

A new cephalopod find in the Eocene beds near Grdoselo in Istria, Croatia

Nova najdba glavonožca v eocenskih plasteh pri Grdoselu v Istri

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Abstract

The article presents a cast fossil of a cephalopod found in sandy limestones (packstones) of Eocene age near Grdoselo in Central Istria. The phragmocone remains most probably belong to the nautilid species *Eutrephoceras* (*Simplicioceras*) *centrale* (Sowerby, 1812). We have determined the age of the fossil with calcareous nannoplankton. The nannofossil assemblage is typical of the Middle Eocene and allows the assignment to the biozone NP15 (*Nannotethrina fulgens*) of the Middle Eocene.

Izvleček

V prispevku je predstavljeno kameno jedro glavonožca iz eocenskih peščenih apnencev pri Grdoselu v osrednji Istri. Ostanek fragmokona najverjetneje pripada navtilidu vrste *Eutrephoceras* (*Simplicioceras*) *centrale* (Sowerby, 1812). Ugotavljali smo tudi starost plasti s pomočjo kalcitnega nanoplanktona. Nanoplanktonska združba je značilna za srednji eocen, prisotnost biostratigrafsko relevantnih vrst omogoča opredelitev starosti na biocono NP15 (*Nannotethrina fulgens*) v srednjem eocenu.

Introduction

Grdoselo is situated approximately 10 km north of Pazin (Fig. 1). The outcrop extends along a cart track leading through the forest. We visited this locality several times and made another thorough inspection of the surface layer of the outcrop in September 2010. The time of the field work was selected with respect to the fact that a certain period of time had passed since our last visit and that there had been some substantial rainfall after which interesting macrofossils are commonly found. This time as well we found some cast fossils of molluscs and sea urchins. Finally, we detected a smooth surface of a few square centimetres and after carefully removing the overlying weathered rocks it became clear that this was not another fossil sea urchin. After its excavation we realised that this was a relatively well preserved cast fossil of a cephalopod (Fig. 2), which was not similar to the *Aturia* specimen found a few years earlier and described in MIKUŽ (2009). Well preserved nautilid fossils are rare in the Eocene of Istria.

The Middle to Late Lutetian age of the rocks outcropping in Grdoselo has been determined by MIKŠA et al. (2005: 101) on the basis of ortho-phragmid foraminifera. They determined assemblages that correspond to biozones SBZ 14/15 or P11–P12. A bit further towards the south, in the vicinity of Pićan, BABIĆ et al. (2007: 96) studied the flysch beds and established that the sediments of the Pazin Basin in that locality can be assigned to P12 to P13 planktonic foraminiferal biozones, while nannoplankton assemblages were consistent with the age of NP16 to NP17. These biozones in fact correspond better to the Late Lutetian and Early Bartonian.

To pinpoint the age of the beds outcropping in the Grdoselo locality we studied them for calcareous nannoplankton. We collected samples from the umbilici of the two nautilid cast fossils from this site (a specimen presented in Plate 1 and another, poorly preserved specimen which is not documented) and another sample from the umbilicus of a fossil gastropod belonging to the genus *Pleurotomaria*, a relatively rare find in this site.

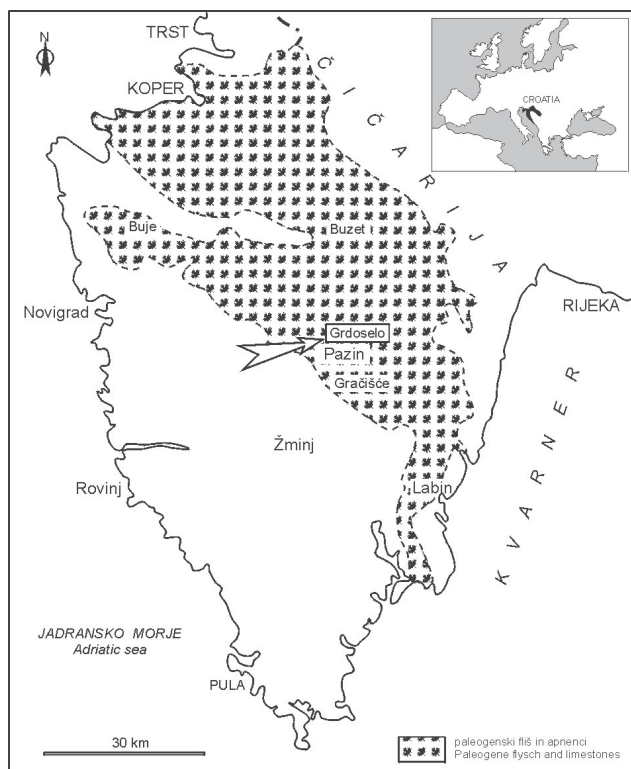


Fig. 1. Geographical location of the site Grdoselo.



Fig. 2. The cast of nautilid »in situ« in the outcrop of site Grdoselo. Size of specimen: 145 x 104 x 90 mm.

Photo: V. Mikuž

The study of Eocene nautilids of Istria

The earliest records of fossil nautilids of Istria are those of HACQUET (1789: 42), the author mentions that in the vicinity of Píčan it is possible to find nautilid remains as well. Almost a century later several researchers mention or present individual nautilid finds in the Istrian peninsula: (1864a; 1864b; 1889), PARONA (1898), SCHUBERT (1905), MANEK (1905), TONIOLO (1909), TOULA (1918), SACCO (1924), ŠIKIĆ (1963), POLŠAK & ŠIKIĆ (1973), ABATE et al. (1988), TARLAO, TUNIS & VENTURINI (1995), MOOSLEITNER (1996), MIKŠA, MEZGA & ČOSVIĆ (2005) and MIKUŽ (2009), the latter includes a survey of older data and some new findings concerning the species *Aturia* cf.

ziczac (Sowerby) found in the same outcrop near Grdoselo. STACHE (1889: 64) mentions that among other macrofossils some nautilid fossils were found in the Kanuš hill near Pazin, he mentions the species *Nautilus* (*Aturia*) *lingulatus* Buch and *Nautilus umbilicaris* Deshayes.

The list of fossil species of nautilids mentioned in the sources listed above includes "*Nautilus*" sp., *Eutrephoceras imperialis* (Sowerby), *E. disculus* (Deshayes), *Hercoglossa* aff. *harrisi* Miller & Thompson, *Aturia ziczac* (Sowerby), *Aturia* sp. and *Aturia* cf. *ziczac* (Sowerby), all found in proximity of Grdoselo.

Systematic palaeontology

Taxonomy in accordance with: KUMMEL 1964 and SCHULTZ 1976

Classis Cephalopoda Cuvier, 1795
Subclassis Nautiloidea Agassiz, 1847
Ordo Nautilida Agassiz, 1847
Superfamilia Nautilaceae Blainville, 1825
Familia Nautilidae Blainville, 1825
Genus *Eutrephoceras* Hyatt, 1894
Subgenus *Simplicioceras* Schultz, 1976

According to KUMMEL (1964: K448) the genus *Nautilus* Linné, 1758 is known only from the Oligocene onwards. This means that the nautilid fossil from Grdoselo cannot be assigned to this genus. The genus *Eutrephoceras* ranges from the Upper Cretaceous to the Eocene (SCHULTZ, 1976: 48), while the subgenus *Simplicioceras* ranges from the Paleocene to the Miocene (SCHULTZ, 1976: 49).

Eutrephoceras (*Simplicioceras*) *centrale*
(Sowerby, 1812)
Pl. 1, Figs. 1a-1d

- 1812 *Nautilus centralis*. – SOWERBY, 11, Left hand figure
- 1840 *Nautilus centralis* – SOWERBY, Pl. 627, Fig. 6
- 1849 *Nautilus Sowerbyi*. Wetherell. – EDWARDS, 48, Pl. 6, Pl. 8, Fig. 3
- p.1863 *Nautilus ellipticus* Schafhäütl – SCHAFHÄÜTL, Taf. 57-58
- 1976 *Eutrephoceras* (*Simplicioceras* nov. subgen.) *centrale* (Sowerby, 1812) – SCHULTZ, 51, Abb. 1C
- 1992 *Nautilus centralis* Sowerby – HAGN, DARGA & SCHMID, 178-179, Taf. 50
- 1993 *Eutrephoceras* (*Simplicioceras*) cf. *centrale* (Sowerby, 1812) – LLOMPART, 46, Lám. 3, Figs. 5, 6
- 2004 *Angulithes* (*Cimomia*) *imperialis* (Sowerby) – MOOSLEITNER, 39, Taf. 3, Fig. 5

Material: A relatively well preserved cast fossil with the basic morphological characteristics of a nautilid (Pl. 1, figs. 1a-1d). The fossil was found on 3 September 2010 by the first author of this paper.

Locality: The Eocene sandy limestones within the megasequence in proximity of Grdoselo (Fig. 2). The beds contain an abundance of various macrofossils. The larger specimens include echinoids, mostly belonging to the *Echinolampas* genus, less commonly to the largest Eocene species *Conoclypus conoideus*.

Description: A relatively large cast fossil represents a phragmocone of a nautilid shell (Pl. 1, figs. 1a–1d). The remains of the living chamber are not preserved. The cast fossil displays the characteristic involute coiling and growth with younger and wider chambers overgrowing the older and narrower parts of the shell. The left hand side of the phragmocone is in a better state of preservation than the right (Pl. 1, fig. 1b), the older part of which is rather heavily corroded (Pl. 1, fig. 1c). 15 to 16 chambers can be distinguished on the surface of the phragmocone, which are separated by relatively simple suture lines. The exact number of the chambers is impossible to determine. The visible older part of the phragmocone consists of short (~10 mm) living chambers, while in the younger part they become progressively longer (~30 mm). The siphuncle is round and somewhat deepened, it lies in the middle of the concave oval septal wall (Pl. 1, fig. 1d) of the last preserved septum, which is relatively wide and low and slightly narrowed in its lower or ventral part.

Note: SOWERBY (1812: 11–12) mentions that the species is named after the position of the siphuncle in the middle of the septa dividing the living chambers in the phragmocone.

Size of the nautilid cast – phragmocone:

Size of specimen = 145 x 104 x 90 mm
 Maximum radius of phragmocone = 93 mm
 Length of septa = 10 to 30 mm
 Radius = 50 mm
 Width of cast fossil = 90 mm
 Height of last whorl = 74 mm
 Distance from outer edge to the center of siphuncle = 40 mm
 Diameter of siphuncle = 6 mm
 Diameter of umbilicus = 9 mm

Remarks: HAGN et al. (1992: Taf. 50) report of a specimen of *Nautilus centralis* Sowerby from the Lutetian strata of the Kressenberg locality in Germany. The size and the form of the suture line are comparable to the specimen from Grdoselo. Certain similarities are also observable with the specimens described by SCHAFHÄUTL (1863). Plate 54, fig. 2a–c illustrates a specimen of *Nautilus macrocephalus* Schafhäutl, the differences between the specimens include size, shape of the last turn of the coil and position of the siphuncle. The specimen from Istria is more comparable to the *Nautilus ellipticus* illustrated by SCHAFHÄUTL (1863) in Plates 57 and 58. They are similar in size, shape of the shell and the suture line but not in the position of the siphuncle as this is not shown in the illustrations of SCHAFHÄUTL (1863).

EDWARDS (1849) describes seven different nautilids from the Eocene of England. Plate 8 illustrates five species with the shape of the last turn of the coil and the position of the siphuncle. The shape of the last turn in the coil of the specimen from Istria is most similar to that of *Nautilus sowerbyi* Wetherell figured by EDWARDS (Pl. 8, fig. 3), while the position of the siphuncle is most similar to *N. centralis* (EDWARDS, 1849: Pl. 8, fig. 2).

CALZADA in VIADER (1983: 406–407) present two Illeridian nautilids from northeastern Spain. The first is a specimen of *Deltoidnautilus rollandi* (Leymerie, 1845) and the other of *Aturoidea parkinsoni* (Edwards, 1849). These specimens are not comparable to the one found in Istria.

The shape of the phragmocone and the suture line of the Istrian specimen is similar to the specimen of *Angulithes (Cimomia) imperialis* (Sowerby) from the Cuisian beds in Austria, figured by SCHULTZ (1998: 36–37, Taf. 10, Fig. 10–11). The shape and width of the septa, size and depth of the umbilicus bear some resemblance to the species *Euciphoceras regale* (Sowerby) and *Cimomia elliptica* (Schafhäutl), figured by GALÁČZ (2004: Text-figs. 2 and 4). The position of the siphuncle and partially the shape of the coil section are rather similar to *Euciphoceras regale* from the London clay and *Euciphoceras* sp. from Fayum in Egypt, figured in DZIK & GAŹDZICKI (2001: 304, fig. 6).

Stratigraphic and geographic range: The presence of the species *Nautilus centralis* in the Eocene London clay is mentioned by SOWERBY (1834: 248). According to SCHULTZ (1976: 51), the specimens of the species *Eutrechoceras (Simplioceras) centrale* (Sowerby, 1812) are characteristic of Lutetian beds. LLOMPART (1993: 46) asserts that in Spain this species is present in the Lower Eocene from Illeridian to Cuisian. The same author writes that the specimens of the species have been found in the Thanetian of Austria, Ypresian of England, Switzerland, Germany and Italy, and in the Upper Eocene of Romania, Austria and Hungary. MOOSLEITNER (2004: 34) presents the nautilid species *Angulithes (Cimomia) imperialis* from the Eocene beds of Helveticum, that is, from the St. Pankraz locality in the area of Salzburg in Austria.

Biostratigraphic dating of the fossil with calcareous nannoplankton

We have sampled the sediment matrix in the umbilici of two cast fossils of nautilids and a cast fossil of a gastropod belonging to the genus *Pleurotomaria*, all from Grdoselo. We studied the samples for calcareous nannoplankton. The nannofossil assemblage is consistent with the biozone NP15 (*Nannotethrina fulgens*) of the Middle Lutetian.

The nannofossils in samples Nautilid 1 and 2 and *Pleurotomaria* are moderately to well preserved. The assemblages are diverse: in total 43

species of nannoplankton were determined with an average of 28 species per sample. The assemblages are characteristic of the Middle Eocene with species like *Chiasmolithus solitus*, *C. grandis*, *Sphenolithus spiniger*, *S. furcatholithioides*, *Helicosphaera heezenii*, *H. seminulum*, *Discoaster wemmelenensis*, *Pseudotriquetrorhabdulus inversus*. In the sample Nautilid-2 a broken, but easily recognisable specimen of *Chiasmolithus gigas* was found (Pl. 2, fig. 9). This stratigraphic range of this species is very short – it occurs only in the CP13b biozone of OKADA & BUKRY, 1980, which can be correlated with the middle part of NP15 of MARTINI, 1971. No zonal markers of the biozone NP16 (*Reticulofenestra umbilicus*, *R. reticulata*, *Discoaster bifax*) were found in any of the three samples. The above allows the assignment of the age of all three samples to the NP15 Nannotethrina fulgens zone of MARTINI, 1971. Some of the biostratigraphically significant species of calcareous nannoplankton are shown in Plate 2.

Conclusions

The cast of a nautilid phragmocone from Istria has been found on the 3rd of September 2010 in Middle Eocene – Lutetian sandy limestone in Grdoselo. The same fossil bearing beds contain abundant echinoid remains, among them several specimens of the species *Conoclypus conoideus*. The fossils of these large sea urchins generally occur in their living position. The cast fossil of the nautilid species *Aturia* cf. *ziczac* (Sowbery, 1812) (MIKUŽ 2009) has also been found in the same locality. The nautilid phragmocone presented here (Pl. 1, fig. 1a–1d) has been determined as *Eutrep hoceras* (*Simplicioceras*) *centrale* (Sowerby, 1812) on the grounds of its relatively simple suture, the position of the siphuncle and some other relevant characteristics.

Several similar forms are mentioned in relevant literature, but they are very difficult to compare, mostly due to the poor state of preservation they are usually in. Furthermore, the reference figures in literature display the nautilid fossils in various ways: their shells, shells combined with cast fossils or cast fossils exclusively, median longitudinal sections of the phragmocone, usually without living chambers etc. It is impossible to observe all the characteristics of an individual Eocene species in deficiently preserved specimens presented in a variety of different ways.

The calcareous nannoplankton assemblages found in the matrix attached to some macrofossil finds allow the assignment of the age of these beds to the NP15 Nannotethrina fulgens zone of MARTINI, 1971 in the Middle Lutetian.

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References

- ABATE, A., BAGLIONI, R. A., BIMBATTI, C. & PICCOLI, G. 1988: Rasegna di molluschi marini bentonici e nectonici del Cenozoico triveneto. Mem. Sci. Geol., Mem. Ist. Geol. Miner. Univ. Padova, 40: 135–171, Tav. 1–4.
- BABIĆ, L., M. HERNITZ KUČENJAK, S. ČORIĆ & ZUPANIĆ, J. 2007: The Middle Eocene age of the supposed Late Oligocene sediments in the flysch of the Pazin Basin (Istria, Outer Dinarides). Nat. Croat., 16/2: 83–103.
- CALZADA, S. & VIADER, J. 1983: Dos Nautilidos del Eocene de Huesca. Estudios geol., 39: 405–408.
- DZIK, J. & GAŹDZICKI, A. 2001: The Eocene expansion of nautilids to high latitudes. Palaeogeography, Palaeoclimatology, Palaeoecology, 172: 297–312.
- EDWARDS, F. E. 1849: A monograph of the Eocene Mollusca or descriptions of shells from the older Tertiaries of England. Part 1. Cephalopoda. Palaeontographical Society, London: 56 p., Pl. 1–9.
- GALÁČZ, A. 2004: Nautiloid cephalopods from the Middle Eocene of Iszkaszetgyörgy, Transdanubian Hungary. Annales Univ. Scient. Budapestensis, Sect. Geologica, 34: 1–7.
- HACQUET, B. 1778–1789: Oryctographia Carniolica, oder Physikalische Erdbeschreibung des Herzogthums Krain, Istrien und zum Theil der benachbarten Länder. I–IV. J. G. I. Breitkopf, Leipzig.
- HAGN, H., R. DARGA & SCHMID, R. 1992: Erdgeschichte und Umwelt im Raum Siegsdorf. Fossilien als Zeugen der geologischen Vergangenheit. Gemeinde Siegsdorf, München: 1–241 p., (Taf. 1–80).
- KUMMEL, B. 1964: Nautiloidea – Nautilida. In: MOORE, R. C. (ed.): Treatise on Invertebrate Paleontology, Part K, Mollusca 3. The Geological Society of America and The University of Kansas Press, Lawrence: K383–K457.
- LLOMPART, C. 1993: Nautiloideos del Eocene del Prepirineo. Batalleria 1989, Barcelona, 3: 37–60, (Lám. 1–4).
- MANEK, F. 1905: Neue Fundorte von Eocänfossilien bei Rozzo (Istrien). Verh. Geol. R. A., Wien, 351–352.
- MARTINI, E. 1971: Standard Tertiary and Quaternary Calcareous Nannoplankton Zonation. In: Farinacci, A. (ed.): Proceedings of the II Planktonic Conference, Roma 1970. Edizioni Tecnoscienza, 2: 739–785.
- MIKŠA, G., MEZGA, A. & ČOSOVIĆ, V. 2005: An Example of Mixed Echinoid Fauna from the Lutetian of Grdoselo, Central Istria. Knjiga sažetaka – Abstract Book, 3. Hrvatski geološki kongres – 3rd Croatian Geological Congress, Opatija 2005. Hrvatski geološki institut – Croatian Geological Survey, Zagreb: 101–102.
- MIKUŽ, V. 2009: Nautilid iz srednjeeocenskih plasti pri Grdoselu v Istri na Hrvaškem. (A nautiloid from Middle Eocene beds at Grdoselo in Istria, Croatia). Geologija, 52/1: 33–43, (Tab. 1), doi:10.5474/geologija.2009.005.

PLATE 1



1a *Eutrephoceras (Simplicioceras) centrale* (Sowerby, 1812); posterior side, Grdoselo, reduced. Natural size of specimen: 145 x 104 x 90 mm.

1b The right side of the same specimen, Grdoselo, reduced.

1c The left side of the same specimen, Grdoselo, reduced.

1d Anterior side, position of siphuncle on the same specimen, Grdoselo, reduced.

Photo: Marijan Grm

PLATE 2

Calcareous nannoplankton in the samples of groundmass from the umbilici of two nautilids and a *Pleurotomaria* sp. from Grdoselo.

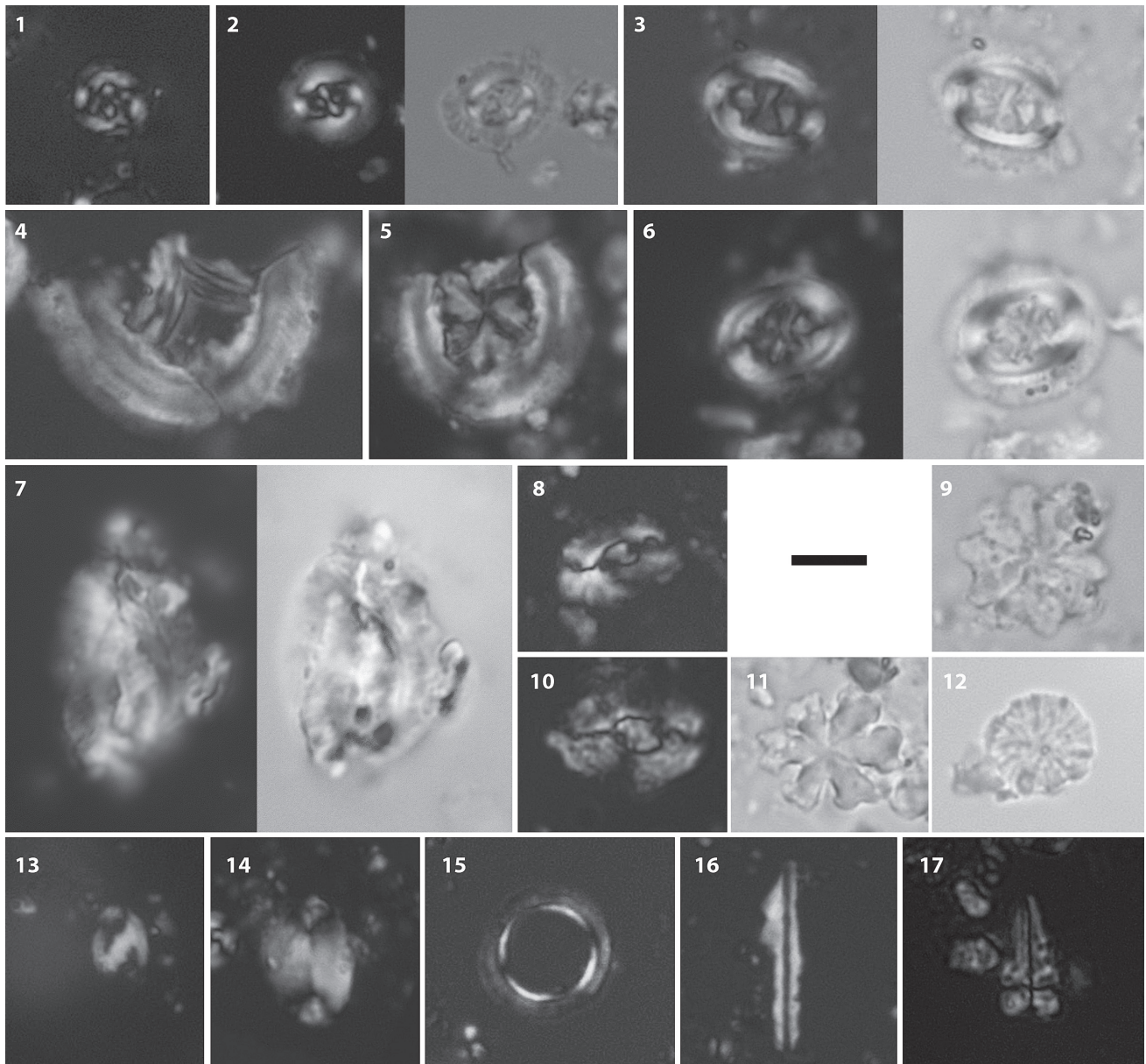
- 1 *Chiasmolithus nitidus* Perch-Nielsen, 1971; Nautilid 1, XPL.
- 2 *Chiasmolithus nitidus* Perch-Nielsen, 1971; *Pleurotomaria*, a- XPL, B-PPL.
- 3 *Chiasmolithus solitus* (Bramlette & Sullivan, 1961) Locker, 1968; Nautilid 2, a-XPL, b-PPL.
- 4 *Chiasmolithus grandis* (Bramlette & Riedel, 1954) Radomski, 1968; fragment, Nautilid 2, XPL.
- 5 *Chiasmolithus gigas* (Bramlette & Sullivan, 1961) Radomski, 1968; fragment, Nautilid 2, XPL.
- 6 *Chiasmolithus solitus* (Bramlette & Sullivan, 1961) Locker, 1968; Nautilid 2, a-XPL, b-PPL.
- 7 *Helicosphaera heezenii* (Bukry, 1971) Jafar & Martini, 1975; Nautilid 2, a-XPL, b-PPL.
- 8 *Helicosphaera bramlettei* (Müller, 1970) Jafar & Martini, 1975; *Pleurotomaria*, XPL.
- 9 *Discoaster barbadiensis* Tan, 1927, emend. Bramlette and Riedel, 1954; PPL.
- 10 *Helicosphaera bramlettei* (Müller, 1970) Jafar & Martini, 1975; Nautilid 1, XPL.
- 11 *Discoaster deflandrei* Bramlette & Riedel, 1954; sample Nautilid 2, PPL.
- 12 *Discoaster wemmeliensis* Achuthan & Stradner, 1969; sample Nautilid 2, PPL.
- 13 *Pontosphaera sigmoidalis* (Locker, 1967), Aubry, 1986; sample Nautilid 2, XPL.
- 14 *Pontosphaera plana* (Bramlette & Sullivan, 1961) Haq, 1971; sample Nautilid 2, XPL.
- 15 *Coronocyclus bramlettei* (Hay & Towe, 1962) Bown, 2005; Nautilid 2, XPL.
- 16 *Pseudotriquetrorhabdulus inversus* (Bukry & Bramlette, 1969) Wise in Wise & Constans, 1976; Nautilid 2, PPL.
- 17 *Sphenolithus radians* Deflandre in Grasse, 1952; Nautilid 1, XPL.

Scale bar – 5 nm

MOOSLEITNER, G. 1996: Fossilien aus dem Mittel-Eozän von Istrien. Fossilien, 2: 105-110.
 MOOSLEITNER, G. 2004: Fossilien sammeln im Salzburger Land. Ein Führer zu klassischen und neuen Fundstellen. Goldsneck im Quelle & Meyer Verlag GmbH & Co., Wiebelsheim: 223 p., (Taf. 1-107).
 OKADA, H. & BUKRY, D. 1980: Supplementary modification and introduction of code numbers to the low-latitude coccolith biostratigraphic zonation. Marine Micropaleontology, 5: 321-325.

PARONA, C. F. 1898: Note sui cefalopodi terziari del Piemonte. Palaeontographia Italica, 4: 155-168, Tav. 12-13 (1-2).
 POLŠAK, A. & ŠIKIĆ, D. 1973: Tumač za list Rovinj. Osnovna geološka karta SFRJ 1 : 100 000. Savezni geološki zavod Beograd, Beograd: 51 p.
 SACCO, F. 1924: L'Istria. Cenni geologici generali. Memorie descrittive della Carta geologica d'Italia, Mondovi, 19: 105 p.
 SCHAFHÄUTL, K. E. 1863: Süd-Bayerns Lethaea Geognostica. Der Kressenberg und die südlich

PLATE 2



von ihm gelegenen Hochalpen geognostisch betrachtet in ihren Petrefacten. Leipzig: 487 p., Taf. 1-86.

SCHUBERT, R. J. 1905: Zur Stratigraphie des istrisch-norddalmatinischen Mitteleocän. Jb. Geol. R. A., 55: 153-188.

SCHULTZ, O. 1976: Zur Systematik der Nautilidae. Anzeiger Österr. Akad. Wiss., mathem.-naturwiss. Kl., 1976/H.6: 43-51.

SCHULTZ, O. 1998: Tertiärfossilien Österreichs. Wirbellose, niedere Wirbeltiere und marine

Säugetiere. Goldschneck-Verlag, Korb: 159 p., (Taf. 1-65).

SOWERBY, J. 1812: The Mineral Conchology of Great Britain; or coloured figures and descriptions of those remains of Testaceous Animals or Shells, which have been preserved at various times and depths in the Earth. Printed by Benjamin Meredith, London 1: VII, 9-234 p.

SOWERBY, J. D. C. 1834: Systematical, stratigraphical and alphabetical indexes to the first six

- volumes of the Mineral Conchology of Great Britain. London: 242-250: 1-11.
- SOWERBY, J. D. C. 1840: No. 106. of the Mineral Conchology of Great Britain; coloured figures and descriptions of those remains of testaceous animals or Shells, which have been preserved at various times and depths in the Earth. London 7: 80 p., Pl. 610-648.
- STACHE, G. 1864a: Die Eocengebiete in Inner-Krain und Istrien. Jb. Geol. R. A., 14: 11-115.
- STACHE, G. 1864b: Geologisches Landschaftsbild des istrischen Küstenlandes. Österr. Revue, 5: 209-222.
- STACHE, G. 1889: Uebersicht der geologischen Verhältnisse der Küstenländer von Österreich-Ungarn. Alfred Hölder, Wien: 84 p.
- ŠIKIĆ, D. 1963: Eine Vergleichende Darstellung der Entwicklung des jüngeren klastischen Paläogens in Istrien, dem Kroatischen Küstenland und Dalmatien. Geol. vjesnik, 15/2: 329-336.
- TARLAO, A., TUNIS, G. & VENTURINI, S. 1995: Lutetian Transgression in Central Istria: Rogovići-Mečari Section Case. 1. Hrvatski geol. kongres Opatija, Zbornik radova, 2: 613-618, Pl. 1-2.
- TONIOLO, A. R. 1909: L'Eocene dei dintorni di Rozzo in Istria e la sua fauna. Palaeontographia Italica, Mem. Paleont., 15: 237-295, Tav. 24-26.
- TOULA, F. 1918: Lehrbuch der Geologie. Ein Leitfaden für studierende. Alfred Hölder, Wien und Leipzig: XI, 556 p., Taf. 1-30.