

New Early Triassic (Smithian) ammonoids from Gornji Brčeli (southern Montenegro)

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Abstract

A rich Early Triassic ammonoid fauna of 14 genera discovered near the village of Gornji Brčeli (Crmnica, southern Montenegro) contains the three new species *Radioceras? tabulatum*, *Pseudoflemingites martellii* and *Parahedenstroemia petkovici* which are described. They belong to a Middle Smithian (*Owenites* beds) fauna and represent a unique finding in the Lower Triassic of the western Tethys where otherwise shallow-water conditions prevailed. The ammonoids originate from a series of grey-green marls and clays with intercalated, thin, mica-rich dark grey sandstones, and point towards a deeper marine environment obviously with a close open-marine connection to the Tethys ocean.

1. Introduction

The first published data on Early Triassic ammonoids from the Crmnica region date back to Petković and Mihailović (1935), who provided a detailed description of the fossiliferous locality and a palaeontological description of the scarce collected fauna. By comparison with other Early Triassic ammonoid faunas of North America and Asia, Petković and Mihailović correlated the Crmnica specimens to the zone with *Meekoceras gracilitatis*, established by Smith (1932) in North America. The authors further pointed to the importance of this fauna for palaeogeographical reconstruction, i. e. for the relationship "between the Eastern (Asian) and Western (European) parts of the great Mediterranean geosyncline" (Petković and Mihailović, 1935, 265).

Although very important, only one published paper exists on this ammonoid fauna so far. In more recent studies, primarily related to the development of a new geological map of Montenegro (sheet Podgorica-3, 1:50 000), the locality of Gornji Brčeli, at first described by Petković and Mihailović (1935), has been re-examined in detail on several occasions, resulting in a collection of a rich fauna, including more than 150 specimens. Additional material was provided by Leopold Krystyn (University of Vienna), and the earlier (1935) described fauna, which is kept in the collection of Faculty of Mining and Geology in Belgrade, has been incorporated and revised. In this paper, only the new forms are described, while the known species are just mentioned and will be documented in a forthcoming paper.

2. Geological and sedimentary setting

Lower Triassic sediments in the area of Crmnica show a total thickness of about 250 m (Pantić-Prodanović, 1975) and are represented by two main lithologies: 1) at the base brown-red and above grey-green clay-marly sediments with intercalated grey and green sandstones with mica, argillaceous sandstones, and rare interlayers of sandy limestone of Smithian

age according to the described ammonoids and rare conodonts; 2) grey to greenish-grey clayey marls with thin light-grey limy intercalations of lense-like graded calcarenites (calcuturbites?) and subordinate mudstone layers. They contain neospathotid conodonts of Spathian age (Krystyn et al., 2014). Underlying rocks have not been detected so far, while the overlying sediments are of Anisian age, represented by conglomerates and „flysch“-like sediments (Crmnica conglomerates and Tuđemili Formation – Dimitrijević, 1967; Dimitrijević and Dimitrijević, 1989).

In southern Montenegro Lower Triassic rocks are generally poor in fossils and therefore dated often on the basis of lithofacies and/or superposition. For the Crmnica region, however, it was relatively early possible to establish more exact ages for certain localities. Petković and Mihailović (1935) described from Brčeli *Meekoceras gracilitatis* WHITE, *Meekoceras (Koninkites) vetustus* WAAGEN, *Hedenstroemia hyatti* SMITH and *Pseudosageceras multilobatum* NÖETLING, and considered the fauna to belong to the zone of *Meekoceras gracilitatis* which is characteristic of Smithian age.

Mirković et al. (1978) cite the gastropod species *Naticella costata* MÜNSTER and *Turbo rectecostatus* HAUER from Limljani (southern Crmnica), and Pantić-Prodanović (1975) mentions further the foraminifera species *Meandrospira iulia* (PREMOLI SILVA) and *Ammodiscus incertus* (D'ORBIGNY) of so-called „Campilian“ age. Based on presently used Early Triassic chronostratigraphic subdivisions, this faunule is equivalent to the Spathian. From Limljani and Mali Raš (Fig. 1C), Krystyn et al. (2014) mention marls and interbedded calciturbiditic limestone with *Novispathodus homeri* of Spathian age. Though Spathian ammonoids have been discovered from other localities in Montenegro (Bešić, 1950; Pantić, 1956), they are missing in the area of Crmnica so far.

Early Triassic palaeogeographic reconstructions show the Crmnica area at about 10 degrees north of the equator loca-

ted in the western part of the Tethys (Fig. 1A) at the margin of a wide shallow shelf bay ranging from the Dinarids through the Southern and Northern Alps towards the Carpathians and beyond (Stampfli, 1996; Brayard et al., 2006). For most of the Early Triassic, environmental conditions were too shallow for ammonoids to thrive there. This also is distinct for the Smithian where, except for Montenegro, ammonoids are known only from far more eastern Tethyan regions, i.e. starting from a meridian to the east of the Black Sea (i.e. Caucasus, Oman). Accordingly, the Gornji Brčeli locality represents with major distance the westernmost locality so far discovered at which ammonoids of Smithian age have been found within the Tethys.

3. Description of the studied section

The locality, herein abbreviated called as Brčeli, is situated less than 500 m to the east of the village Gornji Brčeli and about 6 km to the west of the town of Virpazar (Fig. 1 C). Ammonoids have been found in a small, locally rather restricted area within the upper part of a several hundred metres long outcrop along the southern slope of an un-named creek east of Gornji Brčeli. Lower Triassic sediments are exposed with a total thickness of 35 metres (Fig. 2A). The lower 21 metres of the sequence are made of brown-red marls and clays with thin, dark grey, mica-rich and often lenticular sandstone layers. The upper 13 m thick part consists of grey clayey marls

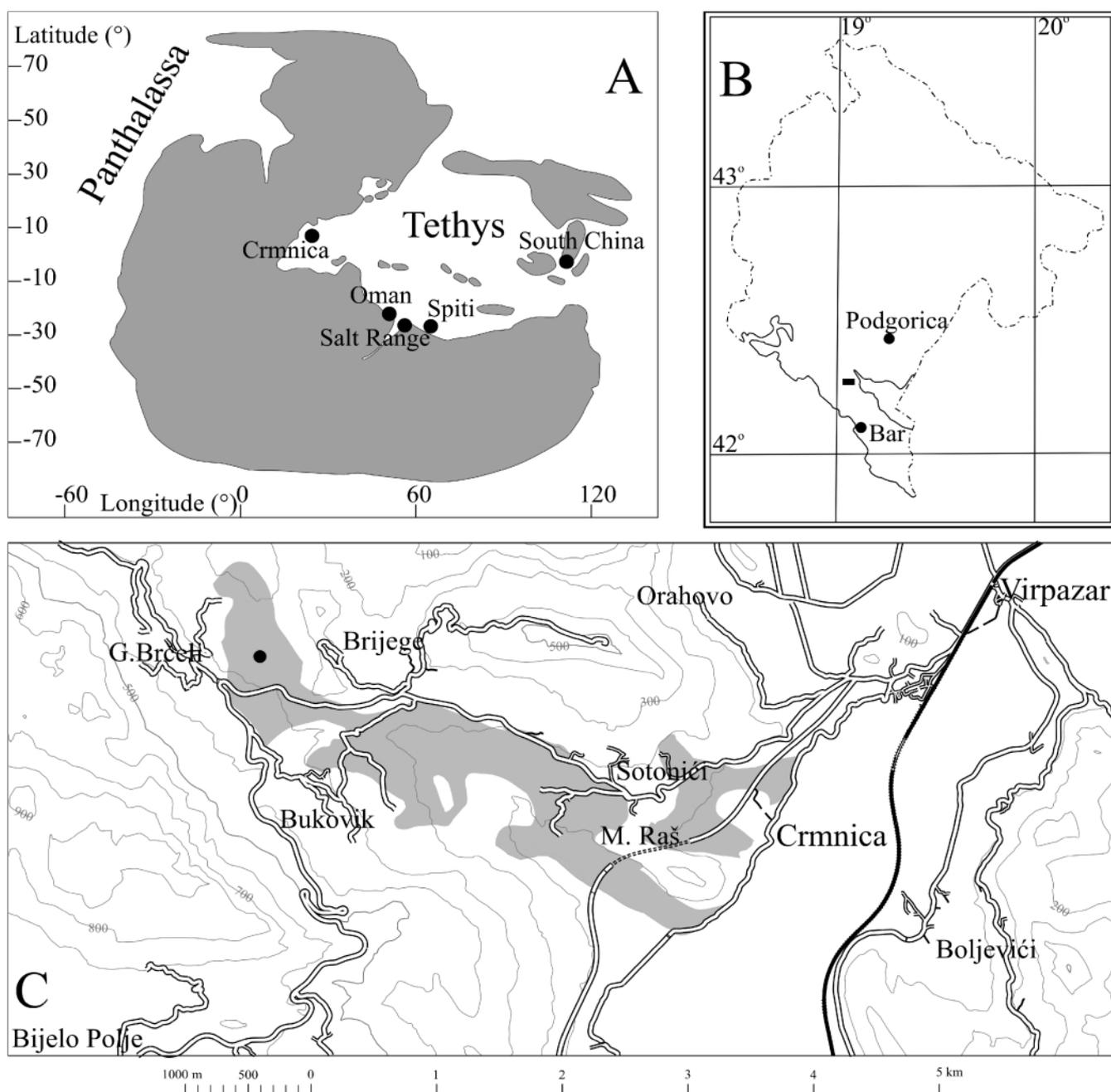


Figure 1: A: Early Triassic palaeogeography with the position of Crmnica (modified after Brayard et al., 2006), B: Map of Montenegro with indication of the studied area (small black box), C: Wider Crmnica area with location of the studied section (black dot) east of Gornji Brčeli (grey: Lower Triassic sediments, after Mirković et al.)

starting with a basal 1 m thick pebbly mass flow bed containing a thick oolitic limestone lens and well rounded Permian reefal limestone boulders up to 15 cm diameter above. The marls were deposited below storm-wave base on a deeper part of the shelf, distally from the shore, while the oolitic grainstone was formed in a shallow-marine environment and redeposited by submarine gliding into the marls. The grey marls are discontinuously overlain by conglomerates of the Anisian Crimnica Formation.

Fossils have unfortunately not been found in situ but have been collected loose on the ground associated with the grey marls, from a single spot, about 10 m² sized. Washed out from these sediments (Fig. 2B), their correct layer(s) could not be established. However, according to the topographic position in the higher part of the slope and the identical grey colour of the sediment attached to the ammonoid shells, it should be obvious that they have come from the upper part of the sequence, i. e. from the grey-green marls and clays above the slump horizon.

4. Biostratigraphical discussion

In the published literature one can find several different chronostratigraphic subdivisions of the Early Triassic. Various authors divided it into two (Induan and Olenekian; Kiparisova and Popov, 1956), three (Griesbachian, Nammalian and Spathian; Guex, 1978) or four stages (Griesbachian, Dienerian, Smithian and Spathian; Tozer, 1967). In this paper, the subdivision in two stages (each with two substages) was used, in accordance with ISC recommendations (Ogg, 2012).

Besides the here described new species *Radioceras? tabulatum*, *Pseudoflemingites martellii* and *Parahedenstroemia petkovići*, a rich ammonoid fauna has been collected from the locality. The following species have so far been determined: *Aspenites acutus*, *Cordillerites angulatus*, *Dieneroceras* sp., *Hemiprionites arthaberi*, *Owenites zitteli*, *Pseudaspenites* cf. *layeriformis*, *Pseudosageceras multilobatum*, *Truempyceras compressum*, *Wyomingites aplanatus*, *Hanielites* cf. *elegans* and *Galfettites omani*. The composition of the fauna indicates middle Smithian age and can be best compared to Spiti (Brühwiler

et al., 2012b), NW Guangxi (Brayard and Bucher, 2008) and Nevada (Jenks et al., 2010). A detailed biostratigraphic analysis and discussion on certain species (*Hemiprionites arthaberi* and *Owenites zitteli*, both described by Smith, 1932), whose validity have been questioned by later authors, will be given in another paper.

5. Systematic paleontology

Systematic descriptions follow the classification given by Brayard and Bucher (2008), as well as by Brühwiler et al. (2012a, b). For all specimens wherever measurements were possible, dimensions of the diameter of the shell (D), whorl height (H), whorl width (W) and umbilical diameter (U) are given in millimeters, and for H/D, W/D and U/D in percentages of D.

Each specimen has an inventory number, which consists of abbreviations for the locality, number of the specimen and the abbreviation for the year when the specimen was found (e. g. GBR 7/11). Specimens collected by Leopold Krystyn contain an additional label (e. g. GBR LK 10/90), while the specimens provided by the Faculty of Mining and Geology in Belgrade have their own separate inventory numbers (e. g. RGF MZ 207).

Class Cephalopoda CUVIER, 1797
 Subclass Ammonoidea ZITTEL, 1884
 Order Ceratitida HYATT, 1884
 Superfamily Meekocerataceae WAAGEN, 1895
 Family Gyronitidae WAAGEN, 1895
Genus *Radioceras* Waterhouse, 1996

Type species: *Meekoceras radiosum* Waagen, 1895

***Radioceras? tabulatum* n. sp.**

v 1935 *Meekoceras* (*Koninckites*) *vetustus* - Petković and Mihailović, p. 257, pl. 1., fig. 1-5.
 Fig. 3, A-U, Fig. 4, A-U

Diagnosis: *Radioceras?* species with tabulate venter and angular ventral shoulders.



Figure 2: A: Outcrop of Early Triassic sediments near Gornji Brčeli, B: Ammonoids occurrence in Gornji Brčeli

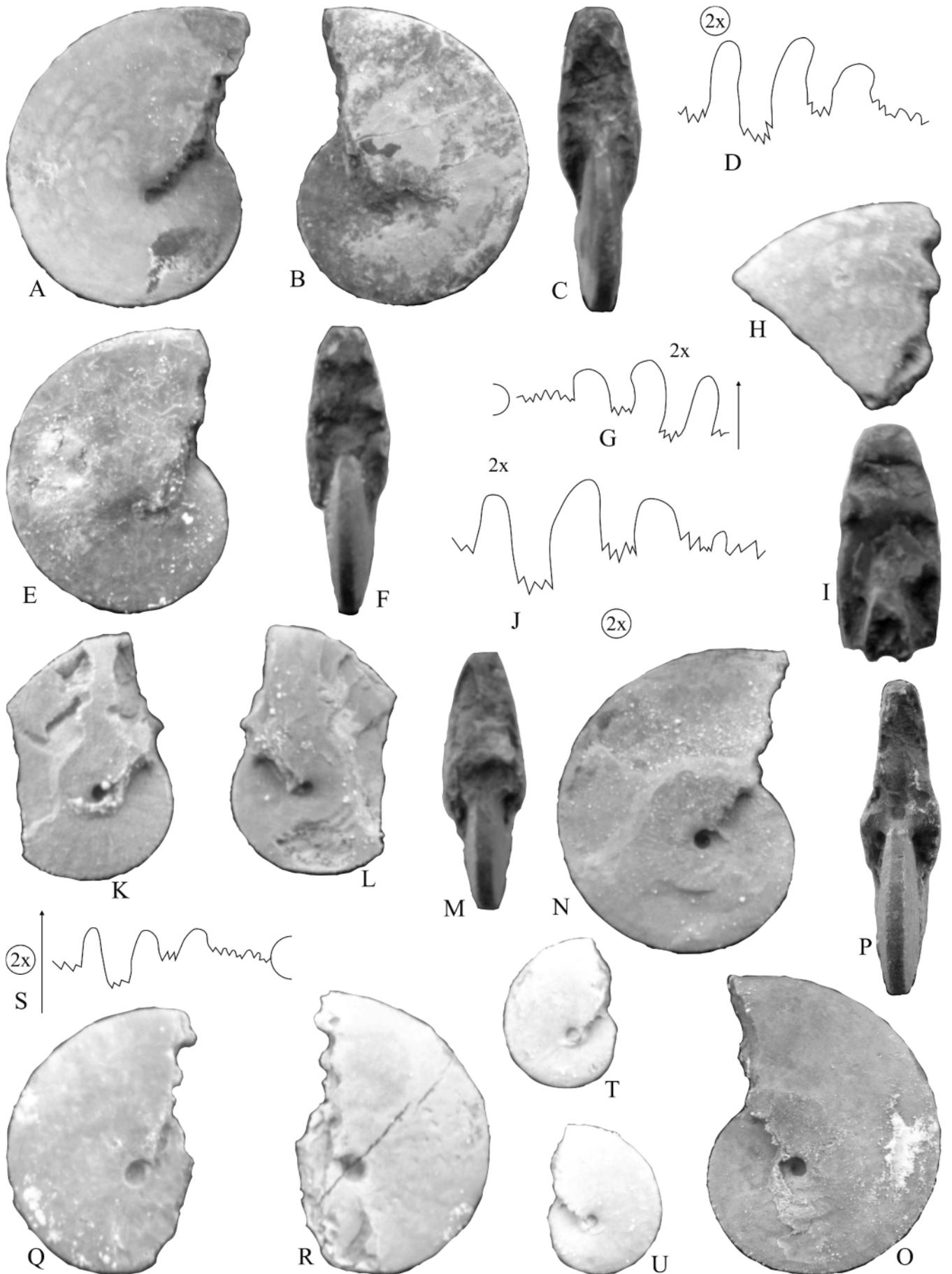


Figure 3: A-U: *Radioceras? tabulatum* n. sp. A-D: RGF MZ 207, holotype; E-G: RGF MZ 208; H-J: RGF MZ 211; K-M: GBR 27/11; N-P: GBR 28/11; Q-S: GBR 7/13; T-U: GBR 2/14. All natural size, unless indicated differently

Holotype: RGF MZ 207 (pl. 1, fig. 1), middle Smithian of Gornji Brčeli.

Derivation of name: Refers to tabulate venter of the species.

Occurrence: Middle Smithian grey marls of Gornji Brčeli (Crmnica, southern Montenegro).

Description: Shell involute, elliptical, platycone. Whorl section subrectangular, with maximum thickness in the middle of the section. Venter tabulate, with angular ventral shoulders. Flanks are slightly convex. Umbilicus is round, very small in comparison to the rest of the shell, with high vertical wall and rounded shoulders. The surface of the shell in most specimens is without ornamentation, but some contain, in the beginning falcoid, and later sinuous, weak ribs, that start from

the umbilicus, but disappear before reaching the venter. Suture line is ceratitic, with indented lobes, slightly phylloid saddles, asymmetrical second lateral saddle and well individualized auxiliary series.

Measurements:

Inv. number	D	H	W	U	H/D	W/D	U/D
RGF MZ 207	50,1	29,8	12,7	3,4	59,5 %	25,4 %	6,8 %
RGF MZ 208	45	28,7	12,6	3,3	63,8 %	28 %	7,3 %
RGF MZ 211	-	30,8	13,6	-	-	-	-
GBR 7/11	22,1	15,7	7	3,6	71 %	31,7 %	16,3 %
GBR 21/11	-	-	-	4,7	-	-	-
GBR 22/11	-	-	-	-	-	-	-
GBR 23/11	-	-	7	3	-	-	-

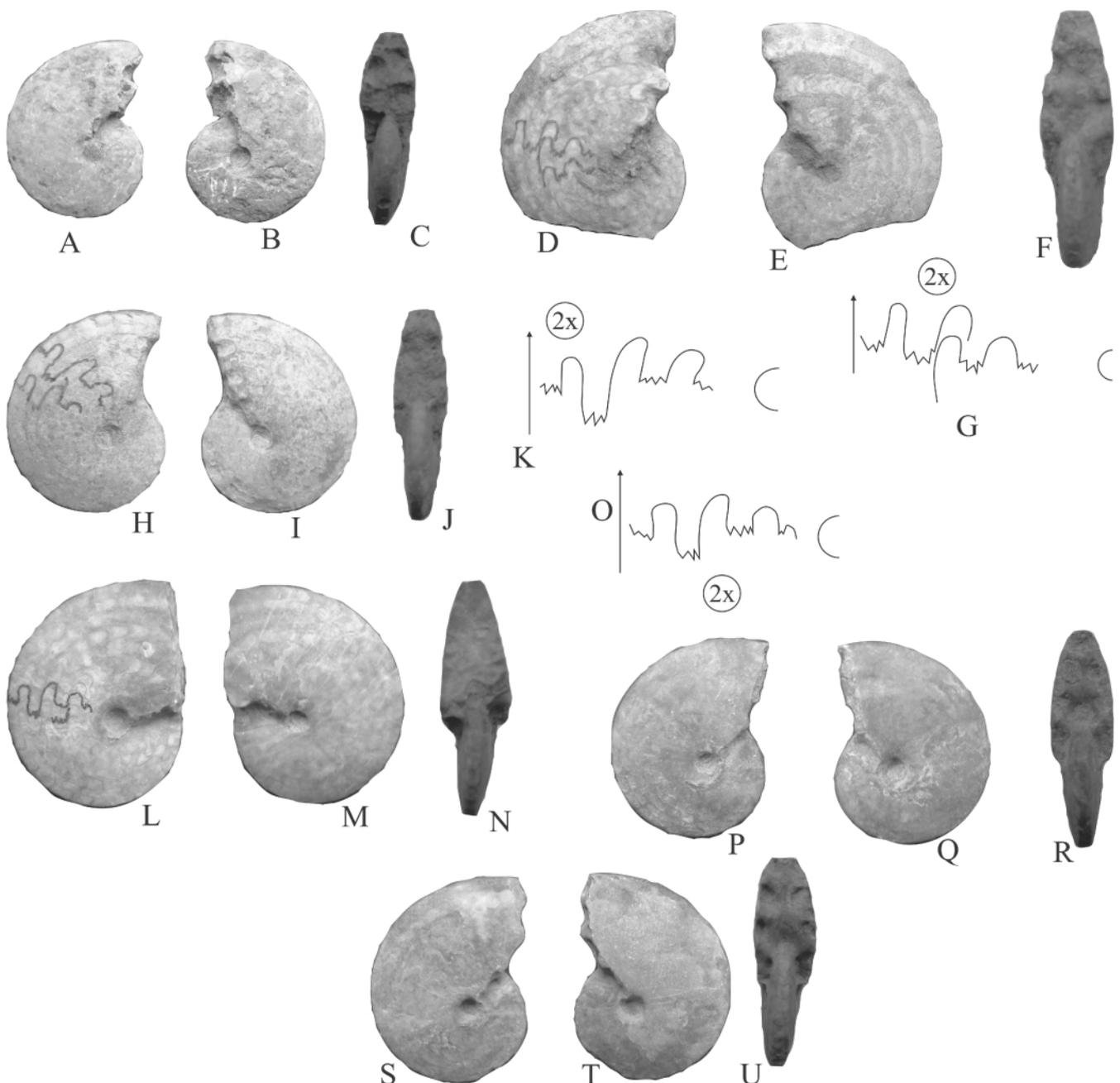


Figure 4: A-U: *Radioceras? tabulatum* n. sp. A-C: GBR LK 11/90; D-G: GBR LK 14/90; H-K: GBR 7/11; L-O: GBR 23/11; P-R: GBR 3/14; S-U: GBR 4/14. All natural size, unless indicated differently

Inv. number	D	H	W	U	H/D	W/D	U/D
GBR 24/11	35,2	21,3	-	2,6	60,5 %	-	7,4 %
GBR 25/11	-	-	9,7	3,1	-	-	-
GBR 26/11	-	-	-	5,1	-	-	-
GBR 27/11	-	-	10,8	3,4	-	-	-
GBR 28/11	49,1	29,6	-	4	60,3 %	-	8,2
GBR 7/13	-	24,6	10,4	5,1	-	-	-
GBR 2/14	-	-	6,9	3	-	-	-
GBR 3/14	27,6	16,8	7,7	3,1	60,9 %	27,9 %	11,2 %
GBR 4/14	27,9	16,7	7,8	3,2	59,9 %	28 %	11,5 %
GBR LK 10/90	-	29,2	-	3,5	-	-	-
GBR LK 11/90	24,3	13,9	6,9	3,4	57,2 %	28,4 %	14 %
GBR LK 12/90	24,7	14,4	-	3,7	58,3 %	-	15 %
GBR LK 13/90	-	18,5	-	2,8	-	-	-
GBR LK 14/90	-	19,4	8,7	3,5	-	-	-
GBR LK 15/90	30	17,6	8,2	4,3	58,7 %	27,3 %	14,3 %

Discussion: Based on characteristics of the shell and the suture line, specimens from Gornji Brčeli are very similar to the species *Radioceras evolvens* revised by Brühwiler and Bucher (2012), but they differ from their Salt Range material and also from a Spiti collection (by L. Krystyn, Vienna, pers. comm.) by having angular ventral shoulders and a distinctly broader venter. Also, some specimens described in this paper have ornamentation that was not noticed on specimens described by Brühwiler and Bucher (2012), but was mentioned by Waagen (1895) for his species *Meekoceras radiosum*. The suture line of specimens from Gornji Brčeli differs from those figured by Brühwiler and Bucher (2012) by a deeper lateral lobe and slender, more elongated saddles. These features make it very similar to the suture line of *Radioprionites abrekensis* SHIGETA and ZAKHAROV (2009) from South Primorye, Russia, but Brčeli specimens lack the strong ornamentation characteristic for the Primorye species. Since the here described form differs from other species of the genus *Radioceras* in ornamentation and shape of the suture line, this species is only tentatively referred to *Radioceras* and may equally be identified as a new genus or alternatively as a sculpture-poor *Radioprionites*.

The species includes also specimens from the collection of Faculty of Mining and Geology in Belgrade that were determined by Petković and Mihailović (1935) as *Meekoceras (Koinckites) vetustus*.

Family Flemingitidae HYATT, 1900

Genus *Pseudoflemingites* Spath, 1930

Type species: *Pseudoflemingites timorensis* Spath, 1930

***Pseudoflemingites martellii* n. sp.**

Fig. 5, A-F

2012 *Pseudoflemingites* cf. *timorensis* - Brühwiler and Bucher, p. 78, fig. 61A-J.

Diagnosis: *Pseudoflemingites* species with subrectangular to elliptical whorl section and strong ribs on the umbilicus.

Holotype: GBR 11/14 (pl. 2, fig. 7), middle Smithian of Gornji Brčeli.

Derivation of name: Named after Italian palaeontologist and geologist Alessandro Martelli.

Occurrence: Middle Smithian grey marls of Gornji Brčeli (Crnica, southern Montenegro).

Description: Shell moderately evolute, elliptical, compressed. Whorl section subrectangular to elliptical in shape. Venter rounded, flanks straight and parallel. Umbilicus wide and shallow, with rounded shoulders. Ornamentation consists of ribs that are strong on the umbilicus, but become weaker on outer whorls and turn in radial folds. Suture line is ceratitic, very simple.

Measurements:

Inv. number	D	H	W	U
GBR 11/14	-	16,6	8	-

Discussion: Specimens from Gornji Brčeli differ from other representatives of this genus by the shape of the whorl section and ornamentation. They show most similarity to the ones described by Brühwiler and Bucher (2012) as *Pseudoflemingites* cf. *timorensis*, which should also be assigned to this species. Due to poor preservation of specimen GBR 2/11, measurements were taken only from specimen GBR 11/14.

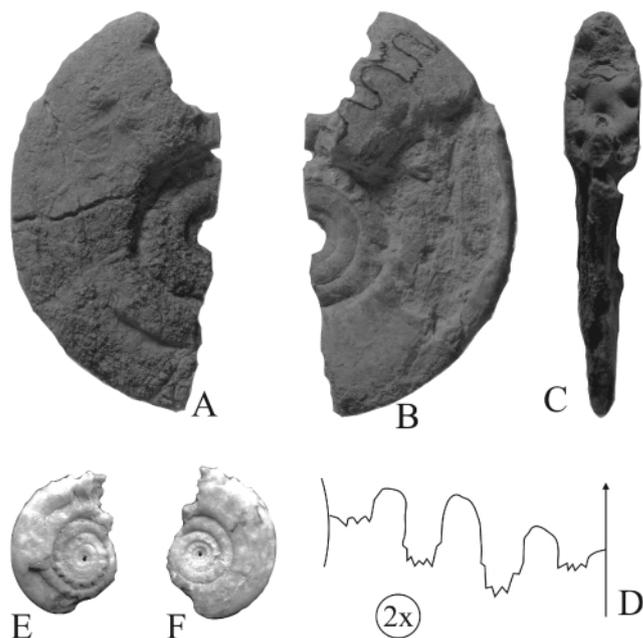


Figure 5: A-F: *Pseudoflemingites martellii* n. sp. A-D: GBR 11/14, holotype; E-F: GBR 2/11. All natural size, unless indicated differently

Superfamily Sagecerataceae HYATT, 1884

Family Hedenstroemiidae WAAGEN, 1895

***Parahedenstroemia petkovi* n. sp.**

Fig. 6, A-K

Diagnosis: *Parahedenstroemia* species with small umbilicus, concave growth lines and weak radial folds.

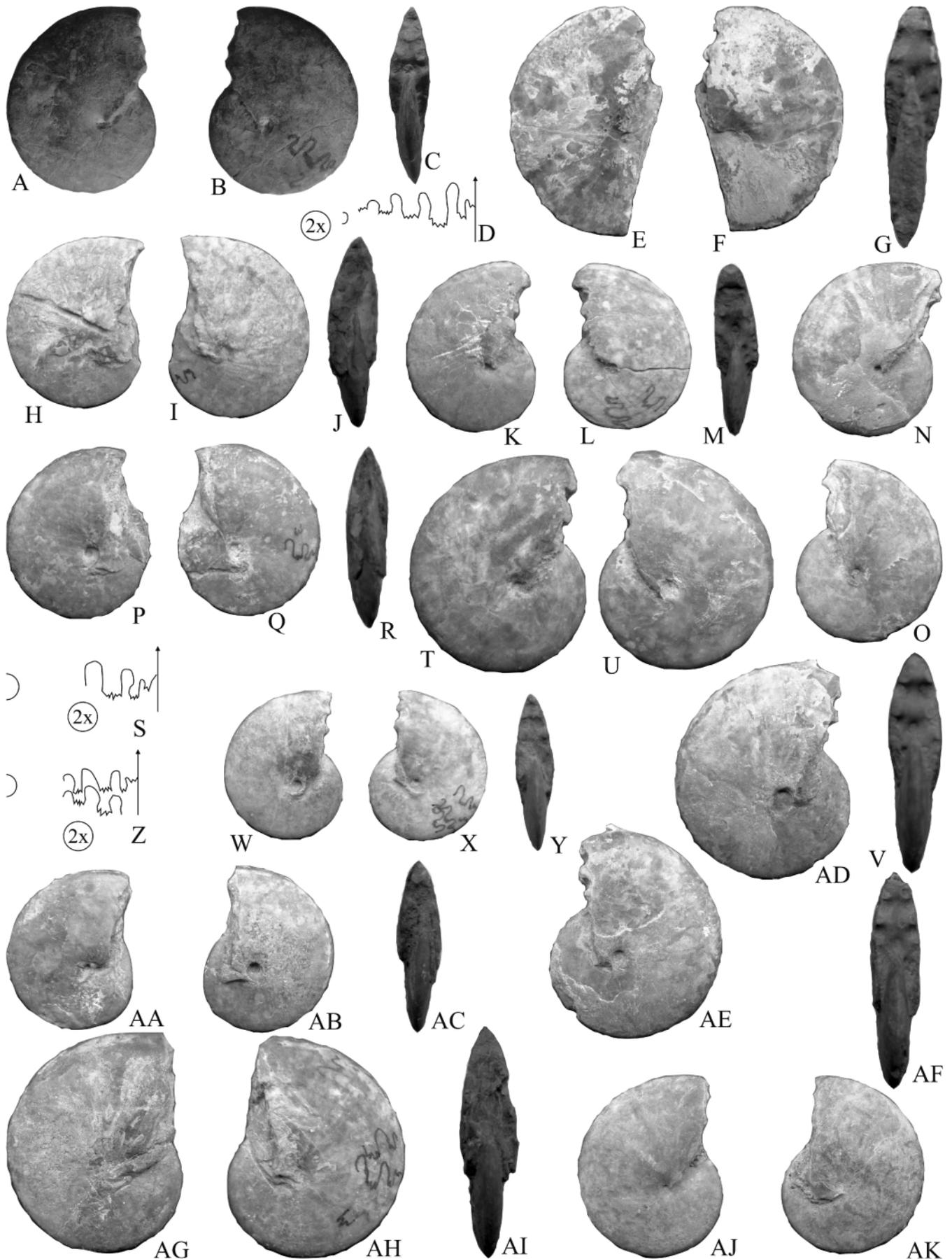


Figure 6: A-AK: *Parahedenstroemia petkovici* n. sp. A-D: GBR 19/14, holotype; E-G: GBR LK 39/90; H-J: GBR LK 40/90; K-M: GBR 46/11; N-O: GBR 81/11; P-S: GBR 90/11; T-V: GBR 93/11; W-Z: GBR108/11; AA-AC: GBR 110/11; AD-AF: GBR 9/13; AG-AI: GBR 17/14; AJ-AK: GBR 18/14. All natural size, unless indicated differently

Holotype: GBR 19/14 (pl. 3, fig. 11), middle Smithian of Gornji Brčeli.

Derivation of name: Named after Serbian geologist Kosta Petković, who first discovered the locality.

Occurrence: Middle Smithian grey marls of Gornji Brčeli (Crnica, southern Montenegro).

Description: Shell involute, elliptical, compressed, oxycone with an acute keel. Whorl section lenticular, with maximum thickness in the middle of the section. Venter acute, keeled, while the flanks are convex. Umbilicus is small, round and deep, with angular shoulders. Ornamentation, only in some specimens, consists of weak, concave growth lines, and rare, weak radial folds. Suture line is ceratitic, with a small adventitious element in the external lobe, indented lobes and slightly phylloid saddles.

Measurements:

Inv. number	D	H	W	U	H/D	W/D	U/D
GBR 46/11	-	-	6,9	2,1	-	-	-
GBR 62/11	-	13,5	5,5	0,9	-	-	-
GBR 75/11	18	10,9	4,5	1,2	60,6 %	25 %	6,7 %
GBR 79/11	-	-	6,1	2,6	-	-	-
GBR 80/11	-	-	-	1,7	-	-	-
GBR 81/11	30,4	18,1	7,2	1,5	59,5 %	23,7 %	4,9 %
GBR 90/11	-	-	6,2	1,9	-	-	-
GBR 92/11	-	-	-	2,3	-	-	-
GBR 93/11	36,3	20,9	8,3	1,9	57,6 %	22,9 %	5,2 %
GBR 94/11	20,3	11,8	5	1,4	58,1 %	24,6 %	6,9 %
GBR 99/11	-	-	4,7	1,3	-	-	-
GBR 100/11	21	12,2	5,1	1,2	58,1 %	24,3 %	5,7 %
GBR 101/11	17,3	10	4,1	1,4	57,8 %	23,7 %	8,1 %
GBR 102/11	26,6	15,7	5,8	1,8	59 %	21,8 %	6,8 %
GBR 106/11	21,3	13	5,2	1,3	61 %	24,4 %	6,1 %
GBR 108/11	25,4	14,9	5,9	1,4	58,7 %	23,2 %	5,5 %
GBR 110/11	27,2	15,6	6,8	2,3	57,4 %	25 %	8,5 %
GBR 113/11	-	20,3	8,6	-	-	-	-
GBR 115/11	-	-	5,2	1,6	-	-	-
GBR 116/11	-	-	8,1	-	-	-	-
GBR 9/13	-	-	7,8	2	-	-	-
GBR 14/14	-	-	-	1,5	-	-	-
GBR 15/14	24,5	14,2	5,2	1,5	58 %	21,2 %	6,1 %
GBR 16/14	26,1	15,2	6,5	1,3	58,2 %	24,9 %	5 %
GBR 17/14	36,7	21,7	8,9	2	59,1 %	24,3 %	5,5 %
GBR 18/14	30,3	17,8	7,6	1,9	58,8 %	25,1 %	6,3 %
GBR 19/14	30,9	18,3	7,0	1,9	59,2 %	22,7 %	6,2 %
GBR LK 38/90	-	-	-	1,5	-	-	-
GBR LK 39/90	-	-	8,2	-	-	-	-
GBR LK 40/90	29,7	17	7,4	1,5	57,2 %	24,9 %	5,1 %
GBR LK 41/90	29,9	16,8	7,5	1,8	56,2 %	25,1 %	6 %

Discussion: *Parahedenstroemia petkovici* n. sp. resembles most *Parahedenstroemia kiparisovae*, described by Shigeta and Zakharov (2009) from South Primorye, both in form and suture line. *P. kiparisovae*, however, differs in ornamentation, a rounding of the venter in later growth stage and a suture with less auxiliary elements. It also resembles *Parahedenstroemia acuta*, the type species of the genus, but misses the occluded umbilicus.

6. Conclusions

From the Lower Triassic of Gornji Brčeli three new ammonoid species (*Radioceras? tabulatum*, *Pseudoflemingites martellii* and *Parahedenstroemia petkovici*) are described belonging to a rich fauna of middle Smithian age which includes 14 genera. The fauna is of major palaeo(bio)geographic importance as – rather isolated – westernmost occurrence of pandemic Smithian ammonoids in the Tethys.

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