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Upper Silurian to Middle Devonian conodont faunas from the Rabat–Tiflet area (northwestern Moroccan Meseta)

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Conodont faunas are generally sparse in Pridoli to middle Givetian deposits from the Rabat–Tiflet area in the northwestern Moroccan Meseta. The Pridoli and Lochkovian rocks consist of dark platy limestones alternating with dark shales containing graptolites in some levels. In the overlying part of the succession carbonate rocks predominate with the development of reefoid limestones in the lower Givetian. The *eosteinhornensis, sulcatus, dehiscens* vel *kitabicus, laticostatus/inversus, partitus, ensensis, hemiansatus, timorensis* and *rhenanus/varcus* zones have been recognized by occurrence of the conodont index species.The first appearance of *Belodella devonica*, occurring together with the graptolite *Monograptus uniformis* is used as a regional index species for the base of the Devonian. The age of some levels in the succession were previously dated by graptolites, dacryoconarids and rare goniatites.

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Key words: Morocco, Meseta, biostratigraphy, Pridoli–middle Givetian, conodonts.

INTRODUCTION

The Rabat–Tiflet area belongs to the most northern part of the western Moroccan Meseta (Figs. 1 and 2). The Silurian-Devonian formations are exposed in an E–W oriented structural zone extending for some 50 kilometres. The rocks are affected by Hercynian folding. From north to south three structural units can be recognized in the Rabat–Tiflet area (El Hassani, 1990). The Sehoul Block consists mainly of Cambrian and Ordovician rocks emergent during the Devonian (El Hassani and Tahiri, 2000). The Bou Regreg synclinal axis consists of Lower Ordovician sandstones and shales alternating with volcanic rocks. They are transgressively overlain by Silurian to Middle Devonian limestones and shales. An important sedimentary break ranging from the Llandeilo until at least to the lower Wenlock occurs. The Bou Regreg axis emerged during the Late Devonian. The northern border of the Sidi-Bettache Basin consists of Upper Devonian–Lower Carboniferous debris flows and conglomerates originating from the northern emergent ridge. The Devonian succession of the Rabat–Tiflet area show similarities with coeval successions in Bohemia (Alberti, 1969, 1988).

In contrast to the Moroccan Anti-Atlas Devonian there are not many studies focussing on Devonian conodonts from the Moroccan Meseta (e.g., Lazreq, 1990, 1992, 1999; Benfrika, 1999; Gouwy *et al*., 2000; Benfrika and Bultynck, 2003). The significance of the present study is that it describes a succession of conodont faunas from the Pridoli to the base of the middle Givetian from strata that previously were mainly dated by graptolites, dacryoconarids, trilobites and rare goniatites (El Hassani, 2000).

The conodont results are based on the study of six sections from which one hundred and ninety-two 2 kg samples were processed. One hundred and twenty-eight samples were productive containing a total of about 24 125 conodont elements: 22 000 belodellid, 1095 icridiodid, 400 polygnathid, 200 ozarkodinid, 194 panderodid, 3 pelekysgnathid and 234 unidentified elements. The most stratigraphically relevant samples are indicated on 3 to 7 Figures.

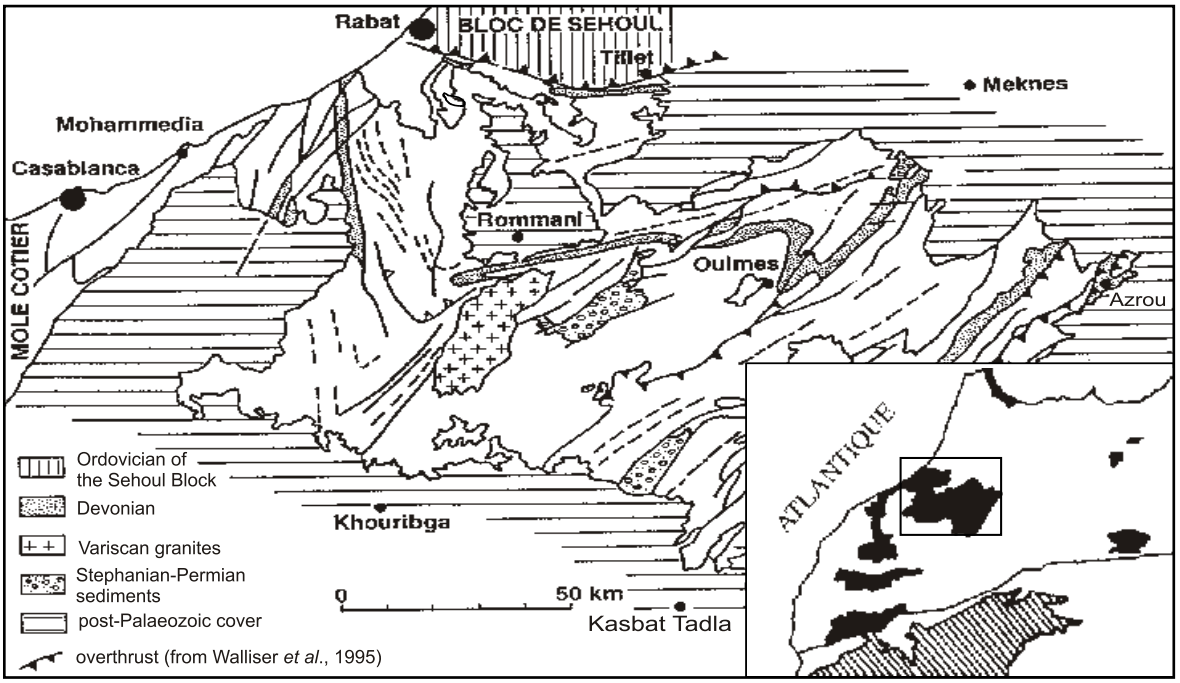

Fig. 1. Simplified map of the Moroccan northwestern Meseta

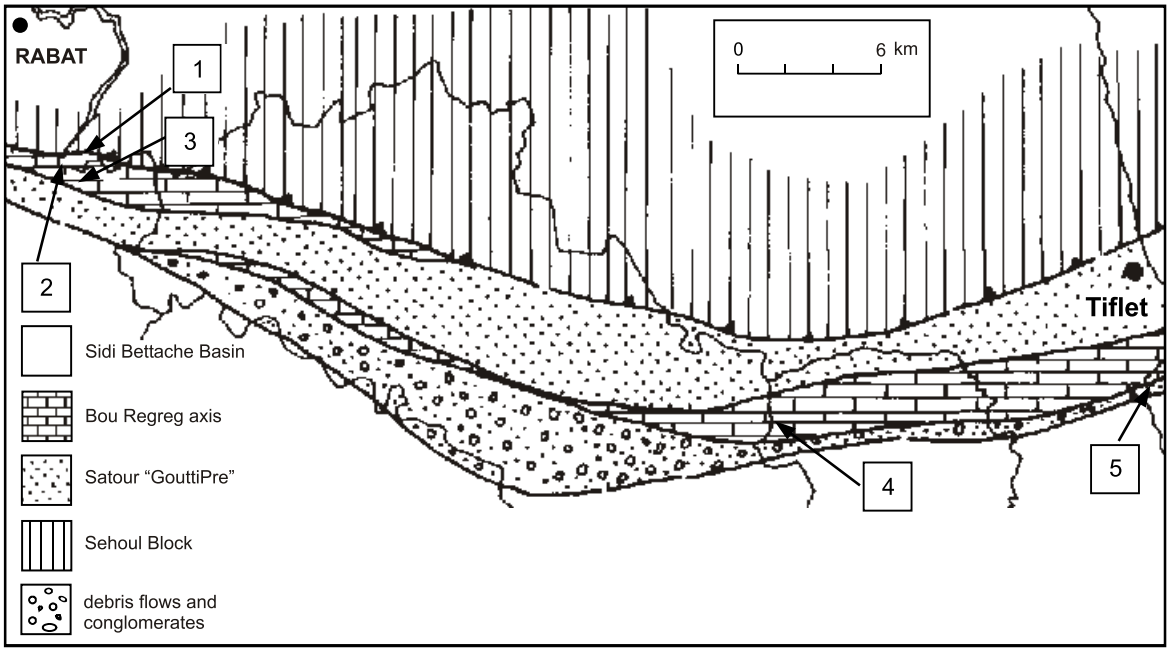

Fig. 2. Simplified map of the Rabat–Tiflet structural zone with location of the sections studied

1 and 2 — left and right banks of the Oued Bou Regreg; 3 — Bled Dfa; 4 — Al Khaloua; 5 — Oued Tiflet

LITHOLOGY AND BIOSTRATIGRAPHY OF THE SECTIONS

SECTIONS ON THE RIGHT AND LEFT BANKS OF THE OUED BOU REGREG

The sections are situated in the western ends of the Rabat–Tiflet structural zone at Had Akrech, 8 km south-east of Rabat. They are exposed along the right and left banks of the Oued Bou Regreg, downstream of the Oued Akrech (Figs. 2, 3 and 4).

The oldest part of the succession exposed along the left bank, belonging to the Ordovician and Silurian, is not represented on the Figures 3 and 4.

The Devonian succession is subdivided into seven units:

— Unit A, representing the upper part of the Hossei Fm., consists of dark platy limestones (wackstones) alternating with

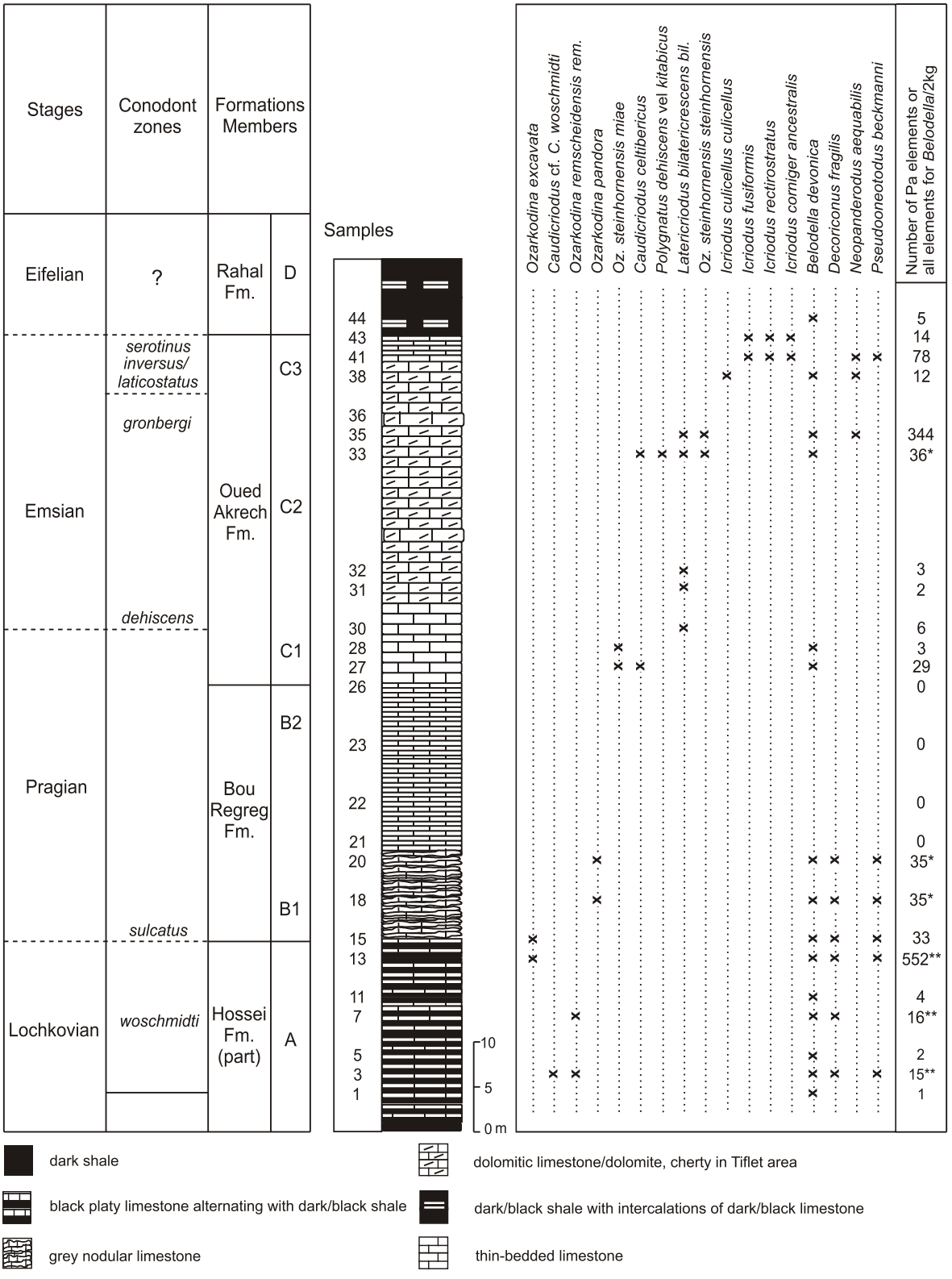

Fig. 3. Conodont distribution in the section on the left bank of Oued Bou Regreg

Number of conodont elements: * — indicates that *Belodella devonica* is dominant in the conodont fauna; ** — indicates that the fauna almost entirely consists of *Bel. devonica* elements

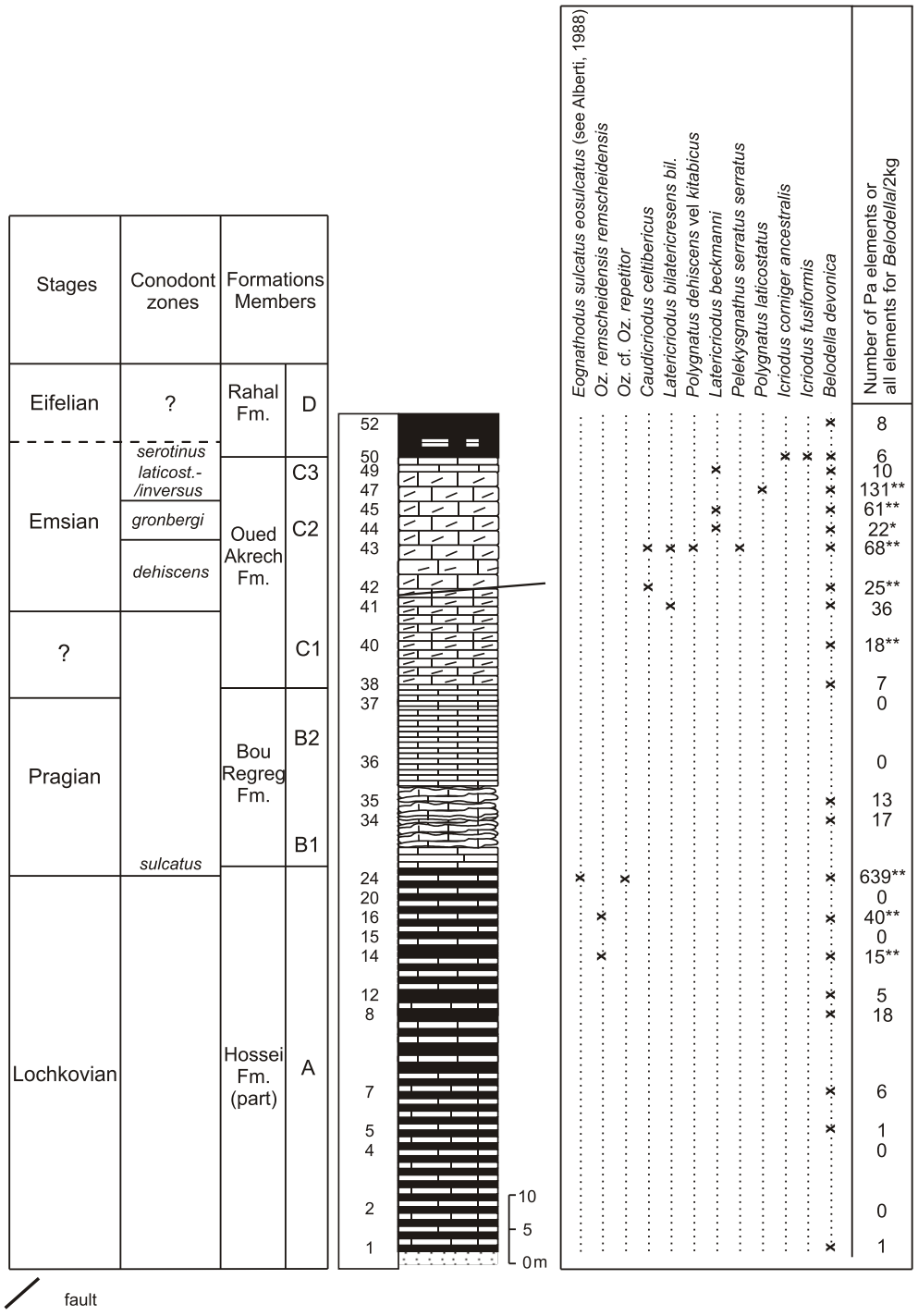

Fig. 4. Conodont distribution in the section on the right bank of Oued Bou Regreg

Other explanations as in Figure 3

thin black shale beds containing graptolites. The limestones are loccaly dolomitised. Bioclasts are mostly from pelagic organisms such as tentaculites, dacryoconarids, orthocones, ostracods, bryozoans and crinoids. *Monograptus uniformis* is present in the lower part of the unit indicating a lower Lochkovian age (Rousselle, 1961; Alberti, 1969; El Hassani *et al.*, 1988). According to Alberti *et al.* (1966) and Alberti (1988) the fauna of the upper part of the unit contains *Monograptus hercynicus* indicating an upper Lochkovian age.

Conodonts. One specimen of *Caudicriodus* cf. *C. woschmidti* and 2 specimens of *Ozarkodina remscheidensis remscheidensis. Belodella devonica*, first appearing near the base of the unit, is the most frequent species.

— Unit B1 is 10 m thick and consists of pale grey nodular limestones (bioclastic wackstones and packstones) with tentaculites and ostracods.

— Unit B2 is 15 to 20 m thick and consists of micritic greyish limestones with tentaculites, bivalves, bryozoans, crinoids and fish scales.

Units B1 and B2 belong to the Bou Regreg Formation. The presence of *Nowakia acuaria* and *Guerichina strangulata* supports a Pragian age (Alberti, 1969).

Conodonts. Alberti (1988) figured a specimen he identified as *Eognathodus* cf. *E. sulcatus* (herein assigned to *E. sulcatus eosulcatus)* 70 cm below the base of the Bou Regreg Fm in the section on the right bank of the Oued Bou Regreg. In the present study *Ozarkodina pandora* alpha morphotype and *Ozarkodina* cf. *O. repetitor* have been found near the base of Unit B1. Unit B2 did not yield conodonts.

— Unit C1 is 10 to 15 m thick and consists of thick-bedded dolomitic limestones with tentaculites, ostracods, bryozoans, brachiopods and crinoid fragments.

— Unit C2 is about 30 m thick and consists of massive dolomitic limestones and thick-bedded dolomites (grainstones with bioclasts of crinoids, brachiopods, gastropods, tentaculites and fish).

— Unit C3 is 5 m thick and consists of bedded limestones (wackstones–packstones with bioclasts of crinoids, tentaculites, ostracodes and fish).

Units C1, C2 and C3 belong to the Oued Akrech Fm., assigned by Alberti (1969) to the "Zlichovian".

Conodonts. Unit C1: first occurrence of *Ozarkodina steinhornensis miae* and *Caudicriodus celtibericus* near the base and *Latericriodus bilatericrescens bilatericrescens* in the upper part; *Polygnatus dehiscens* vel *kitabicus, Latericriodus beckmanni* and *O. steinhornensis steinhornensis* first appear in Unit C2; *Icriodus fusiformis, I. corniger ancestralis, I. culicellus culicellus, I. rectirostratus* and *Polygnathus laticostatus* are restricted to Unit C3.

— Unit D (Rahal Fm.), only partly exposed, consists of shales. According to Alberti (1969) the fauna of unit D shows similarities with the fauna of the Wissenbach Shale. El Hassani (1990) favours correlation with the Daleje Shale, because of the presence of *Anarcestes lateseptatus.*

Conodonts. Only *Belodella devonica* occurs.

The complete distribution of conodont species in the two sections and their biostratigraphic interpretation are shown on Figures 3 and 4.

BLED DFA SECTION

The section is also situated in the western ends of the Rabat–Tiflet structural zone, about 1.5 km east of the section on the right bank of the Oued Bou Regreg described above (Figs. 2 and 5). The lowest part of the succession, consisting of sandstones, belongs to the Arenig.

— Unit A, belonging to the upper part of the Hossei Fm., is 8 m thick and consists of slightly dolomitic limestones alternating with shaly centimetre-scale interbeds with graptolites.

Conodonts. *Dapsilodus obliquicostatus* and *Decoriconus fragilis*.

— Unit B1 is about 50 m thick and consists of dark shales alternating with biosparitic limestones. El Hassani *et al.* (1988) mention Ludlow graptolites from this unit. No conodonts were found.

— Unit B2 is about 20 m thick and consists of black bituminous shales with a few thin limestone beds. The presence of *Monograptus bouceki* and *M. transgrediens* indicate a Pridoli age (Alberti, 1969; El Hassani, 1990).

Conodonts. *Ozarkodina remscheidensis* cf. *eosteinhornensis* occurs in the upper part of the unit and *Belodella devonica* first appears 12 m above.

— Unit C is about 40 m thick and consists of black shales alternating with black platy limestones becoming progressively dominant in the upper part. Rahmani (1978) and El Hassani (1990) found *Monograptus uniformis* (lower Lochkovian) in the shales at the base of the unit. Alberti (1969) recognized *Monograptus hercynicus* and *Paranowakia* aff. *P. bohemica* (upper Lochkovian) in the upper part.

Conodonts. One specimen of *Caudicriodus* cf. *C. woschmidti* and two specimens of *O. remscheidensis remscheidensis* first occur within the unit and *O.* cf. *O. repetitor* is present at the top of the unit.

Units A, B1, B2 and C belongs to the Hossei Fm.

— The Bou Regreg Fm. is 35 m thick and consists of pale grey limestones (wackestones to packstones with bioclasts of tentaculites, ostracods and crinoids). The formation is subdivided into two units. D1 (25 m thick) consists of nodular limestone beds showing slumping. D2 (10 m thick) is a bedded limestone. Rahmani (1978) mentioned *Guerichina strangulata* from the latter unit, indicating an upper Pragian age.

Conodonts.*Caudicriodus celtibericus* first occurs at the top of unit D2.

The Oued Akrech Fm. is subdivided into three units.

— Unit E1 is about 15 m thick and consists of thick-bedded limestones (grainstones with bioclasts) with chert development in some beds.

Conodonts. *C. celtibericus* and *Latericriodus* cf. *L. bilatericrescens*.

— Unit E2 is about 40 m thick and consists of thick-bedded or massive dolomitic limestones.

Conodonts. *C. celtibericus* and *L. bilatericrescens bilatericrescens*.

— Unit E3 is 5 m thick and consists of bedded limestones (packstones and wackestones with bioclasts) with thin shaly interbeds.

Conodonts. *Polygnathus inversus, Icriodus corniger ancestralis* and *I. rectirostratus*.

— Unit F belongs to the Rahal Fm. The exposed part consists of greenish and black shales with some limestone nodules and lenses. According to Alberti (1969) the trilobites indicate an upper Eifelian age.

Conodonts. Only 1 specimen of *Polygnatus angusticostatus* has been found.

The complete distribution of conodont species in the Bled Dfa section and their biostratigraphic interpretation are shown on Figure 5.

AL KHALOUA SECTION

The Al Khaloua section is situated in the eastern part of the Rabat–Tiflet structural zone about 17 km WSW of Tiflet (Fig. 2). The section sampled is exposed on the left bank of the Oued

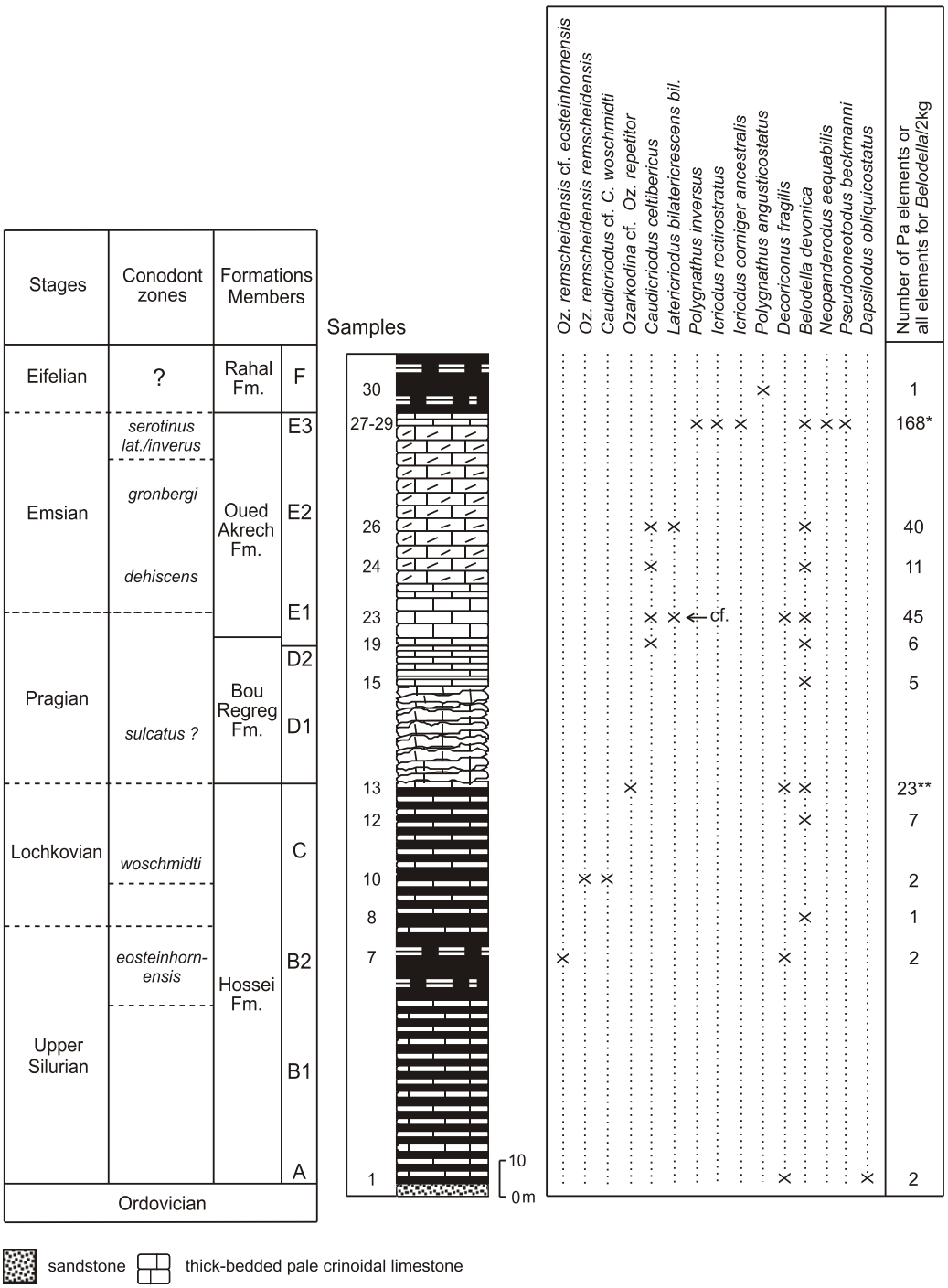

Fig. 5. Conodont distribution in the Bled Dfa section

Other explanation as in Figure 3

Bou Regreg at a locality named Chabet Ben Mkadem. The part sampled for the present study is about 38 m thick and consists of grey bedded limestones, dolomitic limestones and dolomites with chert development.

— The lower part belongs to the Rechoua Fm. consisting of 10 to 20 cm thick limestone beds alternating with dolomitic limestones. The Rechoua Fm. is a lateral equivalent of the Pragian Bou Regreg Fm. (Michard, 1976).

— The upper part belongs to the Safsaf Fm. and consists of 80 to 100 cm thick limestone beds (grainstones with bioclasts of crinoids and brachiopods), dolomitic limestones and dolomites.

According to El Hassani (1990) the two formations in this section belong to the Emsian.

Conodonts. *Caudicriodus celtibericus* and *Belodella devonica* are abundant throughout the section; *Polygnathus dehiscens* vel *kitabicus*, *Ozarkodina steinhornensis miae*, *Latericriodus bilatericrescens bilatericrescens* and *Pelekysgnathus serratus serratus* first appear about 5 m above the base of the Safsaf Fm. This level may represent the Pragian/Emsian boundary.

The complete distribution of the conodont species and their biostratigraphic interpretation are shown on Figure 6.

OUED TIFLET SECTIONS

The Oued Tiflet sections are situated in the eastern ends of the Rabat–Tiflet structural zone (Fig. 2). The stratigraphical column of Figure 7 is based on two sections, the right bank of the Oued Tiflet and the Tiflet quarries.

SECTION ALONG THE RIGHT BANK OF THE OUED TIFLET

The section is located about 2.5 km SSE of Tiflet. The base of the succession consists of oolithic ferruginous sandstones assigned to the Arenig–Llanvirn. They are overlain in stratigraphic order by the Zemmour, Tiflet and Safsaf formations, ranging from Wenlock to the upper Emsian. This succession is subdivided into six units described below.

— Unit A is 18 m thick and consists of black shales alternating with dark grey limestones. The limestones can be thin-bedded or lenticular and contain a rich fauna with bivalves, gastropods, orthocones, crinoids and ostracods El Hassani (1990) assigned this part to the Pridoli, based on the presence of *Monograptus lochkovensis*. Conodonts, including *Kockelella absidta* and *Ozarkodina bohemica*, indicate an older age, namely Wenlock (Benfrika, 1994, 1999).

— Unit B is 34 m thick and consists of black shales with intercalations of nodular limestones or thin-bedded limestones. Three samples from this unit were barren of conodonts.

— Unit C is 40 m thick and consists of micaceous platy limestones alternating with shales becoming progressively dominant in the uppermost part.

Conodonts. *Belodella devonica* first occurs at the base of the unit; sample 17 in the upper part of the unit contained 1600 elements of *Bel. devonica*, 2 specimens of *Caudicriodus* cf. *C. postwoschmidti* and 1 specimen of *Ozarkodina remscheidensis remscheidensis*.

Units A, B and C belong to the Zemmour Fm.

— Unit D1 is 36 m thick and consists of pale grey nodular limestones with thin shaly interbeds. The limestones (wackestones to packstones) contain bioclasts of tentaculites, trilobites and crinoids.

Conodonts. *Ozarkodina pandora* and *Latericriodus steinachensis* first appear in the lower part.

— Unit D2 is 12 m thick and consists of pale grey limestone beds (wackestones to packstones with bioclasts) separated by shaly interbeds.

Conodonts. *Caudicriodus celtibericus* and *Ozarkodina steinhornensis miae* first occur in this unit.

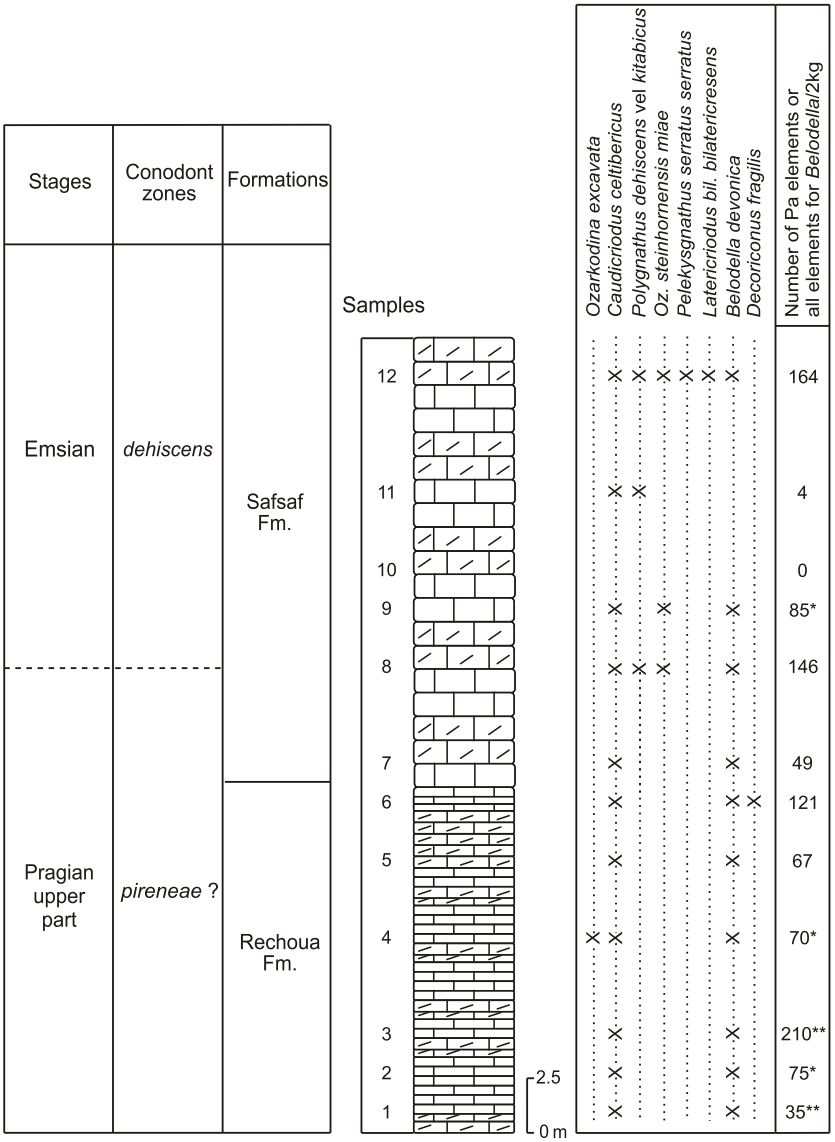

Fig. 6. Conodont distribution in the Al Khaloua section

Explanation as in Figures 3 and 5

Units D1 and D2 belong to the Tiflet Fm.

— Unit E is 45 m thick and it consists of medium-bedded limestones (dolomitic packstones to grainstones with bioclasts of tentaculites, ostracods and crinoids) alternating with thin shaly interbeds. Some of the limestone beds are cherty.

By comparison with the limestones and dolomites of the Oued Akrech Fm., Alberti (1969) assigned unit E to the Emsian.

Conodonts. *Latericriodus bilatericrescens bilatericrescens* and *O. steinhornensis steinhornensis* first appear in the middle part of the unit and *Latericiodus beckmanni* in the upper part.

The complete distribution of the conodont species in the units A to E and their biostratigraphic interpretation are given in Figure 7.

THE TIFLET QUARRIES

About 2 km south of Tiflet are several active and abandoned quarries. The formations A and B shown in the upper-

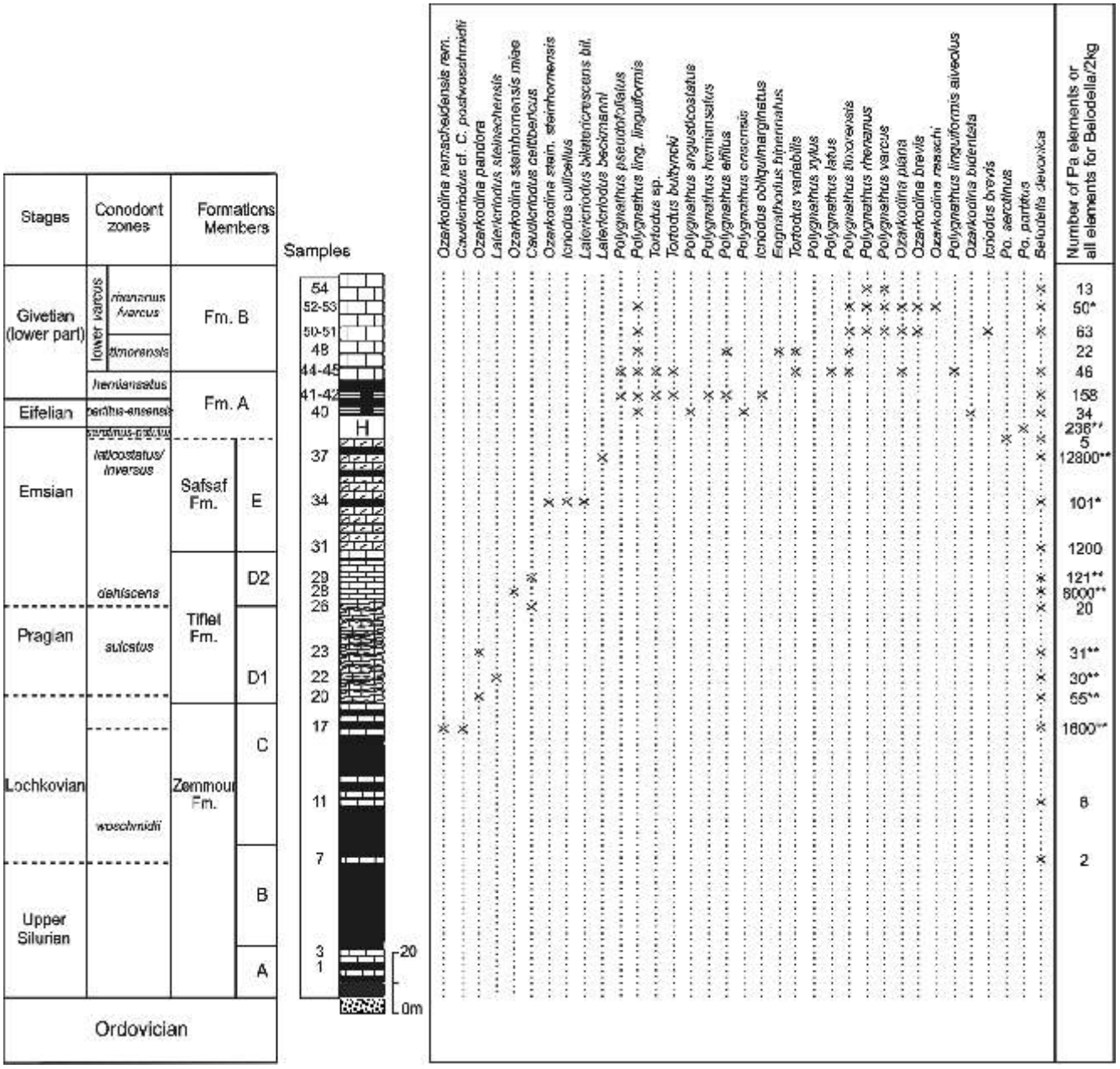

Fig. 7. Conodont distribution in the section along the right bank of Oued Tiflet and nearby quarries

H — hiatus between the Safsaf Fm. and Fm. A (not to scale) that has been completed by Gouwy *et al*. (2000); other explanations as in Figures 3 and 5

most part of the stratigraphic column (Fig. 7) are exposed in a small abandoned quarry, 800 m south-west of the Oued Tiflet section described above.

— Formation A. The contact with the underlying Safsaf Fm. is not exposed. The section shows a 11 m thick succession of dark-greyish shales with intercalations of thin limestone beds (slightly dolomitic wackestones with bioclasts of tentaculites, bivalves, brachiopods) lenses and nodules. Gouwy *et al.*, (2000) studied nearby exposures (sections OT1, OT2 and OT3) showing a nearly complete Formation A, about 60 m thick and separated from the underlying Safsaf Fm. by an unexposed interval about 4 m thick. On the lithogical column of Figure 7 the interval studied by Gouwy *et al*. (2000) is shown in white, indicate with "H"; it is not to scale. In the lowest part of Formation A they recognized a biostratigraphic interval ranging from the *serotinus* to the *patulus* Zone, based on the first occurrence of *Polygnathus linguiformis bultynckі* and *P. serotinus.* It is succeeded by the *partitus* Zone (recognized by the index species) and by an interval ranging from the *costatus* to the *ensensis* Zone. The upper part of Formation A is characterized by the first occurrence of *Polygnathus hemiansatus*, corresponding to the base of the Givetian. Formation A shows similarities with the Rahal Fm. of the Oued Bou Regreg sections near Rabat.

— Formation B. The exposed part of the overlying Formation B is 35 m thick and consists of 30 to 60 cm thick reefoid limestone beds with tentaculites, ostracods, crinoids and corals.

Conodonts. Unit B contains a diversified fauna with *Polygnathus, Ozarkodina, Tortodus, Icriodus* and *Eognathodus.* Most important are the first occurrence of *Polygnathus timorensis* at the base of the unit and *P. rhenanus* and *P. varcus* about 10 m above.

The complete distribution of the conodont species in the formations A and B and their stratigraphic interpretation are shown on Figure 7.

CHRONOSTRATIGRAPHIC, BIOSTRATIGRAPHIC AND ELEMENTARY BIOFACIES INTERPRETATION OF THE CONODONT FAUNAS

The chronostratigraphic and biostratigraphic interpretation of the conodont faunas is shown on Table 1, mentioning also selected species on which this interpretation is based. Most of the stratigraphically critical species are illustrated in Figures 8 and 9.

Biofacies information is limited to the major changes that occur throughout the entire succession. A detailed biofacies analysis is not given because most of the samples contained less than 100 conodont elements and possessed only moderate diversity. The total number of conodont elements per 2 kg samples including only Pa elements of the genera *Caudicriodus, Latericriodus, Icriodus, Pelekysgnathus, Ozarkodina, Eognathodus, Polygnathus* and all elements of *Belodella devonica* is indicated on Figures 3 to 7. One asterisk indicates that *Bel. devonica* is dominant and two asterisks that the conodont fauna almost entirely consists of *Bel. devonica* elements.

SILURIAN

WENLOCK–LUDLOW, PRIDOLI

Benfrika (1999) recognized Wenlock-Ludlow conodont faunas (*sagitta* Zone Walliser, 1964 and *Kockelella variabilis* Zone Barrick and Klapper, 1976) in other sections from the Western Meseta. They are partly recognized at the base of the section on the right bank of the Oued Tiflet but are not discussed herein.

Table 1

Characteristics of the Pridoli/Lochkovian to middle Givetian conodont faunas in the Rabat–Tiflet structural zone

	Stages	Formations Rabat → Tiflet		Conodont zones		Selected Devonian conodonts from Rabat–Tiflet area
Middle Devonian	Givetian (lower part)	Not recognised	Fm. B	Lower *varcus*	*varcus/ rhenanus*	*Polygnathus rhenanus*
						Icriodus brevis, Polygnathus varcus
					timorensis	*Polygnathus timorensis*
		Rahal	Fm. A	*hemiansatus*		*Polygnathus hemiansatus, Icriodus obliquimarginatus*
	Eifelian			*ensensis*		*Polygnathus ensensis, Ozarkodina bidentata, Polygnathus angusticostatus*
				kockelianus		*Polygnathus angusticostatus*
				australis		*Polygnathus angusticostatus* (Bled Dfa near Rabat and Oued Tiflet)
				costatus		
				partitus		*Polygnathus partitus*
Lower Devonian	Upper			*patulus*		} *Polygnathus serotinus*
				serotinus		
	Emsian	Oued Akrech	Safsaf	*laticostatus/inversus*		*Polygnathus inversus* and *Polygnathus laticostatus*
				gronbergi		
	Lower			*dehiscens* vel *kitabicus*		*Polygnathus dehiscens* vel *kitabicus* (extremely rare) and *Latericriodus bilatericrescens* (characteristic in lower Emsian Rabat–Tiflet)
	Pragian	Bou Regreg	Tiflet	*pireneae*		*Caudicriodus celtibericus* (frequent)
				kindlei		
				sulcatus		*Latericriodus steinachensis, Ozarkodina pandora* (extremely rare) *Eognathodus sulcatus eosulcatus* (extremely rare)
	Lochkovian	Hossei	Zemmour	*pesavis*		Conodonts are very rare: two specimens of *Caudicriodus* cf. *C. woschmidti*, one specimen of *Caudicriodus* cf. *C. postwoschmidti* and a few specimens of *Ozarkodina remscheidensis remscheidensis* In the Rabat–Tiflet area, the base of the Lochkovian has been recognized by the occurrence of *Monograptus uniformis* coinciding with the first appearance of *Belodella devonica*
				delta		
				eurekanensis		
				postwoschmidti		
				woschmidti		
Upper Silurian	Pridoli			*eosteinhornensis*		*Ozarkodina remscheidensis* cf. *eosteinhornensis*

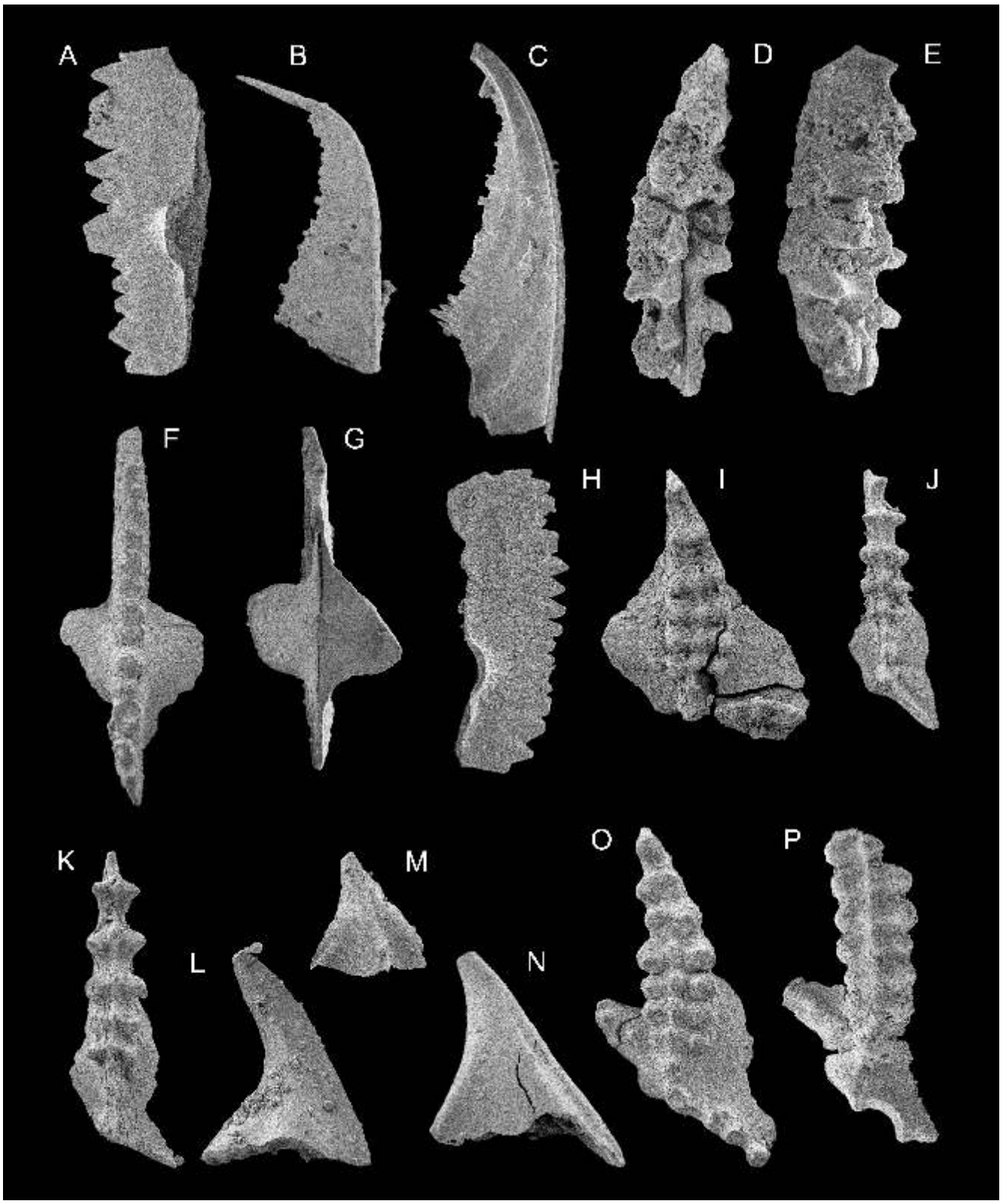

Fig. 8. All specimens are Pa elements except B, C, L, M (S elements) and N (M element)

A — *Ozarkodina remscheidensis remscheidensis* (Ziegler, 1960), sample BG5, lateral view, b5018, ×70; **B, C** — *Belodella devonica* (Stauffer, 1940), sample BG3 and BH40, lateral views of Sc and Sb element, b5019, ×120, b5020, ×170; **D, E** — *Caudicriodus* cf. *C. woschmidti* (Ziegler, 1960), sample BH3, upper and lateral views, b5021, ×90; **F, G, H** — *Ozarkodina pandora* alpha morphotype Murphy, Matti and Walliser, 1981, sample BH20, upper, lower and lateral views, b5022-b5024, ×57; **I** — *Latericriodus steinachensis* (Al Rawi, 1977) eta morphotype of Klapper and Johnson (1980), sample T22, upper view, b5025, ×24; **J** — *Caudicriodus celtibericus* (Carls and Gandl, 1969), sample AK6, upper view, b5026, ×70; **K, L, M, N**— *Caudicriodus celtibericus* (Carls and Gandl, 1969), sample BH27, upper view and three lateral views, b5027, b5028, b5029, b5030, ×70, ×110, ×44, ×110; **O** — *Latericriodus bilatericrescens bilatericrescens* (Ziegler, 1956), sample T34, upper view, b5031, ×70; **P** — *Latericriodus beckmanni* (Ziegler, 1956), sample BD45, upper view, b5032, ×70; AK — Al Khaloua section, BD — Bled Dfa section, BG — section on left bank of Oued Bou Regreg, BH — section on right bank of Bou Regreg, T — Tiflet sections; all specimens are deposited at the Institut Royal des Sciences Naturelles de Belgique under catalogue numbers b5018-b5048

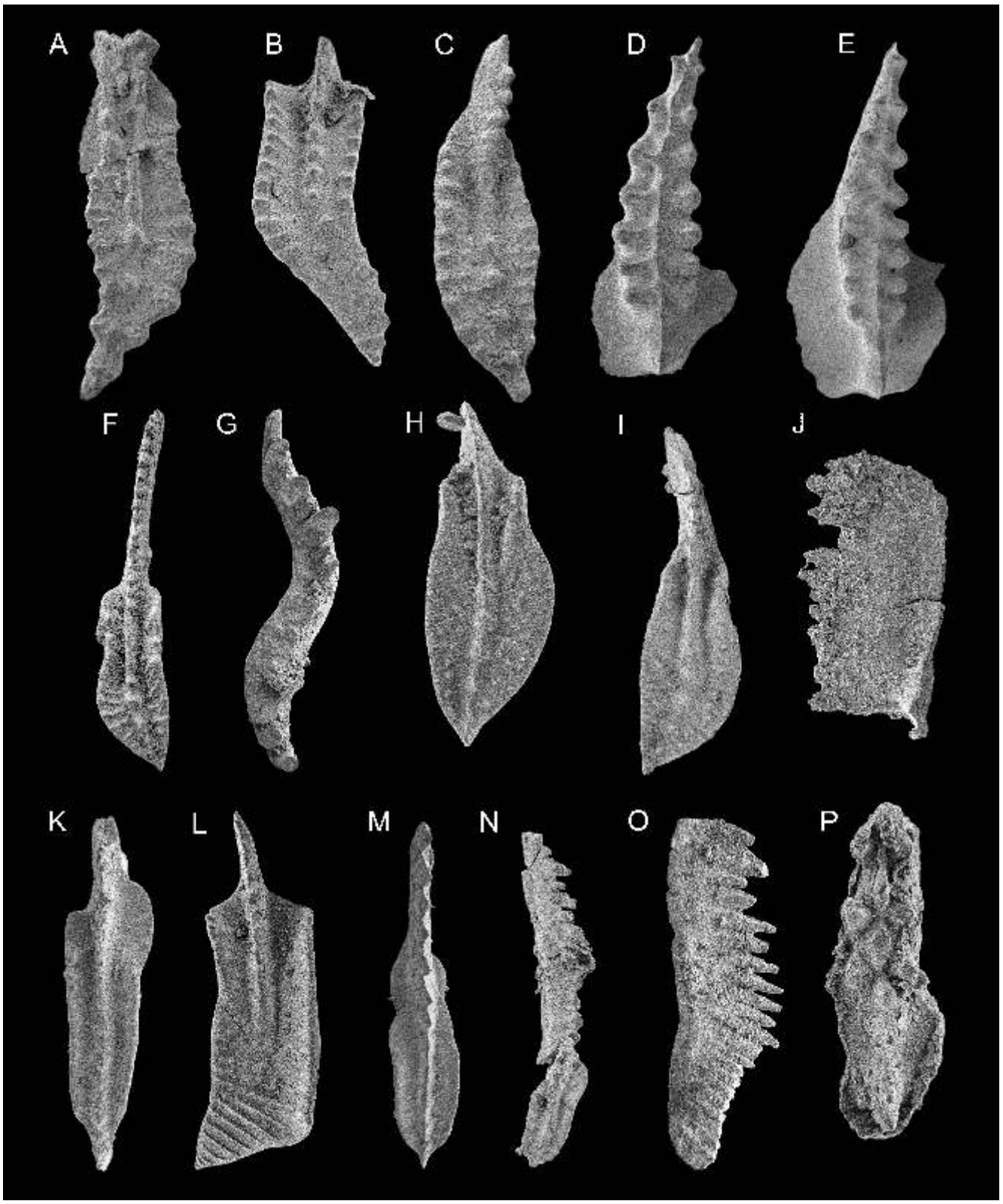

Fig. 9. All specimens are Pa elements in upper view except J and O (lateral view)

A — *Polygnathus dehiscens abyssus* Mawson, 1987 vel *P. kitabicus* Yolkin, Weddige, Izokh and Erina, 1994, sample AK12, b5033, ×130; **B** — *Polygnathus inversus* Klapper and Johnson, 1975, sample BD29, b5034, ×90; **C** — *Polygnathus laticostatus* Klapper and Johnson, 1975, sample BH47, b5035, ×90; **D, E** — *Icriodus rectirostratus* Bultynck, 1970, sample BG41 and BD27, b5036, b5037, ×70; **F** — *Polygnathus hemiansatus* Bultynck, 1987, sampleT41, b5038, ×45; **G** — *Tortodus bultyncki* Aboussalam, 2003, sample T41, b5039, ×37; **H** — *Polygnathus eiflius* Bischoff and Ziegler, 1957, sample T42, b5040, ×70; **I** — *Polygnathus pseudofoliatus* Wittekindt, 1965, sample T46, b5041, ×50; **J** — *Ozarkodina brevis* (Bischoff and Ziegler, 1957), sample T52, b5042, ×100; **K** — *Polygnathus timorensis* Klapper, Philip and Jackson, 1970, sample T49, b5043, ×70; **L** — *Polygnathus linguiformis linguiformis* Hinde, 1879, sample T49, b5044, ×44; **M** — *Polygnathus varcus* Stauffer, 1940, sample T49, b5045, ×100; **N** — *Polygnathus rhenanus* Klapper, Philip and Jackson, 1970, sample T49, b5046, ×44; **O** — *Ozarkodina plana* Bischoff and Ziegler, 1957, sample T45, b5047, ×44; **P** — *Icriodus brevis* Stauffer, 1940, sample T50, b5048, ×120; see also Figure 8 for explanations about sample numbers and catalogue numbers

Sample 7 from the Bled Dfa section may be assigned to the Pridoli by the presence of *Ozarkodina remscheidensis* cf. *eosteinhornensis*. The *eosteinhornensis* Zone is used herein as originally defined by Walliser (1964).

DEVONIAN

LOCHKOVIAN

In the western part of the Rabat–Tiflet structural zone the Lochkovian (Figs. 3–5) is represented by dark platy limestones alternating with black shales (calciturbidites) dated by *Monograptus uniformis*. The deposits belonging to the upper part of the Hossei Fm. are considered to represent a relatively deep continental margin environment. They contain mostly small conodont faunas (1 to 35 elements/2 kg) dominated by *Belodella devonica* that is very abundant in a few samples near the top of the Lochkovian. A few fragmentary specimens of *Caudicriodus* cf. *C. woschmidti* and specimens of *Ozarkodina remscheidensis remscheidensis* have been found. *Belodella devonica* first occurs in the level with *M. uniformis* and is considered as a useful regional index for recognizing the base of the Devonian. *Bel. devonica* first occurs in the Lochkovian of Bohemia (Slavik, 2001; Slavik and Hladil, 2004) and Sardinia (Corradini *et al*., 1998).

Caudicriodus cf. *C. postwoschmidti* is present in a sample in the uppermost part of the Zemmour Fm. (Oued Tiflet section, Fig. 7) a lateral equivalent of the Hossei Fm. In Bohemia *C. postwoschmidti* and *O. remscheidensis remscheidensis* range into the upper Lochkovian.

PRAGIAN

In the Oued Bou Regreg sections and the Bled Dfa section near Rabat the lower and middle Pragian are represented by pale grey nodular and bedded limestones of the Bou Regreg Fm. dated by *Nowakia acuaria*. Conodont faunas are impoverished (maximum 35 elements/2 kg samples) and dominated by *Belodella devonica* (90%). Alberti (1988) figured a specimen identified as *Eognathodus* cf. *E. sulcatus* (identified herein as *E. sulcatus eosulcatus*) from a sample 70 cm below the base of the Bou Regreg Fm. In the present study *Ozarkodina pandora* alpha morphotype has been found in the lower part of the Bou Regreg Fm. According to Slavik and Hladil (2004) the latter taxon occurs together with *E. sulcatus eosulcatus* in the lowermost Pragian of the Barrandian area.

The composition of the conodont faunas changes in the uppermost part of the Bou Regreg Fm. and in the lowest part of the Oued Akrech Fm. (Fig. 5). Faunas are dominated by *Caudicriodus* and *Belodella.Caudicriodus celtibericus* first occurs at this level. Benfrika and Bultynck (2003) found *C. celtibericus* together with *Polygnathus pireneae* in the Al Attamna section of the Oued Cherrat south of Rabat. So the first occurrence of *C. celtibericus* may be indicative of an uppermost Pragian age as is the case in the Barrandian area (Slavik, 2001).

In the Oued Tiflet section the lower part of the Tiflet Fm. contains *Latericriodus steinachensis* eta morphotype and *O. pandora* alpha morphotype. According to Slavik (2001) the former taxon is one of the most significant species for the lower and middle Pragian of the Barrandian area. *C. celtibericus* first occurs in the upper part of the Tiflet Fm., that may belong to the uppermost Pragian.

EMSIAN

Icriodontidae are in general dominant during most of the Emsian (30–90%), although *Belodella* can still be an important or dominant constituent of the faunas. Three samples from the Oued Tiflet section contain respectively about 8000, 1200 and 12 800 belodellid elements. *Polygnathus*, *Ozarkodina* and *Neopanderodus* occur in small numbers.

In the Oued Bou Regreg sections near Rabat the Emsian is represented by the Oued Akrech Fm. with dolomitic limestones in the lower part and dolomitic limestones with shaly intercalations in the upper part. *Nowakia barrandei* occurs in the lower part and *Nowakia elegans* in the upper part. In the eastern part of the Rabat–Tiflet structural zone (Al Khaloua and Tiflet) the Emsian is represented by the Safsaf Fm. consisting of dolomitic limestones and dolomites.

In the Bled Dfa and the Al Khaloua section a few *Polygnathus* specimens were found that are similar to a *Polygnathus kitabicus* specimen figured by Yolkin *et al*. (1994, pl. 1, figs. 3 and 4 only). Mawson (1995) assigned that specimen to *Polygnathus dehiscens*. The discussion of the controversy over the taxonomic status of *P. kitabicus* and *P. dehiscens* is out of the scope of the present paper because of the small number of specimens we found. Therefore the specimens from Al Khaloua are identified as *P. dehiscens* vel *kitabicus* and are considered to indicate the base of the Emsian in the area. *Latericriodus bilatericrescens* is the most common species in the lower part of the Emsian of the Rabat–Tiflet structural zone. In the Barrandian area the first appearance of this species “serves the best biostratigraphic indication of the Emsian base”(Slavik, 2001). In the Cantabrian Mountains (Spain) Garcia-Lopez and Sanz-Lopez (2002*a*, *b*) recognized a local *bilatericrescens* Zone within the lower Emsian.

Polygnathus inversus, *Polygnathus laticostatus*, *Icriodus fusiformis*, *Icriodus rectirostratus* and *Caudicriodus culicellus* first occur in the upper part of the Emsian (Bou Regreg sections; Figs. 3–5). *Polygnathus serotinus* and *Polygnathus linguiformis bultyncki* occurs at the base of Formation A in the Tiflet area (Gouwy *et al.*, 2000). *Polygnathus costatus patulus* characterizing the uppermost Emsian has not been found in the Rabat–Tiflet structural zone but occurs in the Ain al Qcob section about 35 km south-west of Rabat (Benfrika and Bultynck, 2003).

EIFELIAN

Although in the Eifelian conodont faunas from the Tiflet area percentages of *Polygnathus* increase, belodellid and panderodid elements can be very dominant in some samples (Gouwy *et al.*, 2000).

In the Oued Bou Regreg sections near Rabat the Rahal Fm. (Figs. 3–5) consisting of shales with a few limestone intercalations belongs partly to the Eifelian, while the lowest part may be still Emsian. Conodonts are rare and one specimen of *Polygnathus angusticostatus* was found about 10 m above the base of the formation in the Bled Dfa section. Alberti (1998)

mentions *Nowakia holynensis* 15 m above the base of the Rahal Fm. in the same section. In the Barrandian this species ranges from the *serotinus* Zone to the top of the *partitus* Zone.

The Eifelian is well dated in Formation A of the Tiflet area (Fig. 7) and consist of shales with limestone intercalations. The base of the Eifelian with *Polygnathus costatus partitus* was recognized in the lower part of this formation by Gouwy *et al*. (2000). *Polygnathus ensensis* occurs in the upper part (herein).

GIVETIAN

The Givetian has only be recognized in the Tiflet area (Fig. 7) and only the lower Givetian and the base of the middle Givetian are exposed. It consists mainly of reefoid bedded limestones. The 2 kg conodont samples contained between 13 and 158 elements and polygnathid Pa elements are dominant. The section shows a succession of the *hemiansatus, timorensis* and *rhenanus/varcus* zones as defined by Bultynck (1987); see also Gouwy *et al*. (2000).

CONCLUSIONS

A precise and reliable zonal assignment of the conodont faunas from the Rabat–Tiflet structural zone is hampered by the generally sparse number of conodont elements and the scarcity or absence of zonal index species. The precision of the biostratigraphic interpretation gradually improves from the Lochkovian to the Givetian. It is probably related to a progressive change of the conodont biofacies during the Lochkovian-Givetian. Most of the Lower Devonian conodont faunas are dominated by *Belodella.* During the Eifelian the importance of *Polygnathus* increases and finally the genus dominates in the lower part of the Givetian. This change can be respectively linked with the lower Eifelian Chotec and Eifelian/Givetian Kacak events.

Nevertheless, it was possible to establish a regional, relatively continuous conodont zonation that is useful for regional and interregional correlation. The internationally used *sulcatus, dehiscens* vel *kitabicus, laticostatus/inversus, partitus, ensensis, hemiansatus, timorensis* and *rhenanus/varcus* zones have been recognized by the index species.

The presence of the *woschmidti* and *postwoschmidti* zones is suggested by the presence of a few fragmentary specimens of the index species occurring together with *Ozarkodina remscheidensis remscheidensis*. The *eurekanensis, delta* and *pesavis* zones were not identified. However, it should be noted that *Caudicriodus postwoschmidti* and *O. remscheidensis remscheidensis* range into the *delta* Zone (Klapper and Johnson, 1980). No zonally diagnostic species for the *kindlei* Zone were found. The earliest occurrences of *Caudicriodus celtibericus* and *Latericriodus bilatericrescens bilatericrescens* are considered herein to be indicative respectively of the base of the *pireneae* and the *dehiscens* vel *kitabicus* Zones. In the section on the left bank of the Oued Bou Regreg the first appearance of *Ozarkodina steinhornensis steinhornensis* may be within the *gronbergi* Zone (Klapper and Johnson, 1980).

The occurrence of *Polygnathus serotinus* below the *partitus* Zone in the Tiflet area may represent either the *serotinus* and/or the *patulus* Zone. No zonally diagnostic species for reliable recognition of the *costatus, australis* and *kockelianus* zones were found.

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