

## Late Devonian conodonts from the Chah-Riseh area, central Iran

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**Abstract** – In order to refine the chronologic framework for the Chah-Riseh area, north-east of Isfahan, limestone samples were collected from a section measured through the most continuous outcrop of limestone thought to span the youngest Late Devonian and/or Early Carboniferous time interval, through an apparent erosional interval into a substantial sequence of dolomitised carbonate. A small Late Devonian (Early *expansa* Zone) conodont fauna was recovered from the lower half of the section. Above the conodont-bearing horizons a red shale and quartz arenite horizon indicative of an erosional interval proved to be unfossiliferous. Above that again, the sequence of dolomitised carbonates is dated as Early Permian on the basis of their fauna of foraminifers. The hiatus between the lower limestone and the upper dolomitised limestones encompasses latest Famennian, the entire Carboniferous and possibly the earliest Permian horizons. Based on chronology and lithology, the lower limestone is referred to the Shishtu Formation, and the upper dolomitised carbonates to the Jamal Formation.

### INTRODUCTION

Controversy regarding the age of the sequence in the Chah-Riseh area that underlies Permian horizons in the region (Figure 1) has arisen because a variety of ages have been assigned to the thin-bedded limestone, sandy limestone and muddy limestone horizons in the area. Based on palynological data, a late Famennian (Strunian) age was suggested by Hamedani (1996: 320). In contrast, an Early Carboniferous age was proposed by a number of researchers, for example, Djafarian and Brice (1973: 2128), Zahedi (1976: 14–15), Djafarian (1977: 182), Shirani (1995: 20) and Gholamalian (1997: 42, 82). This study was undertaken in order to obtain further time constraining data.

### GEOLOGICAL SETTING

The Chah-Riseh area, northeast of Isfahan in central Iran, is located close to the Qum-Zefreh Fault Zone that consists of many parallel to subparallel minor faults. The trend of the fault system is NW to SE, the common trend of the Zagros Mountain Range and the Zagros Subduction Zone. Minor faults have disturbed the rock sequences of the area acting as horst and graben structures resulting in Devonian sediments being found adjacent to Miocene deposits (Figure 1).

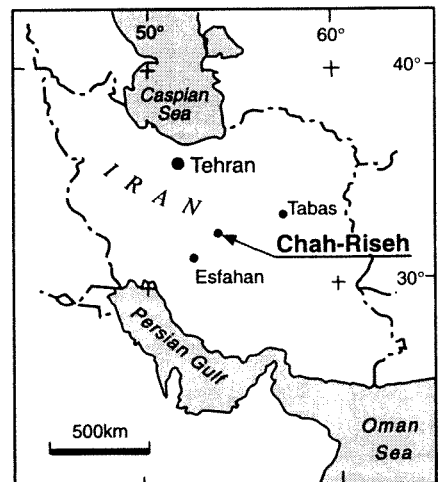
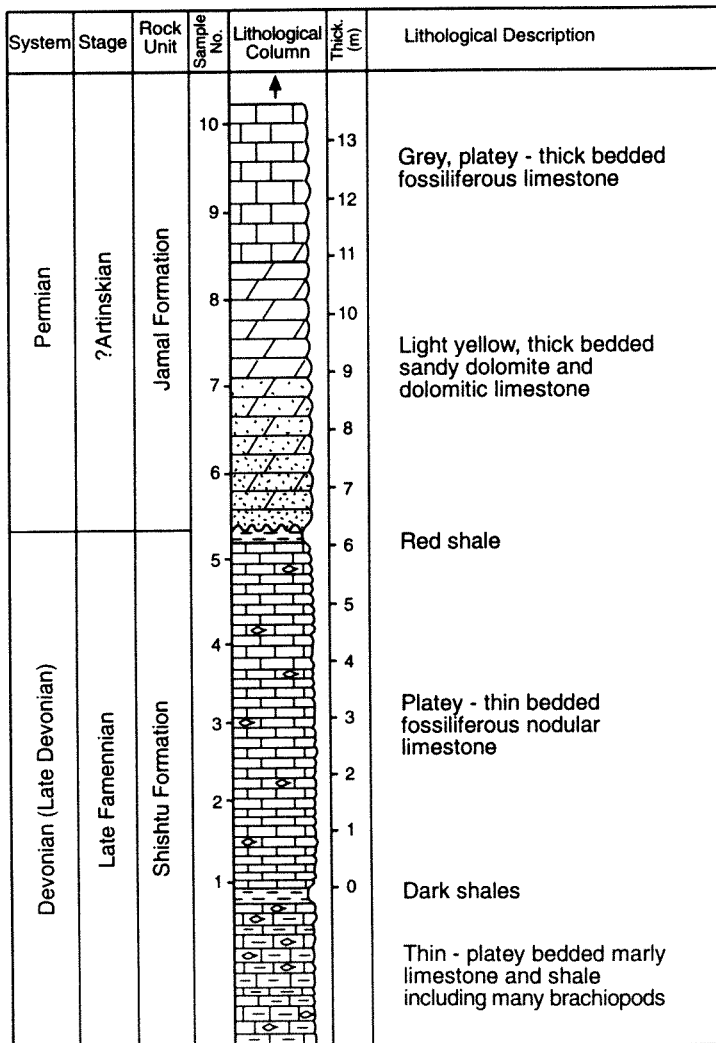
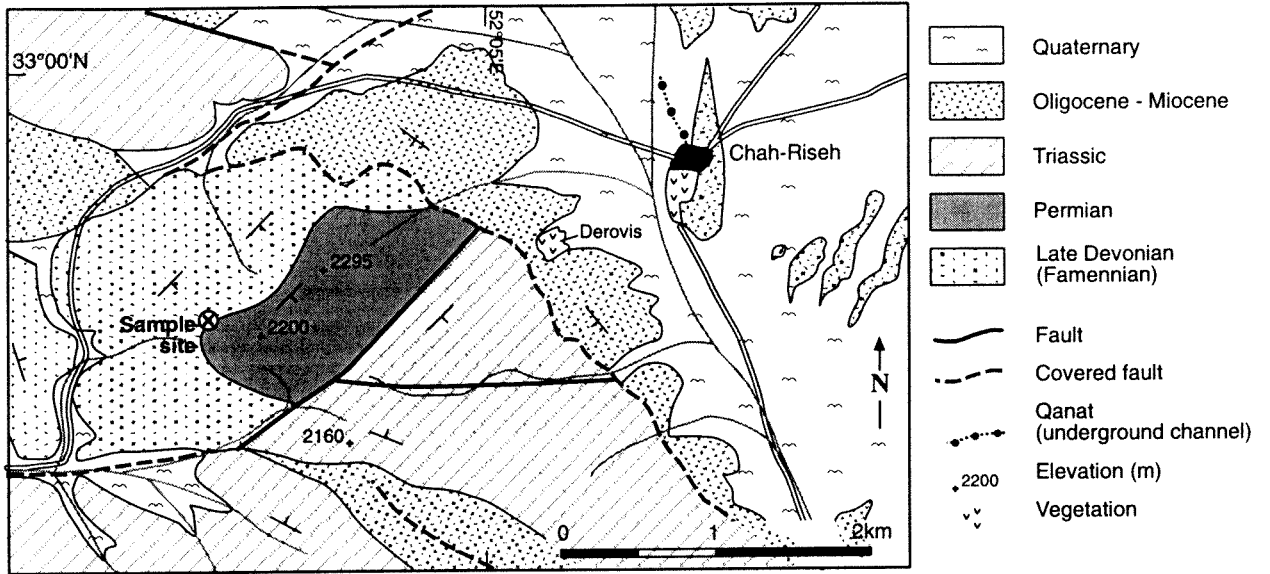
The oldest rock unit exposed in the Chah-Riseh area is a series of sandstone, dolomite, limestone and marls. Gholamalian (1997) suggested the basal beds of this unit were Frasnian in age. The highest

beds of the unit are shown herein to be Famennian (Early *expansa* Zone) in age. According to lithologic and palaeontologic evidence, these deposits are equivalent to the Padeha, Bahram and Shishtu formations and suggest that a shallow sea existed in the area during the late Famennian.

Portion of the Shishtu Formation in the Ozbakkuh Mountains area appears to be equivalent to the Geirud Formation (Member A) in Central Alborz. Stöcklin *et al.* (1965) believed the entire Shishtu Formation in the Shotori Range to range in age from the Late Devonian into the Carboniferous. On the basis of conodont studies in the same area, Yazdi (1996, 1999) has shown the range to be from Frasnian (late Early *hassi* Zone to Early Carboniferous (at least the *anchoralis-latus* Zone). Stöcklin and Setudehnia (1977: 223–225) divided the Shishtu Formation into two parts: Shishtu 1 (Frasnian-Famennian and ?Tournaisian) and Shishtu 2 (late Tournaisian into early Viséan). Wendt *et al.* (1997: 292–294, figures 8, 9) concluded that Famennian horizons are present at Howz-e-Dorah but did not mention the eroded surface below the Permian horizons.

### RESULTS

From a 13.5 m interval of predominantly limestone horizons, 10 samples were acid leached in an attempt to recover age-diagnostic conodonts. The small fauna recovered from the first 5 horizons (Figure 1) is assigned a Late Famennian (Early *expansa*) age on the basis of the co-occurrence in



Legend : Stratigraphic Column

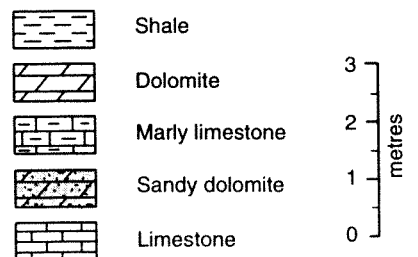


Figure 1 Diagrams showing location and stratigraphic details of the section sampled at Chah-Riseh, northeast of Isfahan, central Iran.

Sample Gh-1 at Chah-Riseh of *Pelekysgnathus guizhoensis* Wang and Wang, *Scaphignathus velifer leptus* Ziegler and Sandberg, *Clydagnathus ormistoni* Beinert *et al.* and *Polygnathus delicatulus* Rhodes, Austin and Druce (see discussion of the age of the species below). Other conodont elements recovered are consistent with an Early *expansa* age.

Samples 6 to 10, collected above the red shales and quartz arenite horizon in thick bedded, highly dolomitised carbonates, failed to produce conodonts. Thin sectioning of the samples revealed an Early Permian foraminiferan fauna of at least 9 species (K. Bell pers. comm. 1999). These are the focus of a paper by Iranian colleagues. Other fossils recovered from these horizons, known elsewhere as the Jamal Formation, included bryozoans, brachiopods, gastropods, algae and corals.

It appears that the red shales and quartz arenite are indicative of an erosional surface; the hiatus in sedimentation it represents at Chah-Riseh is considerable, spanning latest Famennian (from Middle *expansa* Zone), the entire Carboniferous and the earliest Permian. Similarly, a hiatus representing a similar time interval has been identified in the Zagros area (Ghavidel-Syooki 1997) and in central Iran (Yazdi unpub. data). Yazdi (1996, 1999: 178) has also reported such an erosional surface from Howz-e-Dorah in the Shotori Range to the east of Chah-Riseh but here the zones represented by the hiatus are restricted to Middle *praesulcata* Zone through to *sandbergi* Zone. It is postulated, therefore, that uplift in central Iran initiated a west to east regression with the result that the effect of the event close to the source of the uplift in central Iran is greater than in the Shotori Range.

#### SYSTEMATIC PALAEOLOGY

All specimens documented are housed in the Geological Department Museum of Isfahan University, Iran, catalogued with the prefix EUIC.

#### Order Conodontophorida Eichenberg, 1930

#### Family Icriodontidae Müller and Müller, 1957

#### Genus *Pelekysgnathus* Thomas, 1949

#### Type species

*Pelekysgnathus inclinatus* Thomas, 1949

*Pelekysgnathus guizhoensis* Wang and Wang, 1978

Figures 2.17, 19

*Pelekysgnathus guizhoensis* Wang and Wang 1978: 75, pl. 3, figs 7–10

*Pelekysgnathus guizhoensis*: Over and Barrick 1990: pl. 1, figs 10, 11, 14–16

*Pelekysgnathus guizhoensis*: Over 1992: 304, figs 5.5–6, 5.9–12

#### Remarks

These slightly arched, coniform elements with longitudinal striae on the lateral surface are M or S elements of the apparatus. The basal cavity is large and asymmetrical. The specimens from Chah-Riseh resemble coniform elements from south-central Oklahoma (Over 1992: figs 5.5–6, 5.9–12). According to Wang and Wang (1978), *Pel. guizhoensis* occurs in horizons dated as Early *expansa* Zone to Early *praesulcata* Zone. Over (1992) reports they are common in late Famennian horizons of the upper Woodford Shale throughout the Arbuckle Mountains (*expansa?*–Early *praesulcata* zones).

#### Occurrence

Two elements in Sample 1, Chah-Riseh.

#### *Pelekysgnathus* sp.

Figure 2.18

#### Remarks

This coniform M element has a large asymmetrical basal cavity elongated towards the outer margin. In lateral view, longitudinal striae ornament the outer half of the element and become more pronounced above the elongated margin at the base of the element.

#### Occurrence

One element in Sample 1, Chah-Riseh.

#### Order Prioniodinida Sweet, 1988

#### Family Spathagnathodontidae Hass, 1959

#### Genus *Bispathodus* Müller, 1962

#### Type species

*Spathodus spinulicostatus* E.B. Branson, 1934

*Bispathodus bispathodus* Ziegler, Sandberg and Austin, 1974

Figure 3

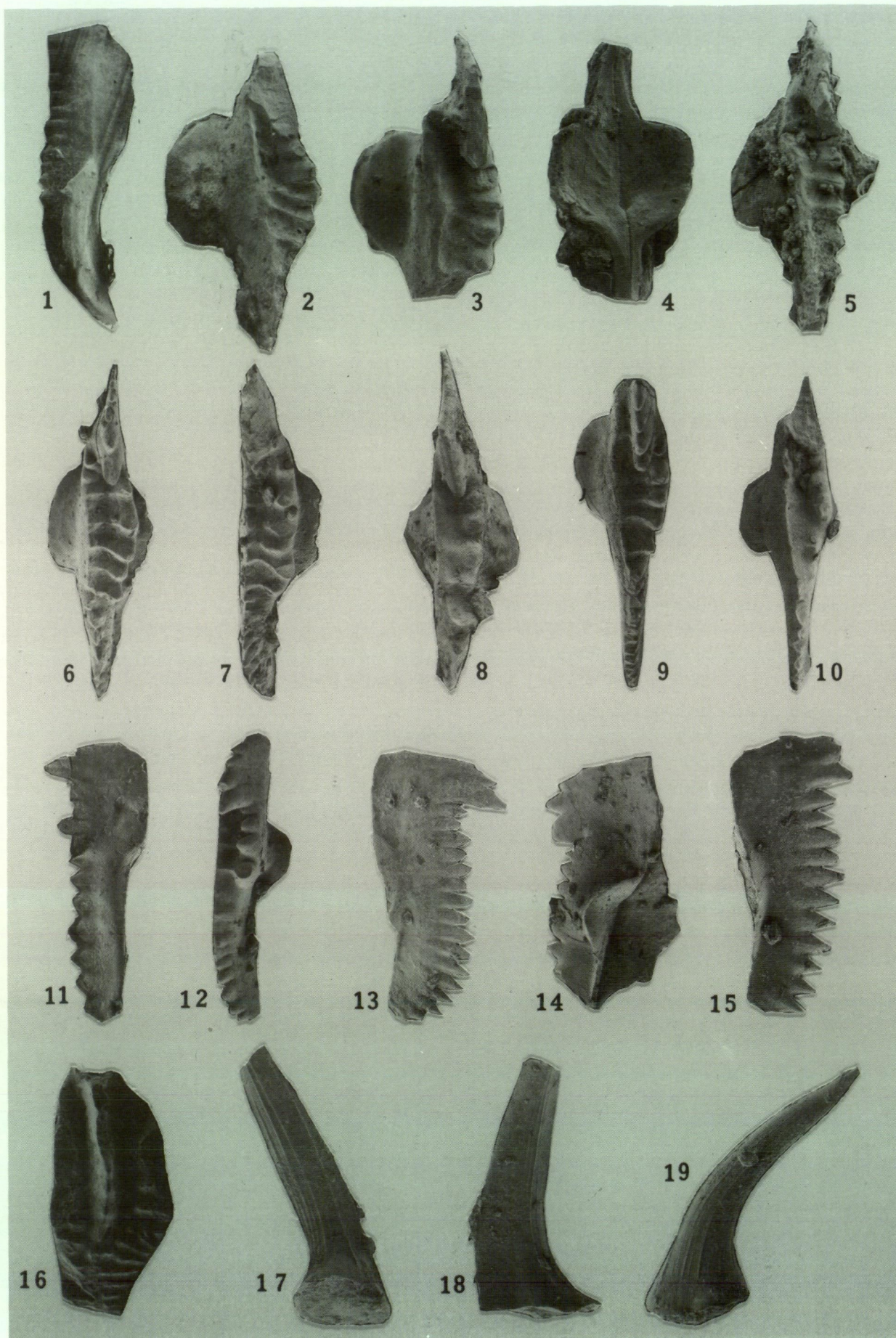
*Spathognathodus aculeatus*: Ziegler 1962: pl. 13, figs 28–30

*Bispathodus bispathodus* Ziegler *et al.* 1974: 102, pl. 3, figs 12, 17, 21

#### Remarks

This narrow species has a large, asymmetrical basal cavity expanded from a little anterior of mid-length of the unit and tapering to the posterior. In lateral view, the 3 anterior-most denticles are enlarged, fused, increasing in height from the







anterior extremity and curve backwards to the posterior. A series of numerous, smaller denticles continue to the posterior extremity. Viewed from above, three lateral denticles are evident on the right side of the free blade. According to Ziegler *et al.* (1974) this species ranges in age from middle part of Late *postera* through *expansa* Zone to Early *praesulcata* Zone.

#### Occurrence

One Pa element from Sample 1, Chah-Riseh.

#### *Bispathodus aculeatus plumulus* (Rhodes, Austin and Druce, 1969)

Figures 2.2, 3, 9, 10, 12; Figure 4

*Spathognathodus aculeatus plumulus* Rhodes *et al.* 1969: pl. 1, figs. 1, 2, 5, 6

*Bispathodus aculeatus plumulus*: Ziegler *et al.* 1974: 101–102, pl. 3, figs. 101, pl. 3, fig. 24, (*q.v.* for synonymy to 1974)

*Bispathodus aculeatus plumulus*: Nicoll and Druce 1979: 21–22, pl. 24, figs. 1–6, (*q.v.* for synonymy to 1979)

*Bispathodus aculeatus plumulus*: Mory and Crane 1982: fig. 8A–C

*Bispathodus aculeatus plumulus*: Barskov *et al.* 1984: pl. 2, figs. 2–6

*Bispathodus aculeatus plumulus*: Mawson and Talent 1997: 210

*Bispathodus aculeatus plumulus*: Molloy *et al.* 1997: pl. 2, figs. 1–4; pl. 3, figs. 1–3

#### Remarks

A small number of specimens referred to the distinctive *Bispathodus aculeatus plumulus* were recovered from low in the section. The species is known to range from the *expansa* Zone through to the *sulcata* Zone and possibly into the *sandbergi* Zone (Sandberg 1979; Mawson and Talent 1997).

#### *Bispathodus stabilis* (Branson and Mehl, 1934)

Morphotype 1 Ziegler, Sandberg and Austin, 1974  
Figure 2.15

*Spathodus stabilis* Branson and Mehl 1934: 188, pl. 17, fig. 20

*Bispathodus stabilis* Morphotype 1 Ziegler *et al.* 1974: 103–104, pl. 1, fig. 10; pl. 3, figs 1–3

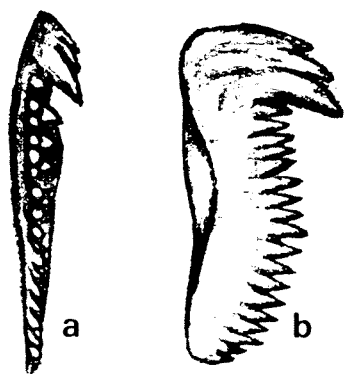


Figure 3 *Bispathodus bispathodus* Ziegler, Sandberg and Austin. a, b, upper and lateral views drawn from EUC 3024 from sample Gh-1 (x60).

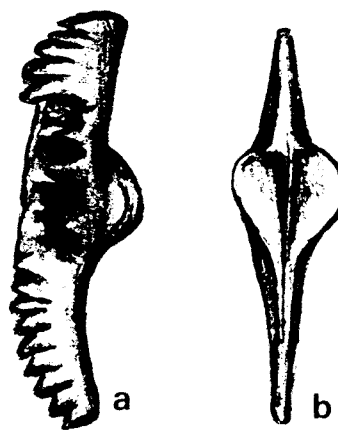


Figure 4 *Bispathodus aculeatus plumulus* (Rhodes, Austin and Druce). a, b, lateral and lower views drawn from EUC 3010 from sample Gh-1 (x60).

Figure 2 1, *Polygnathus delicatulus* Ulrich and Bassler. EUC 3001, Pa element, lateral view, sample Gh-1, (x60). 2, 3, 9, 10, 12, *Bispathodus aculeatus plumulus* (Rhodes, Austin and Druce). EUC 3011 from Gh-1, EUC 3021 from Gh-2, EUC 3019 from Gh-2, EUC 3009 from Gh-1, EUC 3010 from Gh-1, all upper views of Pa elements, (all x60). 4–8, *Clydagnathus ormistoni* Beinert, Klapper, Sandberg and Ziegler. 4, EUC 3016, Pa element, lower view, sample Gh-1, (x60), 5–8, EUC 3028, EUC 3013, EUC 3014, EUC 3015, respectively, all upper views of Pa elements from Gh-1, (all x60). 11, *Scaphignathus velifer leptus* Ziegler and Sandberg. EUC 3026, lateral view of Pa element, Gh-1, (x60). 13, *Mehlina* sp. EUC 3024, lateral view of Pa element, Gh-1, (x60). 14, *Bispathodus* sp. EUC 3009, lateral view of Pa element, Gh-1, (x60). 15, *Bispathodus stabilis* (Branson and Mehl). EUC 3007, lateral view of Pa element, Gh-1, (x60). 16, *Polygnathus semicostatus* Branson and Mehl. EUC 3003, upper view of broken Pa element, Gh-1, (x60). 17, 19, *Pelekysgnathus guizhoensis* Wang and Wang. EUC 3005 and EUC 3004 respectively, lateral views, Gh-1, (x60). 18, *Pelekysgnathus* sp. EUC 3006, Gh-1, (x60).

*Bispathodus stabilis*: Hou *et al.* 1985: 144, pl. 40, figs 11–13

*Bispathodus stabilis* Morphotype 1: Over 1992: 307, pl. 6, figs 1, 16, 21, 26, 28

*Bispathodus stabilis*: Molloy *et al.* 1997: 2, pl. 1, fig. 6

*Bispathodus stabilis*: Mawson and Talent 1997: 208, fig. 11.10, 11, 13

#### Remarks

The basal cavity of this single-rowed Pa element is thin, almost symmetrical basal cavity that does not extend to the posterior extremity of the blade, a feature distinguishing Morphotype 1 (Ziegler *et al.* 1974). In lateral view, the denticles decrease in height from the anterior to the posterior with the anteriormost denticles being fused and more slender and the posteriormost shorter and more discrete. The specimens from Chah-Riseh are very similar to those illustrated by Ziegler *et al.* (1974) and Over (1992). Ziegler *et al.* (1974) give the range of this morphotype as from Late *marginifera* Zone to Late *crenulata* Zone.

#### Occurrence

Two Pa elements (one broken) from Sample 1, Chah-Riseh.

#### *Bispathodus* sp. Figure 2.14

#### Remarks

A broken Pa element is assigned to *Bispathodus* rather than *Mehlina* because of having an expanded basal cavity.

#### Occurrence

One Pa element from Sample 1, Chah-Riseh.

#### Genus *Mehlina* Youngquist, 1945

#### Type species

*Mehlina irregularis* Youngquist, 1945

#### *Mehlina* sp. Figure 2.13

#### Remarks

A Pa element is assigned to *Mehlina* on the basis of its narrow basal cavity. Two Pb elements (not illustrated herein) have high, sharp denticles of irregular height and a narrow basal cavity.

#### Occurrence

One Pa element and 2 Pb elements from Sample 1, Chah-Riseh.

#### Genus *Scaphignathus* Helms, 1959

#### Type species

*Scaphignathus velifer* Helms, 1959

#### *Scaphignathus velifer leptus* Ziegler and Sandberg, 1984

Figure 2.11; Figure 5

*Scaphignathus velifer leptus* Ziegler and Sandberg 1984: 188, pl. 2, figs 9, 10

*Scaphignathus velifer leptus* 1999: Yazdi: pl. 6, figs 5–7

#### Remarks

The platform of the Pa elements of *Sc. velifer leptus* from Chah-Riseh is slightly arched, very slender and has 8 pairs of nodes on the upper surface. They are very similar to the specimen illustrated by Yazdi (1999, pl. 6, fig. 5) from the Niaz section at Kale Sadar. Although Ziegler and Sandberg (1984: 184) indicate that this subspecies becomes extinct at the upper boundary of the Late *postera* Zone, they note that *Sc. velifer leptus* occurs with the oldest known occurrence of *Clydagnathus ormistoni* in East Glenwood Canyon, Colorado (Ziegler and Sandberg 1984: 188). Sandberg and Ziegler (1979) state *C. ormistoni*, as found in Germany and the United States, is restricted to Early *expansa* Zone. If this is so, the co-occurrence of *Sc. velifer leptus* and *C. ormistoni* most likely indicates the interval to be of early Early *expansa* age. Interestingly, Matyja (1993: 56–57) notes the anomalous occurrence of *Sc. velifer velifer* in faunas of Early *expansa* Zone.

#### Occurrence

Two Pa elements from Sample 1, Chah-Riseh.

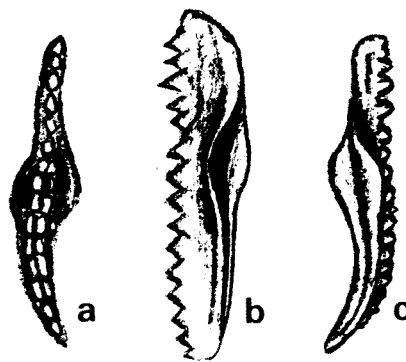
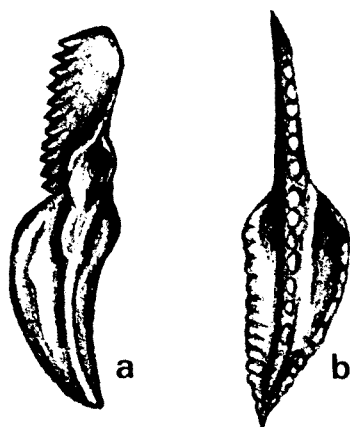


Figure 5 *Scaphignathus velifer leptus* Ziegler and Sandberg. a, b, c, upper, lateral and lower views drawn from EUIC 303026 from sample Gh-1 (x60).



**Figure 6** *Polygnathus delicatulus* Ulrich and Bassler. a, b, upper and lower views drawn from EUIC 3001 from sample Gh-1 (x60).

#### Family *Polygnathidae* Bassler, 1925

#### Genus *Polygnathus* Hinde, 1879

#### Type species

*Polygnathus dubius* Hinde, 1879

#### *Polygnathus delicatulus* Ulrich and Bassler, 1926

Figure 2.1; Figure 6

*Polygnathus delicatulus* Ulrich and Bassler 1926: 45, pl. 7, fig. 9

*Polygnathus delicatulus*: Klapper in Ziegler 1975: 277–278, *Polygnathus* pl. 6, fig. 5 (*q.v.* for synonymy to 1974)

*Polygnathus delicatulus*: Metzger 1989: 518, Fig. 15.5

*Polygnathus delicatulus*: Molloy *et al.* 1997: pl. 5, figs 1, 2

#### Remarks

The narrow, spear-shaped platform is arched downwards. Ornament along the lateral margins of the platform consists of transverse nodes or ridges that are separated from the carina by a smooth, narrow trough. The occurrence of *P. delicatulus* in Sample 2 indicates that the horizon must be at least Early *expansa* Zone.

#### *Polygnathus semicostatus* Branson and Mehl, 1934

Figure 2.16; Figure 7

*Polygnathus semicostatus* Branson and Mehl 1934: 247–248, pl. 21, figs 1–2.

*Polygnathus semicostatus*: Ziegler [ed.] 1973: 317–318 (*q.v.* for synonymy to 1971)

*Polygnathus semicostatus*: Dreesen and Orchard 1974: 17, pl. 1, fig. 7

*Polygnathus semicostatus*: Sandberg and Ziegler 1979: 187, pl. 5, figs 1–5

*Polygnathus semicostatus*: Wang and Ziegler 1982: 155, pl. 1, figs 23, 30, 31

*Polygnathus semicostatus*: Weyant *et al.* 1988: 250, pl. 3, figs 6–7

*Polygnathus semicostatus*: Metzger 1989: 521, fig. 15.17–15.19

*Polygnathus semicostatus*: Johnson and Chatterton 1991: pl. 2, fig. 8

*Polygnathus semicostatus*: Savoy and Harris 1993: 2410, spec. no. 46

*Polygnathus semicostatus*: Ji and Ziegler 1993: 84, text-fig. 6, fig 4

*Polygnathus semicostatus*: Coen and Grossens 1996: 24, fig. 3, pl. 1, fig. 15

*Polygnathus semicostatus*: Coen 1996: pl. 2, fig. 12

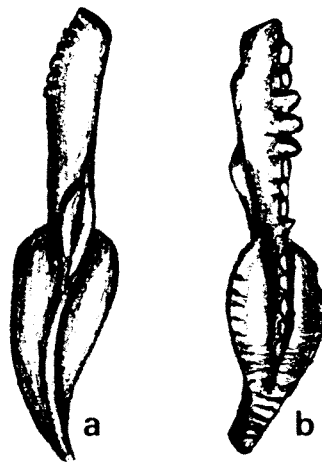
*Polygnathus semicostatus*: Yazdi 1999: pl. 8, figs 8–11

#### Remarks

The complete specimen from Chah-Riseh has a relatively narrow, curved platform and a long the anterior blade with the posterior tongue arching downwards. Transverse ridges are developed across the tongue and thence along the margins of the platform, becoming less distinct close to the anterior margin of the platform. Ji and Ziegler (1993) record this species from the Lali section in south China to range from Middle *crepida* Zone to Late *expansa* Zone.

#### Occurrence

Two Pa elements (one broken) from Sample 2, Chah-Riseh.



**Figure 7** *Polygnathus semicostatus* Branson and Mehl. a, b, lower and upper views drawn from EUIC 3002 from sample Gh-1 (x60).

*Polygnathus communis* group**Remarks**

Barskov *et al.* (1991) have assigned this group to the genus, *Neopolygnathus* on the grounds that the sunken basal cavity surrounded by a shawl-like rim common to the group is unique. Because of having insufficient material we have not been able to confirm the change.

***Polygnathus communis communis* Branson and Mehl, 1934**

*Polygnathus communis* Branson and Mehl 1934: 293, pl. 24, figs 1–4

*Polygnathus communis communis*: Hou *et al.* 1985: 113, pl. 35, fig. 2

*Polygnathus communis communis*: Coen and Grossens 1996: 24, fig. 3, pl. 1, fig. 10

*Polygnathus communis communis*: Molloy *et al.* 1997: 17, pl. 8, fig. 5

*Polygnathus communis communis*: Yazdi 1999: pl. 7, figs 7–13, 15

**Remarks**

The unillustrated specimen from Chah-Riseh has a smooth, narrow, spear-shaped platform with the denticles on the slightly curved carina resembling a series of nodes. The posterior third of the platform arches gently downwards. According to Ji and Ziegler (1993), *P. c. communis* ranges in age from Middle *crepida* Zone to Early Carboniferous.

**Occurrence**

One specimen from Sample 1, Chah-Riseh.

**Family Cavusgnathidae Austin and Rhodes, 1981****Genus *Clydagnathus* Rhodes, Austin and Druce, 1960****Type species**

*Clydagnathus cavusformis* Rhodes, Austin and Druce, 1969.

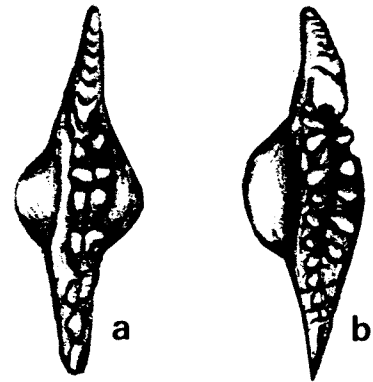
***Clydagnathus ormistoni* Beinert, Klapper, Sandberg and Ziegler 1971**

Figure 2.4–8; Figure 8

*Clydagnathus ormistoni* Beinert *et al.* 1971: 84, pl. 2, figs 13–17

*Clydagnathus ormistoni*: Sandberg and Ziegler 1979: 193, pl. 6, figs 17, 18

*Clydagnathus ormistoni*: Austin *et al.* 1985: pl. 4.8, fig. 4



**Figure 8** *Clydagnathus ormistoni* Beinert, Klapper, Sandberg and Ziegler. a, b, upper views drawn from EUIC 3015, and EUIC 3013 respectively, both from sample Gh-1 (all x60).

*Clydagnathus ormistoni*: Matyja 1985: pl. 22.5, figs 1–4

*Clydagnathus ?ormistoni*: Yazdi 1999: pl. 13, fig. 11, 12

**Remarks**

A number of specimens are assigned to *Clydagnathus ormistoni* because of their high blade attached to the right side of the platform, their large open basal cavity and the medial trough that is evident even in specimens that appear to have lateral nodes that appear to meet. According to Sandberg and Ziegler, (1979), *C. ormistoni* is restricted to the Early *expansa* Zone.

**Occurrence**

Three specimens from Sample 1, Chah-Riseh.

**Family Unknown****Genus *Branmehla* Hass, 1959****Type species**

*Spathodus inornatus* Branson and Mehl, 1934

***Branmehla inornata* (Branson and Mehl, 1934)**

Figure 9

*Spathodus inornata* Branson and Mehl 1934: 185, pl. 17, fig. 23

*Branmehla inornata*: Hass 1959: 381–382, pl. 50, fig. 3

*Branmehla inornata*: Over 1992: 308, pl. 6, fig. 31

*Branmehla inornata*: Molloy *et al.* 1997: 24, pl. 11, figs 4–7

**Remarks**

Both specimens from Chah-Riseh have a straight, unarched blade that declines in height posterior to the main cusp. The denticles are generally sub-equal



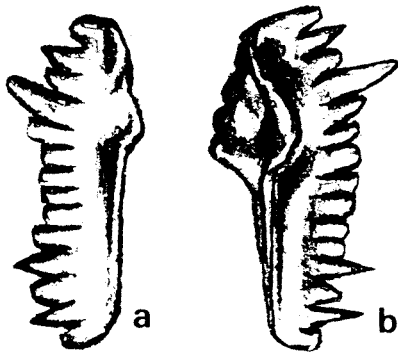


Figure 9 *Branmehla inornata* (Branson and Mehl). a, b, lateral views drawn from EUIC 3029 from sample Gh-1 (x60).

in height with two or three more prominent ones situated towards the anterior. The asymmetrical basal cavity is in the posterior third of the unit. Over (1992) illustrates a specimen from the Arbuckle Mountain, south-central Oklahoma that closely resembles the material from Central Iran. Ziegler and Sandberg (1984) give the range of the species from Late *marginifera* Zone to Late *praesulcata* Zone. Faunas from the Khyber Agency (Molloy *et al.* 1997) that include *B. inornata* have been dated as Late *expansa* Zone to Early *duplicata* Zone.

#### Occurrence

Two Pa elements from Sample 1, Chah-Riseh.

#### ACKNOWLEDGEMENTS

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