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Rudist and foraminifer assemblages in the Santonian-Campanian sequence of Nanos Mountain (Western Slovenia)

Rudistne in foraminiferne združbe v santonijsko-campanijskih plasteh Nanosa (Zahodna Slovenija)

Mauro CAFFAU[1] & Mario PLENIČAR[2]

[1] Dipartimento di Scienze Geologiche Ambientali e Marine University of Trieste, Weiss 2, 34127 Trieste, Italy
[2] Katedra za geologijo in paleontologijo NTF, Aškerčeva 2, 1000 Ljubljana. Slovenija

Keywords: Rudists, Foraminfers, Santonian-Campanian, Nanos mountain, Adriatic-Dinaric Carbonate Platform, Slovenia

Ključne besede: rudisti, foraminifere, santonij-campanij, Nanos, Jadransko-dinarska karbonatna platforma, Slovenija

Abstract

The Santonian-Campanian limestones of Nanos Mountain are mainly characterized by wackestone-packstone with benthic foraminifers, thaumatoporellaceans and rudists. Rudists in growth position are rare and rudist congregations are found only in bouquets with less than ten individuals. Rudist shells are chaotically deposited in beds and frequently show signs of bioturbation and erosion. The analyzed sequence from Nanos Mountain testifies an inner shelf environment in a ramp-like depositional setting. In the lower part of the sequence, rudist assemblages are characterized by abundant hippuritids and radiolitids whereas benthic foraminifers are rare and poorly preserved. In the upper part of the sequence, rudist assemblages consist of abundant radiolitids and rare hippuritids. Benthic foraminifers are usually well-preserved and the presence of the *Keramosphaerina tergestina* (Stache) is recorded. The vertical distribution of rudist and foraminifer assemblages with the presence of *K. tergestina* reflect sea level changes in an inner shelf environment during Santonian-Campanian.

Kratka vsebina

Apnenci santonijske in campanijske starosti so značilni kot tip wackestone-packstone z bentičnimi foraminiferami, thaumatoporelami in rudisti. Rudisti v položaju rasti so redki in rudistne skupnosti najdemo v šopih z manj kot desetimi posameznimi primerki. Lupine rudistov so v plasteh nepravilno razporejene ter pogostno kažejo znake bioturbacije in erozije. Preučevano zaporedje z Nanosa kaže podobno razporeditev kot na pregibu notranjega šelfa . V spodnjem delu zaporedja je rudistna združba značilna po številnih hipuritidih in radiolitidih, medtem ko so bentične foraminifere redke in slabo ohranjene. V zgornjem delu zaporedja so v rudistnih združbah številni radiolitidi in meloštevilni hipuritidi. Bentične foraminifere so navadno dobro ohranjene. Ugotovljena je bila vrsta *Keramosphaerina tergestina* (Stache). Vertikalna razširjenost rudistnih in foraminifernih združb z vrsto *K. tergestina* odraža nihanje morske gladine v okolju notranjega šelfa v času santonija in campanija.

Introduction

The Santonian-Campanian carbonate sequence of Nanos Mountain (Western Slovenia) is characterized by rudist-rich limestones. Rudist assemblages consist of individuals from the Radiolitidae and Hippuritidae families. The latter has been described by Pleničar (1975). Brachiopods, echinoids and crinoids also occur.

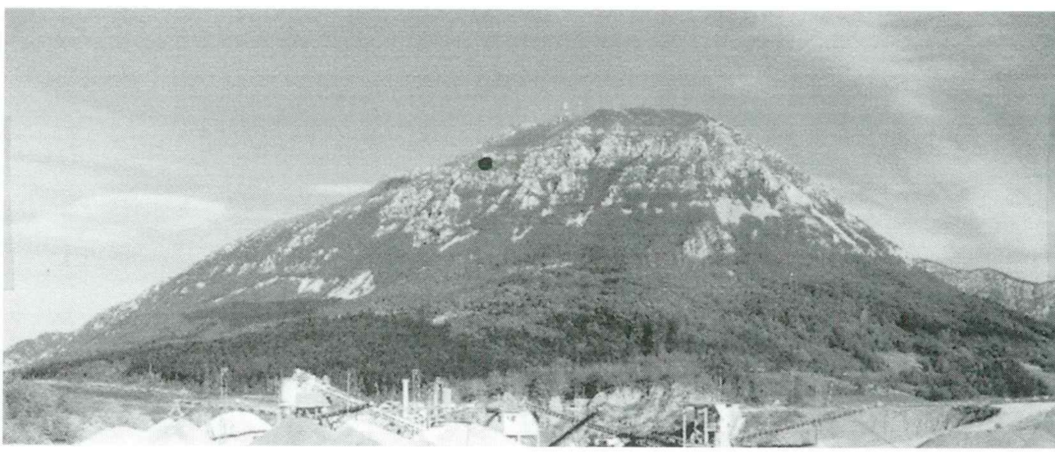
In this area, the colonization of the inner shelf environment in a carbonate ramp setting during the Santonian-Campanian is characterized by a medium-high diversity and a high production of individuals, mainly of *Vaccinites, Bournonia, Gorjanovicia, Medeella, Radiolitella, Katzeria* and *Biradiolites* genera. Several rudist shell beds are present in the sequence which have been classified in two shell bed categories: "*Primary Shell Concentration*" and "*Hydraulic Shell Concentration*" as proposed by Kidwell (1991) and Kidwell & Holland (1991).

Rudists in growth position are rare and small bouquets with less than ten individuals are present. Transported rudists give rise to shell accumulations with randomly oriented shells that show frequent signs of bioturbation and erosion.

The presence of numerous individuals of *Keramosphaerina tergestina* in several levels of the sequence and the analysis of their size and abundance allowed to distinguish the autochthonous from the allochthonous forms, already described by Caffau et al. (2001).

Location of the studied area and geological setting

The Nanos Mountain belongs to the Hrušica overthrust, of which is the highest peak (1313 m). The summit is 700 m above the mean altitude of the Trieste-Komen plateau to the west (Fig. 1). Towards the Vipava valley, which separates the Nanos from the Trieste-Komen pla-



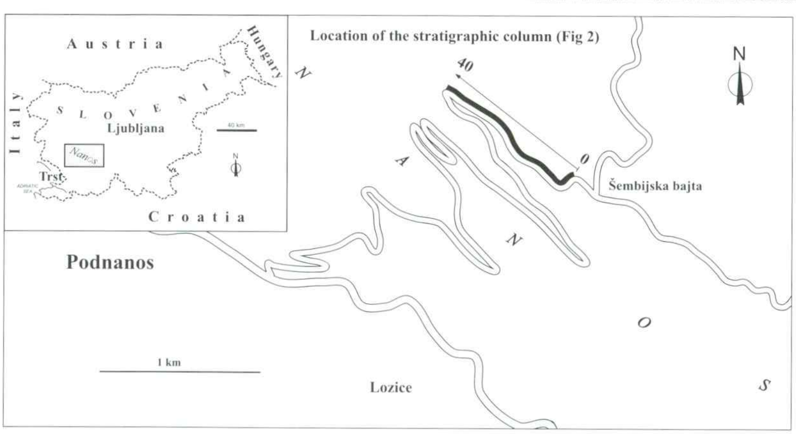


Fig. 1 – Location map of the studied sequence and panoramic view of the Nanos Mountain.

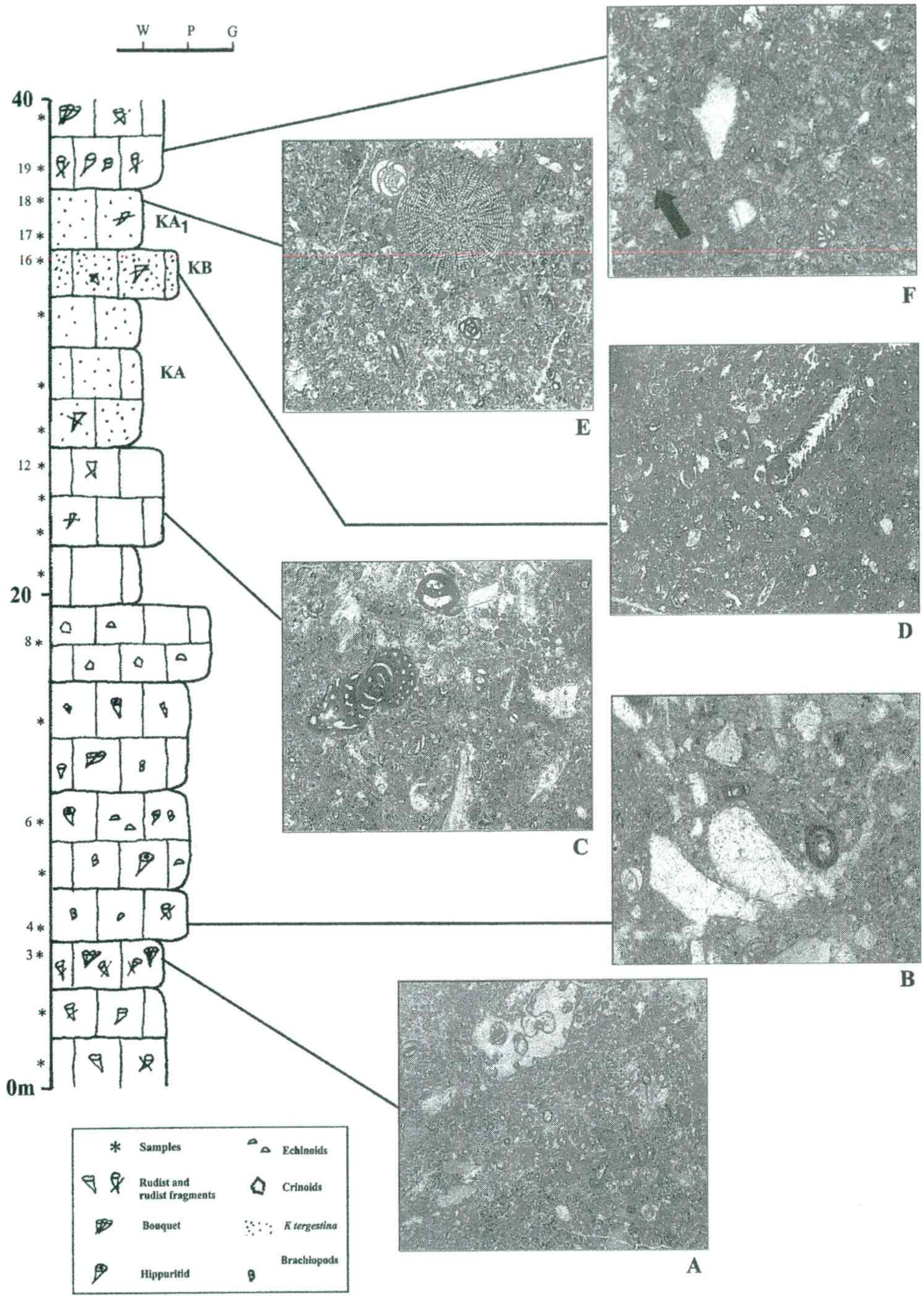


Fig. 2 – Stratigraphic column and photomicrographs of foraminiferal assemblages. (A) Packstone with *Thaumatoporella parvovesiculifera*, small miliolids and fragments of bioeroded rudists; x 20. (B) Packstone with *T. parvovesiculifera* and fragments of eroded rudists; x 20. (C) Packstone with *Murciella cuvillieri*, miliolids, pellets and rudist fragments; x 20. (D) Packstone with *Scandonea samnitica* and miliolids; x 20. (E) Packstone with *Keramosphaerina tergestina*, *Accordiella conica* and bioclastic fragments; x 20. (F) Packstone with *Accordiella conica* (indicated by an arrow) small miliolids and bioclastic fragments; (KA_1, KB, Ka víde p. 46) x 15.

teau, the Nanos has a steep flank of about 1000 m in height. This western flank exposes white Upper Cretaceous limestones with characteristic bedding which can be followed for several kilometres along the Vipava valley. The beds of the Nanos are overturned and thrust over Eocene flysch in the west. Thus, from the Vipava valley towards the top of the Nanos, successively older beds are encountered. One of the best outcrops is along the road from the small village Podnanos to the slope of Nanos and where the studied sequence is located.

Stratigraphic sequence

The sequence is about 40 m thick (Fig. 2). The stratigraphic distribution of *K. tergestina* is indicative of Santonian-Campanian age (cf. Buser, 1965; Koch, 1977; Koch et al., 1996; Gušić & Jelaska, 1990; Caffau et al., 2001 and Tešović et al., 2001). The sequence is subdivided in two intervals on the bases of lithofacies and faunal elements, which are mainly characterized by concentrations of shells of bivalves (rudists, brachiopods) and crinoids. Orientation, arrangement, packing and sorting of the skeletal elements testify the different hydrodynamic activities in the carbonate platform. As far as the taphonomy is concerned the recognized shell beds have been classified in two classical categories: a) shell beds considered as "*Primary Shell Concentration*" in which the shell concentration is formed by individuals in growth position; b) shell beds considered as "*Hydraulic Shell Concentration*" which were deposited under the influence of physical factors such as waves and currents and/or the input of surrounding bioclastic sediments (cf. Kidwell, 1991; Kidwell & Holland, 1991; Ruberti & Toscano, 2002).

Lower interval: The interval thickness is 22 metres with a bed thickness which varies from 35 to 180 cm. The most common lithofacies is represented by wackestone-packstone (lower part), packstone with benthic foraminifers (medium part) and grainstone (upper part).

Rudist shell beds are characteristic of the lower part of this interval. The shells have mainly a parallel to sub-parallel orientation with regard to the bedding. Generally, only right disarticulated valves are present, whereas complete individuals rarely occur. In some levels, shell fragments exhibit frequent signs of bioerosion (Fig. 2A). In other levels, the random orientation of disarticulated valves and the lack of bioerosion (Fig. 2B) suggest both a shell transport from neighbouring areas and a rapid burial. The resulting shelly sheets may be attributed to "*Hydraulic Shell Concentration*". Rudist assemblages consist of radiolitids like *Bournonia excavata* (d'Orbigny), *Gorjanovicia lipparinii* Polšak, *Medeella zignana* (Pirona), *Radiolitella forojuliensis* (Pirona) and subordinately, hippuritids as *Vaccinites sulcatus* (Defrance) and *Hippurites* sp.

In the medium part rudist fauna, echinoids and brachiopods occur. Rudist assemblages consist of hippuritids with rare radiolitids that are mainly found as fragments. Together with hippuritids, abundant brachiopods and subordinately, echinoids are found (Fig. 3A). Hippuritids are commonly found in growth position forming groups of 3-4 individuals and sometimes isolated. They are bioclastic supported in a silt-packstone matrix. Radiolitid shells are usually fragmented. Rudist assemblages consist of *V. sulcatus*, *Vaccinites vredenburgi* (Kühn), *Vaccinites archiaci* (Munier-Chalmas), *Vaccinites braciensis* Sladić-Trifunović, *Vaccinites oppeli* (Douvillé) and *Radiolites* sp. together with echinoids and brachiopods as *Cyclothyris ? globata* (Arnaud) (Fig. 4). The study of benthic foraminifers reveals a poor and not very well preserved fauna. *Accordiella conica* Farinacci, *Scandonea samnitica* De Castro *Dicyclina schlumbergeri* Munier-Chalmas, *Moncharmontia apenninica* (De Castro), *Rotorbinella scarselai* Torre, *Thaumatoporella parvovesiculifera* (Raineri), *Cuneolina* sp. and miliolids are found.

The prevalence of shells in growth position in the medium part of this interval suggests a hidrodinamic energy condition characterized by a low degree of reworking and transport of the shells. Thus, these shell beds can be considered as "*Primary Shell Concentration*".

The upper part is characterized by a storm layer with echinoid and crinoid fragments (Fig. 3B), red algae and bryozoans in a packstone-grainstone matrix which upwards changes in wackestone-packstone with very rare echinoid and crinoid fragments and red algae. In this part no benthic foraminifers were observed.

The upper interval shows a thickness of 18 metres and the bed thickness varies from 30 to 15 cm. The lithofacies is commonly represented by wackestone and wackestone-pac-

Fig. 3 – Field evidence of some fossiliferous beds. (A) Hippuritids (h), brachiopods (b) and echinoids (e), sample 6; scale bar 2.5 cm. (B). Storm accumulations of echinoid and crinoid fragments, sample 8; nat. size.

The numbering of the samples corresponds to the stratigraphic column.

Fig. 4 - *Rynchonella contorta* d'Orbigny, sample 8; x 1.5.

kstone. Within this interval the rudist fauna (Fig. 5) mainly occurs in chaotic accumulations of right valves (both intact and fragmented). Small groups of biradiolitids composed of 3-4 individuals in growth position also

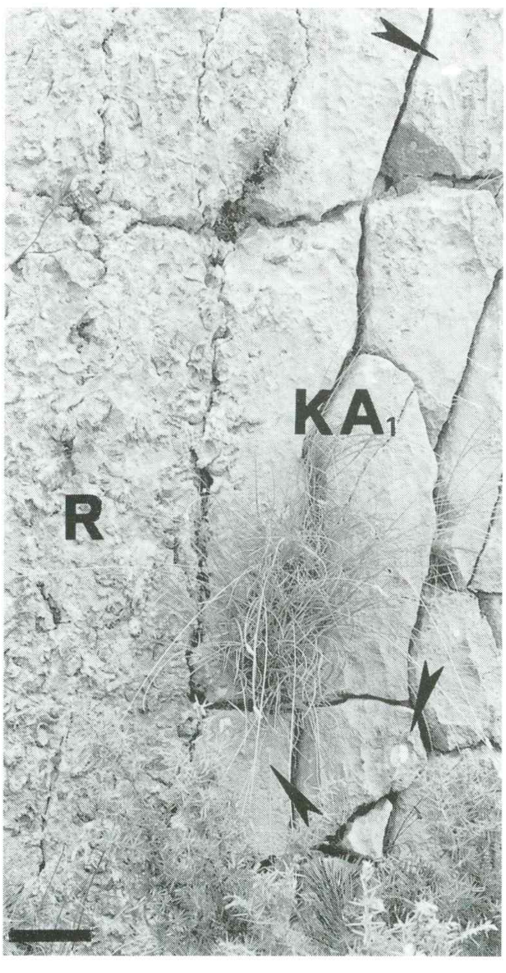


Fig. 5 - Boundary between the KA_1 (sample 18) and storm rudist shell accumulation (R) (sample 19). Arrows indicate some *Keramosphaerina tergestina*. The strata are vertical; scale bar 4 cm. Numbering of the samples correspond to the stratigrafic column.

occur. Shell fragments exhibit slight signs of bioerosion and abrasion. Rudist assemblages consist of *Medeella zignana*, *Katzeria hercegovinaensis* Slišković, *Biradiolites fissicostatus* d'Orbigny, *Biradiolites rotundatus* Pleničar, *R. forojuliensis*, *G. lipparini*. The prevalence of shells in growth position (Pl.3, fig.2) supported by a bioclast sediment and the good preservation-state of the shells in several beds of this interval suggest low energy condition and low degree of post-mortem disturbance. Thus, these shell beds can be considered as "*Primary Shell Concentration*".

Within this interval a rich foraminiferal association with well-preserved individuals is found. The most frequent species are *Murciella cuvillieri* Fourcade (Fig. 2C), *Keramosphaerina tergestina* (Stache), *Cuneolina pavonia* d'Orbigny, *A. conica* (Fig. 2F), *S. samnitica* (Fig. 2D), *D. schlumbergeri* and *M. apenninica* whereas miliolids and *T. parvovesiculifera* occasionally occur.

K. tergestina specimens were found with different concentrations in three levels. In the **KA** level, individuals of *B. fissicostatus* and *B. rotundatus* (Pl.3, fig.1) are found along with *K. tergestina,* which in this level is less abundant than in the **KA**$_1$ level (Figs. 2E and 6A). In both levels, the individuals of *K. tergestina* have very variable size (the diameter varies from 2 to 14 mm) and are supported in a wackestone matrix. In the **KB** level, either dense deposits of *K. tergestina* and shell fragments of radiolitids or deposits of radiolitid fragments with scarce *K. tergestina* (Fig. 6B) ocurr. In this level, *K. tergestina* individuals have almost the same size (diameter varies from 7 to 13 mm) and are supported in a packstone matrix. According to Caffau et al. (2001), the larger range of diameters (levels **KA** and **KA**$_1$) is correlated with autochthonous forms, whereas dense deposits of *K. tergestina* individuals and a reduced range of diameters (level **KB**) indicate allochthonous forms.

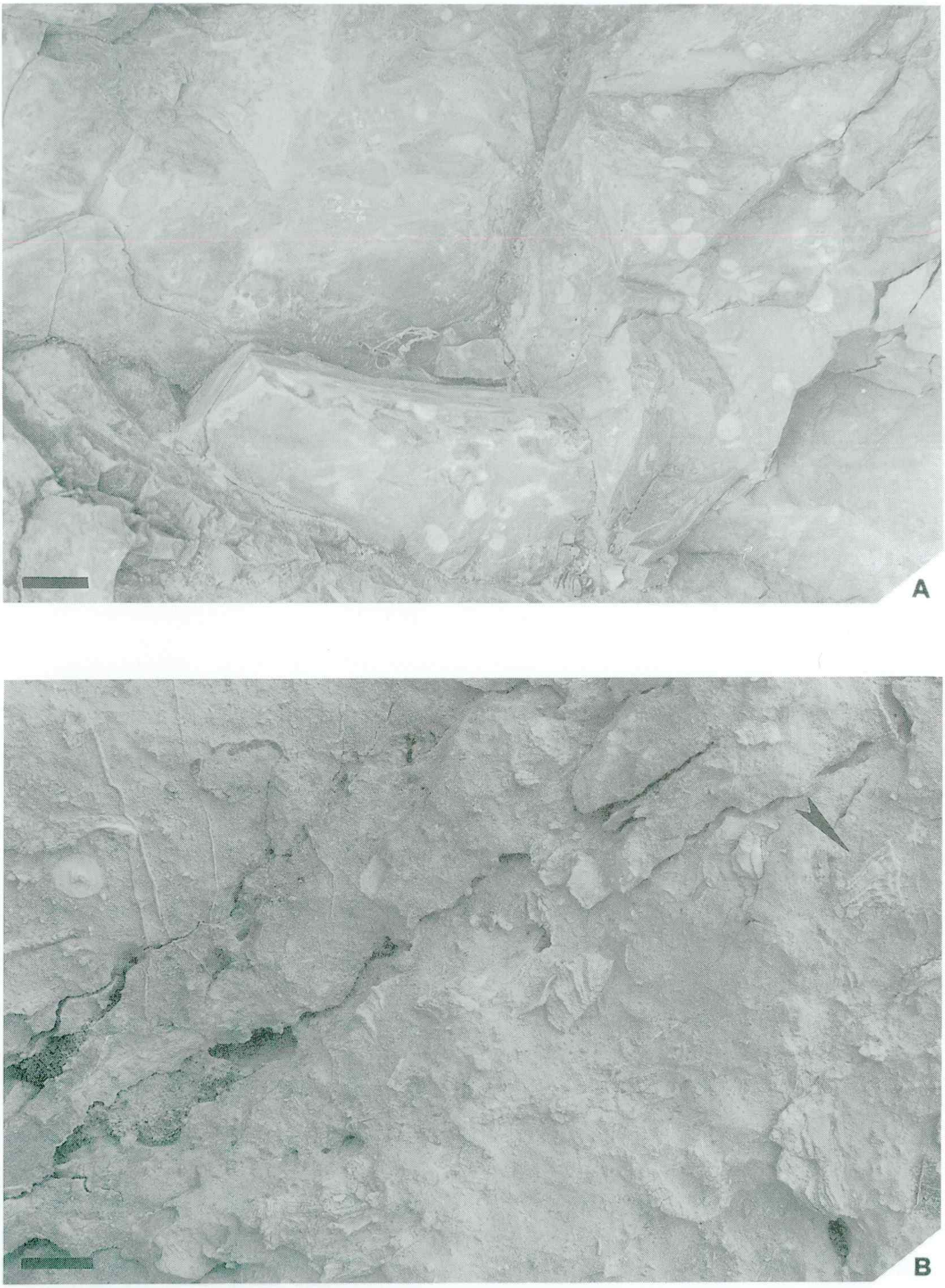


Fig. 6 - Field evidence of *Keramospharina tergestina* beds. (A) *K. tergestina* autochthonous individuals. Level KA_1; scale bar 2 cm. (B) *K. tergestina* allochthonous individuals with *Radiolitella forojuliensis* (indicated by an arrow) and radiolitid fragments. Level KB; scale bar 1.5 cm.

Systematic palaeontology

In the studied sequence, rudist associations consist of genera of the Hippuritidae and Radiolitidae families. In the present work, only the systematic description of the species of the Radiolitids genera are presented. For the systematic description of hippuritids see Pleničar (1975).

Genus *Bournonia* Fischer, 1887

Bournonia excavata (D'Orbigny, 1847)
Douvillé, 1902
Pl.1, fig.2

1902 *Bournonia excavata* Douvillé - Douvillé, 472.

1907 *Agria excavata* D'Orbigny - Toucas, 27, Pl.2, figs.11-13; figs. in text 11-12.

1910 *Bournonia excavata* D'Orbigny - Douvillé, 25, fig.in text 24.

1912 *B. excavata* (D'Orbigny) - Parona, 284, fig.in text 4.

1932 *B. excavata* (D'Orbigny) - Douvillé - Kühn, 95.

1968 *B. excavata* (D'Orbigny) - Pejović, Pl.5, fig.2.

1970 *B. adriatica* Pejović - Pejović, 244-246, fig. 4 figs. in text.

1972 *B. excavata* (D'Orbigny) - Campobasso, 366, fig.1/8.

1975 *B. excavata* (D'Orbigny) - Civitelli & Mariotti, 94, fig.6 in text; cum syn.

1987 *B. excavata* (D'Orbigny) - Cestari & Sirna, 135, Pl.5, figs.1-3.

1988 *B. adriatica* Pejović - Pleničar, 171, figs. in text 7-8.

Fossil material: Numerous transverse sections of lower valves from the lower part of the sequence.

Description: The transverse section of the lower valve is oval with a diameter of about 15 mm. The siphonal ridge E is narrower and shorter than the siphonal ridge S. The elements of the cardinal apparatus are not visible. The ligament ridge is absent. The prismatic structure typical also for the *Bournonia* is partially visible and consists of lamellae and transverse partitions. In some specimens the pedal ridge is also visible. The transverse section of the lower valve is somewhat similar to the species *Bournonia adriatica* Pejović, however the species *B. excavata* is usually larger than the *B. adriatica*.

Genus *Biradiolites* D'Orbigny, 1847

Biradiolites fissicostatus D'Orbigny, 1847
Pl.1, fig.1

1907 *B. fissicostatus* D'Orbigny - Toucas, 118, Pl.24, figs.4-5.

1908 *B. fissicostatus* D'Orbigny - Parona, 15, fig. in text 11.

1932 *B. fissicostatus* D'Orbigny - Kühn, 86-87.

1968 *B. fissicostatus* D'Orbigny - Pejović, Pl.6, fig.2.

1992 *B. fissicostatus* D'Orbigny - Caffau et al., Pl.1, fig.3.

1995 *B. fissicostatus* D'Orbigny - Cestari & Sartorio, pgs. 157, 160, 161.

Fossil material: Chaotic accumulations of left valves and small groups of biradiolitids in growth position from the upper part of the sequence.

Description: The valve shows lamelar structure. It is ornamented with strong and sharp ribs and curved towards the cardinal region. The siphonal region represents the wide concave band S, a conical intersiphonal zone (a strong rib) and a concave band E. The ligamental ridge is absent. Two protruding ribs in the opposite site of the siphonal zone, and two wide concave siphonal bands with a conical interband are typical elements of the species.

Plate 1

1 – *Biradiolites fissicostatus* d'Orbigny, transverse section, sample 17. x 1.5.

2 – *Bournonia excavata* (d'Orbigny), transverse section, sample 3. x 1.5.

3 – *Medeela zignana* (Pirona), transverse section, sample 3. x 1.1.

4 – *Radiolitella forojuliensis* (Pirona), transverse section, sample 4. x 1.5.

5 – *Biradiolites rotundatus* Pleničar; scale bar 2 cm.

6 – *Katzeria hercegovinaensis* Slišković. 1 : 1.

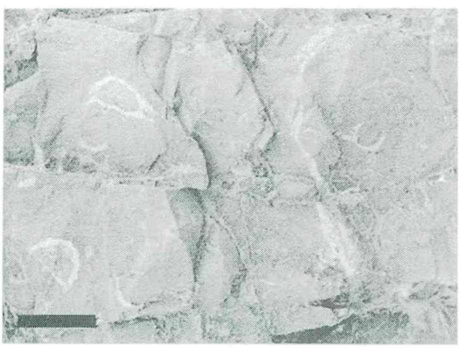
Numbering of the samples corresponds to the stratigraphic column.

1

2

3

4



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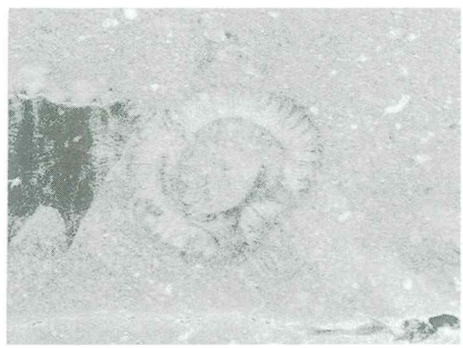


6

Biradiolites rotundatus Pleničar, 1982
Pl.1, fig.5; pl.3, fig.1

1974 *Biradiolites* sp. Pleničar - Pleničar, 163-164, (177), fig. 54.

1982 *Biradiolites rotundatus* n. sp. - Pleničar, 17-18, Pl.4, fig. 2, Pl.5, fig. 1, fig. in text 8.

1992 *B. rotundatus* Pleničar - Caffau *et al.*, Pl. 1, figs. 4-5.

Fossil material: Several cross and oblique sections of lower valves from the upper interval of the sequence.

Description: Transverse sections with a diameter of 10 mm x 15 mm. Strong ribs occur around the outer side of the lower valve. The siphonal bands E and S are concave and both bordered by strong ribs on the outer side. Two interband ribs like crab claws are the characteristic feature of this species. The cardinal apparatus is not preserved in any section.

Genus *Gorjanovicia* Polšak, 1967

Gorjanovicia lipparinii Polšak, 1967
Pl.2, fig.3, 5

1967 *Gorjanovicia lipparinii* Polšak - Polšak, 107 (205), Pl. 67, fig. 1, in text fig. 3.

1982 *G. lipparinii* Polšak - Polšak *et al.* in text fig. 3.

1985 *G. lipparinii* Polšak - Laviano, 330, Pl.15, fig. 2.

1994 *G. lipparinii* Polšak - Steuber, 58, fig.13.

1995 *G. lipparinii* Polšak - Caffau & Plenićar, 233, Pl.15, figs.1-3, fig. in text 4.

1998 *G. lipparinii* Polšak - Plenićar & Jurkovšek, 21, Pl.11, figs 3-4.

Fossil material: Transverse sections of lower and upper valves from both intervals of the sequence.

Description: The lower valve has a diameter of 40 mm x 30 mm and a shell thickness varying from 5 mm to 8 mm. The lower valve is crossed by longitudinal, wide and protruding ribs which are rounded at the apex, equidistant and separated by furrows as large as the ribs. Ribs and furrows are crossed by widely spaced megacycles with zigzag borders.

The E siphonal band is represented by a wide concavity and the S band is protruding and as wide as the E band. The siphonal bands are separated by a concave, narrow and deep interband. The whole siphonal area is crossed by longitudinal thin ribs. Transverse section shows a polygonal cell structure. Two evident inflexions of the mantle indicate the area of the radial siphonal structures. Ligamental ridge is rectangular. The upper valve is slightly convex and crossed by radial sharp ribs.

Genus *Katzeria* Slišković, 1966

Katzeria hercegovinaensis Slišković,1966
Pl. 1, fig. 6; Pl. 3, fig. 2

1966 *Katzeria hercegovinaensis* Slišković - Slišković, figs. in text 1,2.

1968 *K. hercegovinaensis* Slišković - Pejović, Pl.6, fig.3.

1973 *K. hercegovinaensis* Slišković - Plenićar, 214, Pl.10, fig.1.

1974 *K. hercegovinaensis* Slišković - Plenićar, 178, figs. in text 64-66.

1985 *K. hercegovinaensis* Slišković - Plenićar, 254, Pl.2, fig.5.

1988 (2002) *K. hercegovinaensis* Slišković - Pejović, 197, Pl. 4, fig.s.1-3.

1991 *K. hercegovinaensis* Slišković – Šribar & Plenićar, Pl.10, fig.1.

1992 *K. hercegovinaensis* Slišković - Caffau et al. Pl.2, fig.1

1995 *K. hercegovinaensis* Slišković - Caffau & Plenićar, 233-234. Pl.6, figs.1,1a, 2, 3, 4.

1997 *K. hercegovineansis* Slišković - Plenićar & Jurkovšek, 123, Pl.5, figs. 9-12.

2000 *K. hercegovinaensis* Slišković - Pejović, 28, Pl.4, figs.1-3.

Fossil material: Small groups and accumulations of rudists in growth position from the upper part of the sequence.

Description: Numerous cylinder-conical lower valves with a shell thickness of 4 mm. The shell is crossed by longitudinal and very thin ribs. The siphonal structure is represented by two slight protruding ribs. Transverse section shows a radial shell structure, whereas no traces of polygonal cell structure are found. The pseudopillar E is pseudo-rectangular in shape and the S one is triangular.

Genus *Medeella* Parona, 1924

Medeella zignana (Pirona, 1869)
Pl.1, fig.3

1869 *Radiolites zignana* - Pirona, 25, Pl.7.

Plate 2

1 – *Vaccinites vredenburgi* (Kühn), transverse section, sample 6. x 0.5.

2 – *Vaccinites oppeli* (Douvillé), transverse section, sample 5. x 0.5.

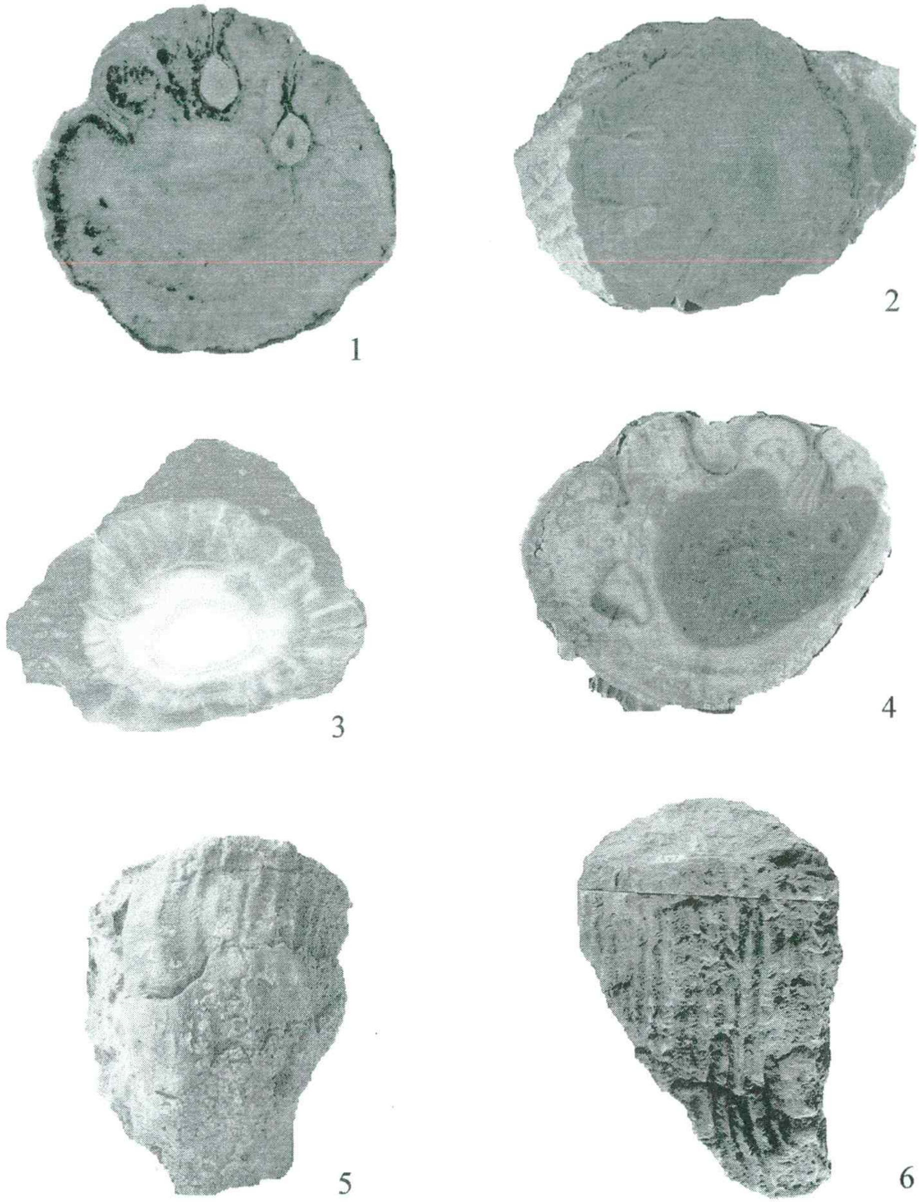
3 – *Gorjanovicia lipparini* Polšak, transverse section, sample 2. x 1.

4 – *Vaccinites archiaci* (Munier-Chalmas), transverse section, sample 6. x 0.5.

5 - *Gorjanovicia lipparini* Polšak, ventral view, sample 1. x 1.

6 – *Vaccinites oppeli* (Douvillé) transverse section, sample 6. x 0.5.

Numbering of the samples corresponds to the stratigraphic column.



1923 *Medeella zignana* Pirona - Parona, 146, figs. in text 1, 2a-b.

1926 *M. zignana* (Pirona) - Parona, 30, Pl. 3, fig 9.

1932 Radiolites (Medeella) zignana Pirona - Kühn, 160.

1934 *Radiolites (Medeella) zignana* (Pirona) - Wiontzek, 22.

1957 *Medeella zignana* (Pirona) - Milovanović, 132, fig. in text 5.

1967 *M. zignana* (Pirona) - Polšak, 100-101, (199-200), Pl. 24, figs. 1-4, Pl. 68. figs.1 10, Pl. 70, fig.3, Pl. 71, figs.1-2.

1987 *M. zignana* (Pirona) - Cestari & Sirna, Pl.7, figs.1-3.

1990 *M. zignana* (Pirona) - Šribar & Pleničar, Pl.8, figs.2-3.

1995 *M. zignana* (Pirona) - Caffau & Pleničar, 234-235, Pl.8, fig.2.

1997 *M. zignana* (Pirona) - Pleničar & Jurkovšek, 121-122, Pl.5, figs.1-7.

Fossil material: Some transverse sections of lower valves from the upper an lower interval of the sequence.

Description: Lower valve with a diameter of 16 mm and a shell thickness of 3 mm. The shell is smooth and subdivided in equidistant lamellae curved towards the basal part. Both siphonal bands E and S are represented by protruding, robust and rounded ribs. The siphonal area is smooth and slightly concave. In transverse section, slightly oval pseudopillar structure is observed. The ligamental ridge is short and wide.

Genus *Radiolitella* Douvillé, 1904

Radiolitella forojuliensis (Pirona) Douvillé, 1904
Pl.1, fig.4; fig.6b in text

1904 *Radiolitella forojuliensis* (Pirona) - Douvillé, 535, Pl.14, figs.1-3.

1974 *R.* cf. *forojuliensis* (Pirona) - Pleničar, 146, in text figs. 26-28.

1992 *R. forojuliensis* (Pirona) - Caffau *et al.*, 164, 168, Pl.2, fig.2.

1995 *R. forojuliensis* (Pirona) - Caffau & Pleničar, 237, Pl.11, figs. 4-5.

Fossil material: Some transverse sections of lower valves from the lower and upper intervals of the sequence.

Description: The transverse section of the lower valve shows a structure with polygonal and large cells with thin walls. The ligamental ridge is small and thin. The shell thickness varies from 1 mm to 3 mm at the siphonal area and from 4 mm to 5 mm at the dorsal area. The shell is crossed by sharp and very protruding ribs.

Final consideration

The analyzed sequence from Nanos Mountain testifies an inner shelf environment in a ramp-like depositional setting that is recorded in two intervals. This study provides additional palaeontological and micropalaeontogical data. In the lower interval, the presence of a faunal association of radiolitids, hippuritids, brachiopods, echinoids and benthic foraminifers is related to an inner platform setting with high hidrodinamism. In the upper interval, the presence of radiolitids and *K. tergestina* indicate a low hidrodinamism in the inner platform setting.

The vertical distribution of rudist and foraminifer assemblages and the presence of *K. tergestina*, reflect sea level changes in an inner platform environment during Santonian-Campanian. This environmental evolution can be compared with surrounding areas such as Trieste-Komen Plateau in Slovenia, the upper part of the Sežana formation and the lower part of Lipica formation (Jurkovšek et al., 1996), the upper part of Borgo Grotta Gigante member in the Trieste Karst (Caffau et al., 2001) and the Island of Brač in Croatia in the Pučišće formation (Gušić & Jelaska, 1990 and Tešović et al., 2001).

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References

Buser, S. 1965: Stratigraphic position of the beds with *Keramosphaerina (Bradya) tergestina* (Stache) in Slovenian Dinarids. - Geologija, *8*, 130-134, Ljubljana.

Caffau, M., Tsakiridou, E., Colizza, E., Melis, R. & Pugliese, N. 2001: Il Santoniano-Campaniano nel Carso Triestino: il livello a *Keramosphaerina tergestina* (Stache). - Studi Trentini di Sc. Nat. Acta geologica. 7, 73-79, Trento.

Caffau, M., Pirini Radrizzani, C., Pleničar, M. & Pugliese, N. 1992: Rudist fauna and microfossils of the late Senonian (Monte Grisa area, Karst of Trieste, Italy). - Geologica Romana, *28*, 163-171, Roma.

Caffau, M. & Pleničar, M. 1995: Santonian-Campanian rudist fauna from the area of Basovizza/Bazovica (Northeastern Trieste Karst): systematic and paleoecological aspects. - Razprave 4. razr. SAZU, *36/10*, 223-275, Ljubljana.

Campobasso, V. 1972: Rudiste del Cretaceo superiore delle Murghe sud-orientali. Boll. Sc. Nat., *81*, 433-460, Napoli.

Cestari, R. & Sirna, G. 1987: Rudiste fauna in the Maastrichtian deposits of southern Salento

Plate 3

1 - *Biradiolites fissicostatus, Biradiolites rotundatus* and *Keramosphaerina tergestina* in the KA level.

2 - Primary shell concentration of *Katzeria hercegovinaensis*, sample 12; scale bar 2cm.

Numbering of the samples corresponds to the stratigraphic column.


1


2

(Puglia - Italy). - Mem. Soc. Geol. It., *40*, 133-147, Roma.

Cestari, R. & Sartorio, D. 1995: Rudists and Facies of the Periadriatic Domain. - Agip S. p. A. S. Donato Milanese, 1-207, Milano.

D'Orbigny, A. 1847: Pal. française, Crét., *4*, p.215.

Douvillé, H. 1902: Classification des Radiolitidés. - B. S.g. F, (2), 2, p. 472, Paris.

Douvillé, H. 1910: Études sur les Rudistes de Sicilie, d'Algerie, d'Egipte, du Liban et de la Perse. - Mém. S.g. F., 18, Mém., *41*, 1-84, Paris.

Gušić, I. & Jelaska, V. 1990: Stratigrafija gornjokrednih naslaga otoka Brača (Upper Cretaceous Stratigraphy of the Island of Brač). - Djela Jugoslavenske akademije znanosti i umjetnosti, knj. *69*, 1-190, Zagreb.

Jurkovšek B., Toman, M., Ogorelec, B., Šribar, L., Drobne, K., Poljak, M., & Šribar, Lj. 1996: Geological map of the southern part of the Trieste-Komen Plateau 1:50.000. Institut za geologijo, geotehniko in geofiziko, 1-143, Ljubljana.

Kidwell, S.M. 1991: Thaphonomic feedback (live/dead interactions) in the genesis of bioclastic beds: keys to reconstructing sedimentary dynamics. – In Einsele et. al. (Eds.): Cycles and events in Stratigraphy. Springer-Verlag Berlin, Heidelberg, 268-282.

Kidwell, S. M. & Holland, S. M., 1991: Field description of coarse bioclastic fabrics. - Palaios. 6, 426-434.

Koch, R. 1977: Mikrofazielle Untersuchungen in der Kreide Sloweniens. Diss. Univ. Heidelberg, 123 p., Heidelberg.

Koch, R., Buser, S. & Bucur, I.I. 1996: Biostratigraphy and facies development of Mid-to Late Cretaceous strata from the Nanos mountain (Western Slovenia, High Karst). Zbl. Geol. Paläont. H.*11/12* (1998) 1195-1215, Stuttgart.

Kühn, O. 1932: Fossilium Catalogus, I. Animalia, Rudistae, 54, Berlin.

Laviano, A. 1985: Paleontological description on some Rudists from the Upper Cretaceous of Ostuni (BR-Italy). - Riv. It. Pal. Strat. 91 (3), 321-356, Milano.

Milovanović, B. 1957: Sifonalna cona rudista. - Vesnik Zavoda za geol. i geof. istrage. NRS, *13*, 115-148, Beograd.

Parona, C.F. 1908: Alcune Rudiste del Cretaceo superiore del Cansiglio nelle Prealpi Venete. - Mem. della Reale Accademia delle Scienze di Torino, *2/59*, 137-157, Torino.

Parona, C.F. 1912, (1911): Nuovi studii sulle Rudiste dell' Appennino (Radiolitidi). - Mem. R. Accademia delle Scienze di Torino, *62*, 274-293, Torino.

Parona, C.F. 1923, (1924): Osservazioni sopra alcune specie della fauna a rudiste del Colle di Medea (Friuli). - Atti della R. Accad. delle Scienze di Torino, *59*, 143-152, Torino.

Parona, C.F. 1926: Ricerche sulle Rudiste e su altri fossili del Cretacico superiore del Carso Goriziano e dell' Istria. - Mem. dell'Istituto Geol. della R. Università di Padova, *7*, 1-56, Padova.

Pejović, D. 1968: Contribution a la connaissance des Rudistes du Montenegro. - Bull. inst. Recherches Geol. Geophys., *26*, 167-176, Beograd.

Pejović, D. 1970: Two new Species of Rudists from the Maastricht Sediments of the Island of Brač. - Bull. Sc, Sect. A.T. *15*, 7-8, 244-245, Zagreb.

Pejović, D. 1988: New Bournonias from the Senonian of Brač. - Bull. Acad. Serbe des Sciences, Class. sc. nat. et math., *28*, 41-45, Beograd.

Pejović, D. 2000: Sur la structure du test des Radiolitidae et Hippuritidae. - Razprave 4. razr. SAZU, *61/1*, 25-49, Ljubljana.

Pirona, G.A. 1869 (1868): Le Ippuritidi del Colle di Medea nel Friuli. - Mem. del R. Istituto Veneto di Sc., Lettere ed Arti, *14*, 400-432, Venezia.

Pleničar, M. 1973: Radioliti iz krednih skladov Slovenije I. - Geologija, *16*, 187-226, Ljubljana.

Pleničar, M. 1974: Radioliti iz krednih skladov Slovenije II. - Geologija, *17*, 131- 179, Ljubljana.

Pleničar, M. 1975: Hippuritidae of Nanos and the Trieste-Komen Plain. Razprave 4. razr. SAZU, *18*(4), 81-115, Ljubljana.

Pleničar, M. 1985: Senonijske rudistne biostrome severno od Kočevja. - Razprave 4. razr. SAZU, *26*, 247-258, Ljubljana.

Pleničar, M. & Zucchi-Stolfa, M. L. 1988: Rudistid fauna from Maastrichtian in Dolenja Vas section (in the proceeding: Drobne, K., Ogorelec, B., Pleničar, M., Zucchi-Stolfa, M.L. & Turnšek, D.: Maastrichtian, Danian and Thanetian beds in Dolenja Vas (NW Dinarides, Yugoslavia) Microfacies, Foraminifers, Rudists and Corals) - Razprave 4. razr. SAZU, *29*, 168-214, Ljubljana.

Pleničar, M. & Jurkovšek, B. 1997: Rudisti iz Lipiške formacije v kamnolomu Lipica I. - Annales, *11*/97, 115-140, Koper.

Pleničar, M. & Jurkovšek, B. 1998: Zgornjesantonijski rudisti osrednjega dela Tr'aško-komenske planote. - Razprave 4. razr. SAZU, *39/1*, 3-53, Ljubljana.

Polšak, A. 1967: Macrofaune crétacée de l'Istrie Méridionale (Yougoslavie). - Paleont. Jugoslavica, *8*, 1-219, Zagreb.

Polšak, A., Bauer, V. & Slišković, T. 1982: Stratigraphie du Crétacé superieur du Dinarides externes. - Geol. vjesnik, *22*, 229-245, Zagreb.

Radulović, V. & Motchurova - Dekova, N: 2002: The Rhynchonellide Brachiopod Cyclothyris ? GLOBATA (Arnaud), 1877) from the Santonian-Campanian of Pannonides, Carpatho-Balcanides and Dinarides (Southeastern Europe). - Ann. Géol. Pénins. Balk, *64*, 107-135, Beograd.

Ruberti, D & Toscano, F. 2002: Microstratigraphy and taphonomy of rudist shell concentrations in Upper cretaceous limestone, Cilento area (central-southern Italy). - Geobios *35*, Mémoire spécial 24, 228-240, Lyon.

Slišković, T. 1966: *Katzeria hercegovinaensis* n. gen., n. sp. aus den Obersenonischen Ablagerungen der Südherzegowina. - Bull. Sci. Conseil Acad. RSF Yougoslavie *11*, 176-177, Zagreb.

Steuber, T. 1994: Neue Rudisten (Radiolitidae) aus der Oberkreide Böotien, Mittelgriechenland. - Paläontologische Zeitschrift, *68*, 1/2, 1-282, Stuttgart.

Šribar, L. & Pleničar, M. 1991 1990: Upper Cretaceous assemblage zones in southwestern Slovenia. - Geologija, *33*, 171-205, Ljubljana.

Tešović - Cvetko B., Gušić I., Jelaska V. & Bucković D. 2001: Stratigraphy and microfacies the Upper Cretaceous Pučišća Formation, Island of Brač, Croatia. – Cretaceous Research, *22*, 591-613, Zagreb.

Toucas, A. 1907-1909: Études sur la classification et l'évolution des Radiolitidés. - Mém. S. g. F., *36*, 1-46, Paris.

Wiontzek, H. 1934: Rudisten aus der oberen Kreide des mittleren Isonzogebietes. - Palaeontographica, *80* (A), 1-40, Stuttgart.