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PALAEONTOLOGICAL AND STRATIGRAPHIC DESCRIPTION OF A RUDIST DEPOSIT OF THE UPPER TURONIAN IN SLIVIA, TRIESTE KARST, ITALY

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ABSTRACT

The study of the stratigraphic sequence located in the occidental area of the Trieste Karst, in the surroundings of Slivia, characterized by limestones with a highly rich rudist fauna brought to light an oncoidal limestone level for the first time in the Trieste Karst. This level is comparable with the Gračišče Oncolite of the Gornji Humac Formation (Gušić & Jelaska, 1990, 1993) on the island of Brač, Croatia, and with the Oncoidal limestone of the Sežana Formation, Slovenia (Jurkovšek et al., *1996). Both levels are attributed to the Upper Turonian and testify a rapid and global marine regression (Hancock & Kauffman, 1979 and Schlanger, 1986). Rudist association in the stratigraphic sequence of Slivia consists of species from the Upper Turonian:* Hippuritella resecta *(DEFRANCE),* Hippurites requieni *(MATHERON),* Hippurites requieni *var.* subpolygonia *DOUVILLÉ,* Vaccinites *cf.* inferus *(DOUVILLÉ),* Neoradiolites turoniensis *PAŠIĆ,* Distefanella ? robusta *CAFFAU & PLENIČAR* Distefanella kochanskae *SLIŠKOVIĆ and* Durania arnaudi *(CHOFFAT). Some of these species are described for the first time in the Trieste Karst. This association also includes gastropods, corals and incrusting algae.*

Key words: Rudists, Oncoids, Upper Turonian, Trieste Karst

INTRODUCTION

In the occidental area of the Trieste Karst (Fig. 1) near the small village of Slivia, a stratigraphic sequence of light gray to gray, very fossiliferous limestones was studied. These limestones belong to the lower part of the Borgo Grotta Gigante Member of the still informal Limestone Formation of the Trieste Karst (Cucchi *et al.*, 1987). Caffau and Pleničar (1992) reported the association of *Hippuritella resecta* (DEFRANCE), *Distefanella robusta* CAFFAU & PLENIČAR, *Neoradiolites turoniensis* PAŠIĆ and *Durania arnaudi* (CHOFFAT) from the Upper Turonian in the area of Slivia.

The aims of this work are: 1. the description and chronological attribution of the fossiliferous limestones sequence, 14 meters thick, in which 7 intervals that testify a carbonate platform environment are recognized; 2. the description of an oncoidal limestone level and its comparison with the Gračišče Oncolite level of the Gornji Humac Formation (Gušić & Jelaska, 1990, 1993) in the island of Brač, Croatia, and with the Sežana Formation, Slovenia (Jurkovšek *et al.*, 1996), both attributed to the Upper Turonian and 3. the systematic study of the rudist association that consists of *Hippuritella resecta* (DEFRANCE), *Hippurites requieni* (MATHERON), *Hippurites requieni* var. *subpolygonia* DOUVILLÉ, *Vaccinites* cf. *inferus* (DOUVILLÉ), *Neoradiolites turoniensis* PAŠIĆ, *Distefanella ? robusta* CAFFAU & PLENIČAR, *Distefanella* cf. *kochanskae* SLIŠKOVIĆ and *Durania arnaudi* (CHOFFAT).

STRATIGRAPHIC SEQUENCE

The studied deposit (fig. 2) belongs to the lower part of the Borgo Grotta Gigante Member. This member is located above the Zolla Member, which is characterized by limestones rich in radiolitids in the lower part and *Pithonella* (Cucchi *et al.*, 1987 and Caffau *et al.*, 1994) in the upper part. The lithology of the sequence of Slivia (Fig. 3) consists of ligth gray to gray, very fossiliferous limestones and sterile gray limestones.

The study of the rudist associations and the microfacies allowed to subdivide the sequence into 7 intervals:

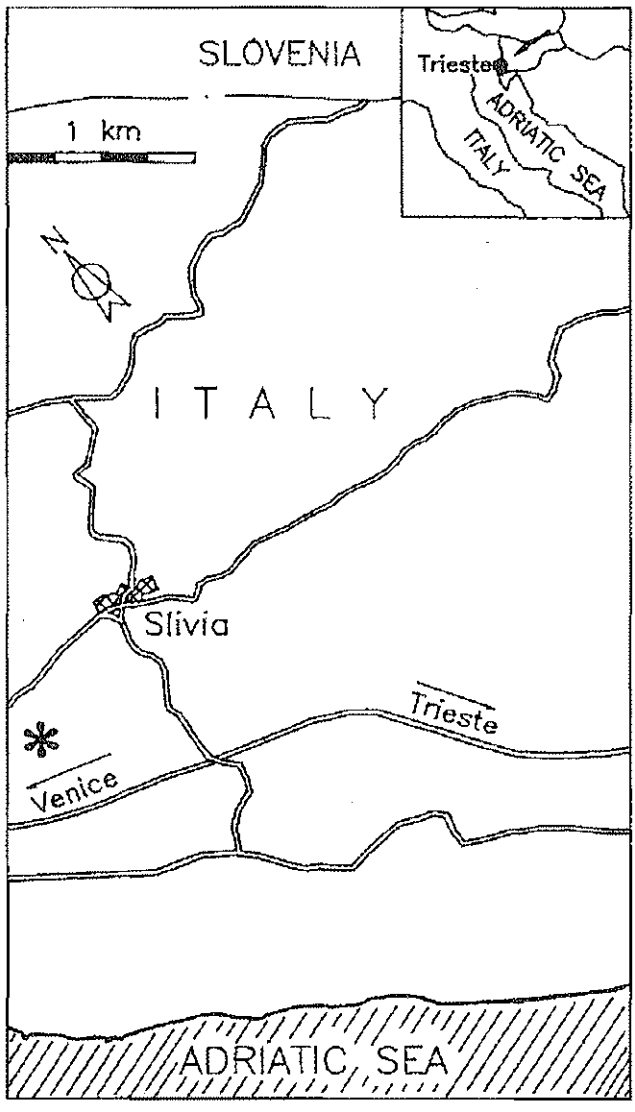


Fig. 1: Studied area and location of the stratigraphic sequence of Slivia, indicated by a star.
Sl. 1: Obravnavano območje z lokacijo stratigrafskega stolpca v Slivju, ki je označena z zvezdico.

Interval 1: this interval, 5 metres thick, consists of light gray, compact, bioclastic limestones. Fossils consist mainly of wavy lamellar fragments of upper valves of radiolitids, probably *Distefanella ? robusta* CAFFAU & PLENIČAR (tab. 6, fig. 1). The limestone microfacies is bioclastic grainstone, with rare Miliolids. This interval testifies a palaeoenvironment of inner carbonate platform with moderated bottom-energy that led to a selective transport mainly of fragments of radiolitid upper valves.

Interval 2: this 2.5 metres thick interval consists mainly of compact bioclastic limestones which are light gray towards the bottom and dark gray at the top. Bafflestone clusters of *Distefanella ? robusta* CAFFAU & PLENIČAR with *Neoradiolites turoniensis* PAŠIĆ, *Hippuritella resecta* (DEFRANCE), *Hippurites requieni* (MATHERON) and *Vaccinites* cf. *inferus* (DOUVILLÉ), occur in the middle-high part of this interval. Isolated individuals of *Hippurites requieni* var. *subpolygonia* DOUVILLÉ and *Distefanella* cf. *kochanskae* SLIŠKOVIĆ are found in the lower part. This association also includes calcareous algae. The microfacies consists of bioclastic-intraclastic grainstones where the bioconstructions occur and bioclastic-intraclastic wackestone-packestones in the lower part of this interval. Microfossils are represented by rare *Cuneolina* sp. and Miliolids. This is the only interval which presents aggregations of rudists, in addition to a large amount of chaotically disposed individuals around the bioconstructions.

Interval 3: this 20 centimetres thick interval consists of compact, dark gray limestones. The microfacies is mudstone-wackestone with fenestrae and includes rare microfossils such us *Cuneolina* sp. and Miliolids. This interval testifies a palaeoenvironment of inner carbonate platform which became adverse for the benthic life.

Interval 4: this interval, 1.2 metres thick, consists of gray, bioclastic, very fossiliferous limestones. Fossils are represented by chaotic accumulations of many fragments and complete individuals of *Hippuritella resecta* (DEFRANCE), *Hippurites requieni* (MATHERON), *Hippurites requieni* var. *subpolygonia* DOUVILLÉ, *Vaccinites* cf. *inferus* (DOUVILLÉ), *Neoradiolites turoniensis* PAŠIĆ, *Distefanella? robusta* CAFFAU & PLENIČAR and *Distefanella* cf. *kochanskae* SLIŠKOVIĆ. Gastropods and calcareous algae are also found. The microfacies is bioclastic-intraclastic grainstone with rare microfossils as *Cuneolina* sp. and Miliolids in the lower part and bioclastic wackestone-packestone with *Cuneolina* sp., *Moncharmontia apenninica* (DE CASTRO), Miliolids and the algae *Thaumatoporella parvovesiculifera* (RAINERI) in the upper part of this interval.

Interval 5: This interval is 1 metre thick and is characterized by the presence of different levels of light gray or gray bioclastic limestones. The dimension and selection of bioclasts varies from one level to the other, which testify different phases of transport of the bioclasts in this interval. In detail, the lower level of this interval, 30 cm thick, is characterized by chaotic accumulations (Fig. 4) of fragments and complete shells of *Hippuritella resecta* (DEFRANCE), *Hippurites requieni* (MATHERON), *Hippurites requieni* var. *subpolygonia* DOUVILLÉ, *Vaccinites* cf. *inferus* (DOUVILLÉ), *Neoradiolites turoniensis* PAŠIĆ, *Distefanella ? robusta* CAFFAU & PLENIČAR and *Distefanella* cf. *kochanskae* SLIŠKOVIĆ, frequently encrusted by blue-green algae. Gastropods encrusted by blue-green algae and calcareous algae are also found. The microphacies is bioclastic-intraclastic grainstone. The subsequent level, 25 cm thick, presents bioclastic beds with fragments of rudist shells that vary from few milimitres to one centimetre (Fig. 5). The

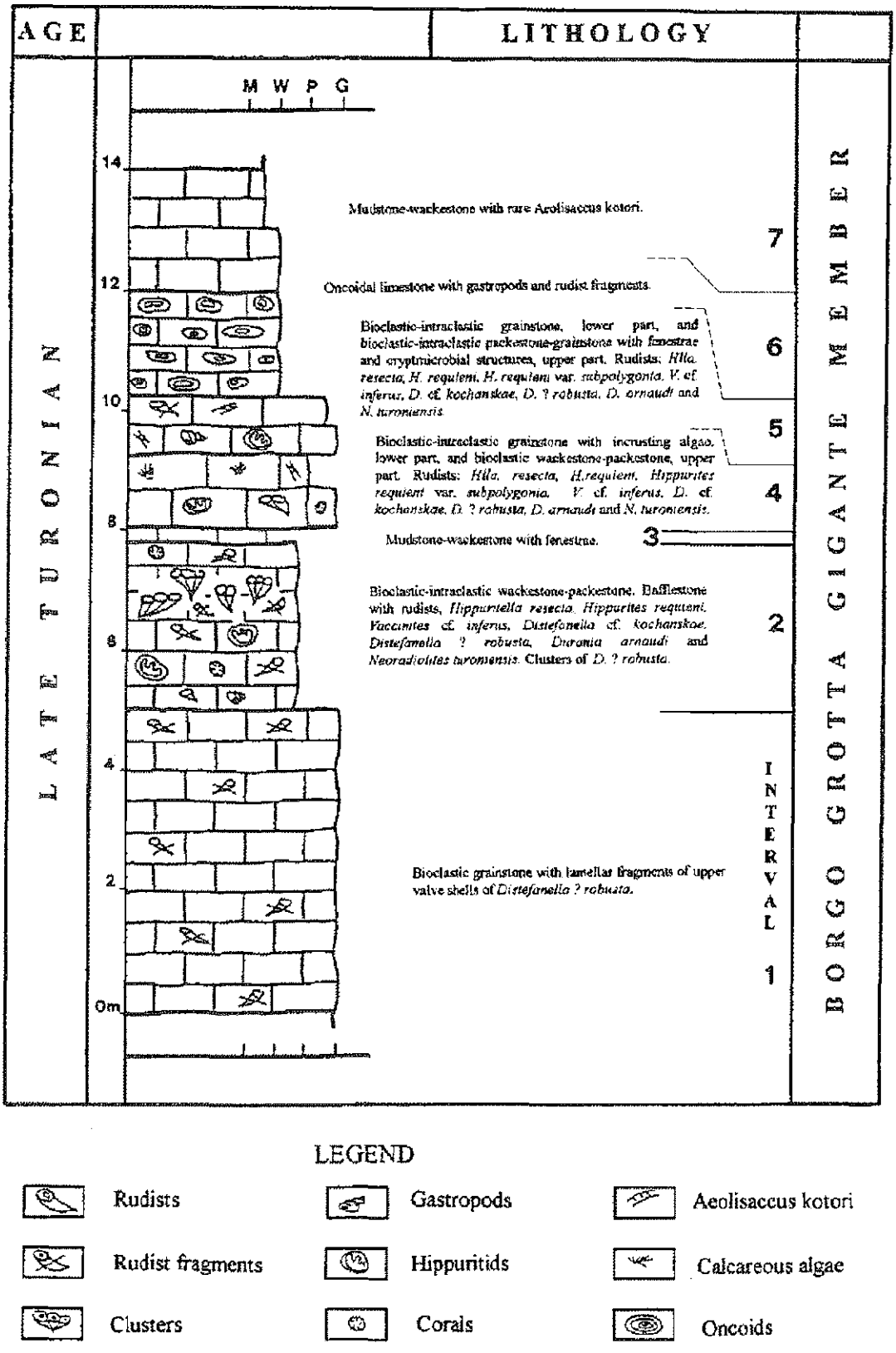


Fig. 2: Stratigraphic sequence of Slivia.
Sl. 2: Stratigrafski stolpec Slivja.

Fig. 3: View of the oncoidal level, indicated by an arrow.
Sl. 3: Posnetek onkoidnega nivoja, označenega s puščico.

Fig. 4: Bioclastic grainstones with fragments of rudist shells encrusted by blue-green algae. Interval 5, lower part. Scale bar: 1cm.
Sl. 4: Bioklastični "grainstones" s fragmenti lupin rudistov, ki so preraščene z modrozelenimi algami. Interval 5, spodnji del. Merilo: 1 cm.

microphacies is bioclastic-intraclastic grainstone. In the middle-high part of this interval, isolated individuals of *Hippuritella resecta* (DEFRANCE), *Hippurites requieni* (MATHERON), gastropods and large nodules of calcareous algae are present (Fig. 5). The thickness of this level is 30 cm. The uppermost level of this interval is characterized by fragments of hippuritids and radiolitids and a large amount of benthic foraminifers. The microfacies is bioclastic-intraclastic packestone-grainstone, very fossiliferous, including *Moncharmontia apenninica* (DE CASTRO) and the algae *Aeolisaccus kotori* RADOIČIĆ (pl. 7, fig. 3). In addition, cryptmicrobial structures (pl. 7, fig. 2) and fenestrae are found. This interval evidenciates a change from chaotic accumulations of rudists encrusted by blue-green algae at the lower part, to bioclastic levels of rudist fragments that are smaller than the previous ones at the upper part.

Interval 6: this interval, 1.8 metres thick, consists of very compact, gray limestones with oncoides of 10 to 45 mm in diameter (Fig. 6). The oncoid nucleus usually consists of gastropods of the Nerineidae family, either complete or in fragments, and rarely of fragments of shell rudists.

Interval 7: this 1.5 metres thick interval consists of very compact gray limestones, without fossils. The microfacies is mudstone-wackestone with rare *Aeolisaccus kotori* RADOIČIĆ.

Considerations: from the bottom up to interval 5, the lithology of the sequence of Slivia is characterized by bioclastic limestones. Rudist deposits are chaotic and traces of endolithization are usually found in rudist shells. In interval 2, rudists also form bafflestone clusters. The middle-upper part of interval 5 exhibits bioclastic levels that testify a selection of rudist fragments,

Fig. 5: Bioclastic grainstones with selected fragments of rudist shells. Scale bar: 1 cm.
Sl. 5: Bioklastični "grainstones" z izbranimi odlomki lupin rudistov. Merilo: 1 cm.

with shells that are frequently endolithized and encrusted by blue-green algae. A 10 cm thick level very rich in benthic foraminifers, mainly *Moncharmontia apenninica* (DE CASTRO), is evident at the top of interval 5. Subsequently, in interval 6, a level of oncoidal limestones associated to gray limestones with dissication pores evidenciates a clear lithological change. This level is similar to the Gračišće oncolite located in the lower part of the Gornji Humac Formation on the Brač island from the Upper Turonian (Gušić & Jelaska, 1990, 1993) where *Hippurites requieni* and the foraminifer *Moncharmontia apenninica* (DE CASTRO) make their first appearance. In addition, *Aeolisaccus kotori* RADOIČIĆ, gastropods of the Nerineidae family and cryptmicrobial structures are found. The oncolite horizon of the Sežana Formation, Slovenia, from the Upper Turonian (Jurkovšek *et al.*, 1996) is characterized by the presence of *Hippuritella sp.* and *Hippurites requieni* (Jurkovšek and Pleničar, *pers. comm.)* along with *Aeolisaccus kotori* RADOIČIĆ, *Taumatoporella parvovesiculifera* (RAINERI), gastropods of the Nerineidae family, while benthic foraminifers are extremely rare (Jurkovšek *et al.*, 1996).

Gušić & Jelaska (1990), Jurkovšek *et al.* (1996), Hancock & Kauffman (1979), Schlanger (1986), Flexer *et al.* (1986) and Haq *et al.* (1987, 1988) confirmed the occurrence of a rapid marine regression in the area of the Dinaric carbonate platform during the Late Turonian as testified by the Gračišće oncolite. This rapid eustatic drop of the sea level in the Late Turonian is also confirmed by the oncolite horizon of the Sežana Formation described by Jurkovšek *et al.* (1996). Therefore, the oncolite level of the stratigraphic sequence of Slivia provides additional evidence of the occurrence of this phenomenon in the studied area.

Fig. 6: Detail of the oncoidal limestone. Scale bar: one square= 0.5 cm.
Sl. 6: Detajl onkoidnega apnenca. Merilo: kvadrat = 0,5 cm.

SYSTEMATIC PALAEONTOLOGY

Familia Hippuritidae GRAY, 1848
Genus Hippuritella DOUVILLÉ 1908
Hippuritella resecta (DEFRANCE) 1821
Pl. 1; fig. 1, 2, 3.

1892 *Hippurites resectus* (Defrance) - DOUVILLÉ, 54, pl. fig. 9-12.

1904 *Orbignya requieni* var. *resecta* (Defrance) - TOUCAS, 20, pl. 1, fig. 4.

1961 *Hippurites (Hippuritella)* (Defrance) - PLENIČAR, 68, textfig. 22.

1970 *Hippurites (Hippuritella) resectus* (Defrance) - PEJOVIĆ, pl. 3, fig 1.

1993 *Hippuritella resecta* (Defrance) - STEUBER, 39, textfig. 3c-d.

Material: one lower valve and ten lower valves in the deposit.

Description: lower valves conical-elongated in shape, 50 to 65 mm long and 24 to 32 mm wide at the commisure. Shell traversed by wide rounded ribs separated by deep furrows. In transverse section, the *aréte cardinale* is wide, triangular in shape, truncated and slightly concave at the end. The values of the angles α (L-P2) and β (L-B1,B) are 90° and 79°, respectively. The first pillar (P1) is rounded while the second pillar (P2) is protruding and slightly pinched at the base.

It is noticeable that individuals of this species usually grew attached to shells of large individuals of *Distefanella ? robusta* CAFFAU & PLENIČAR and, less frequently, they lived as isolated individuals.

Geographic and stratigraphic distribution: Turonian in France and Spain. Middle-Upper Turonian in the Periadriatic area.

Genus Hippurites LAMARCK, 1801
Hippurites requieni (MATHERON), 1842
Pl. 2, fig. 1, 2, 3, 6

1890 *Hippurites requieni* Matheron - DOUVILLÉ, 58, pl. 8, fig. 1-5.

1903 *Orbignya requieni* Matheron - TOUCAS, 18, texfigs. 23-26, pl. 1, fig. 1-3.

1907 *Hippurites (Orbignya) requieni* Matheron - PARONA, 143, textfig. 1.

1932 *Hippurites (Orbignya) requieni* Matheron - KÜHN, 63

1984 *Hippurites (Hippurites) requieni* Matheron - BILOTTE, 342, pl. 38, fig. 3.

1992 *Hippurites requieni* Matheron - PONS & SIRNA, 344.

1996 *Hippurites (Hippurites) requieni* Matheron - BILOTTE & PLATEL, 23, pl. 3, fig. 3.

Material: forty lower valves in the deposit.

Description: cylindrical lower valve with a length that varies from 40 to 170 mm and a diameter of 10 to 30 mm at the commisure. Shell traversed by thin ribs. In transverse section, myocardinal elements are well preserved. The *aréte cardinale* (L) is protruding, triangular in shape and truncated at the end (Pl. 2, fig. 6). The first pillar (P1) is short with a wide base. The second pillar (P2) is slightly longer than the previous one and somewhat pinched at the base. The values of the angles α (L-P2) and β (L-B1, B) are 97° and 66°, respectively. The dorsal cavity (DC) lies between the anterior tooth socket (B1) and the shell inner layer. The posterior tooth socket (B) is smaller than B1. The posterior myophore (mp) located between B and P1, is oval in shape. The body cavity (BC) extends to about half of the lower valve cavity.

Remarks: Toucas (1903) described an evolution of the myocardinal elements of this species from the Lower to the Upper Turonian. The author indicated that most evident variations include the dimension and shape of the *aréte cardinale*, which is larger and protruding in more recent individuals, while its truncated end is a constant characteristic of this species. In addition, the dimension of the body cavity (BC) is also subjected to evolution, being smaller in more recent individuals than in ancient ones. The inner elements of the individuals studied in this work are similar to those of the individuals in figs. 25 and 26, p. 19, Toucas (1903).

Geographic and stratigraphic distribution: Upper Turonian in France, Spain and Periadriatic area.

Hippurites requieni var. *subpolygonia* DOUVILLÉ, 1892
Pl. 2, fig. 4, 5

1892 *Hippurites requieni* var. *subpolygonia* - DOUVILLÉ, 54, pl. 5, figs. 10-11

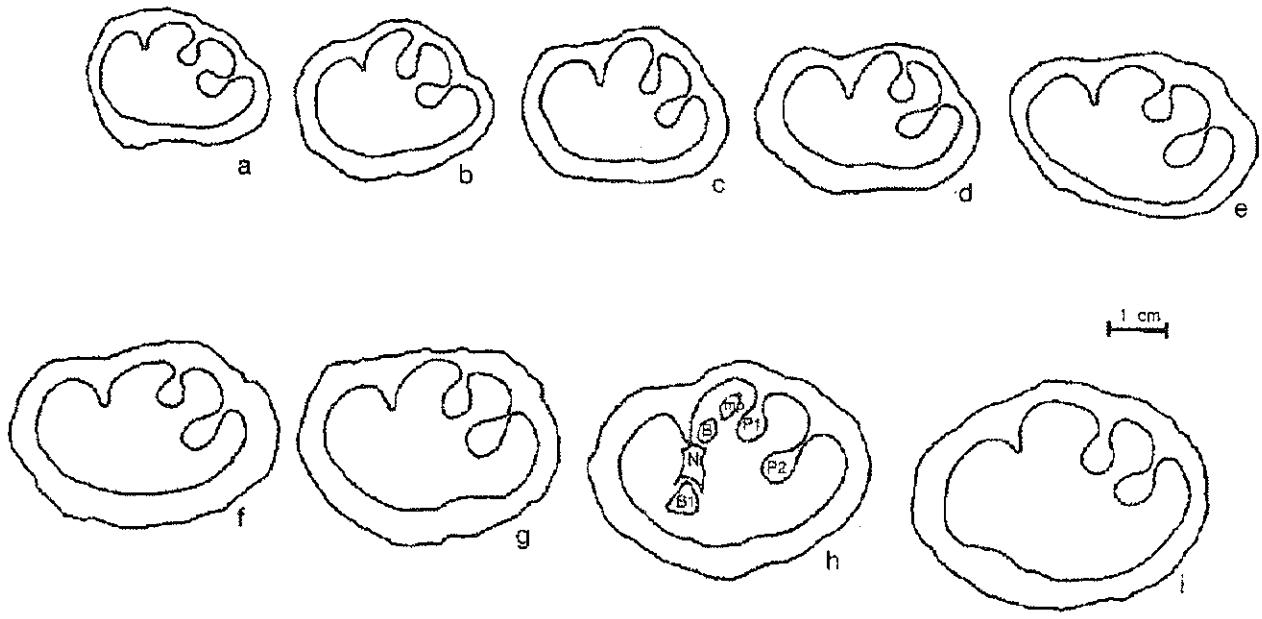
1903 *Orbignya requieni* var. *subpolygonia* Douvillé - TOUCAS, 22, figtext. 32, pl. 1, fig. 5

1932 *Hippurites (Orbignya) requieni* var. *subpolygonia* Douvillé - KÜHN,64

Material: twenty lower valves in the deposit.

Description: cylindrical lower valve, 35 to 160 mm long and 10 to 30 mm wide at the commisure.The shell is traversed by protruding ribs, 0.6 to 2 mm wide, with irregular and slightly rounded edges. The ribs are separated by well marked furrows. In transverse section, myocardinal elements are well preserved. The *aréte cardinale* (L) is protruding, triangular in shape and truncated at the end.The first pillar (P1) is short with a wide base while the second pillar (P2) is slightly longer than the previous one and somewhat pinched at the base. The values of the angles α (L-P2) and β (L-B1,B) are 91° and 89°, respectively. The anterior tooth socket (B1) is larger than the posterior tooth socket (B).

Remarks: morphological characters of rudist shells, such as ornamentation, shape and dimension should be taken into account as taxonomical characters only if they are unique for the species under consideration (Cestari, 1992). This is the case for the shell ornamentation taken as a taxonomical character to di-



Figs. 7a-i.: *Vaccinites cf. inferus* ***DOUVILLÉ. Successive transverse sections of the same lower valve. Scale bar: 1 cm. Fig. 7h: P1=first pillar; P2=second pillar; B1=anterior tooth socket; B=posterior tooth socket; mp=posterior myophore; N=lower valve tooth. Scale bar: 1cm.***
Sl. 7a-i: *Vaccinites cf. inferus* ***DOUVILLÉ. Zaporedni prečni prerezi spodnje lupine. Merilo: 1 cm. Slika 7h: P1=prvi stebriček; P2=drugi stebriček; B1=anteriorna zobna jamica; B=posteriorna zobna jamica; mp=posteriorni mišični odtisek; N=zob v spodnji lupini. Merilo: 1 cm.***

stinguish between *Hippurites requieni* (MATHERON) and *Hippurites requieni* var. *subpolygonia* DOUVILLÉ. The upper valve of the species *Hippurites requieni* var. *subpolygonia* DOUVILLÉ is characterized by polygonal pores regularly distributed, as described by Toucas (1903), and differs from the upper valve of *Hippurites requieni* (MATHERON) which presents pores that are slightly elongated and distributed in a linear manner.

These morphological differences that also imply functional differences allow to distinguish individuals that belong to two groups genetically different and therefore they assume taxonomical value.

Geographic and stratigraphic distribution: Upper Turonian in France.

Genus *Vaccinites* FISCHER 1887
Vaccinites cf. *inferus* (DOUVILLÉ) 1891
Pl. 1, fig. 4-8

1891 *Hippurites inferus* - (DOUVILLÉ), 23, pl. 2 fig. 6
1894 *Hippurites inferus* (Douvillé) - DOUVILLÉ, 115.
1904 *Vaccinites inferus* (Douvillé) - TOUCAS, 90, textfigs. 139-140; pl. 13, fig. 1.
1993 *Vaccinites inferus* (Douvillé) - STEUBER, 41, textfigs. 2a-i, 3a-f, 8; pl. 8, figs. 1-3.

Material: two lower valves and twenty valves in the deposit.

Description: cylindrical lower valve, 135 mm long and 45 mm wide at the commisure. The shell is traversed by protruding and rounded ribs, 1 mm wide. In transverse section, the first pillar (P1) is less developed than the second one (P2) and both are pinched at the base. Nine transverse sections (Textfig. 7), 15 mm equidistant one from the other, were obtained from the lower valve of a well conserved individual. The analysis of these transverse sections allowed to evidenciate morphological differences in the *aréte cardinale* (L) during the ontogenical development of the individual: from a truncated form in the lower part of the individual (Textfigs. 7 a-e) turns to be rounded in shape in the upper part (Textfigs. 7 f-i). Although the lower valve is slightly flattened at the dorsal side, the values of the angle α (L-P2) measured in the different transverse sections range from 56° to 71°, consistent with the range given by Steuber 1993 for *Vaccinites inferus* (DOUVILLÉ).

Geographic and stratigraphic distribution: Turonian in France. Middle-Upper Turonian in Greece.

Family Radiolitidae GRAY 1848
Genus Distefanella PARONA 1901
Distefanella cf. *kochanskae* POLŠAK 1968
Pl. 4, fig. 5, 6

1968 *Distefanella kochanskae* - POLŠAK, 183, textfigs. 8, 9.

Material: two transverse sections of a lower valve.

Description: small individuals, rarely larger than 10 mm with a thin shell, about 0.5 mm thick, traversed by triangular and very robust ribs. Four to six ribs are evident in the dorsal area. Radial bands lie between two very well developed ribs. The E radial band is twice as wide as the S band, flattened and traversed by 3 to 4 pronounced ribs. The S band is flattened and traversed by 3 ribs, less developed than those of the E band. The cardinal laminae or traverse saeptum is not visible.

Similarities and differences: as it was previously demonstrated for other rudist genera (Cestari, 1992; Caffau & Pleničar, 1996; Caffau *et al.*, 1997), the examined individuals of this species from Slivia are also characterized by a large morphological variability. For this reason, the number of ribs of the dorsal area and the radial bands are not significant for diagnosis. Further analysis may elucidate the range of variation of the morphological characters of these individuals.

The examined individuals from Slivia differ from those of *Distefanella kochanskae* POLŠAK by the lower number of ribs in the dorsal area and in the interband. Individuals of *Distefanella raricostata* SLIŠKOVIĆ differ from those of Slivia by the larger amount of ribs in the dorsal area and the smooth S radial band.

Geographic and stratigraphic distribution: Turonian in Istria.

Distefanella ? robusta CAFFAU & PLENIČAR 1992
Pl. 3, fig. 1-4; Tab. 4, fig. 1-4

1992 *Distefanella robusta* - CAFFAU & PLENIČAR, 191, pl. 1-3; textfigs. 2, 3.

Material: ten lower valves and four complete individuals.

Description: lower valve cylindro-conical in shape, with a length that varies from 40 to 210 mm and a diameter of 15 to 80 mm at the commisure. The shell is traversed by protruding and robust ribs interrupted by widely spaced megacycles. The siphonal area is represented by two wide, flattened and/or slightly concave bands, longitudinally traversed by thin ribs. The E radial band is crossed by 16 ribs while the S band exhibits 10 ribs. Both radial bands are separated by a very pronounced ridge that in some individuals devides into 3 ribs near the commisure (tab. 3, fig. 2). The upper valve is flat or slightly convex. In the inner part, the myocardinal apparatus consists of two teeth that form an angle of 50° between them and two large myophores. The dorsal cavity, oval in shape, is evident between both teeth. The shell structure is characterized by large polygonal cells. No ligamental ridge is present.

Discussion: Caffau & Pleničar (1992) described the species *Distefanella robusta*, identified as a new species of *Distefanella* because of the presence of a dorsal cavity delimited by a transverse saeptum or dorsal laminae (sensu Polšak, 1968), which is one of the most evident diagnostic characteristics of the genus *Distefanella* (Parona, 1901; 1912; 1926; Polšak, 1968 and Sliškovič, 1971). In this work, the analysis of several other individuals of this species allowed to verify that the dorsal cavity (DC), oval in shape and belonging to the lower valve, is not delimited by a dorsal laminae but by a wall formed by the inner layer of the lower valve shell. In addition, in some individuals this cavity is detached from the inner layer of the shell (tab. 4, figs. 1-4). Therefore, the morphology of the DC of *Distefanella ? robusta* CAFFAU & PLENIČAR differs from that of the DC of the genus *Distefanella* (sensu Polšak 1968) delimited by the dorsal laminae that separates the DC from the ventral cavity. Another observed difference is the angle formed by the teeth, which is 50° to 60° in *Distefanella? robusta* CAFFAU & PLENIČAR and about 180° in the genus *Distefanella* described by Polšak (1968). On the basis of these new observations, detailed analyses are in progress to confirm the validity of the systematic attribution of *Distefanella ? robusta* CAFFAU & PLENIČAR.

Geographic and stratigraphic distribution: Upper Turonian in the Trieste Karst.

Genus *Neoradiolites* MILOVANOVIĆ 1935
Neoradiolites turoniensis PAŠIĆ 1957
Pl. 5, fig. 2-5.

1957 *Neoradiolites turoniensis* PAŠIĆ - pl. 2, fig. 4; pl. 4, fig. 1, pl. 6, fig. 1, 2.

1976 *Neoradiolites turoniensis* CHARVET-DECROUEZ-POLŠAK - 248, pl. 2, fig. 2, 3; pl. 5, fig. 1, 2.

Material: two lower valves embedded in the limestone and one free lower valve.

Description: conical lower valve, 60 mm long and 40 mm wide at the commisure. The shell, 5 mm thick at the siphonal area and 10 mm at the dorsal area, is traversed by rounded and slightly concave ribs, about 1 mm wide. The inner structure is characterized by a dense mesh of small polygonal cells (tab. 5, fig. 5). The ligamental ridge of the myocardinal apparatus, hammer-shaped, is well developed. The angle formed between teeth is 60°. The anterior myophore (ma) is about twice as large as the posterior myophore (mp).

Geographic and stratigraphic distribution: Middle Turonian in Serbia and Greece.

Genus *Durania* DOUVILLÉ 1908
Durania arnaudi (CHOFFAT) 1891
Pl. 4, fig. 5, 6; tab. 5, fig. 1

1909 *Sauvagesia arnaudi* - TOUCAS, 93, pl. 18, figs. 3-7.

1910 *Durania arnaudi* - DOUVILLÉ, 50, pl. 3, fig 1.

1911 *Durania arnaudi* - PARONA, 290.

1926 *Durania arnaudi* - PARONA, 37, pl. 3, fig. 11.

1967 *Durania arnaudi* - POLŠAK, 90, pl. 7, fig. 3; pl. 55, figs. 1-7.

1968 *Durania arnaudi* - POLŠAK, 187, textfig. 11.

1973 *Durania arnaudi* - PLENIČAR, 221, pl. 4, fig. 1; pl. 12, fig. 3; pl. 13, fig. 1.

1982 *Durania arnaudi* - ACCORDI *et al.*, 772, pl. 4, fig. 9; pl. 5, fig. 4.

Material: two lower valves.

Description: cylindrical lower valve up to 120 mm long, with a shell thickness of 13 mm at the commisure. At the dorsal area, the shell is traversed by wide and robust ribs with a triangular profile, which turn to be thinner near the radial bands. The E radial band is concave and traversed by thin ribs. The S band is slightly smaller and less concave than the previous one and is also traversed by thin ribs. The shell is thin at the radial bands and wider at the interband. The latter is wide, very protruding and traversed by 2 to 3 ribs. The interband of the individual in table 5, fig. 1 seems greatly pronounced due to the slightly oblique transverse section. The inner structure of the shell is a mesh of large polygonal cells. The myocardinal apparatus consists of two myophores, being better developed the anterior than the posterior one. The teeth are equal in dimension and the angle formed between them is 62°.

Remarks: the individuals of *Durania arnaudi* (CHOFFAT) are externally similar to those of *Distefanella ? robusta* CAFFAU & PLENIČAR but differ from this species by the lack of the dorsal cavity. Comparative analysis of *Distefanella ? robusta* and *Durania arnaudi* (CHOFFAT) are in progress to verify if the presence of the dorsal cavity could be considered as a morphofunctional characteristic typical of one of these species.

Geographic and stratigraphic distribution: Turonian in France, Spain and Periadriatic area.

CONCLUSIONS

The study of the stratigraphic sequence of Slivia allowed to describe a rich rudist fauna of the Upper Turonian. The rudist association includes some species described for the first time in the Trieste Karst: *Hippurites requieni* (MATHERON), *Hippurites requieni* var. *subpolygonia* DOUVILLÉ, *Vaccinites* cf. *inferus* (DOUVILLÉ), *Neoradiolites turoniensis* PAŠIĆ and *Distefanella kochanskae* SLIŠKOVIĆ, along with *Hippuritella resecta* (DEFRANCE), *Distefanella? robusta* CAFFAU & PLENIČAR and *Durania arnaudi* (CHOFFAT). Rudists are found *in situ* only in interval 2, as testified by the presence of bouquets and clusters in physiological position in this interval. The poor development of the rudist fauna may have been due to the large production of bioclasts and their transport that prevented the formation of a rigid an stable substrate, required for rudist growth. Bioclastic accumulations consist mainly of fragments of rudist shells.

Moreover, an oncolite level is described for the first time in the Trieste Karst. This level is comparable with two oncolite horizons of the Upper Turonian: the Gračišće oncolite of the Gornji Humac Formation on the island of Brač in Croatia (Gušić & Jelaska, 1990; 1993) and the oncolite horizon of the Sežana Formation in Slovenia (Jurkovšek *et al.*, 1996). The oncolite horizons of both formations record the most evident phase of an important environmental change, with a rapid eustatic change of the marine level that characterized the Late Turonian (Haq *et al.*, 1987; Gušić & Jelaska, 1990). The oncoidal level of Slivia also testifies a regression of the marine level, although this change seems to have been more slow compared with that recorded in other areas of the Dinaric carbonate platform, *e.g.* on the Brač island and in Slovenia. In fact, in the Trieste Karst, the lithological transition from the limestones rich in *Phitonella*, in the upper part of the Zolla Member (Cucchi *et al.*, 1987; Caffau *et al.*, 1994) to the limestones rich in rudists and to the oncolite level of Slivia is gradual. The presence of an oncoidal level in the sequence of Slivia extends the area of the Dinaric carbonatic platform which has been described to be subjected to a global marine regression.

ACKNOWLEDGMENTS

I would like to thank Prof. Mario Pleničar for his generous help and the critical revision of the work, Dr. Bogdan Jurkovšek for his helpful advices on the stratigraphy and Dr. M. Inés Gutiérrez for her long work of translation into English. I'm very grateful to Mr. Alceo Tarlao for the continuous discussions on rudists.

PLATES - TABLE

PLATE 1 / TABLA 1

Figs. 1-3:** Hippuritella resecta **(DEFRANCE). Transverse sections of lower valves of three different individuals. Scale bar: 1 cm.
Figs. 4 and 5:** Vaccinites **cf.** inferus **(DOUVILLÉ). Lower valve and transverse section of the same individual. Scale bar: 1 cm.
Figs 6-8:** Vaccinites **cf.** inferus **(DOUVILLÉ). Transverse sections of three individuals. Scale bar: 1 cm.

Sl. 1-3:** Hippuritella resecta **(DEFRANCE). Prečni prerezi spodnjih lupin treh različnih osebkov. Merilo: 1 cm.
Sl. 4 in 5:** Vaccinites **cf.** inferus **(DOUVILLÉ). Spodnja lupina in prečni prerez istega osebka. Merilo: 1 cm.
Sl. 6-8:** Vaccinites **cf.** inferus **(DOUVILLÉ). Prečni prerezi treh osebkov. Merilo: 1 cm.

PLATE 2 / TABLA 2

Fig. 1:** Hippurites requieni **(MATHERON). Transverse section of two lower valves embedded in the limestone. Interval 2. Scale bar: 1 cm.
Fig. 2: Polished transverse section with** Hippurites requieni **(MATHERON), fragments of rudist shells and incrusting blue-green algae. Interval 5. Scale bar: 1 cm.
Fig. 3:** Hippurites requieni **(MATHERON). Transverse section of lower valve. Scale bar: 1 cm.
Figs. 4 and 5:** Hippurites requieni **var.** subpolygonia **(DOUVILLÉ). Transverse sections of two lower valves. Scale bar: 1 cm.
Fig. 6:** Hippurites requieni **(MATHERON). Transverse section, view of the truncated aréte cardinale. x 24.

Sl. 1:** Hippurites requieni **(MATHERON). Prečni prerez dveh spodnjih lupin, vraščenih v apnenec. Interval 2. Merilo: 1 cm.
Sl. 2: Poliran prečni prerez z vrsto** Hippurites requieni **(MATHERON), z odlomki rudistnih lupin in inkrustirane modrozelene alge. Interval 5. Merilo: 1 cm.
Sl. 3:** Hippurites requieni **(MATHERON). Prečni prerez spodnje lupine. Merilo: 1 cm.
Sl. 4 in 5:** Hippurites requieni **var.** subpolygonia **(DOUVILLÉ). Prečna prereza dveh spodnjih lupin. Merilo: 1 cm.
Sl. 6:** Hippurites requieni **(MATHERON). Prečni prerez, pogled na odrezani ligamentni greben. x 24.

PLATE 3 / TABLA 3

Figs. 1-2:** Distefanella ? robusta **CAFFAU & PLENIČAR. Lower valve, view of the radial bands E-S and detail of the interband with 3 thin ribs in the upper part. Scale bar: 1 cm.
Fig. 3:** Distefanella ? robusta **CAFFAU & PLENIČAR. Polished transverse section of a lower valve. Scale bar: 1 cm.
Fig. 4:** Distefanella ? robusta **CAFFAU & PLENIČAR. Transverse section of a lower valve. Scale bar: 1cm.
Figs. 5 and 6:** Distefanella **cf.** kochanskae **POLŠAK. Polished transverse section of lower valves of two individuals. Scale bar: 1 cm.
Fig. 7: Polished section with corals, rudists and calcareous algae. Scale bar: 1cm.

Sl. 1-2:** Distefanella ? robusta **CAFFAU & PLENIČAR. Spodnja lupina, pogled na radialni progi E-S in detajl medsifonalne proge s 3 šibkimi rebri v zgornjem delu. Merilo: 1 cm.
Sl. 3:** Distefanella ? robusta **CAFFAU & PLENIČAR. Poliran prečni prerez spodnje lupine. Merilo: 1 cm.
Sl. 4:** Distefanella ? robusta **CAFFAU & PLENIČAR. Prečni prerez spodnje lupine. Merilo: 1 cm.
Sl. 5 in 6:** Distefanella **cf.** kochanskae **POLŠAK. Polirana prečna prereza spodnjih lupin dveh osebkov. Merilo: 1 cm.
Sl. 7: Poliran presek s koralami, rudisti in kalcitnimi algami. Merilo: 1 cm.

PLATE 4 / TABLA 4

Figs.1-3:** Distefanella ? robusta **CAFFAU & PLENIČAR. Polished transverse sections of lower valves of three individuals. The dorsal cavity is clearly visible. Scale bar: 1 cm.
Fig. 4:** Distefanella ? robusta **CAFFAU & PLENIČAR. Thin transverse section of lower valve. The structure of the dorsal cavity is clearly visible. x 1,5.
Fig. 5:** Durania arnaudi **(CHOFFAT). Polished transverse section of lower valve with endolithized shell. Scale bar: 1 cm.
Fig. 6:** Durania arnaudi **(CHOFFAT). Transverse section of lower valve with incomplete cardinal apparatus. Scale bar: 1 cm.

Sl. 1-3:** Distefanella ? robusta **CAFFAU & PLENIČAR. Zbruski prečnih prerezov spodnjih lupin treh osebkov. Dorzalna votlina je dobro vidna. Merilo: 1 cm.
Sl. 4:** Distefanella ? robusta **CAFFAU & PLENIČAR. Zbrusek prečnega prereza spodnje lupine. Dobro je vidna struktura dorzalne votline. x 1,5.
Sl. 5:** Durania arnaudi **(CHOFFAT). Polirani prečni prerez spodnje lupine z endolitizirano lupino. Merilo: 1 cm.
Sl. 6:** Durania arnaudi **(CHOFFAT). Prečni prerez spodnje lupine z nepopolnim kardinalnim aparatom. Merilo: 1 cm.

PLATE 5 / TABLA 5

Fig. 1: Durania arnaudi (CHOFFAT). Transverse section of lower valve embedded in the limestone. Scale bar: 1 cm.
Figs. 2 and 3: Neoradiolites turoniensis PAŠIĆ. Lower valve and polished transverse section of the same individual. Scale bar: 1 cm.
Fig. 4: Neoradiolites turoniensis PAŠIĆ. Polished transverse section of lower valve, view of the hammer-shaped ligamental ridge. Scale bar: 1 cm.
Fig. 5: Neoradiolites turoniensis PAŠIĆ. Thin transverse section showing the myocardinal apparatus and the inner structure characterized by small cells. Scale bar: 1 cm.

Sl. 1: Durania arnaudi (CHOFFAT). Prečni prerez spodnje lupine, vraščene v apnencu. Merilo: 1 cm.
Sl. 2 in 3: Neoradiolites turoniensis PAŠIĆ. Spodnja lupina in polirani prečni prerez istega osebka. Merilo: 1 cm.
Sl. 4: Neoradiolites turoniensis PAŠIĆ. Zbrusek prečnega prereza spodnje lupine; pogled na kladivasto oblikovan ligamentni rob. Merilo: 1 cm.
Sl. 5: Neoradiolites turoniensis PAŠIĆ. Zbrusek prečnega prereza, ki prikazuje miokardinalni aparat in notranjo strukturo, za katero so značilne male celice. Merilo: 1 cm.

PLATE 6 / TABLA 6

Fig. 1: Bioclastic grainstones with lamellar fragments of upper valves of Distefanella ? robusta CAFFAU & PLENIČAR. Interval 1. Scale bar: 1 cm.
Fig. 2: Oncoidal limestones with gastropods of the Nerineidae family. Interval 6. Scale bar: 1 cm.
Fig. 3: Detail of the oncoidal limestone with gastropods of the Nerineidae family. Interval 6. Scale bar: 1 cm.

Sl. 1: Bioklastični "grainstones" z lamelarnimi odlomki zgornjih lupin vrste Distefanella ? robusta CAFFAU & PLENIČAR. Interval 1. Merilo: 1 cm.
Sl. 2: Onkoidni apnenec s polži iz družine Nerineidae. Interval 6. Merilo: 1 cm.
Sl. 3: Detajl onkoidnega apnenca s polži iz družine Nerineidae. Interval 6. Merilo: 1 cm.

PLATE 7 / TABLA 7

Fig. 1: Packestone-grainstones with Moncharmontia apenninica (DE CASTRO), Aeolisaccus kotori RADOIČIĆ and Miliolids. x 30. Interval 5, upper part.
Fig. 2: Packestone-grainstones with cryptmicrobial structure, fragments of shell rudists, Aeolisaccus kotori RADOIČIĆ and Miliolids. x 30. Interval 5, upper part.
Fig. 3: Packestone-grainstones with Moncharmontia apenninica (DE CASTRO), Aeolisaccus kotori RADOIČIĆ and Miliolids. x 30. Interval 5, upper part.

Sl. 1: "Packestone-grainstones" z Moncharmontia apenninica (DE CASTRO), Aeolisaccus kotori RADOIČIĆ in miliolidami. x30. Interval 5, zgornji del.
Sl. 2: "Packestone-grainstones" z kriptomikrobnimi strukturami, odlomki lupin rudistov, Aeolisaccus kotori RADOIČIĆ ter miliolida x 30. Interval 5, zgornji del.
Sl. 3: "Packestone-grainstones" z vrstama Moncharmontia apenninica (DE CASTRO) in Aeolisaccus kotori RADOIČIĆ ter miliolida. x 30. Interval 5, zgornji del.

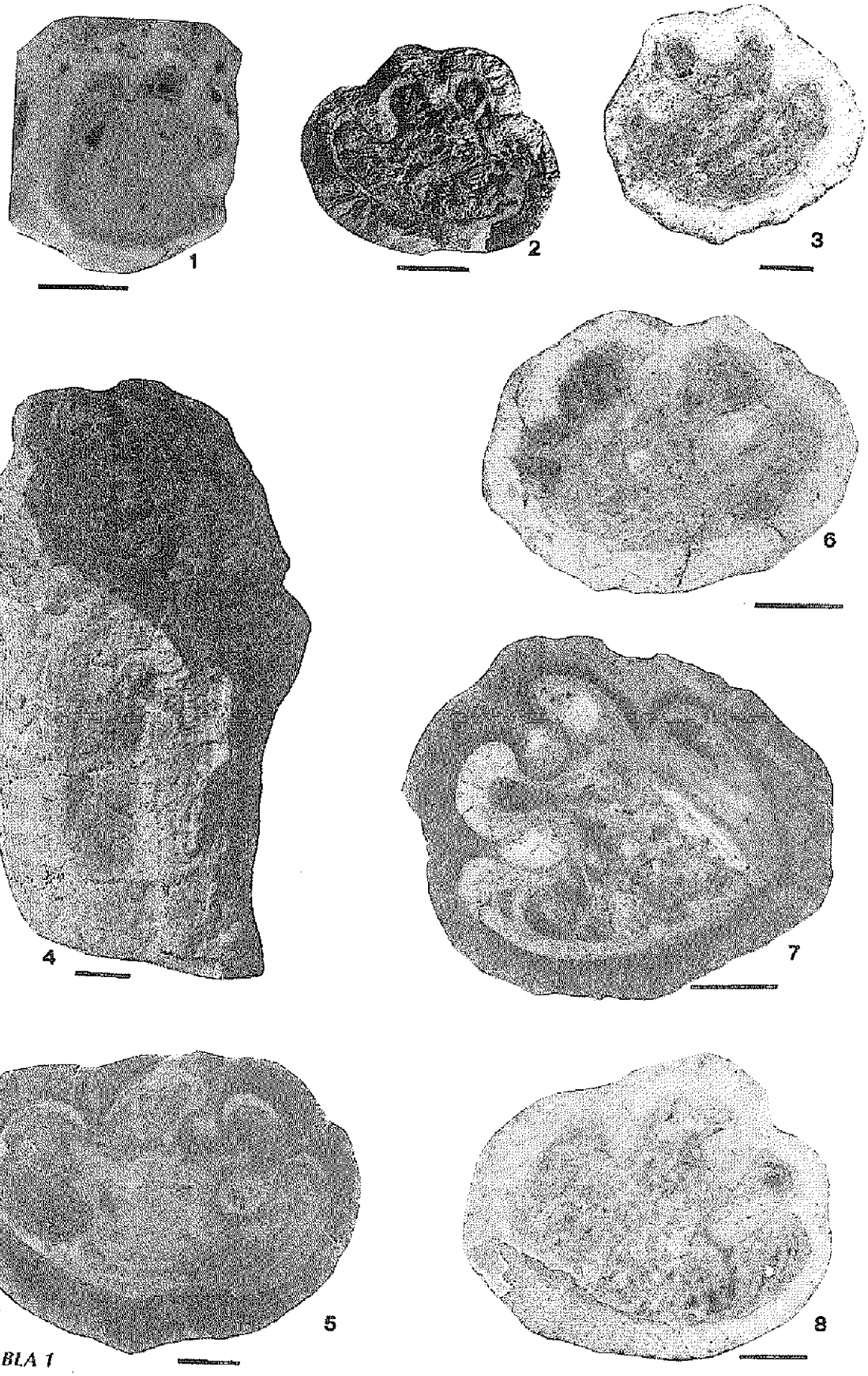
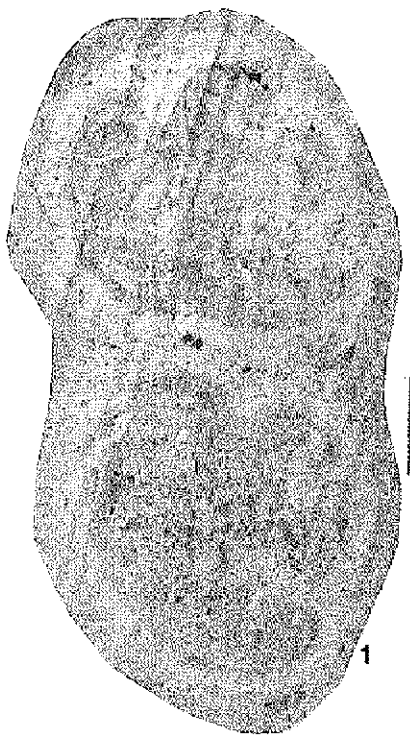


PLATE 1 / TABLA 1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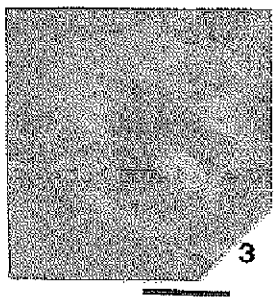
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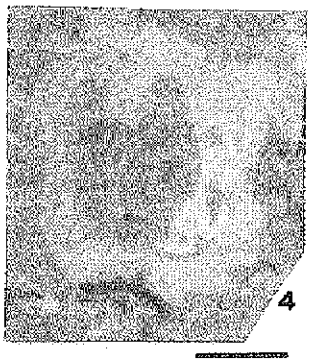
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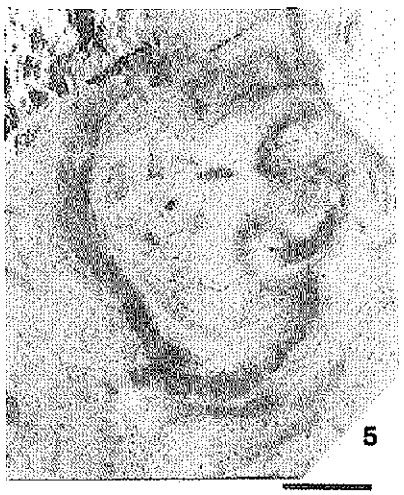
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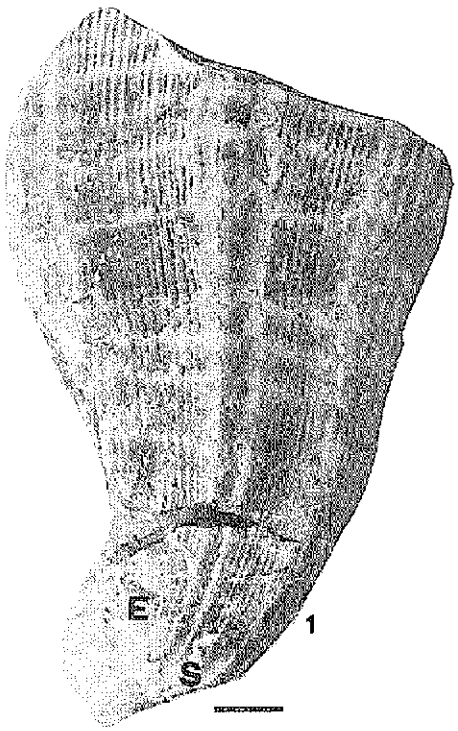
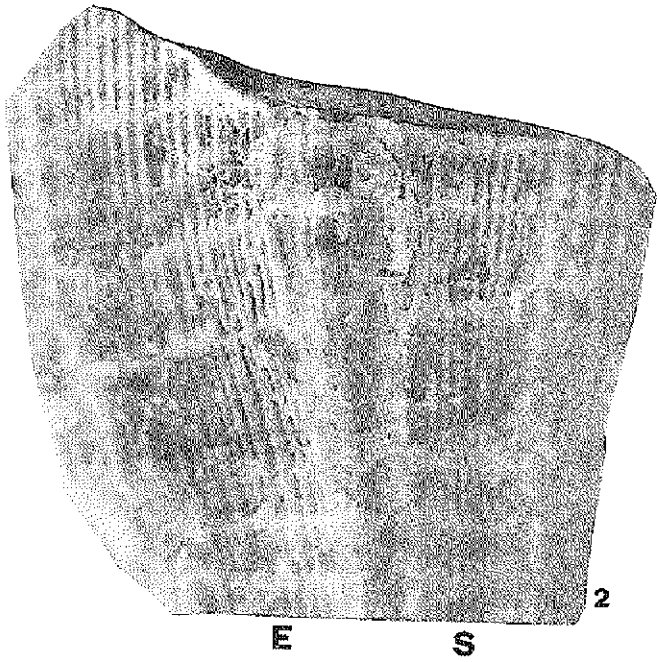
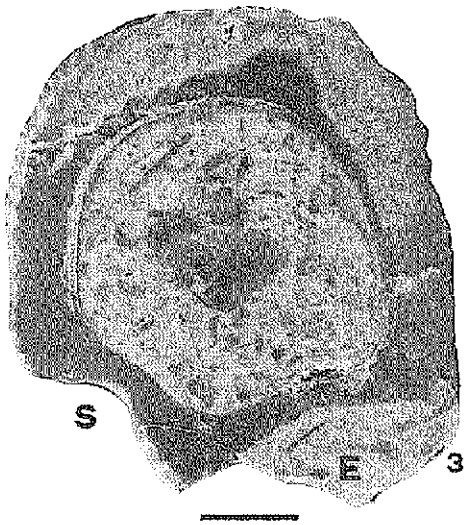
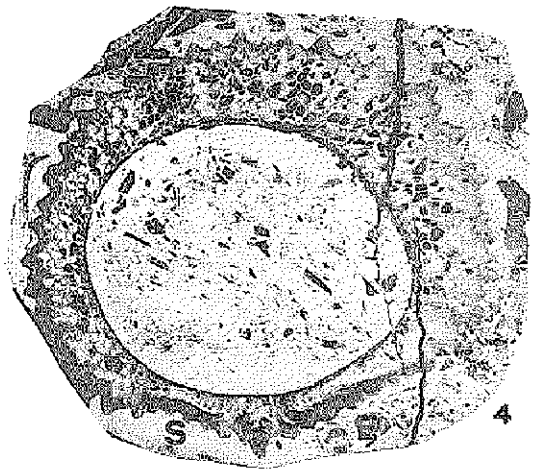
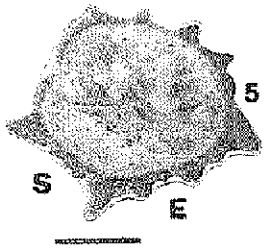
PLATE 2 / TABLA 2

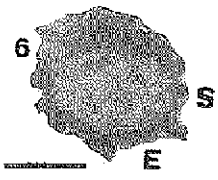


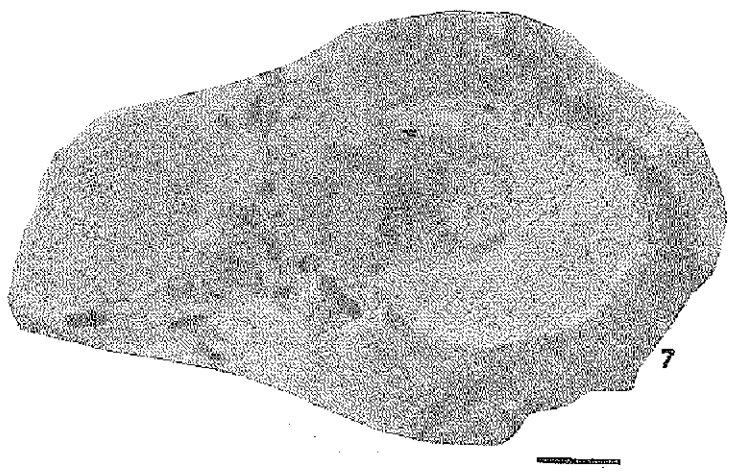












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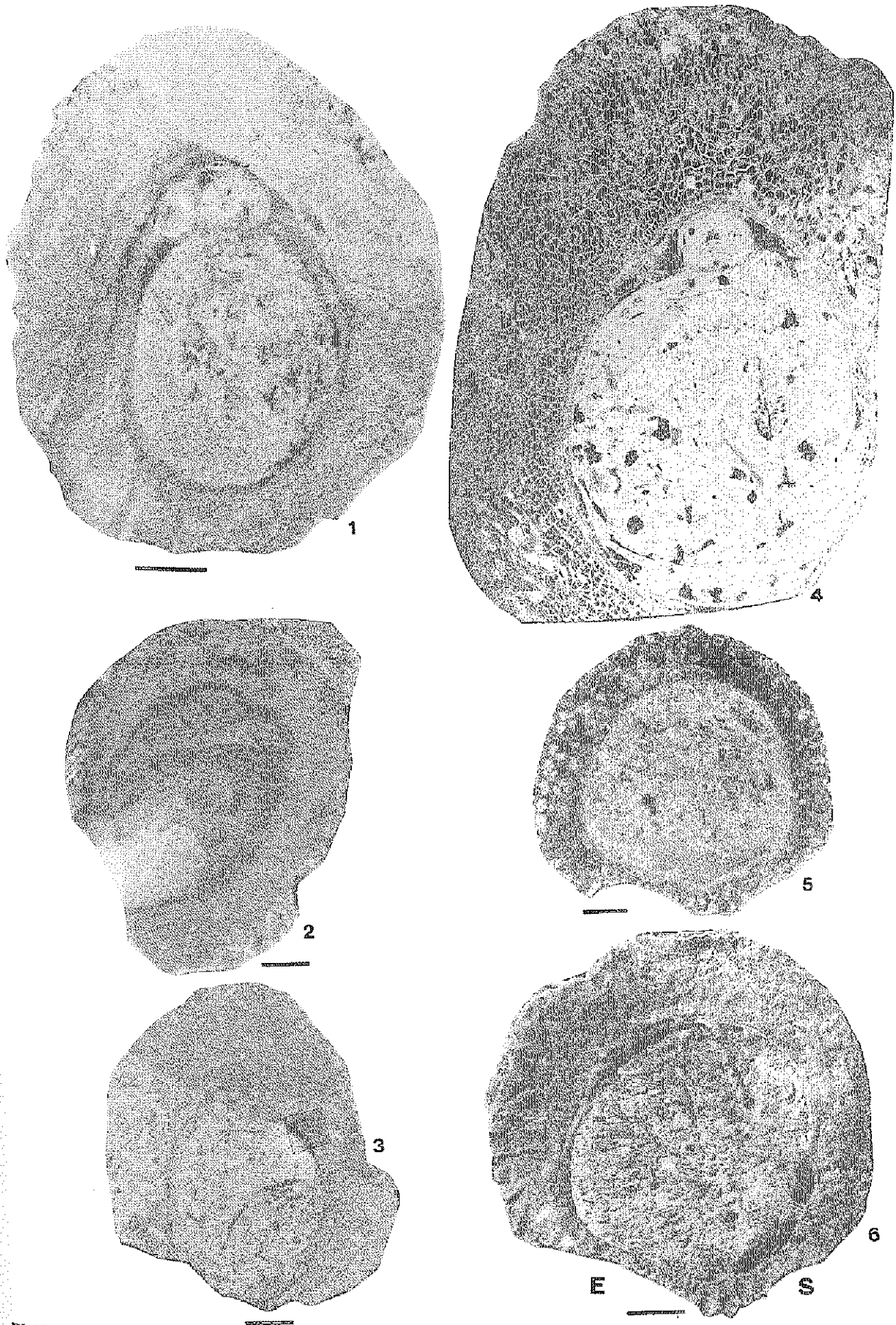
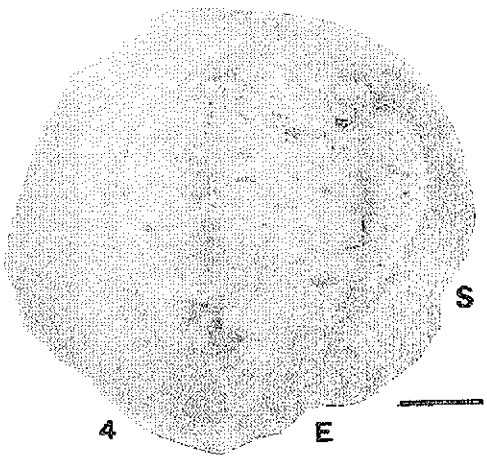
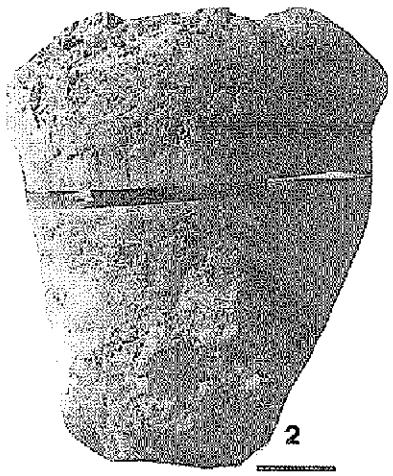
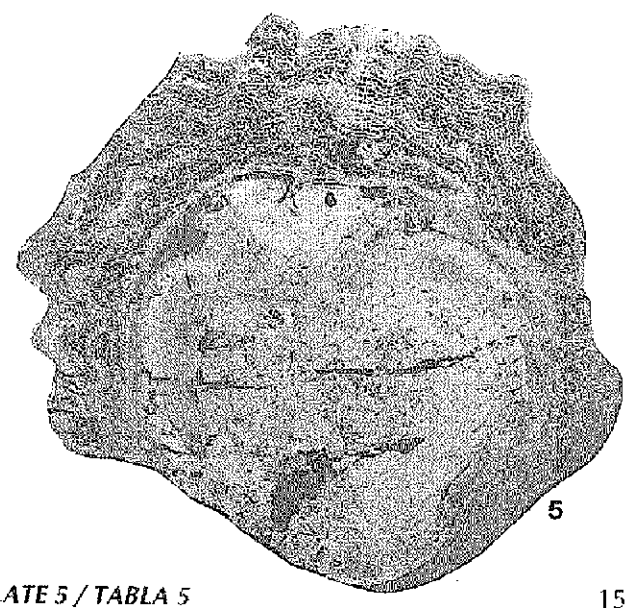


PLATE 4 / TABLA 4







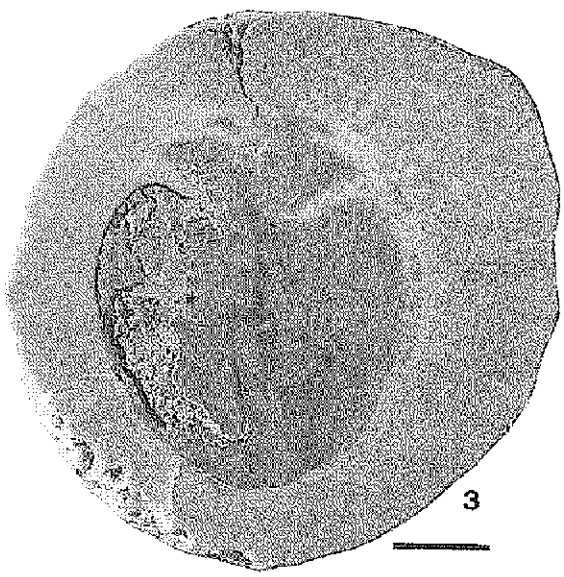
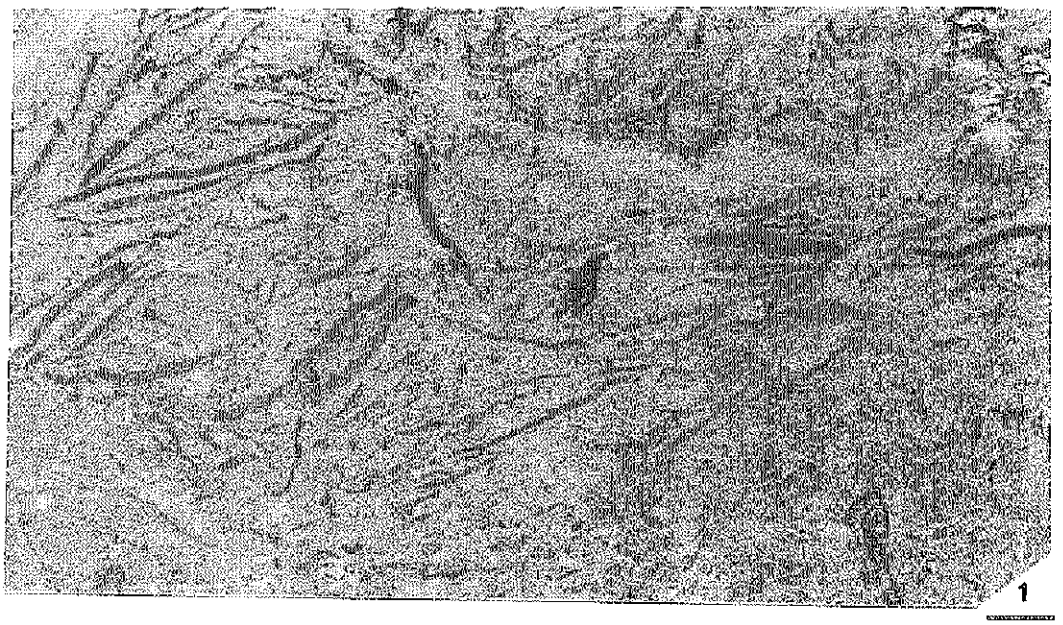


PLATE 5 / TABLA 5



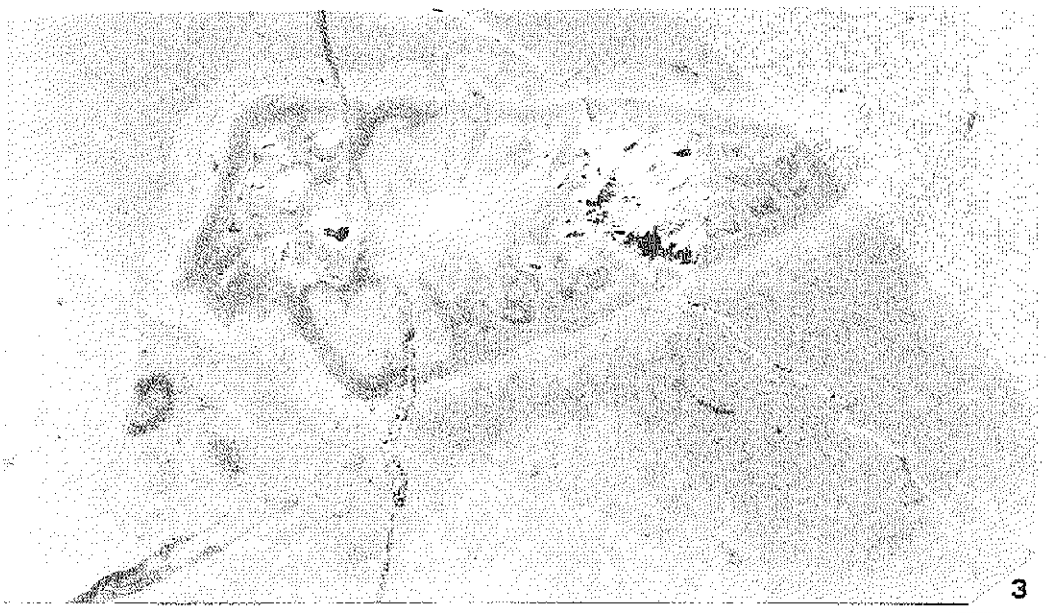
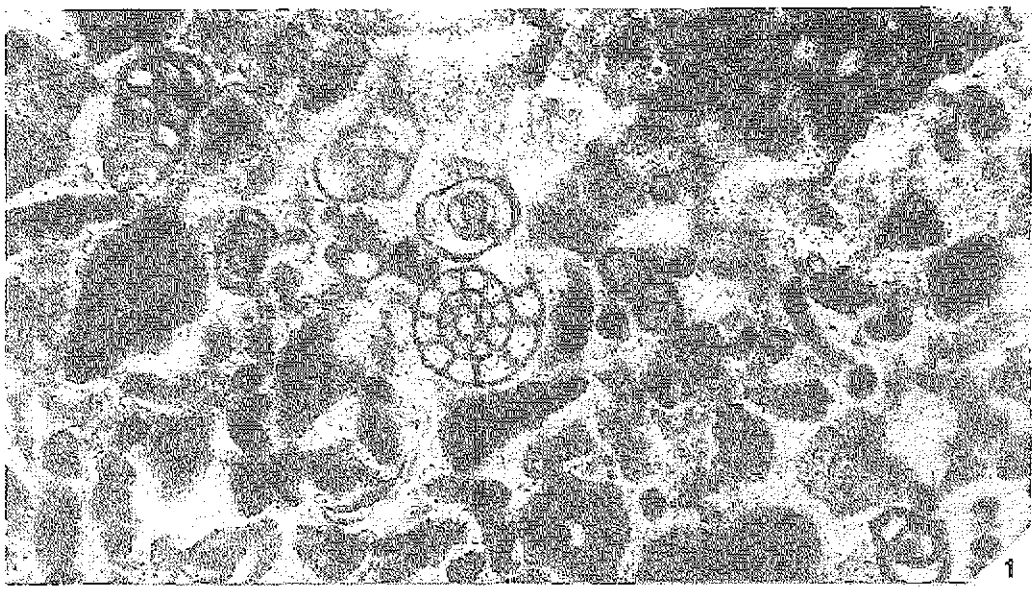


PLATE 6 / TABLA 6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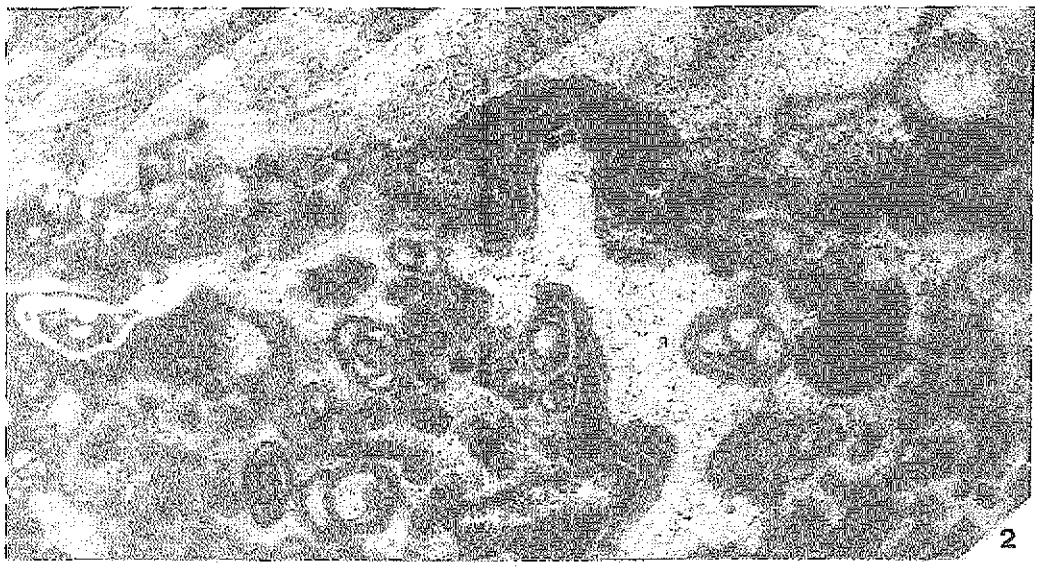
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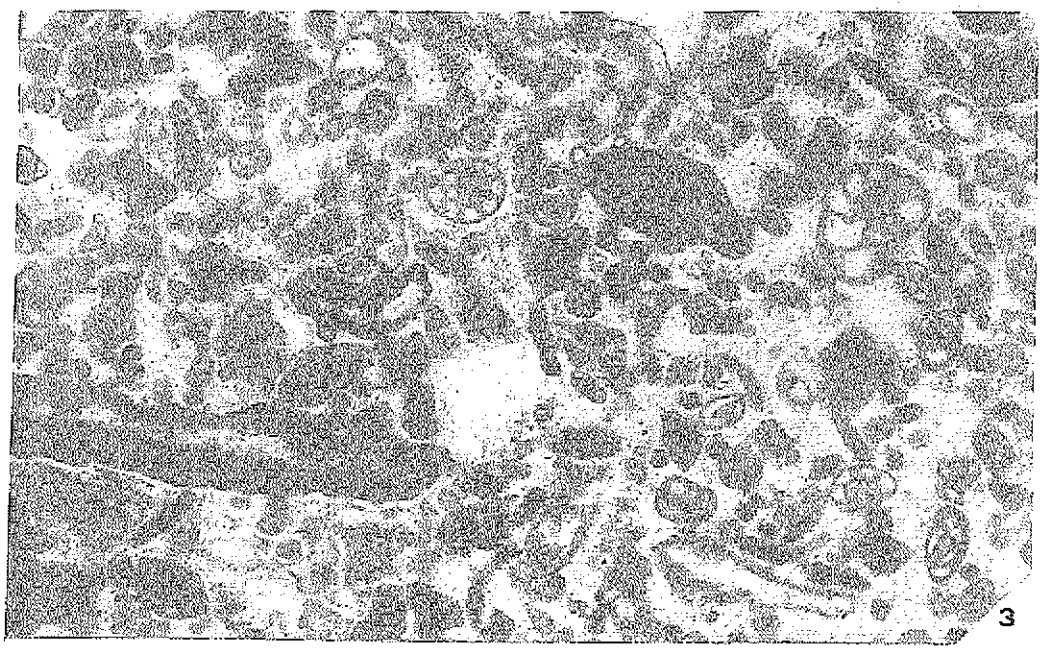
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PLATE 7 / TABLA 7

PALEONTOLOŠKI IN STRATIGRAFSKI OPIS ZGORNJETURONIJSKIH PLASTI Z RUDISTI V SLIVJU, TRŽAŠKI KRAS, ITALIJA

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POVZETEK

Pri preučevanju stratigrafskega zaporedja apnencev z bogato rudistno favno na vzhodnem delu Tržaškega Krasa pri Slivju je bil prvič odkrit na Tržaške, Krasu horizont onkoidnega apnenca. Ta horizont lahko primerjamo z onkolitom v formaciji Gornji Humac pri Gračiću (Gušić & Jelaska, 1990, 1993) na otoku Braču (Hrvaška) ter z onkoidnim apnencem Sežanske formacije (Jurkovšek et al., *1996). Oba horizonta, ki ju prištevamo h zgornjemu turoniju, dokazujeta hitro in globalno morsko regresijo (Hancock & Kauffman, 1979 in Schlanger, 1986). Rudistno združbo v stratigrafskem zaporedju pri Slivju sestavljajo naslednje zgornjeturonijske vrste:* Hippuritella resecta *(Defrance),* Hippurites requieni *(Matheron),* H. requieni *var.* subpolygonia *Douvillé,* Vaccinites *cf.* inferus *(Douvillé),* Neoradiolites turoniensis *Pašić,* Distefanella? robusta *Caffau & Pleničar,* Distefanella kochanskae *Sliškovic,* Durania arnaudi *Choffat in* Biradiolites *sp. Nekatere od teh vrst so opisane prvič na Tržaškem Krasu. Asociacija obsega še polže, korale in kalcitne ter inkrustirane alge.*

Ključne besede: Rudisti, onkoidi, zgornji turonij, Tržaški Kras

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