

Devonian conodonts from the Foča–Prača Paleozoic complex (Durmitor Nappe, southeastern Bosnia and Herzegovina)

Konodonti iz fočansko-pračanskega paleozojskega kompleksa (durmitorski pokrov, jugovzhodna Bosna in Hercegovina)

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Ključne besede: konodonti, devon, vrtina CR-17, Crna rijeka, Bosna in Hercegovina

Abstract

Conodont study of the Crna Rijeka borehole CR-17, positioned in the frontal part of the Durmitor Nappe (Foča – Prača Paleozoic complex, SE Bosnia and Herzegovina) is presented. The obtained fauna indicates an Early-Middle Devonian age and due to poor preservation an identification at a generic level is possible only. The recovered conodont elements have a high Color Alteration Index (CAI = 6,5–7) indicating a degree of metamorphism corresponding to a temperature interval from 440 °C to 720 °C.

Izvleček

Predstavljene so konodontne raziskave vrtine Crna rijeka CR-17 v čelnem delu pokrova Durmitor (paleozojski kompleks Foča – Prača, jugovzhodna Bosna in Hercegovina). Konodontna favna dokazuje spodnje-srednjo devonsko starost, vendar je zaradi slabe stopnje ohranjenosti mogoča le določitev na stopnji rodov. Dobljeni konodontni elementi imajo visok barvni indeks (CAI = 6,5–7), ki kaže na stopnjo metamorfoze v temperaturnem intervalu od 440 °C do 720 °C.

Introduction

The goal of the CR-17 borehole (Fig. 1) was to acquire knowledge about the thickness of Devonian carbonate in the Crna Rijeka area of Bosnia and to recognize the geological characteristics of the area to support the project of the »Crna Rijeka Dam«, near Sarajevo (BAŠAGIĆ & SKOPLJAK, 2007).

In this short report a documentation is presented of a conodont study carried out in Paleozoic strata of the Crna Rijeka CR-17 borehole, interval from 12 to 203 meters. The obtained conodont fauna indicates an Early-Middle Devonian age of the investigated samples present in some of the oldest strata in Bosnia and Herzegovina.

Geological setting

Geographically, the Crna Rijeka is located southeast of Sarajevo (Fig. 1). The area of Crna Rijeka is included in the Foča-Prača Paleozoic



Fig. 1. Location map of the Crna Rijeka CR-17 borehole.

complex of southeastern Bosnia and Herzegovina and is positioned in the frontal part of the Durmitor Nappe, which tectonically overlies the Bosnia Flysch Nappe (Fig. 2).

Southeastern Bosnia and Herzegovina comprises the areas of Foča, Goražde and Prača. In the between the Foča and Goražde areas the oldest Paleozoic formations crop out in which Variscian age structures are preserved. Thick-bedded limestone occurs at Ustikolina with Late Silurian conodonts *Ozarkodina* and *Panderodus* present (BUZALJKO, 1971; RAMOVŠ, 1989).

Lower Devonian strata are represented by dark gray platy limestone with conodonts (*Neoprioniodus*, *Plectospathodus*) and Upper Devonian limestone are marked by the presence of conodonts (*Palmatolepis*), bryozoans and crinoids (BUZALJKO, 1971; RAMOVŠ, 1989).

In the area of Klek on the easternmost slopes of Mt. Jahorina, "Orthoceras limestone" with Early and Late Silurian conodonts and tentaculides are present in the Prača thrust below Triassic formations (KOSTIĆ-PODGORSKA, 1958). Here, a rich fauna of corals, stromatoporoids, hydrozoans, bryozoans, brachiopods and crinoids was collected in

Lower and Middle Devonian limestone (KOSTIĆ-PODGORSKA, 1958; ŽIVANOVIĆ, 1963; PANTIĆ, 1963). Some Paleozoic formations of the Foča area are of a presumed Devonian age. The thickness of the Paleozoic formations attains up to 800 m in the area (BUZALJKO, 1971).

Devonian formations are overlain by Early Carboniferous flysch that is up to 1000 m thick. The flysch sediments contain ammonoids (goniatites, orthoceratides), mollusks, gastropods, brachiopods and corals. At Podkoran, an occurrence of Early Carboniferous strata containing goniatites was studied in detail by KITTL (1904). Based on the goniatite data, FRECH (1906) and SCHMIDT (1924) supported a Visean age of some Paleozoic formations. PODGORSKA (1939) published data on fauna from crinoidal limestone from the area of Prača.

KRSTIĆ et al. (1988) gave explanation of the origin for the Silurian and Devonian limestones in the Prača area of SE Bosnia considering them as allochthonous clasts and olistoliths in the Lower Carboniferous „Culm“ flysch. FILIPOVIĆ & JOVANOVIĆ (1994) later provided new data for age and characteristics of the same rocks in the Prača (SE

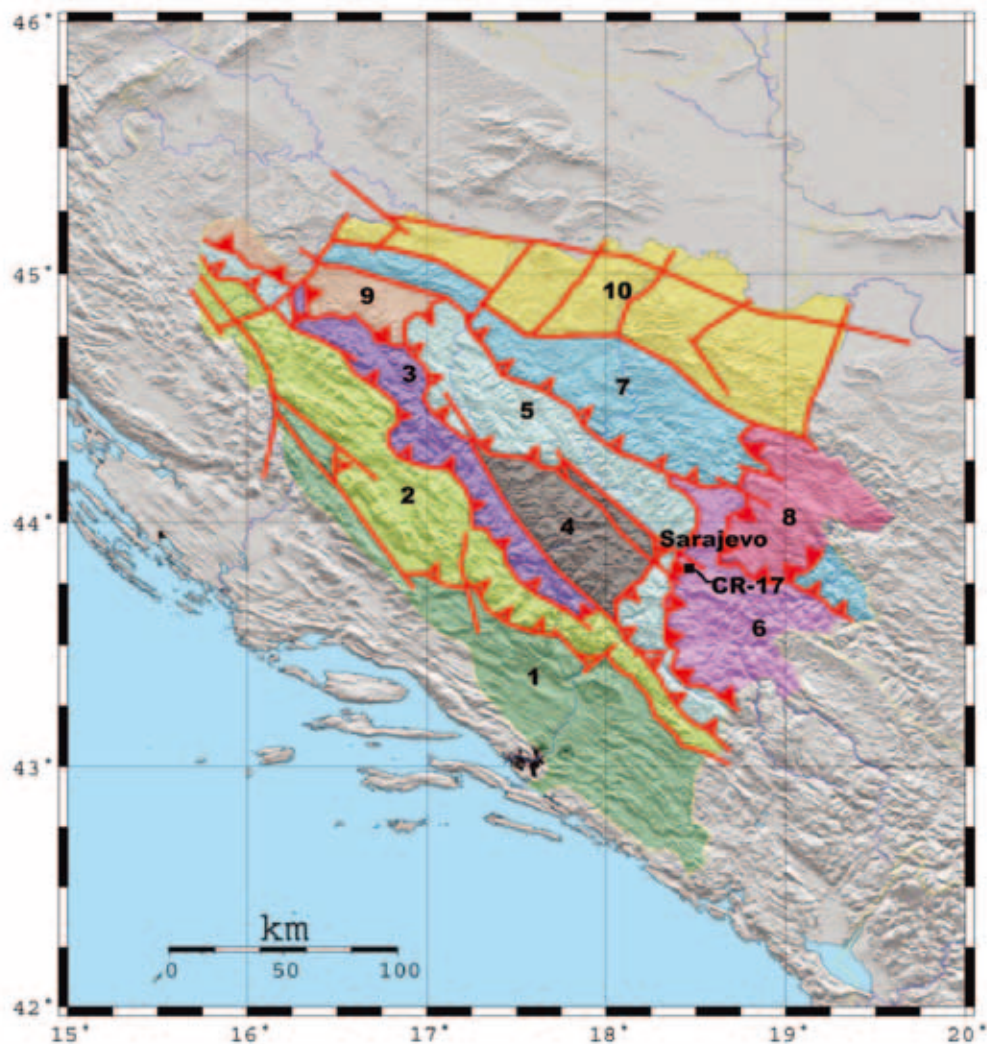


Fig. 2. Main structures of the Dinarides of Bosnia and Herzegovina (HRVATOVIĆ, 2006): ■ - CR-17 borehole. 1. Karst Nappe, 2. Una-Drežnica-Gacko Nappe, 3. Ključ-Raduša Nappe, 4. Mid-Bosnian Schists Mts., 5. Bosnian Flysch Nappe, 6. Durmitor Nappe, 7. Ophiolite Nappe, 8. Golija Nappe, 9. Sana-Una Nappe, 10. Sava-Vardar Nappe.

Bosnia) and Vlasenica (NE Bosnia) areas, and they interpreted them as Upper Carboniferous olistostromes connected with Asturian phase of Variscan orogenesis.

A break in sedimentation took place during the Late Carboniferous and Early Permian. The Upper Permian is represented by reddish clastics overlain by Bellerophon limestone bearing gastropods (*Bellerophon*) and calcareous algae (*Gymnocodium*). The Bellerophon limestone was first recorded by BITTNER (1880) and documented later by KITTL (1904) at Han Orahovica, KATZER (1926) at Zbišće and Musići, and KOSTIĆ-PODGORSKA (1958) at Vihor, Lunji and Razbojište. In the area of Tjentište, CADET (1966) reported finding of brachiopods, mollusks and gastropods in dark gray thick bedded limestone of Latest Permian age. In the area of the Kolina Valley, Fočanska Jabuka and further towards Prača sideritic-ankeritic limestone were discovered with sulphides: pyrite, chalcopyrite, arsenopyrite, galena and antimonite. BUZALJKO (1971) made a detailed stratigraphic subdivision of the Permian rocks of the Southeast Bosnia area (Fig. 3).

Conodont study

The present study is based on collections from the borehole CR 17 of Crna Rijeka and made in 2006 (KOLAR-JURKOVŠEK & JURKOVŠEK, 2006). Ten carbonate samples were collected, averaging approximately 2 kg each. They were processed for

conodont analyses. All of them are composite samples, covering over one meter of the most perspective divisions, i. e. in the less recrystallized and less tectonized parts of the drill hole. Three samples were composite samples embracing over three to six meters of the borehole in order to obtain positive results. A standard technique for conodont extraction was applied by use of acetic acid and then heavy liquid separation. The samples were dissolved at the Geološki zavod Slovenije / Geological Survey of Slovenia.

Out of the 10 examined samples from the investigated interval, six samples were productive for conodonts. However, conodont yields are rather low (Fig. 4). The obtained elements are largely fragmented. An identification at a generic level is possible only due to poor state of preservation. The conodont elements recovered have a high Color Alteration Index (CAI = 6.5–7) indicating a degree of metamorphism corresponding to a temperature interval from 440 °C to 720 °C (REJEBIAN et al., 1987).

Most of the forms are indeterminate and only the elements of the two samples (CR 74–79 m and CR-17 193–195 m) enable comparison with Early–Middle Devonian taxa.

Materials and methods

Photographs of all illustrated conodont elements presented herein were taken on the JSM-

M	Age	Lithology	Environments	Fossils
<100	P ₃	Bellerophon limestone, – sandstone, – gypsum, – redish schist, – siltstone	Shallow marine-lagoonal	<i>Bellerophon</i> sp., <i>Archaeocidaris ladina</i> , <i>Gymnocodium</i> sp.
			Land?	
850	P _{1,2}	– redish conglomerate, and quartz sandstone, – gray schist, marble, bedded limestone, – breccia	Shallow marine to fluvial	<i>Naneionella</i> , <i>Mizzia cornuta</i> , <i>Globivalvulina</i> , <i>Tubertina</i> sp.
100	C ₃	Sandstone, claystone, conglomerate, schist	Trench	<i>Lepidodendron weltheimianum</i>
	C ₂	Flysch:	Trench	<i>Verneulites librovitchi</i>
700	C ₁	Flysch: Subgraywacke, sandstone, claystone, clayey-quartz-sericite schist, microconglomerate, massive limestone	Trench	<i>Lepidodendron lassenii</i> , <i>Glyphyoceras sphaericum</i> , <i>Aviculopecten pračaensis</i> , <i>Cyathocarinia rasliana</i> , <i>Chonetes</i> , <i>Nereites</i>
200	D ₃	Bedded limestone	Marine platform	<i>Hindeodella</i> sp., <i>Palmatolepis glabra pectinata</i> , <i>P. rhomboidea</i> , <i>Belodella triangularis</i>
450	D ₂	Massive reefal limestone	Marine platform	<i>Favosites</i> sp., <i>Polygnathus linguiformis</i>
200	D ₁	Bedded limestone, layered schist	Marine platform	<i>Neoprioniodus bicurvatus</i> , <i>Plectospathodus</i> , <i>Panderodus unicostatus</i>
100	S ₃	Massive limestone	Marine platform	<i>Ozarkodina</i> , <i>Panderodus</i>

Fig. 3. Geological description of Paleozoic strata of SE Bosnia (HRVATOVIĆ, 2006; after BUZALJKO 1971; KULENOVIĆ, 1985).

5500 LV Scanning Electron Microscope of the Slovenian National Building and Civil Engineering Institute (ZAG Ljubljana). The conodont material is stored in the micropaleontological collection of Geological Survey of Slovenia (Geološki zavod Slovenije) under the inventory numbers GeoZS 4072-4080, 4085.

Sample CR-17 74-79 m (GeoZS 4077)

A single element was recovered from this sample. It is a spathognathodiform element (Pl. 1, Fig. 1) but the upper part of the denticles is broken away but it appears to represent an Early-Middle Devonian species of *Ozarkodina* or *Pandorinellina* (ROBISON, 1981; SUTTNER 2007). However, the form also has certain similarities to *Ozarkodina pandora* Murphy, Matti & Walliser, an important Lockhovian datum (MURPHY et al., 1981).

Sample CR-17 193-195 m (GeoZS 4080)

The sample yielded two fragments of coniform elements with distinct longitudinal striation, yet partly etched (Pl. 1, Fig. 2). The specimens are marked by fine striation characteristic for *Neopanderodus* that ranges from the Lower to the Middle Devonian (ROBISON, 1981). Nevertheless, the specimens can be compared with *Belodella striata* Kozur, the only belodellid representative with fine striated ornamentation. This species was first described from the basal Pragian of the Uppony Mts. in Hungary (KOZUR, 1984).

Remarks on the Early-Middle Devonian conodont faunas of Bosnia and Herzegovina

The first Lower Devonian conodont faunas in Bosnia were described from the Dvor na Uni area on the Croatian-Bosnian border (ĐURĐANOVIĆ, 1968, 1973). Later, a few localities with equivalent

faunas were reported from Jezera area near Jajce in western Bosnia (MUDRENOVIĆ et al. 1969) and from the platy limestones of SE Bosnia and Herzegovina (KULENOVIĆ, 1983). All faunas are characterized by the presence of *Belodella*. Near the village of Kolakovići in SE Bosnia, Early Devonian apparatuses of *Belodella bosniensis* Ramovš and *B. elegans* Ramovš were reconstructed that are accompanied by *Ozarkodina remscheidensis* (Ziegler), *Ozarkodina wurmi* (Bischoff & Sanne-mann), and *Icriodus steinachensis* (Al Rawi) (RAMOVŠ, 1989).

Conodont faunas of Early Devonian age are also well documented from eastern Serbia and are marked also by the presence of the genera *Belodella* and *Ozarkodina* (KRSTIĆ et al. 1970, 1995; KRSTIĆ & SUDAR, 1992, 1994).

The studied conodonts are strongly affected by metamorphism as indicated by a high CAI. Furthermore, most recovered conodonts are fragmented, corroded and recrystallized. This state of preservation is a result of the regional metamorphism and it markedly differs from the preservation of Triassic conodonts of Bosnia and Herzegovina that show a lower CAI (ALJINOVIĆ et al., 2006, 2011) and have lesser alteration. The comparison with observations made on conodonts of the Albanides is obvious (SCHÖNLAUB & MEČO, 1986).

Conclusions

A brief geologic overview of southeastern Bosnia and Herzegovina is presented and the results of a micropaleontological study carried out in the Crna Rijeka are documented herein. Conodonts were recovered from the Paleozoic strata of the CR-17 borehole. The scant conodont fauna indicates an Early-Middle Devonian age of the studied interval. The presence of conodonts in the tectonized carbonate facies is of significant importance for further study. The obtained results provide a reliable basis for a detailed biostratigraphic study aiming at a precise time assignment of the studied Devonian strata.

Taxon \ Depth (m)										
	12	68	74-79	136	144/2	164	180-185	188	193-195	203
<i>Ozarkodina</i> sp. or <i>Pandorinellina</i> sp.	-	-	1	-	-	-	-	-	-	-
<i>Neopanderodus</i> sp. or <i>Belodella</i> sp.	-	-	-	-	-	-	-	-	2	-
conodont fragments	1	-	-	-	-	-	2	3	-	1
crinoid ossicles	-	-	-	-	+	-	+	-	-	-

Fig. 4. Numerical distribution of recovered conodonts and presence of crinoids in the studied samples of the Crna Rijeka CR-17 borehole.

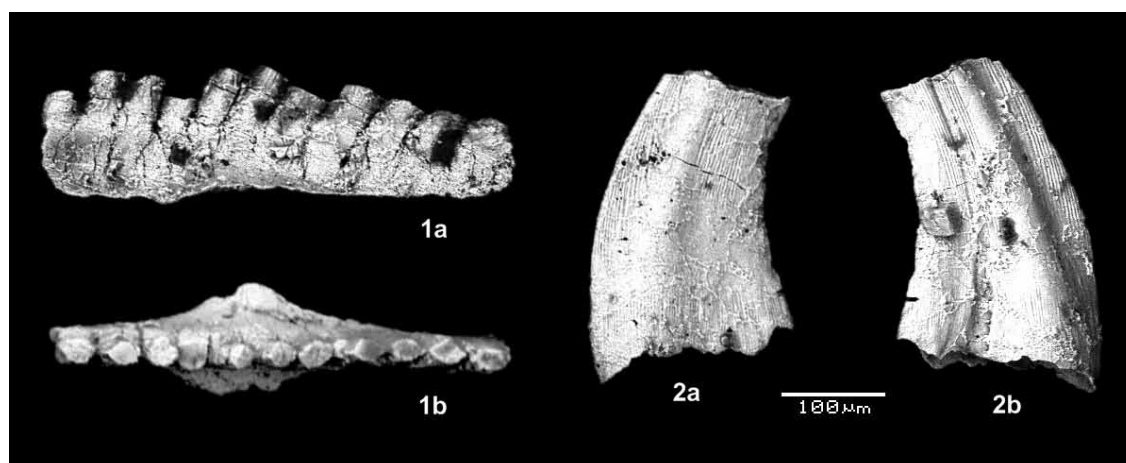


PLATE 1

Conodonts from the Crna Rijeka CR-17 borehole, Bosnia and Herzegovina, Early-Middle Devonian.

- 1 a–b *Ozarkodina* sp. or *Pandorinellina* sp. Sample CR-17 74–79 m (GeoZS 4077). a – lateral view, b – upper view.
- 2 a–b *Neopanderodus* sp. or *Belodella* sp. Sample CR-17 193–195 m (GeoZS 4080). a – b – lateral views.

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