Some upper Silurian - middle Devonian conodonts from the northern part of Western Meseta of Morocco: systematic and palaeogeographical relationships

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ABSTRACT – This is the first report on Wenlock-Givetian conodonts from the northern part of Western Meseta of Morocco. The systematic study of this North African material brings complementary data on the palaeogeographic distribution over the world at this period. Faunal affinities are recognised between Western Moroccan Meseta, Central Europe and North America, particularly during the Upper Silurian and Lower Devonian.


INTRODUCTION

The purpose of this paper is to describe some conodonts of Silurian and Devonian age from the northern part of Western Meseta of Morocco and to present palaeogeographical relationships between these faunas and those from other parts of the world.

The North Western Meseta is characterised by a continuous sequence of marine sediments (carbonates and shales) from Lower Silurian until Middle Devonian. The Silurian strata represent a transgressive sequence resulting to a sea level rise, as consequence of the melting of the Late Ordovician glaciers. This transgression reached its maximum in the Llandovery. The most common facies of the Silurian are the graptolitic black shales with intercalations of limestone (beds or lenses) in the upper part of the sequence.

In the Lower-Middle Devonian, Morocco continued to be part of the Gondwana passive margin. The sedimentation from the Silurian to the Devonian was steady without any effects of the late Caledonian orogeny. The Lower Devonian lithofacies is formed by shales with bioclastic carbonate intercalations, whereas, in the Middle Devonian, carbonate sedimentation prevailed with extensive development of reef buildups. In North Western Meseta, the Silurian and the Devonian crop out mainly in Rabat-Tiflet area, Oued Cherrat, Oulad Abbou, Mechraa Ben Abbou, Ben Ahmed (Text-figs. 1, 2). The more complete study of conodonts in this region reported here brings additional precision about the stratigraphy of the Silurian to Middle Devonian (Benfrika, 1994).

RELATIONS

UPPER SILURIAN

The Wenlock-Ludlow, identified in northern part of Western Meseta (Rabat-Tiflet area), has particularly yielded condonts, which show similarity with North American and central European conodonts; for example, Kocicellela absidata, Kocicellela stauro, Kocicellela variabilis, Ozarkodina bohemica, Ozarkodina excavata, Ozarkodina sagitta sagitta, Polygnathoides emarginatus.

This conodont fauna occurs mainly in Oued Grou (SE of Rabat). The lithofacies in this area is represented by condensed successions with a lower part composed of graptolitic black limestone and an upper part with crinoidal limestones. The sagitta Zone and the lower variabilis Zone are identified in this sequence by the presence of the index fossils, Ozarkodina sagitta sagitta and Kocicellela variabilis, According to Garcia-Loper et al. (1996), this type of condensed succession occurs in the Southern Montagne Noire, Caledonian Coastal Ranges and Sardinia. In other part, it seems that North Western Mesetian Silurian conodont fauna, and particularly that from the Rabat-Tiflet area, show a relatively higher diversity in Gondwana as compared with those from Spain, for example.
**LOCHKOVIAN**

During the Lochkovian, a conodont fauna identical with central Europe and North America has been found in North Western Moroccan Meseta, for example: *Caudicriodus woschmidtii, Ozarkodina remschidenis remschidenis, Ozarkodina steinhornensis repetitor, Ozarkodina wurmi*.

The majority of these conodonts occurs from upper Lochkovian of SE of Rabat, where the lithofacies is represented by black, bituminous, fine-grained, platy limestones with intercalations of thin layers of shales. The limestone contains a few conodonts, tentaculites, ostracods, brachiopods and trilobites. The shales contain graptolites. According to Alberti (1988), the Rabat-Tiflet area, during the Silurian and Devonian, is very reminiscent of the Barrandian area in facies and faunal development.

**PRAGIAN**

During the Pragian, the species of North Western Moroccan Meseta are *Caudicriodus celtibericus, Caudicriodus curvicauda, Latericriodus steinachensis, Ozarkodina pandora, Ozarkodina steinhornensis miae*.
and, after Alberti (1988), *Eognathodus sulcatus*. Except for *Caudicriodus celtibericus*, all species are recognised at Central Europe (Chlupac et al., 1980; Chlupac, 1993) and North America. The species *Ozarkodina steinbornensis miae*, *Caudicriodus celtibericus* and *Caudicriodus curvicauda* were also recognised in Spain. These species occur mainly in Rabat-Tiflet area, where the lithofacies is composed of bioclastic nodular limestone of grey colour with numerous tentaculites.

**Emsian and Middle Devonian**

With the Emsian, the conodont faunas of Moroccan Meseta presented more affinities with Pre-Saharian (Anti-Atlas) and European Faunas, compared with those from North America: *Latericriodus bilatericrescens*, *Latericriodus bekmannii*, *Icriodus ancestralis*, *Icriodus culicellus*, *Icriodus fusiformis*, *Icriodus rectirostratus*, *Ozarkodina steinbornensis steinbornensis*, *Pelekygnathus*...
serratus, Polygnathus dehiscens, Polygnathus inversus.

During the Middle Devonian, the conodonts from Morocco (Anti-Atlas, Meseta, Central Morocco) showed increasing cosmopolitanism: Eognathodus bipennatus, Icriodus brevis, Icriodus corniger, Icriodus obliquimarginatus, Icriodus struwei, Ozarkodina bidentata, Ozarkodina brevis, Ozarkodina plana, Ozarkodina raschi, Polygnathus angusticoicatus, Polygnathus angustipennis, Polygnathus costatus, Polygnathus latus, Polygnathus linguiformis, Polygnathus pseudofoliatus, Polygnathus rhenanus, Polygnathus timorenensis, Polygnathus varcus, Polygnathus xylus, Tortodus kockelianus, Tortodus variabilis.

**CONCLUSIONS**

During the Upper Silurian and Lower Devonian (Lochkovian and Pragian), the closest palaeogeographical relationships are between North Western Moroccan Meseta, central Europe and North America compared with Spain. For the Emsian, the communications with North America decreased, while they increased with Europe and Moroccan Pre-Sahara.

With the Middle Devonian, the conodonts of Morocco showed increasing cosmopolitanism, privileged by greater communication between most palaeogeographical areas. So, most conodonts from Moroccan Meseta are cosmopolitan and illustrate the faunal homogeneity between North Gondwanan regions and other palaeogeographic area.

Furthermore, the systematic study of these North African fossils brings complementary precisions about the stratigraphy from Wenlock (sagitta Zone) to Givetian (varcus Zone) of the North Western Moroccan Meseta and corroborates the affinities (at the species level) between Spanish-Central European and North American faunas.

**SYSTEMATIC PALAEOONTOLOGY**

**Kockelella absidata** Barrick & Klapper, 1976

Pl. 1, fig. 5

*Pa element*

1964 Ozarkodina fusadomumata (Walliser) - **Walliser**, pp. 56-57, pl. 23, figs. 5-16, 18-24.

1976 *Kockelella absidata* n. sp. - **Barrick & Klapper**, p. 73, pl. 2, figs. 15-16.

Remarks and relations - Some features of mesetean specimens, like the width of cusp, the outline of basal cavity, are slightly different from those illustrated by Barrick & Klapper (1976). The arched posterior blade is not considered here like one characteristic feature. The other elements are identical with corresponding elements of *K. variabilis*.

Range and distribution – Wenlock-Ludlow from Rabat-Tiflet area (sagitta/stauroi Zone - Lower variabilis Zone).

Material and occurrence - 16 Pa elements from Oued Grou (SE of Rabat), samples G4, G14, G15, G17; 4 Pa elements, 2 Pb, 2 Sa, 1 Sb, 5 Sc from Oued Tiflet (S of Tiflet), samples T2, T3.

**Kockelella stauros** Barrick & Klapper, 1976

Pl. 1, fig. 8

*Pa element*

1976 *Kockelella stauros* sp. nov. - **Barrick & Klapper**, pp. 76-77, pl. 3, figs. 1-11.

Remarks and relations - The Sa and Sb are identical with corresponding elements of *K. variabilis*.

Range and distribution – Wenlock from S.E. of Rabat (sagitta/stauros Zone).

Material and occurrence - 3 Pa elements, 2 Sa, 1 Sb from Oued Grou (SE of Rabat), sample G14.

**Kockelella variabilis** Walliser, 1957

Pl. 1, fig. 4

*Pa element*

1957 *Kockelella variabilis* n. sp. - **Walliser**, p. 35-36, pl. 1, figs. 3-10.

1964 *Kockelella variabilis* Walliser - **Walliser**, p. 40, pl. 8, fig. 12, pl. 16, figs. 1-15.


Remarks and relations - The mesetean specimens with the position of the expanded part of the basal cavity and its process compare closely with those illustrated by Walliser (1957, 1964). The other elements (Pb, M, Sa, Sb and Sc) are similar to those illustrated by Barrick & Klapper (1976). The Pa element of *Kockelella variabilis ichnisae* Serpagli & Corradini 1998 differs from that of mesetean specimens principally by a platform bordered by a rim and by fused denticles on the anterior blade.

Range and distribution – Ludlow of Rabat-Tiflet (Lower variabilis Zone).

Material and occurrence – 4 Pa elements, 1 Pb, 1 M, 2 Sa, 1 Sb, 1 Sc from Oued Grou (SE of Rabat), sample
G17; 12 Pa elements from Oued Stour, samples N1, N2 (Rabat-Tiflet area).

**Ozarkodina bohemica** (Walliser, 1964)

Pl. 1, fig. 1, 2

Pa element:
1964 *Spathognathodus sagitta bohemicus* Walliser, p. 83, pl. 18, figs. 23-24.
1975 *Ozarkodina sagitta bohemica* (Walliser) Aldridge, p. 327, pl. 47, fig. 21.
1987 *Ozarkodina bohemica* (Walliser) Over & Chatterton, pl. 8, figs. 13, 14.

Remarks and relations — Ozarkodina najdri (Walliser) differs from *Ozarkodina bohemica* in the width and the extension of its basal cavity. This basal cavity is broad and does not extend to the posterior end.

Range and distribution — Wenlock (sagittalistauros Zone) from Oued Grou (SE of Rabat) and Oued Tiflet (S of Tiflet).

Material and occurrence — 14 Pa elements from Oued Grou (SE of Rabat), samples G5, G9, G10, G11, G15; 1 Pa element from Oued Tiflet (S of Tiflet), sample T2.

**Ozarkodina remsecidensis Remscheidensis**

(Ziegler, 1960)

Pl. 1, fig. 6

Pa Element
1960 *Spathognathodus remsechidensis* n.sp. Ziegler, pp. 194-196, pl. 13, figs. 1-2, 4-5, 7-8, 10-14.
1989 *Ozarkodina remsechidensis remsechidensis* (Ziegler) Wilson, p. 138, pl. 11, figs. 8-10.

Remarks and relations — The specimens from the Lochkovian of Meseta show several types. In some types, the denticles at the anterior end are higher than the others and are closely similar to Pa element figured by Ziegler (1960).

The other elements are closely comparable with those illustrated by many authors.

Range and distribution — Lochkovian from Rabat-Tiflet area.

Material and occurrence — 20 Pa elements, 18 Pb, 1 M, 1 Sa, 10 Sb, 19 Sc from Oued Grou (SE of Rabat), samples G22, G23, G24; 1 Pa element from Oued Tiflet (S of Tiflet), sample T17; 3 specimens Pa from Oued Bou Regreg (SE of Rabat).

**Ozarkodina sagitta sagitta** (Walliser, 1964)

Pl. 1, fig. 3

Pa element:
1964 *Spathognathodus sagitta sagitta* nssp. Walliser, pp. 82-84, pl. 18, figs. 8-11.
1975 *Ozarkodina sagitta sagitta* (Walliser) Aldridge, p. 330, pl. 47, fig. 15 (Pa element).

Remarks and relations — The Pa element of *Ozarkodina sagitta rhenana* and *Ozarkodina sagitta sagitta* are similar, but in the Pa element of *O. sagitta rhenana*, the denticles are distinctly broader, less closely spaced and less numerous. The Pa element of *Ozarkodina bohemica* (Walliser) has a broad basal cavity and characteristic fusion of the denticles above the cavity.

Range and distribution — Wenlock from Oued Grou (SE of Rabat).

Material and occurrence — 15 Pa elements, 1 Sa, 2 Sb, 5 Sc, from Oued Grou (SE of Rabat), samples G4, G6.

**Ozarkodina excavata** (Branson & Mehl, 1933)

Pl. 1, fig. 7

Remarks and relations — This species has a large range from the Silurian to early Devonian and shows various morphotypes (subspecies?). The different elements the meseta taxa are closely similar to those illustrated by numerous authors, for example Wilson (1989).

Range and distribution — Wenlock to Late Pragian-Early Emsian from Western Moroccan Meseta.

Material and occurrence — The different elements of this species are common in the Silurian and the Lower Devonian in the moroccan meseta.

**Ozarkodina pandora** Murphy, Matti & Walliser, 1981 alpha morphotype

Pl. 1, fig. 16-18

Pa element:
1981 *Ozarkodina pandora* n. sp. alpha morph. Murphy, Matti & Walliser, pp. 762-763, pl. 1, figs. 1-13, 16, 22-24; pl. 2, fig. 13; pl. 3, figs. 3-5; text-figs. 4, 8-9, 11-12.
1989 *Ozarkodina pandora* Murphy, Matti & Walliser, - Sorrentino, p. 94, pl. 3, figs. 10-11, 14, 16.
1989 *Ozarkodina pandora* alpha morph. Murphy, Matti & Walliser - Wilson, p. 139, pl. 12, figs. 1, 4-5.

Remarks and relations — The specimens from the Moroccan meseta resembles *Ozarkodina pandora* morphotype alpha from lower Devonian of central Nevada figured by Murphy *et al.* (1981) and to a specimen from New South Wales illustrated by
Sorentino (1989) and Wilson (1989). They have the same characteristic features: Outline of expanded basal cavity, posterior position of the expanded basal cavity, the lack of ornament on their platform lobes.

Range and distribution - Late Lochkovian – Early Pragian from Tiflet and SE of Rabat.

Material and occurrence – 7 Pa elements from Oued Bou Regreg (SE of Rabat), samples BG18, BG20; 2 Pa elements from Oued Tiflet (S of Tiflet), samples T20, T23.

OZARKODINA STEINHORNENSIS MIAE (Bultynck, 1971)

Pl. 1, fig. 19

Pa element
1971 Spathognathodus steinhornensis miae n.ssp. Bultynck, p. 25, pl. 4, figs. 13-14; pl. 5, figs. 1-14; text-figs. 19-21.
1989 Ozarkodina steinhornensis miae (Bultynck) - Bultynck, pl. 16, figs. 10-11.

Remarks and relations – Bultynck (1971) has distinguished 3 subspecies (α, β, γ) on the basis of differences in the denticles. The mesetean material is similar in the lack of prominent cusp to morphotype α.

Range and distribution – Pragian- Emsian (kindlei-debiscens Zone) from Rabat-Tiflet area.

Material and occurrence – 28 Pa elements, 2 Pb, 1 Sa, 3 Sc from Al Khaloua, samples AK 8, AK 9, AK 12; 2 Pa elements from Oued Bou Regreg (SE Rabat), samples BG 27, BG 28; 1 Pa element from Oued Tiflet (S. of Tiflet), sample T28.

OZARKODINA STEINHORNENSIS REPETTOR (Carls & Gandl, 1969)

Pl. 1, fig. 11

Pa element
1969 Spathognathodus steinhornensis repettor n.ssp. Carls & Gandl, pp. 198-200, pl. 19, fig. 3.
1971 Spathognathodus steinhornensis repettor Carls & Gandl - Bultynck, pp. 18-25, pl. 3, figs. 1-24; pl 4, figs. 1-5; text-figs. 12-14.

Range and distribution – Upper Lochkovian from SE of Rabat.

Material and occurrence – 3 Pa elements from SE of Rabat (Bled Dfa, Bou Regreg, Oued Grou), samples D13, BD24, G 25.

CAUDICRIODUS CURVICAUDA (Carls & Gandl, 1969)

Pl. 1, fig. 13

Pa element
1969 Icriodus huddlei curvicauda n.ssp. Carls & Gandl, pp. 180-182, pl. 16, figs. 10-17
1976 Caudicriodus curvicauda (Carls & Gandl) - Bultynck, pp. 28-29, pl. 6, figs. 10-15, text-fig. 3.

Remarks and relations – This species differs from Caudicriodus celtibericus by the fact that the lateral process is arched.

Range and distribution – Pragian (kindlei Zone) from Al Attamna.


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EXPLANATION OF PLATE 1

Figs. 1-2 - Ozarkodina bohemia (Walliser, 1964).
1) Pa element; lateral view (x130), G-8.
2) Pa element; aboral view (x90), G-11.

Fig. 3 - Ozarkodina sagina sagina (Walliser, 1964). Pa element; oral view (x70), G-4.

Fig. 4 - Kockeledella variabilis Walliser, 1957. Pa element; oral view (x70), G-16.

Fig. 5 - Kockeledella abis diata Barrick & Klapper, 1976. Pa element; lateral view (x111), G-14.

Fig. 6 - Ozarkodina remschiedensis remschiedensis (Ziegler, 1960). Pa element; lateral view (x70), G-22.

Fig. 7 - Ozarkodina excavata (Branson & Mehl, 1933). Pa element; oral view (x70), G-3.

Fig. 8 - Kockeledella staurus Barrick & Klapper, 1976. Pa element; oral view (x70), G-14.

Fig. 9 - Polygnathoides emargnatus (Branson & Mehl, 1933). Pa element; lateral view (x90), S-2.

Fig. 10 - Caudicriodus woschmidtii (Ziegler, 1960). Pa element; lateral view (a) and oral view (b) (x90), BH-3. (Processes is broken).

Fig. 11 - Ozarkodina steinhornensis repettor (Carls & Gandl, 1969). Pa element; lateral view (a) and aboral view (x150), BH-18.

Fig. 12 - Caudicriodus celtibericus (Carls & Gandl, 1969). Pa element; oral view (x70), AK-6.

Fig. 13 - Caudicriodus curvicauda (Carls & Gandl, 1969). Pa element; oral view (x70), AA-18.

Fig. 14 - Peakegnathus serratus serratus Jentsch, 1962. Pa element; oral view (x100), AK-4.

Fig. 15 - Latericriodus steinachensis (Al-Rawi, 1977). Pa element; oral view (x44), T-22.

Figs. 16-18 - Ozarkodina pandora Murphy, Matti & Walliser, 1981. Oral view, lateral view and aboral view (x90), BH-20.

Fig. 19 - Ozarkodina steinhornensis miae (Bultynck,1971). Pa element; oral view (x90), AK-12.
CAUDICRIODUS CELTIBERICUS (Carls & Gandl, 1969)
Pl. 1, fig. 12

Pa element
1969 Icriodus buddleii celtibericus n.ssp. CARLS & Gandl, pp. 182-183; pl. 6, figs. 18-20
1976 CAUDICRIODUS CELTIBERICUS (Carls & Gandl) - Bultynck, pp. 29-31, pl. 6, figs. 7-19; pl. 7, figs. 27-29.

Remarks and relations - The mesetean material is closely similar to spanish material.

Range and distribution - The Pragian-Emasion (kindleidebiscens Zone) from Rabat-Tiflet area, Oued Cherrat and Mechraa Ben Abbou.

Material and occurrence - 335 Pa elements, 13 Pb, 13 M, 17 S from Al Khaloua, samples AK1-AK12; 133 Pa elements, 1 Pb, 3 M, 2 S, from Sidi Ahmed El Mdoun (Al Attamna), samples AA1-AA14, AT18-AT20; 122 Pa elements, from Oued Bou Regreg (SE of Rabat), samples BG26, BG34, D19, D 3-D26; 40 Pa elements, 1 Pb, 1 S from Oued Tiflet (S of Tiflet), samples T16, T27; 12 Pa elements, 1 Pb, 2 M from Ain AL Qsob (Oued Cherrat), samples AQ1-AQ4; 4 Pa elements from Koudiat Ed Dib (Mechraa Ben Abbou), sample KD3; 2 Pa elements from Oued Grou (SE Rabat), sample G31.

CAUDICRIODUS WOSCHMIDTI (Ziegler, 1960)
Pl. 1, fig. 10

Pa element

Range and distribution - Lochkovian from SE of Rabat.

Material and occurrence - 1 Pa element from Oued Bou Regreg (SE of Rabat), sample BG1.

LATERICRIODUS STEINACHENSIS (Al-Rawi, 1977)
Pl. 1, fig. 15

Pa element
1977 Icriodus steinachensis n. sp. AL-RAWI, pp. 55-56, pl. 5, fig. 42.

Remarks and relations - In Latericriodus nevadensis Klapper and Johnson (1980), the basal cavity is more narrow at the anterior part; in Latericriodus bilatericrescens bilatericrescens: the main denticle is longer; the angle with the main lateral process is greater; the transverse rows are regular; the process branches from the posterior end; the basal cavity is less broad. In Latericriodus beckmanni, the platform is more slender; the number of transverse rows is more important.

Range and distribution - Lower part of Pragian (sulcatus Zone) from S of Tiflet.

Material and occurrence - 1 Pa element from Oued Tiflet (S of Tiflet), sample T22.

PELEKYSGNATHUS SERRATUS SERRATUS Jentzsch, 1962
Pl. 1, fig. 14

Pa element
1962 Pelekygnathus serratus n. sp. JENTZSCH, p. 970-971, pl. 2, figs. 7-8; pl. 3, figs. 6, 9, 13, 16.
1969 Pelekygnathus serratus elatus n.ssp. CARLS & Gandl, p. 192-193, pl.19, figs. 10-14.
1976 Pelekygnathus aff. Serratus elatus - Bultynck, p. 60, pl. 5, figs. 6-11.

Remarks and relations - Bultynck (1976) distinguished in Spanisch Conodonts, Pelekygnathus aff. P. serratus from Pelekygnathus serratus elatus. The main distinction is the presence in P. serratus elatus of a cusp not arched posteriorly. The mesetean material shows the same difference. P. aff. P. serratus elatus illustrated by Bultynck (1976) is here considered as conspecific, because of its transitionnal connection.

Range and distribution - Emsian (dehiscens Zone) from Rabat-Tiflet area.

Material and occurrence - 2 Pa elements from Al Khaloua, sample AK12; 1 Pa element from Oued Bou Regreg (SE of Rabat), sample BD43.

POLYGNATHOIDE S EMARGINATUS (Branson & Mehl, 1933)
Pl. 1, fig. 9

Pa element
1933 Polygnathellus emarginatus n. sp. BRANSON & MEHL, p. 49, pl. 3, fig. 38.
1964 Polygnathoides emarginatus (Branson & Mehl) - Walliser, p. 66, pl. 8, fig. 16; pl. 18, figs. 1-6.
1975 Polygnathoides emarginatus (Branson & Mehl) - KLAPPER & Murphy, p. 56, pl. 8, figs. 22-25.

Range and distribution - Ludlow from Al Khaloua (Lower variabilis Zone).

Material and occurrence - 1 specimen Pa from Oued Stour (Al Khaloua), sample AS2.
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