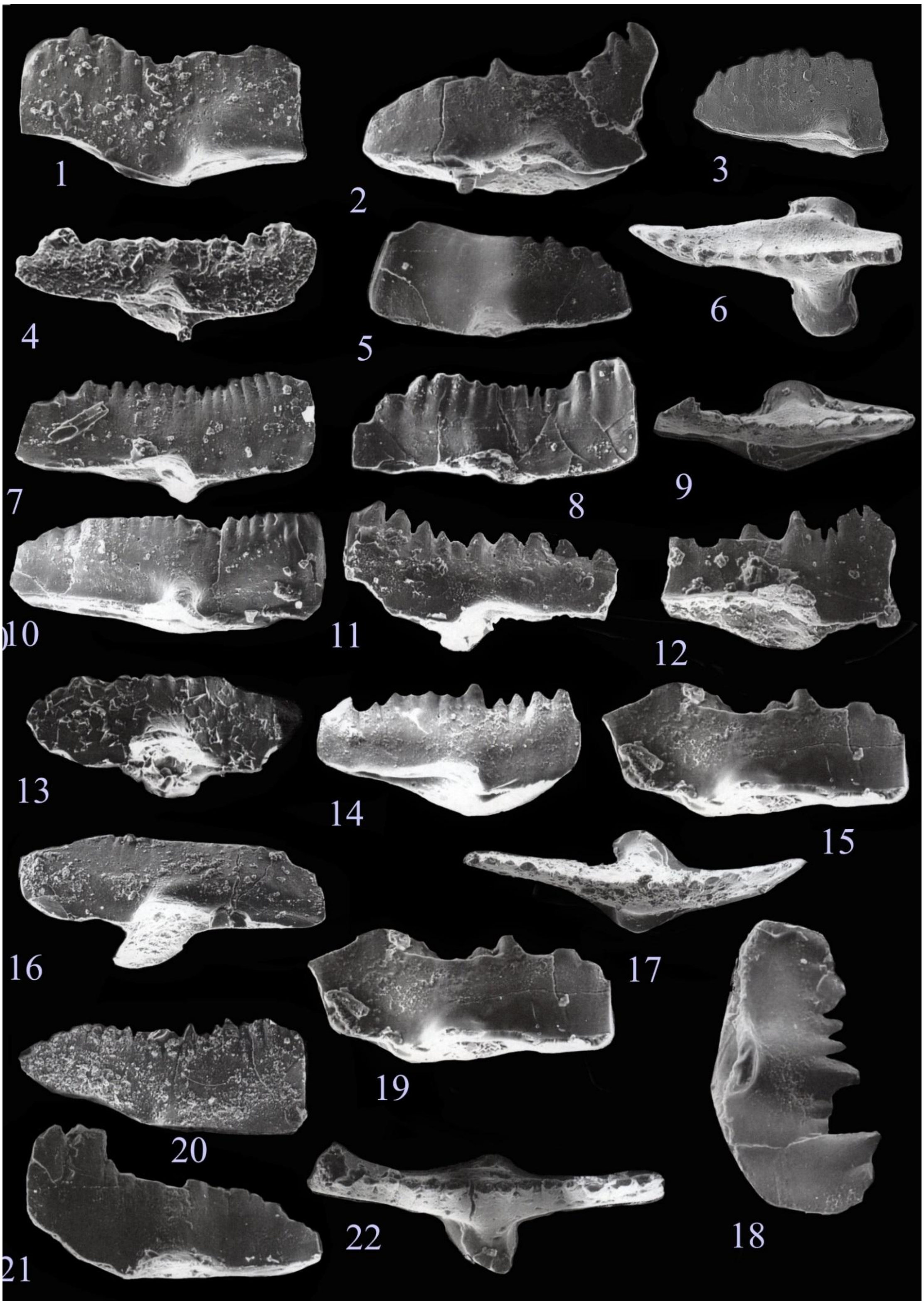

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Plate 7

1. *Icriodus brivis spicatus* Youngquist and Peterson, 1947 no. 65
2. *Icriodus brevis brevis* Stauffer, 1940
3. *Icriodus regularicresens* Bultynck, 1970
4. *Icriodus regularicresens* Bultynck, 1970
5. *Icriodus sp* Branson and Mehl, 1934
6. *Icriodus regularicresens* Bultynck, 1970
7. *Icriodus regularicresens* Bultynck, 1970
8. *Icriodus struvei* Weddige, 1977
9. *Icriodus.regularicresens* Bultynck, 1970
10. *Icriodus struvei* Weddige, 1977
11. *Icriodus regularicresens* Bultynck, 1970
12. *Icriodus struvei* Weddige, 1977
13. *Icriodus regularicresens* Bultynck, 1970
14. *Icriodus* sp
15. *Icriodus brivis spicatus* Youngquist and Peterson, 1947
16. *Icriodu brivis spicatus* Youngquist and Peterson, 1947

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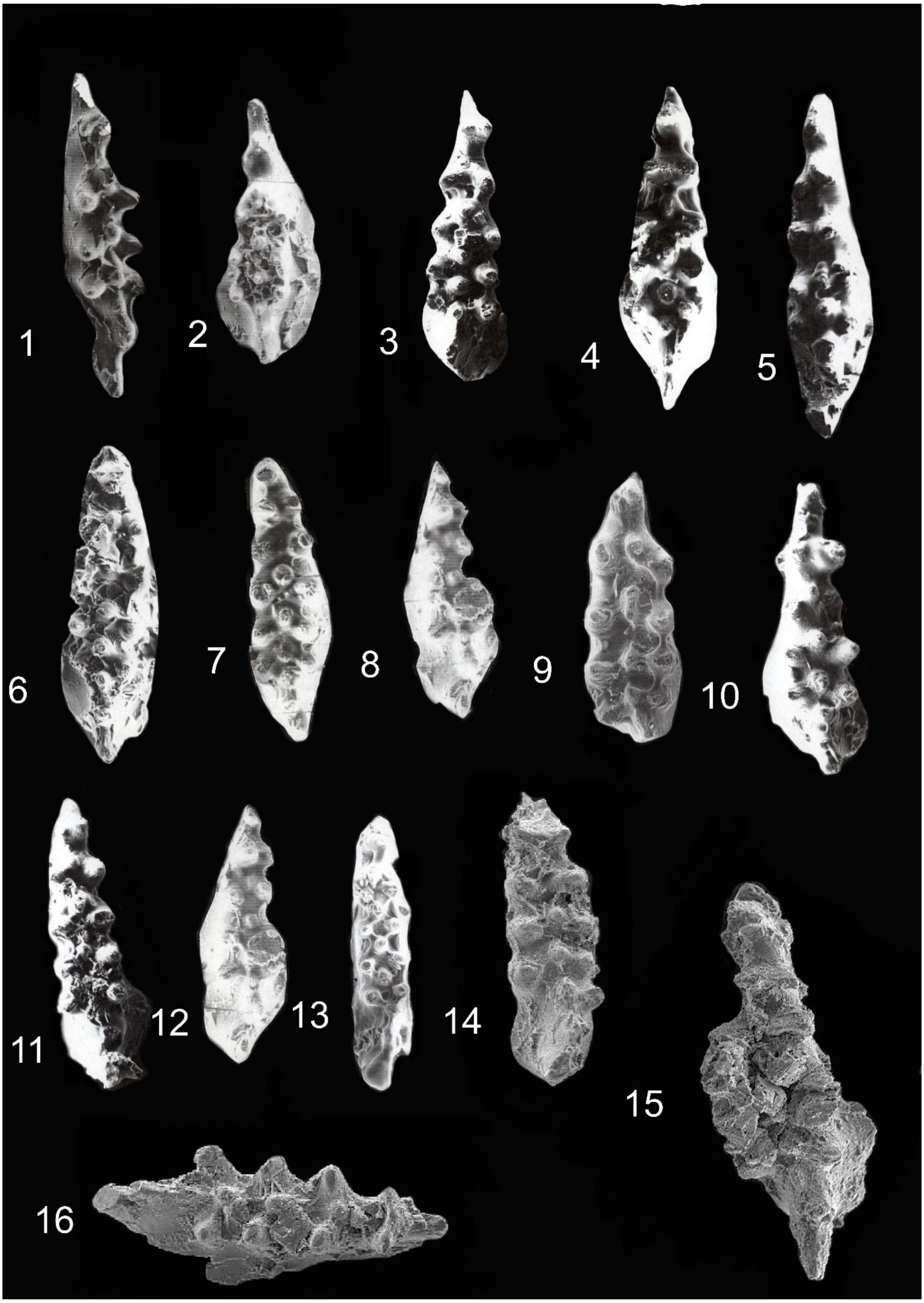

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