Middle Devonian-Early Carboniferous Conodont Faunas from the Khoshyeilagh Formation, Alborz Mountains, North Iran

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Abstract

Conodonts of Khoshyeilagh Formation, the most complete section of Devonian rocks in the Alborz Mountains, northern Iran, has been studied, and subspecies of the genera Icriodus, Bipennatus, Polygnathus, Pelekysgnathus, Ancyrodella, Palmatolepis, Bispachinathus, Scaphignathus, Clydagnathus, Gnathodus, Scalpegnathus and Dollymae have been obtained from the studied section. The faunas indicate an Eifelian to Tournaisian age. The falsiovalis, Late rhomboidea-Early marginifera, Latest marginifera-trachytera, Middle expansa-Middle praesulcata, bouckaerti and anchoralis-latus conodont zones have been identified in the formation. Six new species are described: Icriodus ariaei, Ic. alborzensis, Ic. khoshyeilaghensis, Polygnathus klapperianus, Pelekysgnathus housei and Pe. talenti.

Keywords: Conodonts; Devonian; Carboniferous; Iran; Alborz Mountains; Khoshyeilagh Formation

Introduction

The existence of Middle and Upper Devonian rocks in the eastern Alborz (Figs. 1 and 2) was firstly mentioned by Bozorgnia et al. [12] in an unpublished report of the Iranian National Oil Company; it was later named Khoshyeilagh Formation and described by Bozorgnia [13]. It consists of 1345 m of carbonates (mainly limestone), sandstone and shale with a rich fauna of brachiopods and less abundant tentaculitids and bryozoans. It is conformable with the Padeha Formation below and the Mobarak Formation above.

The Khoshyeilagh Formation was divided into six members and seventeen “Beds” by Bozorgnia [13]. Later workers have proposed their own division of the formation. For example Brice et al. [14] suggested seven members and twelve “Beds” within the formation. Comparison of previous studies and the current one is shown in Figure 3. In the present study the original subdivisions suggested by Bozorgnia [13] are used, though the explained proposal of Brice et al. [14] is perhaps a better representation of the sequence since it is distinguishable simply in the field.

Stratigraphy

The ages of members 1 and 6 of the formation have been challenged by previous researchers; the greatest
controversy is concern with Member 1. Age assignments were given to the members on the basis of brachiopods (Brice in [13]) as follows: Couvinian for Member 1, Givetian for Member 2, Frasnian for Member 3, Frasnian-Famennian for Member 4, Famennian for Member 5 and Late Famennian for Member 6. Bozorgnia [13] reported two algal intervals in the Khoshyeilagh Formation: Trochiliscus “Zone” from lower part of the section (Couvinian age according to brachiopods) and Umberella “Zone” an especially distinctive interval in the Upper Devonian of Iran; it is Frasnian-Famennian. Ahmadzadeh [2] studied conodont and brachiopod faunas from the lower part of the Khoshyeilagh Formation: Trochiliscus “Zone” from lower part of the section (Couvinian age according to brachiopods) and Umberella “Zone” an especially distinctive interval in the Upper Devonian of Iran; it is Frasnian-Famennian. Brice et al. [14] reported on the brachiopod and bryozoan faunas but provided some information on corals and conodonts. On the basis of brachiopods, they suggested that most of Member 1 was Eifelian with, in its upper part, some early Givetian limestone beds. Members 2 and 3 and most of Member 4 were believed to be Givetian. The Givetian-Frasnian boundary occurs in the upper part of Member 4. The Famennian begins with Member 6 and includes a third of Member 7 as well. The upper two thirds of the Member 7 is Latest Famennian (“Strunian”).}

Figure 1. Simplified geological map of part of the Central and Eastern Alborz Mountains.
Previous Conodont Studies

Ahmadzadeh [1] examined the Devonian-Carboniferous boundary and Lower Carboniferous strata in the Central Alborz, northern Iran, on the basis of brachiopods and conodonts. An Ordovician-Devonian section S of Bojnurd in the eastern Alborz was studied by Ahmadzadeh [3], again on the basis of brachiopods and conodonts. His specimens have been reviewed by Weddige [16,17]. Ahmadzadeh et al. [4] gave a preliminary report on conodonts of the Khoshyeilagh Formation from the Mighan section SW of the type locality of the formation. Ashouri [6-11] studied Devonian-Carboniferous conodont faunas from the Khoshyeilagh Formation and, in recent years much unpublished research on conodonts from Iran has been undertaken by postgraduate students.

Biostratigraphy

Reported conodonts here from “Bed” 10 to the top of the formation are the first records of conodonts from these horizons. Previous records cover up to “Bed” 9 [2] and “Bed” 7 [15].

Conodonts from Member 1 (sample S. 205) include species of *Icriodus* and *Eognathodus. Eognathodus bipennatus* from “Bed” 2 of Member 1 probably indicates a Middle Devonian (pre-*varcus* Zone) age. Despite 17 samples from Member 2, the faunas were poor with only two samples (S.209 & S.210) producing species of *Icriodus* and *Polygnathus*, and another (S. 211) only conodont fragments. The predominant genera in Member 3 are *Icriodus* and *Polygnathus*. Of 19 samples from this member (S.226-S.244) the most important one (S. 241) has a rich fauna of *Ancyrodella,*...
Figure 3. Comparison of previous studies of the Khoshyeilagh Formation and the present study. The section and the lithological description is based on Bozorgnia [13].
the species *A. binodosa* and *A. pristina* indicating the fasiovalis Zone (Lowermost asymmetricus Zone) of the latest Middle Devonian-Early Frasnian. Thus the Middle-Upper Devonian boundary lies beneath this sample, possibly close to sample 240. The last sample from this member (S. 244) contains *Icriodus iowaensis iowaensis* indicating Early Famennian. Doubtless due to facies (mainly sandstones) only a few *Icriodus* and *Polygnathus* specimens were obtained, not sufficient to indicate precise horizons.

The last member of the formation, Member 6, includes a single bed (Bed 17 of [13]), containing *Polygnathus* and *Bispathodus*. The uppermost strata of Member 6 produced species of *Polygnathus*, *Bispathodus*, *Gnathodus*, *Scaliognathus* and *Dollymae*. The most important fauna of the uppermost Devonian was from sample S. 286. It produced richer and a more diverse fauna including *Icriodus*, *Polygnathus*, *Pelekysgnathus*, *Palmatolepis* and, in its uppermost part, *Clydagnathus*. Sample 270 with *Palmatolepis quadratinodosa inflexa* is the most important sample from this member. This species has a short range from the Upper *rhomboidea* to Lower *marginifera* Zone. *Scaphignathus*, mainly *S. velifer* (samples S. 276-S. 279), indicates the uppermost *marginifera-trachytera* zones for the upper part of Member 5.

The last member of the formation, Member 6, includes a single bed (Bed 17 of [13]), containing *Polygnathus* and *Bispathodus*. The uppermost strata of Member 6 produced species of *Polygnathus*, *Bispathodus*, *Gnathodus*, *Scaliognathus* and *Dollymae*. The most important fauna of the uppermost Devonian was from sample S. 286. It produced *Polygnathus delicatus* indicative of the old *costatus* Zone. Co-occurrence of *Bispathodus aculeatus* aculeatus indicates restriction to the Middle *expansa* Zone. Despite lack of evidence of facies changes, no conodonts were found in the next three samples (S.278-S.289). These samples were from an interval with rich Late Devonian and middle Tournaisian faunas in the underlying and overlying samples. The Devonian-Carboniferous boundary thus lies somewhere in this interval.

A Carboniferous fauna was obtained from S. 290. It produced *Dollymae bouckaerti*, indicator of the *bouckaerti* Zone within the middle Tournaisian. A diverse conodont fauna from the last sample (S. 292), from the top of formation included species of *Polygnathus*, *Bispathodus*, *Scaliognathus* and *Gnathodus*. The presence of *Scaliognathus anchoralis europensis* indicates the *anchoralis-latus* Zone the uppermost biozone of the Tournaisian.

**Taxonomy**

Only pa elements have been described in the present study. The figured specimens herein are housed in the department of geology of Ferdowsi University of Mashhad, Mashhad, Iran with the prefix AFUM. Figure 4 displays distribution of conodont species and subspecies in the present study. All studied samples in this research, obtained from the type section of the Khoshyeilagh Formation, 105 km south of Khoshyeilagh village (Fig. 2).

**Family ICRIODONTIDAE MÜLLER & MÜLLER, 1957**

**Genus Icriodus BRANSON & MEHL, 1938**

*Icriodus alborzensis* n. sp.

Plate 1, Figures 14-19

**Derivation of name:** From the Alborz Mountains, northern Iran.

**Holotype:** AFUM270, the specimen illustrated on Plate 1, Figure 15 from sample S. 233.

**Locus typicus and stratum typicum:** The type locality of the Khoshyeilagh Formation (Fig. 2); bioclastic limestone, 402 m above the base of the formation (Fig. 3).

**Diagnosis:** A species of *Icriodus* with alternation of lateral and medial rows of rounded, discrete denticles of similar size. The basal cavity is extended on the lower margin of the posterior part and shows a spur. The medial row of denticles is extended posterior to the lateral rows and there is a posterior cusp.

**Description:** The middle row of denticles is extended posterior relative to the lateral rows of denticles by two to three denticles joined by a ridge; the most posterior denticle is the largest and forms a posterior cusp.

A single specimen (Pl. 1, Fig. 14) displays very uniform and openly spaced denticles. One specimen (Pl. 1, Fig. 15) has a more or less asymmetrical outline and a flaring lower margin. Two specimens show closely spaced denticles; one of them (Pl. 1, Fig. 16) has a well-developed basal cavity in the posterior part and the other (Pl. 1, Fig. 17) displays a distinct spur. Two specimens show a wide basal cavity in the posterior part; one of them (Pl. 1, Fig. 19) has a narrower spindle and narrow basal cavity. The other (Pl. 1, Fig. 18) is a broad form with a large basal cavity, well developed spur and lacks a medial row of denticles anteriorly.

**Occurrence:** Member 3 of the Khoshyeilagh Formation; age Late Givetian.

**Material:** 10 I elements.

**Icriodus ariaei** n. sp.

Plate 1, Figure 12

**Derivation of name:** In honor of Dr. Ali Asghar Ariaei, my first geological teacher who has spent about 50 years of his life on the geology of Iran.
<table>
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<td>* * *</td>
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<tr>
<td>Icriodus obtusumarginatus</td>
<td>*</td>
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<tr>
<td>Icriodus regularisrecessus</td>
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<tr>
<td>Icriodus arkonensis</td>
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<tr>
<td>Polygnathus ling. ling. delta</td>
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<tr>
<td>Polygnathus cf. purbhona</td>
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<td>Polygnathus alveolus</td>
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<td>Icriodus difficilis</td>
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<tr>
<td>Icriodus alternatus alternatus</td>
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<td>Icriodus alborzensis</td>
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<td>Gnathodus pseudoconical</td>
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<tr>
<td>Scaphognathus anchoralis anchoralis</td>
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Figure 4. Distribution of conodont species in the Khoshyeilagh Formation.
Genus Pelekysgnathus THOMAS, 1949

Pelekysgnathus housei n. sp.
Plate 3, Figure 1

Derivation of name: For Prof. Micheal House, my first conodont teacher who continually encouraged me and contributed greatly to knowledge of the Devonian.

Holotype: AFUM797, the specimen illustrated on Plate 3, Figure 1 from sample S. 260.

Locus typicus and stratum typicum: The type locality of the Khoshyeilagh Formation (Fig. 2); bioclastic limestone, 910 m above the base of the formation (Fig. 3).

Diagnosis: A species of Pelekysgnathus characterized by a relatively circular outline in its posterior two-thirds, rather sharply converging in the anterior third, and with a triangular outline denticulation consist of a relatively strong, short and reclined cusp and apparently six denticles, irregular in form and size. A thin ridge, visible on the left side of the cusp and just anterior of it, extends laterally downward nearly to one-third of the lower margin.

Description: The species differs from Pe. furnishi by having a more extended basal cavity and a small thin ridge from one side; it lacks distinct transverse ridges intersecting the main row. Pe. glenisteri has two well-developed denticulated accessory processes in the posterior end of the main row and intersected denticles in the main row.

Occurrence: Member 5 of the Khoshyeilagh Formation. Based on the associated fauna, the species can be referred to the Late rhomboidea to the Early marginifera zones.

Material: 8 I elements

Pelekysgnathus talenti n. sp.
Plate 3, Figure 2

Derivation of name: In honor of Prof. John Talent who has generously helped people around the world with knowledge of the Devonian.

Holotype: AFUM798, the specimen illustrated on Plate 3, Figure 2 from sample S. 262.

Locus typicus and stratum typicum: The type locality of the Khoshyeilagh Formation (Fig. 2); bioclastic limestone, 940.5 m above the base of the formation (Fig. 3).

Diagnosis: A species of Pelekysgnathus with a basal cavity of relatively quadrangular outline in its posterior two-thirds, becoming much narrower in the anterior third. The main row of denticles comprises a strong reclined cusp and only two strong denticles. Two thin
ridges just anterior to the cusp extend laterally nearly half way to the lower margin.

Description: This species is distinguished from *Pe. furnishi* by having a strong cusp and only two strong denticles in the main row with no intersecting transverse ridges. *Pe. glenisteri* has denticulated accessory processes and six or more denticles in the main row. The species differs from *Pe. housei* in its outline and the number of denticles in the main row.

Occurrence: Upper part of Member 5 of the Khoshyeilagh Formation. On the basis of the stratigraphical position an early Famennian age is assigned.

Material: 8 I elements

Family POLYGNATHIDAE BASSLER, 1925
Genus *Polygnathus* HINDE, 1879
*Polygnathus klapperianus* n. sp.
Plate 2, Figure 7

Derivation of name: In honour of Prof. Gilbert Klapper who has contributed importantly on Devonian conodonts.

Holotype: AFUM316, the specimen illustrated on Plate 2, Figure 7 from sample S. 266.

Locus typicus and stratum typicum: The type locality of the Khoshyeilagh Formation (Fig. 2); bioclastic limestone, 1001 m above the base of the formation (Fig. 3).

Diagnosis: A small species of *Polygnathus* with a large depression occupying the anterior aboral surface. Platform is rounded and flattened. Free carina distinctly developed in the posterior part of the platform.

Description: The specimen is fragmentary, missing small parts of the anterior end of the free blade. The platform is rounded and flattened, with upturned outer margin in the middle part. The ornament is shagreen-like on the outer margin. The carina bears strong denticles developed distinctly in the posterior part. The aboral depression bears concentric striae and a strong keel gradually disappearing about the centre of the depression. Large pit present at the conjunction of the platform anterior margin with the keel.

Occurrence: Upper part of Member 5 of the formation; not older than *marginifera* Zone.

Material: 6 Pa elements

EXPLANATION OF PLATES
Plate 1

Figures 1-3, 8, 15-18: ×100; Figures 4, 6, 7, 9, 10, 12, 14, 20, 21, 24, 26: ×80; Figures 5: ×50; Figures 11, 13, 19, 22, 23, 25: ×60.

*Icriodus brevis* STAUFFER, 1940
Fig. 1. Upper view of AFUM103. S. 229.

*Icriodus obliquimarginatus* BISCHOFF & ZIEGLER, 1957
Fig. 2. Upper view of AFUM111. S. 210.

*Icriodus cf. regularicrescens* BULTYNCK, 1970
Fig. 3. Upper view of AFUM113. S. 210.

*Icriodus expansus* BRANSON & MEHL, 1934
Fig. 4. Upper view of AFUM136. S. 261.

*Icriodus costatus darbyensis* KLAPPER, 1958
Fig. 5. Upper view of AFUM126. S. 259.

*Icriodus difficilis* ZIEGLER & KLAPPER, 1976
Fig. 6. Upper view of AFUM140. S. 235.

*Icriodus orri* KLAPPER & BARRICK, 1983
Fig. 7. Upper view of AFUM156. S. 210.

*Icriodus arkonensis* STAUFFER, 1938
Fig. 8. Upper view of AFUM166. S. 210.

*Icriodus cf. iowaensis iowaensis* YOUNQUIST & PETERSON, 1947
Fig. 9. Upper view of AFUM214. S. 255.

*Icriodus subterminus* YOUNQUIST, 1947
Fig. 10. Upper view of AFUM237. S. 264.

*Icriodus cf. raymondi* SANDBERG & ZIEGLER, 1979
Fig. 11. Upper view of AFUM266. S. 266.

*Icriodus ariaei* n. sp.
Fig. 12. Upper view of holotype, AFUM262. S. 260.

*Icriodus khoshyeilaghensis* n. sp.
Fig. 13. Upper view of holotype, AFUM259. S. 271.

*Icriodus alborzensis* n. sp.
Fig. 14. Upper view of AFUM267. S. 234.
Fig. 15. Upper view of holotype, AFUM270. S. 233.
Fig. 16. Upper view of AFUM271. S. 230.
Fig. 17. Upper view of AFUM274. S. 233.
Fig. 18. Upper view of AFUM267. S. 237.
Fig. 19. Upper view of AFUM275. S. 238.

*Icriodus alternatus alternatus* BRANSON & MEHL, 1934
Fig. 20. Upper view of AFUM184. S. 229.

*Pelekysgnathus inclinatus* THOMAS, 1949
Fig. 21. Upper view of AFUM14. S. 269.

*Bipennatus bipennatus* (BISCHOFF & ZIEGLER, 1957)
Fig. 22. Upper view of AFUM508. S. 205.
Fig. 23. Upper view of AFUM504. S. 205.
Fig. 24. Upper view of AFUM505. S. 205.
Fig. 25. Upper view of AFUM506. S. 208.
Fig. 26. Upper view of AFUM511. S. 208.

Plate 2

Figures 1, 2, 13, 22: ×60; Figures 3, 7, 15: ×100; Figures 4, 5, 9, 11, 14, 24, 25: ×50; Figures 6, 12, 16,
18, 21: ×80; Figures 8, 10, 17, 19, 20, 23, 26: ×40.

**Polygnathus angustidiscus** YOUNGQUIST, 1945
Fig. 1. Upper-lateral view of AFUM300. S. 262.

**Polygnathus linguiformis alveolus** WEDDIGE, 1977
Fig. 2. Upper-lateral view of AFUM302. S. 210.

**Polygnathus weddigei** (CLAUSEN, LEUTERITZ & ZIEGLER, 1979)
Fig. 3. Upper-lateral view of AFUM303. S. 210.

**Polygnathus linguiformis linguiiformis gamma morphotype** KLAPPER, 1987
Fig. 4. Side view of AFUM304. S. 210.

**Polygnathus cf. perbonus** (PHILIP, 1966)
Fig. 5. Side view of AFUM308. S. 210.

**Polygnathus xylus xylus** STAUFFER, 1938
Fig. 6. Oblique upper view of AFUM315. S. 234.

**Polygnathus klapperianus** n. sp.
Fig. 7. Upper, side, oblique lower views of holotype, AFUM316. S. 266.

**Polygnathus alatus** HUDDLE, 1934
Fig. 9. Side view of AFUM337. S. 247.

**Polygnathus semicostatus** BRANSON & MEHL, 1934
Fig. 10. Side view of AFUM378. S. 271.

**Polygnathus cf. nodocostatus** BRANSON & MEHL, 1934
Fig. 11. Upper view of AFUM393. S. 288.

**Polygnathus bischoffi** RHODES, AUSTIN & DRUCE, 1969
Fig. 12. Upper-lateral view of AFUM447. S. 292.

**Polygnathus perplexus** THOMAS, 1949
Fig. 13. Side view of AFUM427. S. 271.

**Polygnathus communis communis** BRANSON & MEHL, 1934
Fig. 14. Side view of AFUM449. S. 269.
Fig. 15. Side view of AFUM456. S. 291.
Fig. 16. Lower view of AFUM458. S. 229.

**Polygnathus delicatus** ULRICH & BASSLER, 1926
Fig. 17. Upper view of AFUM465. S. 286.

**Polygnathus sp. A**
Fig. 18. Upper view of AFUM491. S. 284.

**Polygnathus sp. B**
Fig. 19. Upper view of AFUM497. S. 265.

**Clydagnathus cavisformis** RHODES, AUSTIN & DRUCE, 1969
Fig. 20. Upper view of AFUM723. S. 279.

**Clydagnathus darensis** RHODES, AUSTIN & DRUCE, 1969
Fig. 21. Upper view of AFUM724. S. 281.

**Clydagnathus ornistoni** BEINERT, KLAPPER, SANDBERG & ZIEGLER, 1971

Fig. 22. Upper view of AFUM730. S. 279.

**Scaphignathus velifer** HELMS, 1959
Fig. 23. Upper view of AFUM740. S. 276.

**Bispathodus aculatus aculatus** ZIEGLER, SANDBERG & AUSTIN, 1974
Fig. 25. Upper view of AFUM688. S. 286.
Fig. 26. Upper view of AFUM679. S. 286.

### Plate 3
Figures 1, 10, 16: ×40; Figures 2, 11, 13, 17: ×80; Figures 3, 4, 6-9, 12, 14: ×60; Figure 5: ×50; Figure 15: ×100.

**Pelekysgnathus housei** n.sp.
Figs. 1. a, b. Upper and lateral views of holotype, AFUM797. S. 260.

**Pelekysgnathus talenti** n.sp.
Figs. 2a, b. Upper and lateral views of holotype, AFUM798. S. 262.

**Ancyrodella sinelamina** (BRANSON & MEHL, 1934)
Fig. 3. Upper view of AFUM536. S. 260.

**Ancyrodella binodosa** UYENO, 1967
Fig. 4. Side view of AFUM516. S. 241.
Fig. 5. Upper view of AFUM520. S. 241.
Fig. 6. Upper view of AFUM517. S. 241.
Fig. 7. Upper view of AFUM515. S. 241.
Fig. 8. Upper view of AFUM521. S. 241.

**Ancyrodella pristina** KHALYMBADZHA & CHERNYSHEVA, 1970
Fig. 9. Upper view of AFUM630. S. 271.

**Palmatolepis cf. wolskajae** OVNATANOVA, 1969
Fig. 10. Upper view of AFUM630. S. 271.

**Palmatolepis quadratinodosa inflexa** MÜLLER, 1959
Fig. 11. Upper view of AFUM552. S. 270.

**Pseudopolygnathus oxypageus** LANE, SANDBERG & ZIEGLER, 1980
Fig. 12. Upper view of AFUM722. S. 290.

**Dollymae bouckaerti** GROESSENS, 1977
Fig. 13. Upper view of AFUM768. S. 290.

**Gnathodus pseudoemigler** THOMAS & FELLOW, 1970
Fig. 14. Upper view of AFUM767. S. 292.
Fig. 15. Upper view of AFUM766. S. 292.
Fig. 16. Upper view of AFUM761. S. 292.

**Scaliognathus anchoralis europensis** LANE & ZIEGLER, 1983
Fig. 17. Upper, side and lower views of AFUM784. S. 292.
Plate 2
Acknowledgments

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