

DINOFLAGELLATE CYST STRATIGRAPHY OF THE SCISTI A FUCOIDI FORMATION (EARLY CRETACEOUS) FROM PIOBBICO, CENTRAL ITALY: CALIBRATED EVENTS FOR THE ALBIAN OF THE TETHYAN REALM

STEFANO TORRICELLI

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Abstract. Rich and well preserved organic-walled dinoflagellate cyst assemblages recovered from the Scisti a Fucoidi Formation at Piobbico, central Italy are presented. Distributions of 83 taxa, plotted against the independent stratigraphic framework established from planktonic foraminifers and nannofossils, are compared with ranges documented in the literature in order to identify and calibrate reference horizons for the Albian dinoflagellate cyst stratigraphy of the Tethyan Realm. The following events have been selected: the lowest occurrences of *Kleithrisphaeridium atlasense* and *Tehamadinium coummia* at the Aptian/Albian boundary, of *Leberidocysta defloccata* in the Lower Albian, of *Adnatosphaeridium tutulosum*, *Litosphaeridium arundum* and *Ovoidinium* sp. A sensu Davey (1979) in the Middle Albian, of *Dapsilidinium? pumilum*, *Litosphaeridium conspicinum*, *Tehamadinium mazaganense* and *Hapsocysta dictyota* in the Upper Albian; the highest consistent occurrences of *Hapsocysta peridictya* in the Lower Albian, of *Codoniella psygma* and *Damassadinium chibane* in the Middle Albian, of *Tehamadinium sousense* in the Upper Albian.

Riassunto. Sono presentate le associazioni a cisti di dinoflagellate a parete organica rinvenute negli Scisti a Fucoidi carotati a Piobbico (Italia centrale). La distribuzione degli 83 taxa identificati è posta a confronto con la biostratigrafia di dettaglio del carotaggio elaborata negli anni '80 con foraminiferi planctonici e nannoplancton calcareo. Ciò consente di calibrare orizzonti di riferimento per la stratigrafia a dinoflagellate dell'Albiano nella Provincia Tetide. Gli eventi-guida proposti, selezionati in base alle marcate peculiarità morfologiche dei taxa e alla coerenza con i dati di distribuzione stratigrafica reperibili in letteratura, sono i seguenti: le comparse di *Kleithrisphaeridium atlasense* e *Tehamadinium coummia* al limite Aptiano/Albiano, di *Leberidocysta defloccata* nell'Albiano inferiore, di *Adnatosphaeridium tutulosum*, *Litosphaeridium arundum* e *Ovoidinium* sp. A sensu Davey (1979) nell'Albiano medio, di *Dapsilidinium? pumilum*, *Litosphaeridium conspicinum*, *Tehamadinium mazaganense* e *Hapsocysta dictyota* nell'Albiano superiore; le scomparse di *Hapsocysta peridictya* nell'Albiano infe-

riore, di *Codoniella psygma* e *Damassadinium chibane* nell'Albiano medio, di *Tehamadinium sousense* nell'Albiano superiore.

Introduction

Although two decades have passed since the beginning of the biostratigraphic investigations of the Aptian-Albian Scisti a Fucoidi Formation cored at Piobbico (Erba 1986), this study represents the first contribution to the palynological characterization of the Piobbico core.

In considering the integrated stratigraphies presented in Cretaceous Chart 5 (Hardenbol et al. 1998), no dinoflagellate cyst datums are shown for the Lower and Middle Albian of the Tethyan Realm. Although the dinoflagellate cysts of the Scisti a Fucoidi Formation cropping out at Monte Petrano, about 15 km southeast of Piobbico, have already been studied and a biozonation has been established within the Albian (Fiet & Masure 2001), the lack of firm dinoflagellate cyst horizons calibrated for the Tethyan Realm has been confirmed in most recent papers where almost all of the events plotted for the Albian refer to the Boreal Realm (Williams et al. 2004; Brinkhuis et al. 2004). This is probably due to the fact that the independent stratigraphic control of the biozonation proposed by Fiet & Masure (2001) relied only on lithological criteria, as foraminiferal analyses were carried out only on spot samples in order to correlate the Monte Petrano section within the Umbria-Marche basin, and no range chart was presented owing to the accidental destruction of the original dataset (Fiet & Masure 2001, p.67).

The aim of this paper is to document well preserved assemblages of organic-walled dinoflagellate cysts recovered from the Albian section cored at Piobbico. Relying on the independent stratigraphic framework already available, which encompasses high resolution nannofossil and foraminiferal biostratigraphies (Erba 1986, 1988; Tornaghi et al. 1989), emphasis is put on the calibrations of lowest and highest occurrences of selected taxa in order to identify reference horizons for the Albian dinoflagellate cyst stratigraphy of the Tethyan Realm and help to fill the gap of Chart 5 (Hardenbol et al. 1998).

Geological setting and location of the drilling site

The Umbria-Marche succession of the central Apennines, central Italy is expression of largely continuous pelagic-hemipelagic sedimentation which took place from the Jurassic to the Paleocene. Within the Umbria-Marche succession, the Aptian-Albian Scisti a Fucoidi Formation was the product of cyclic deposition, resulting in interbedded red and green marlstones

and calcareous marlstones, dark grey to black calcareous shales, light green-grey marly limestones and limestones. These rhythmically deposited pelagic sediments attracted the attention of a consortium of Italian and American geoscientists who drilled a borehole to recover a continuous core from the Scisti a Fucoidi Formation. The aim of the Piobbico core project was to investigate the Aptian-Albian in the Tethyan Realm by performing comprehensive stratigraphic studies of the cored succession.

The Piobbico core was drilled at Le Brece, located 3 km west of the town of Piobbico, Marche, central Italy (Fig. 1). The total length of the core is 84 metres, with 98.8% recovery. It penetrated the entire Scisti a Fucoidi Formation including the upper transition to the Scaglia Bianca Formation and the lower transition to the Maiolica Formation. Since the mean bedding dip is 23°, the stratigraphic thickness of the Piobbico core is 77.7 m (76 m represents the overall thickness of the Scisti a Fucoidi Formation, whereas the remaining 1.7 m represents the transition with the underlying Maiolica Formation). Detailed lithostrati-

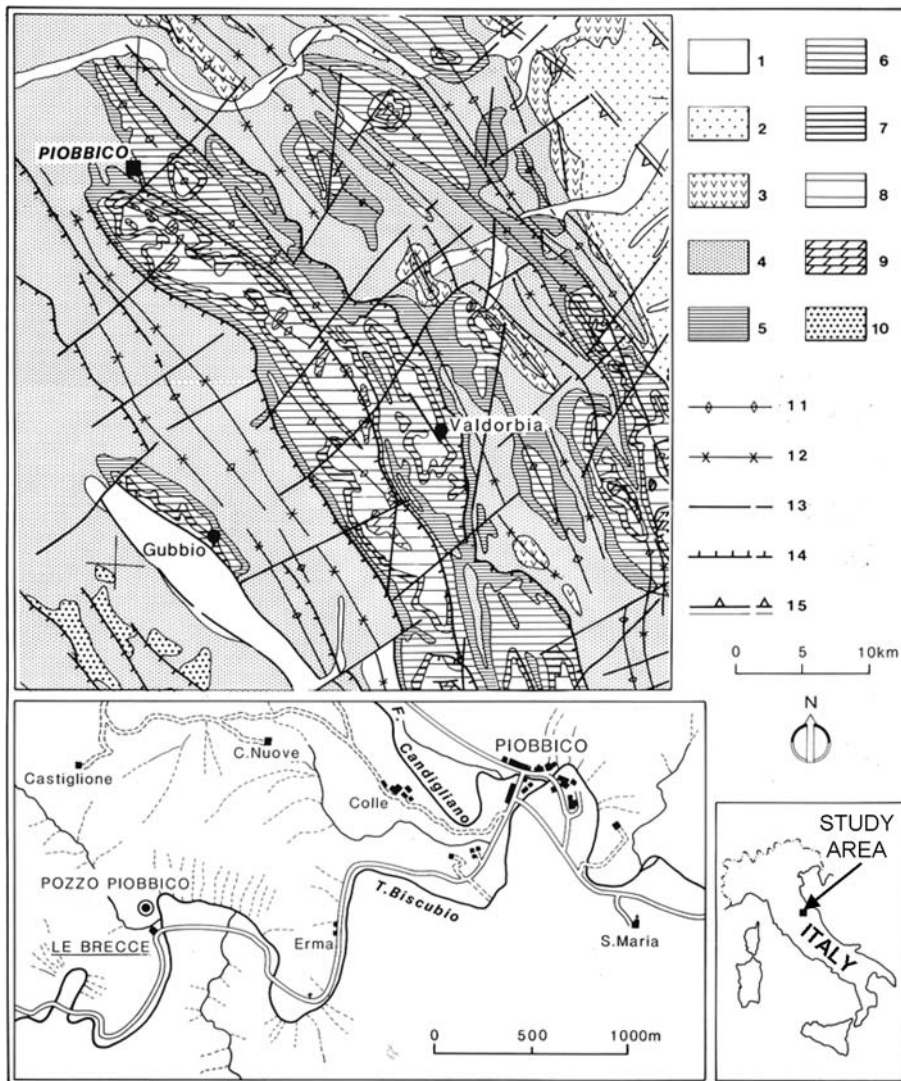


Fig. 1 - Geological map of the study area showing the location of the Piobbico drill site. 1) Quaternary and Pliocene continental deposits; 2) Quaternary and Pliocene marine deposits; 3) Messinian evaporites; 4) Miocene marine deposits; 5) Paleogene marine pelagic sediments; 6) Upper Cretaceous marine sediments; 7) Aptian-Albian Scisti a Fucoidi Fm; 8) Lower Cretaceous - Lower Jurassic pelagic sediments; 9) Lower Jurassic - Upper Triassic carbonate platform deposits; 10) allochthonous units; 11) anticline; 12) syncline; 13) fault; 14) thrust; 15) buried inverse fault. Modified after Erba (1988).

graphic and sedimentological analyses resulted in the definition of 19 units within the cored succession (Erba 1986, 1988; Tornaghi et al. 1989). From 70.65 m to 75.83 m, 'black shales' consisting of radiolarian bearing dark grey-black marly clays, represent the Livello Selli established for the Umbria-Marche basin by Wezel (1985) and described by Coccioni et al. (1987). High resolution nannofossil and foraminiferal biostratigraphies (Erba 1988; Tornaghi et al. 1989) provide the reference stratigraphic framework of the present study.

Material and methods

Seventy-five samples (labelled as PP-1 to PP-75) were collected from marlstones and calcareous shales, processed and analysed for palynomorphs. Since the stratigraphic thickness is 77.7 m, the average sample spacing is about one metre.

The palynological processing was carried out in the ENI Exploration & Production laboratories and involved cold chemical treatment of 20 g of sediment with 37% hydrochloric acid (HCl) for 2 hours to remove the calcareous fraction and subsequently with 38% hydrofluoric acid (HF) for 2 hours to remove the silicates, sieving with 250 µm and 15 µm meshes, heavy liquid separation with zinc chloride (ZnCl₂), and centrifuging to concentrate the residues. After each step the residue was washed in distilled water. Two slides were prepared for each sample with residue greater than 15 µm using Norland optical adhesive as a mounting medium.

One slide per sample was counted in full in order to obtain the abundances of dinoflagellate cyst taxa, whereas the second slide was examined to check for the presence of rare species. Furthermore, a third slide per sample prepared by Petrobras-CENPES within the context of a cooperation carried out in the 1990s between ENI and the Brazilian oil company was also checked for additional taxa. Eighty-three dinoflagellate cyst and acritarch taxa identified in the present study are listed in the Appendix and the analytical results are fully tabulated in the occurrence chart (Fig. 2).

The analytical method applied in this study is qualitative, since all of the samples prepared were used for palynostratigraphic investigation independently of overall dinoflagellate cyst recovery and percentages were not calculated because most of the samples yielded less than 100 determinable specimens per slide. Nevertheless, the good to excellent state of preservation of the Piobbico core palynomorphs and the diverse morphologic aspects of the taxa involved, allowed the taxonomic identification of almost all the dinoflagellate cysts, including fragments. Within the scope of the present study these will be discussed with reference to their biostratigraphic significance.

The palynomorph assemblages also comprise bisaccate pollen, inaperturate pollen, other pollen grains (especially *Classopollis* spp.) and trilete spores in fluctuating relative abundances, but terrestrially derived palynomorphs have not been considered herein.

Light photomicrographs were taken using a Zeiss Axioplan microscope and interference contrast illumination (Plates 1-6). For taxonomic citations reference is made to Williams et al. (1998).

All the slides examined in this study are housed in the palynological slide collection at the Stratigraphic Department of ENI S.p.A., Exploration & Production Division, San Donato Milanese, Italy.

Dinoflagellate cyst stratigraphy

The main aim of this study was to identify reference horizons for the Aptian-Albian dinoflagellate cyst

stratigraphy of the Tethyan Realm by calibrating lowest and highest occurrences of key taxa against the independently established bio-chronostratigraphic framework of the Piobbico core (Erba 1986, 1988; Tornaghi et al. 1989). Accordingly, the distribution chart of dinoflagellate cysts (Fig. 2) has been compared to published sources concerning the stratigraphic distributions of each taxon in order to reduce the risk of local biases in the Piobbico records and highlight actual first and last appearance datums. Thereafter, since fossil dinoflagellate cysts show highest species diversity in the Albian (Stover et al. 1996), and this was apparently confirmed by the richness of the assemblages investigated, attention was preferentially focused on the most distinctive taxa whose diagnostic morphological characters can be unequivocally identified even by fragments or badly preserved material. On this basis, the events selected and discussed in the following paragraphs are hereby proposed as marker horizons for the Albian of the Tethyan Realm (Fig. 3).

The lower part of the Piobbico core, from sample PP-75 to PP-49, yielded few dinoflagellate cysts, hence is unsuitable for the identification of key events in the Aptian. The basal ranges of taxa near the Aptian/Albian boundary may therefore not be accurate because of the adverse conditions for preservation of cysts in the Aptian strata. However, it is worthwhile noting that *Kiokansium unituberculatum* (Pl. 2, fig. 23), also reported in the literature as *K. polypes* (junior synonym of *K. unituberculatum* according to Williams et al. 1998), occurs only in three poor Aptian assemblages and never within the rich Albian ones. This record is in agreement with the absence of *K. unituberculatum* in the Albian section at Monte Petrano (Fiet & Masare 2001), hence suggesting a central Tethyan range-top in the Upper Aptian for this species. This event has a local validity, as *K. unituberculatum* has been extensively reported from the Albian-Cenomanian both in the Boreal Province (Duxbury 1983; Nøhr-Hansen 1993; Prössl 1990) and in the Southern Hemisphere (Cookson & Eisenack 1962).

The consistent and often common occurrence of *Kleithriasphaeridium atlasiense* (Pl. 1, figs 2-9) from sample PP-47 (43.35 m) upwards, is in close agreement with previous observations from several Albian sections in Italy (Fiet & Masare 2001; Torricelli 2000, 2001). *Kleithriasphaeridium atlasiense*, originally described from the basal Albian *Tardefurcata* ammonite Zone of Morocco (Below 1982), has also been recovered from the uppermost Aptian *Jacobi* ammonite Zone in the Vercorian Basin of southeast France (H. Leereveld, pers. comm.). Its lowest occurrence in sample PP-47, within the basal part of the NC 8 nannofossil Zone, confirms that this species appeared in the fossil record close to the Aptian/Albian boundary and represented one of the

SCISTI A FUCOIDI										LITHOSTRATIGRAPHY			
MADOLICA	APTIAN	LATE APTIAN			EARLY ALBIAN		MIDDLE ALBIAN		LATE ALBIAN			AGE	
67A	67A	67A	67A	67A	67A	67A	67A	67A	67A	67A	67A	CORE	
123	123	123	123	123	123	123	123	123	123	123	123	INTERVAL (cm from the top)	
												DEPTH (m)	
												SAMPLE	
												Pr-1	1 <i>Batiacospaera saidensis</i>
												Pr-2	2 <i>Cassiculosphaeridia reticulata</i>
												Pr-3	3 <i>Oligosphaeridium complex</i>
												Pr-4	4 <i>Hystriochodinium pulchrum</i>
												Pr-5	5 <i>Damassadinium chibane</i>
												Pr-6	6 <i>Eyrea nebulosa</i>
												Pr-7	7 <i>Kiokansium unituberculatum</i>
												Pr-8	8 <i>Valensia tazadensis</i>
												Pr-9	9 <i>Palaeoperidinium cretaceum</i>
												Pr-10	10 <i>Odontochitina operculata</i>
												Pr-11	11 <i>Protoliposodinium seghire</i>
												Pr-12	12 <i>Oligosphaeridium totum</i>
												Pr-13	13 <i>Batiacospaera granulosa</i>
												Pr-14	14 <i>Chytroisphaeridia? scabrata</i>
												Pr-15	15 <i>Codonella psigma</i>
												Pr-16	16 <i>Cometodinium</i> spp.
												Pr-17	17 <i>Dapsilidinium warrenii</i>
												Pr-18	18 <i>Fromea amphora</i>
												Pr-19	19 <i>Leptodinium? hyalodemopse</i>
												Pr-20	20 <i>Odontochitina ancala</i>
												Pr-21	21 <i>Pervosphaeridium brevispinum</i>
												Pr-22	22 <i>Pterodinium? comutum</i>
												Pr-23	23 <i>Pterodinium cingulatum</i>
												Pr-24	24 <i>Spiniferites</i> spp.
												Pr-25	25 <i>Stanfordella? cretacea</i>
												Pr-26	26 <i>Subtilisphaera perlucida</i>
												Pr-27	27 <i>Tehamadinium sousense</i>
												Pr-28	28 <i>Wrevittia helicoidea</i>
												Pr-29	29 <i>Codonella campanulata</i>
												Pr-30	30 <i>Coronifera oceanica</i>
												Pr-31	31 <i>Cribroperidinium tensitense</i>
												Pr-32	32 <i>Cyclonephelium paucimarginatum</i>
												Pr-33	33 <i>Dapsilidinium multispinosum</i>
												Pr-34	34 <i>Exochosphaeridium phragmites</i>
												Pr-35	35 <i>Hapsocysta peridictya</i>
												Pr-36	36 <i>Kleithrisphaeridium atlasiense</i>
												Pr-37	37 <i>Membranilamacia polycladata</i>
												Pr-38	38 <i>Pervosphaeridium pseodhystriochodinium</i>
												Pr-39	39 <i>Rotnestia wetzeli</i>
												Pr-40	40 <i>Systematophora? sp. MAZ sensu Below, 1984</i>
												Pr-41	41 <i>Tehamadinium coummia</i>
												Pr-42	42 <i>Carpodinium granulatum</i>
												Pr-43	43 <i>Leptodinium milloudi</i>
												Pr-44	44 <i>Nematosphaeropsis singularis</i>
												Pr-45	45 <i>Oligosphaeridium djenn</i>
												Pr-46	46 <i>Prolixosphaeridium conulum</i>
												Pr-47	47 <i>Pseudoceratium almohadense</i>
												Pr-48	48 <i>Florentinia mantelli</i>
												Pr-49	49 <i>Cyclonephelium brevispinatum</i>
												Pr-50	50 <i>Leberidocysta defloccata</i>
												Pr-51	51 <i>Prolixosphaeridium parvispinum</i>
												Pr-52	52 <i>Adnatosphaeridium tutulosum</i>
												Pr-53	53 <i>Cyclonephelium compactum</i>
												Pr-54	54 <i>Wallodinium inflatum</i>
												Pr-55	55 <i>Ovoidinium diversum</i>
												Pr-56	56 <i>Chlamydothorea nyei</i>
												Pr-57	57 <i>Ascodinium ovatum</i>
												Pr-58	58 <i>Coronifera sp.</i>
												Pr-59	59 <i>Ovoidinium sp. A sensu Davey, 1979</i>
												Pr-60	60 <i>Hapsocysta? cf. bentae</i>
												Pr-61	61 <i>Litosphaeridium arundum</i>
												Pr-62	62 <i>?Microdinium crinitum sensu Davey, 1969</i>
												Pr-63	63 <i>Ovoidinium incomptum</i>
												Pr-64	64 <i>Ovoidinium implanum</i>
												Pr-65	65 <i>Oligosphaeridium albertense</i>
												Pr-66	66 <i>Tehamadinium mazaganense</i>
												Pr-67	67 <i>Florentinia cooksoniae</i>
												Pr-68	68 <i>Litosphaeridium cf. arundum sensu Below, 1984</i>
												Pr-69	69 <i>Ovoidinium scarbrosium</i>
												Pr-70	70 <i>Dapsilidinium? pumilum</i>
												Pr-71	71 <i>Dapsilidinium duma</i>
												Pr-72	72 <i>Cribroperidinium exilicristatum</i>
												Pr-73	73 <i>Dapsilidinium laminispinosum</i>
												Pr-74	74 <i>Florentinia stellata</i>
												Pr-75	75 <i>Forma A</i>
												Pr-76	76 <i>Pervosphaeridium truncatum</i>
												Pr-77	77 <i>Litosphaeridium conspurium</i>
												Pr-78	78 <i>Hapsocysta dictyota</i>
												Pr-79	79 <i>Apteodinium sp.</i>
												Pr-80	80 <i>Aptea aff. polymorpha</i>
												Pr-81	81 <i>Pseudoceratium eisenackii</i>
												Pr-82	82 <i>Florentinia radiculata</i>
												Pr-83	83 <i>Ellipsoidinium rugulosum</i>
													TOTAL COUNTS DINOFLAGELLATE CYSTS

Fig. 2 - Distribution chart of dinoflagellate cysts identified in the Piobbico core, ordered according to first occurrences. Numbers refer to counted specimens in a single slide. Taxa discussed in the text for their biostratigraphic importance are shaded. Vertical scale is not proportional to stratigraphic thicknesses. The litho-chronostratigraphic framework is derived from published studies (Erba 1988; Tornaghi et al. 1989) and therefore is independent from the interpretation of the dinoflagellate cyst distribution.

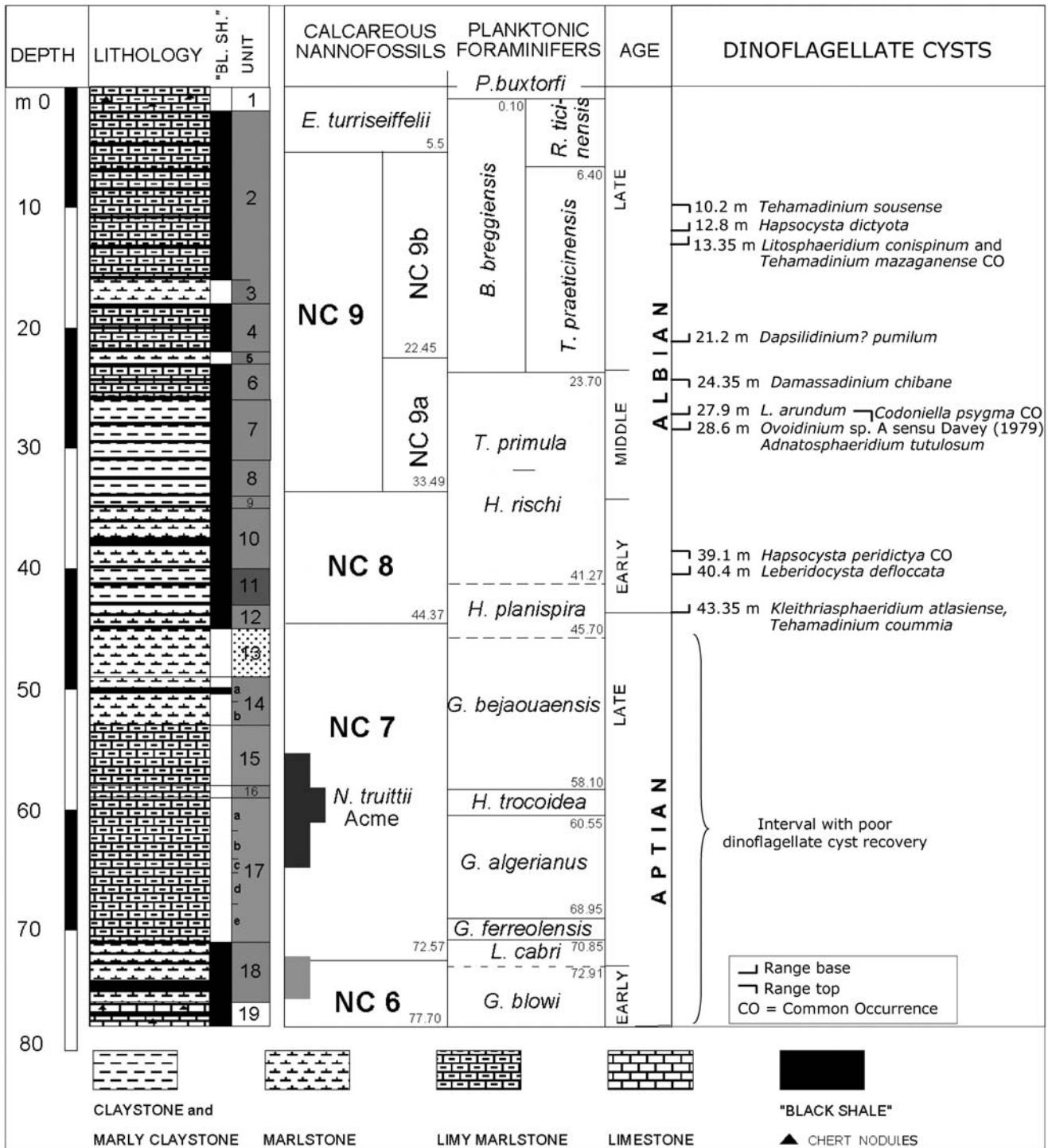


Fig. 3 - Integrated stratigraphic log of the Piobbico core. Lithostratigraphy is after Erba (1988). Key dinoflagellate cyst events identified in the present study are plotted against calcareous nannofossil and planktonic foraminiferal biostratigraphies (Erba 1988; Tornaghi et al. 1989). Numbers reported on the zonal boundaries refer to depth (m from the top).

most distinctive elements of the central Tethyan dinoflagellate cyst assemblages throughout the Albian.

Although discontinuous, *Tehamadinium coummia* (Pl. 3, figs 6-8) exhibits the same stratigraphic distribution of *K. atlasienne* throughout the Albian of the Piobbico core. Its common occurrence in the basal Albian (sample PP-47, 43.35 m) is deemed to approximate

to the first appearance datum of this taxon, whose oldest record is documented at the Aptian/Albian transition (Prössl 1990). *Tehamadinium coummia* was described from the Albian of Morocco (Below 1981) and thereafter reported from the Lower Albian of offshore Portugal (Masure 1984), from the Upper Albian and basal Cenomanian of offshore Morocco (Below 1984)

and from the Lower-Middle Albian of northwest Germany (Prössl 1990). In the Monte Petrano section of central Italy, the lowest occurrence of *T. coummia* was reported from the lower Middle Albian (Fiet & Masure 2001), hence higher than in the Piobbico core, but this is probably due to the scarcity of this species in the Lower Albian.

Leberidocysta defloccata (Pl. 4, figs 18-19) has a lowest occurrence in sample PP-43 (40.4 m), within the NC 8 nannofossil Zone and within the basal part of the *T. primula* foraminifer Zone (Lower Albian). The range base of *T. primula*, which is dated at 109.5 Ma (Shipboard Scientific Party 2002), was recorded at 41.27 m (Tornaghi et al. 1989). The lowest occurrence of *L. defloccata* in the Piobbico core approximates its first appearance datum, since it has never been reported from strata older than early Albian, similarly to the congeneric species *Leberidocysta chlamydata* (Prössl 1990; Stover et al. 1996; Fiet & Masure 2001). However, it should be noted that close resemblances existing amongst *L. defloccata*, *L. chlamydata* and *Ovoidinium* sp. A sensu Davey, 1979 (see discussion in the annotated species list) could have originated in the literature misleading records of these taxa.

Hapsocysta peridictya (Pl. 6, figs 4-5) is common from sample PP-47 (43.35 m) to sample PP-41 (39.1 m), within the lower part of the NC 8 nannofossil Zone. The regular presence of this species in the lower part of the Monte Petrano section led Fiet & Masure (2001) to establish a *H. peridictya* Zone in the Lower Albian. The appearance of *H. peridictya* in the Tethyan Realm, however, is much older, since it was consistently reported from the Upper Hauterivian of the Cismon core section in northern Italy (Torricelli 2000). Instead, the highest common and continuous occurrence of *H. peridictya* in sample PP-41 (39.1 m) is proposed hereby as a reliable marker horizon within the Lower Albian of the Tethyan Realm, consistently with evidence from southeast France (Kennedy et al. 2000). Its position in the Piobbico core is 2.17 m above the base of the foraminifer *T. primula* (at 41.27 m in Tornaghi et al. 1989) whose first appearance is dated at 109.5 Ma (Premoli Silva & Sliter 1999; Shipboard Scientific Party 2002). Nevertheless, published ranges of *H. peridictya* extend into the Upper Albian (Davey 1979; Masure 1988; Prössl 1990; Fiet & Masure 2001), hence the single specimen observed in sample PP-12 (12.8 m) within the *B. breggensis/T. praeticinensis* foraminifer Zone is probably *in-situ* and approximates the last appearance datum of this species.

Damassadinium chibane (Pl. 2, figs 1-4) was described by Below (1981) from the Aptian of Morocco. In the Piobbico core, *D. chibane* has a strikingly continuous distribution in the Lower Albian and a range-top in sample PP-27 (24.35 m) within the Middle Albian NC 9a nannofossil Zone and uppermost *T. primula*

foraminifer Zone. The highest occurrence of *D. chibane* is slightly lower than the inception of the foraminifer species *B. breggensis*, recorded at 23.7 m (Tornaghi et al. 1989) and dated at 105 Ma (Premoli Silva & Sliter 1999; Shipboard Scientific Party 2002). *Damassadinium chibane* was not considered in the zonation established by Fiet & Masure (2001) at Monte Petrano as it was reported to occur indistinctly throughout the section. However, evidence in support of a distribution of *D. chibane* extending consistently into the uppermost Albian is questionable at Monte Petrano, since the authors provided neither quantitative nor qualitative information concerning the content of each sample. In contrast, data from offshore Morocco (Below 1984) confirm the absence of *D. chibane* in the Upper Albian consistently with the Piobbico data.

Codoniella psygma (Pl. 2, figs 17-18) is another remarkable species, characterised by polar funnel-like structures and clearly defined paracingular tabulation which make easy and firm the taxonomic identification even in badly preserved material. Unfortunately its lowest occurrence in the Piobbico core sample PP-48 (45 m, uppermost Aptian) is immediately above the palynologically barren Aptian succession, hence no precise information concerning the first appearance of this species is achievable. However, the highest common/regular occurrence of *C. psygma* in sample PP-32 (27.9 m), within the NC 9a nannofossil Zone and the *T. primula* foraminifer Zone, is a useful horizon for Middle Albian dinoflagellate cyst stratigraphy. *Codoniella psygma* was reported as a common component of the *H. peridictya* Zone established at Monte Petrano in the Lower Albian (Fiet & Masure 2001) and, although a single specimen has been here found in the Upper Albian (sample PP-3 at 3.35 m), the mostly Lower to Middle Albian stratigraphic distribution of *C. psygma* is documented also in the Boreal Realm (Prössl 1990). *Codoniella psygma* apparently became extinct before the end of the Albian (Davey 1979; Below 1984; Masure 1988).

Ovoidinium sp. A sensu Davey (1979) is characterised by a highly variable pericoel and is distinguished by the similar and often co-present species *L. defloccata* by the presence of a strongly indented archeopyle margin (Pl. 4, figs 1-5). In the Piobbico core, *Ovoidinium* sp. A sensu Davey (1979) has a lowest occurrence in sample PP-34 (28.66 m) within the NC 9a nannofossil Zone and exhibits a discontinuous record through the Middle-Upper Albian as well as *Ovoidinium diversum*, *O. implanum*, *O. incomptum* and *O. scabrosum*.

Litosphaeridium arundum (Pl. 1, figs 10-14) has its lowest occurrence in sample PP-32 (27.9 m), still within the NC 9a nannofossil Zone and the *T. primula* foraminifer Zone. This datum is perfectly consistent with observations from southern France (Masure, in Machour 1988; Kennedy et al. 2000) and from Monte

Petrano (Fiet & Masure 2001) where a *L. arundum* Zone was established in the upper Middle Albian. It is therefore confirmed that this species appeared in the Tethyan fossil record in the Middle Albian. Conversely, the range base of *L. arundum* in the Boreal Realm is in the Lower Albian (Costa & Davey 1992; Davey & Verdier 1971; Hardenbol et al. 1998; Prössl 1990).

The lowest occurrence of *Adnatosphaeridium tutulosom* (Pl. 6, fig. 6) was found in sample PP-34 (28.66 m). Since the appearance of this species is immediately beneath the inception of *L. arundum* in the Middle Albian of the Monte Petrano section (Fiet and Masure 2001), and above the inception of the foraminifer *T. primula* in the Bay of Biscay (Davey 1979; Dupeuple 1979) and Bahamas (Masure 1988), it is hereby confirmed as a consistent datum for the Middle Albian.

The lowest occurrences of *A. tutulosom*, *L. arundum*, *Ovoidinium* sp. A sensu Davey (1979) and the highest common/regular occurrence of *C. psygma* are recorded about midway between the inception of the nannofossil *A. albianus* (at 33.49 m, in Erba 1988) and the inception of the foraminifer *B. breggiensis* (at 23.7 m, in Tornaghi et al. 1989). According to recent calibrations (Premoli Silva & Sliter 1999; Shipboard Scientific Party 2002), the first appearance datums of *A. albianus* and *B. breggiensis* are respectively at 106.1 Ma and 105 Ma. Hence these four dinoflagellate cyst horizons can be dated approximately at 105.5 Ma.

Dapsilidinium? pumilum (Pl. 1, figs 21-26) has rarely been reported in the literature. It has a lowest occurrence in sample PP-23 (21.2 m) and a highest occurrence in sample PP-12 (12.6 m). Its distribution in the Piobbico core is therefore confined within the NC 9b nannofossil Zone and the *T. praeticinensis* foraminifer Zone, corresponding to the lower part of the Upper Albian. The range base of *Dapsilidinium? pumilum* was found in proximity of the range bases of the foraminifer species *T. praeticinensis* and *B. breggiensis* also in the Monte Petrano section (Fiet & Masure 2001), hence this event might represent a reliable biohorizon for the characterisation of the Middle/Upper Albian boundary in the central Tethyan Province.

Tehamadinium mazaganense (Pl. 3, figs 1-5) is a species described from the Upper Albian of Morocco (Below 1984). The rows of interconnected parasutural spines allow its identification even when the 2P archeopyle is hidden, or the material is badly preserved. In the Piobbico section, it has a single occurrence in sample PP-28 (24.8 m) within the Middle Albian, and then regularly occurs from sample PP-14 (13.35 m) upwards within the *T. praeticinensis* and *R. ticinensis* foraminifer Zones. Accordingly, its consistent and common occurrence is a distinctive feature of the latest Albian assemblages. This is in agreement with data published from offshore Morocco (Below 1984; Leckie 1984), from the

Bahamas (Masure 1988) and from central Italy (Fiet & Masure 2001) where the *T. mazaganense* Zone was established in the Upper Albian of the Monte Petrano section.

Litosphaeridium conispinum (Pl. 1, figs 15-18) was described from the Upper Albian *Inflatum* ammonite Zone of southeast France (Davey & Verdier 1973) and has the lowest occurrence in sample PP-14 (13.35 m) within the *T. praeticinensis*/*B. breggiensis* foraminifer Zone and the *P. achlyostaurion* nannofossil Zone of Erba (1988). *Litosphaeridium conispinum* exhibits a continuous/common record throughout the upper part of the Piobbico core section similarly to *T. mazaganense*. Its inception is therefore lower and older than that of the nannofossil *E. turriseiffelii*, recorded in the Piobbico core at 5.5 m (Erba 1988) and calibrated at 101.7 Ma (Hardenbol et al. 1998; Shipboard Scientific Party 2002) and is apparently higher than the range base of the foraminifer species *T. praeticinensis* and *B. breggiensis*, recorded in the Piobbico core at 23.7 m (Tornaghi et al. 1989) and calibrated at 105 Ma (Premoli Silva & Sliter 1999; Shipboard Scientific Party 2002). Relying on these calibrations and assuming a constant and continuous sedimentation rate through this part of the succession, the range base of *L. conispinum* and the lowest common occurrence of *T. mazaganense* can be dated in the Piobbico core approximately at 103 Ma. It must be mentioned that the range base of *L. conispinum* had been reported from Monte Petrano four meters beneath the base of the *T. praeticinensis*/*B. breggiensis* Zone (Fiet & Masure 2001) hence it is possible that the lowest occurrence in the Piobbico core does not record the true first appearance of this taxon in the central Tethys. Conversely, and more likely, the actual first appearances of *T. praeticinensis* and *B. breggiensis* could have been missed at Monte Petrano due to a sampling gap, as the foraminiferal control was carried out on spot samples only (Fiet & Masure 2001).

Hapsocysta dictyota (Pl. 6, figs 1-3) has a lowest occurrence in sample PP-12 (12.8 m), slightly higher than that of *L. conispinum*, still within the *T. praeticinensis*/*B. breggiensis* foraminifer Zone. This is in close agreement with data reported by Prössl (1990) from northwest Germany, by Below (1984) and Leckie (1984) from Morocco and by Davey (1979) and Dupeuple (1979) from the Bay of Biscay, where the lowest occurrence of *H. dictyota* was actually found in association with *B. breggiensis* and *R. subticinensis*. In the Monte Petrano section the lowest occurrence of *H. dictyota* is reported as coincident with that of *Litosphaeridium siphoniphorum* (Fiet & Masure 2001) and these two species are proposed as zonal co-markers for the uppermost Albian. However, present evidence suggests that the inception of *H. dictyota* is significantly older than that of *L. siphoniphorum* (see the discussion be-

low). In conclusion, owing to the consistent stratigraphic records and the distinctive morphology which enables species identification even by means of periplagmal fragments, the inception of *H. dictyota* is an excellent horizon within the Upper Albian and in the Piobbico core section it is calibrated approximately at 103 Ma.

Tehamadinium sousense (Pl. 3, figs 9-11) has a lowest occurrence in sample PP-48 (45 m, uppermost Aptian), the first fossiliferous sample above the palynologically barren Upper Aptian succession. Therefore no information concerning the first appearance of this species can be derived from the Piobbico core, but its presence throughout the Aptian has already been documented (Below 1981, 1984; Fiet & Masure 2001). In contrast, the highest occurrence of *T. sousense* in sample PP-10 (10.2 m) within the Upper Albian NC 9b nannofossil Zone and the *T. praticinensis* foraminifer Zone, is thought to approximate to the last appearance datum, as this species has never been reported in the literature from strata younger than late Albian (Below 1984; Fiet & Masure 2001).

In the Piobbico core, *L. siphoniphorum* has not been recovered, either because the analysed section does not reach high enough into the uppermost Albian to record its first appearance or because no diagnostic samples were analysed from the uppermost part of the section. Sample PP-2 (3 m) is the highest fossiliferous sample of this study and yielded several specimens of *L. conispinum* suggesting that, up to this bed, no ecological exclusion was responsible for the absence of the closely related species *L. siphoniphorum*. Since both the nannofossil *E. turriseiffelii* and the foraminifer *R. ticinensis* already occur at this horizon (Erba 1988; Tornaghi et al. 1989), the lowest occurrence of *L. siphoniphorum* is apparently higher than the inceptions of these species and it is deemed to approximate the *P. buxtorfi* foraminifer Zone, the base of which is recognised in the Piobbico core at 0.1 m (Tornaghi et al. 1989) and calibrated worldwide at 100.2 Ma (Shipboard Scientific Party 2002). Since at Monte Petrano *L. siphoniphorum* was found in association with the foraminifer *R. subticinensis* (Fiet & Masure 2001) whose extinction is calibrated at 100.2 Ma (Hardenbol et al. 1998; Premoli Silva & Sliter 1999), the first appearance datum of *L. siphoniphorum* reported in Chart 5 (Hardenbol et al. 1998) at 100.9 Ma is realistic and indirectly confirmed by the present data.

Summary and conclusions

The organic-walled dinoflagellate cyst content of the Scisti a Fucoidi Formation cored at Piobbico, central Italy is presented here for the first time. The dis-

tribution of selected taxa, plotted against the independent stratigraphic framework established by means of planktonic foraminifers and nannofossils, is compared with the literature in order to identify reliable datums for the Albian dinoflagellate cyst stratigraphy of the Tethyan Realm.

Kleithriasphaeridium atlasiense has a lowest occurrence in proximity of the Aptian/Albian boundary and a common and continuous record up to the top of the Piobbico core: consistently with previous records, it is one of the most typical elements of Tethyan dinoflagellate cyst assemblages throughout the Albian. The following events are furthermore proposed as reliable datums: the lowest occurrences of *Tehamadinium coummia* and *Leberidocysta defloccata* in the Lower Albian, of *Adnatosphaeridium tutulosum*, *Ovoidinium* sp. A sensu Davey (1979), *Litosphaeridium arundum* in the Middle Albian, of *Dapsilidinium? pumilum*, *Litosphaeridium conispinum*, *Tehamadinium mazaganense* and *Hapsocysta dictyota* in the Upper Albian; the highest consistent occurrences of *Hapsocysta peridictya* in the Lower Albian, of *Codoniella psygma* and *Damassadinium chibane* in the Middle Albian, of *Tehamadinium sousense* in the Upper Albian.

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PLATE 1

Dinoflagellate cysts from the Scisti a Fucoidi Formation cored at Piobbico.

(1) *Florentinia mantellii*. (2) Dorso-ventrally oriented specimen of *Kleithriasphaeridium atlasiense*, sample PP-6, slide A29929; arrows indicate the single-plate precingular archeopyle and the short horn in apical position which are distinctive features of this taxon. (3-9) Specimens of *Kleithriasphaeridium atlasiense* showing intraspecific morphological variability in size and processes' striations. (10-14) *Litosphaeridium arundum*. (15-18) *Litosphaeridium conispinum*. (19) *Litosphaeridium* spp. (20) *Litosphaeridium* cf. *arundum* sensu Below (1984), sample PP-19, slide A30100. This is apparently an intermediate form between *L. arundum* and *Dapsilidinium? pumilum*. (21-26) *Dapsilidinium? pumilum*. Specimens in figs. 21-23, from sample PP-12, slide A30089, show the thickish intraperforate wall which was already observed by Davey (1979) to characterise sometimes late Albian forms. (27) *Dapsilidinium duma*. (28) *Dapsilidinium warrenii*. (29) *Chlamydothorella nyei*.

40 μ m

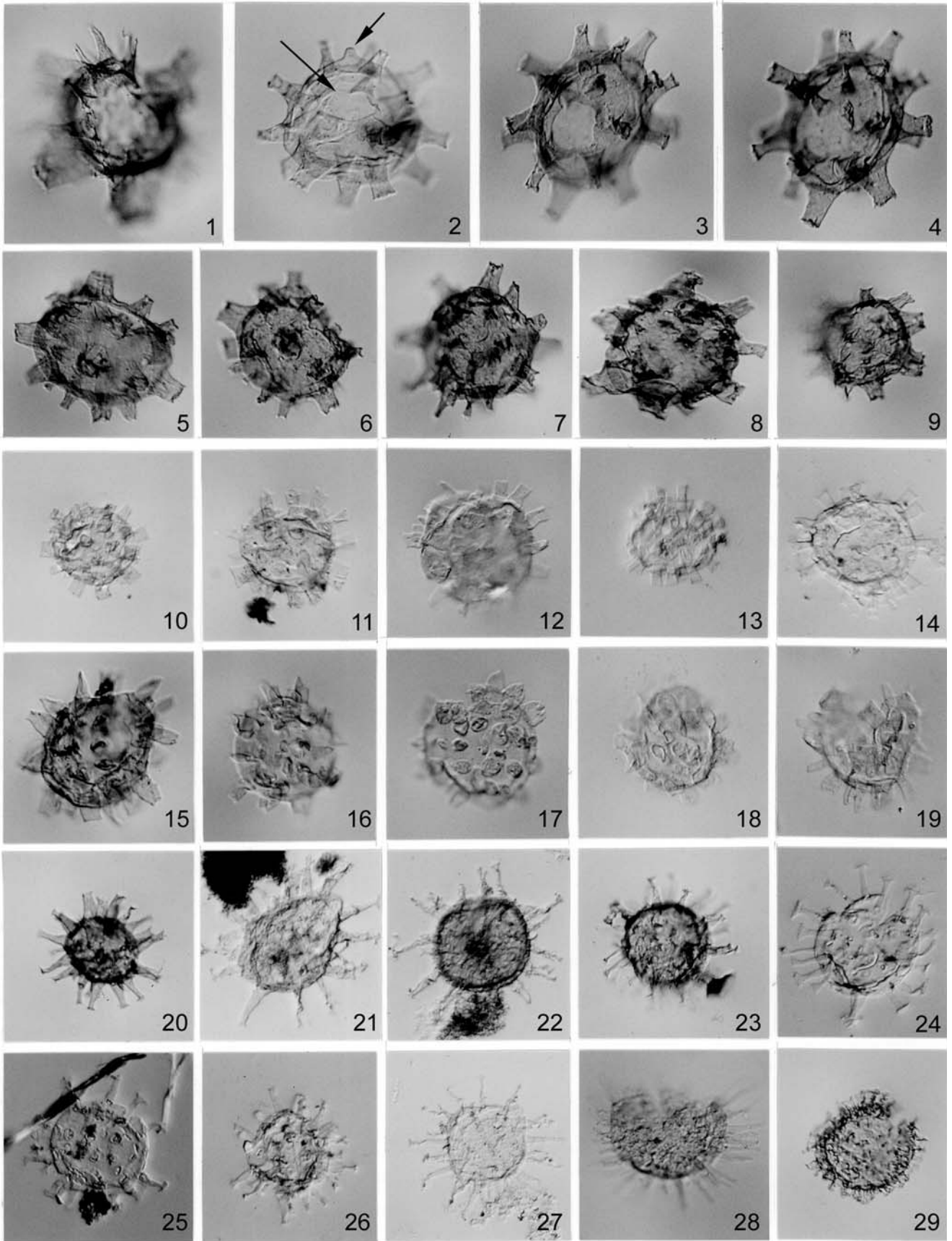


PLATE 1

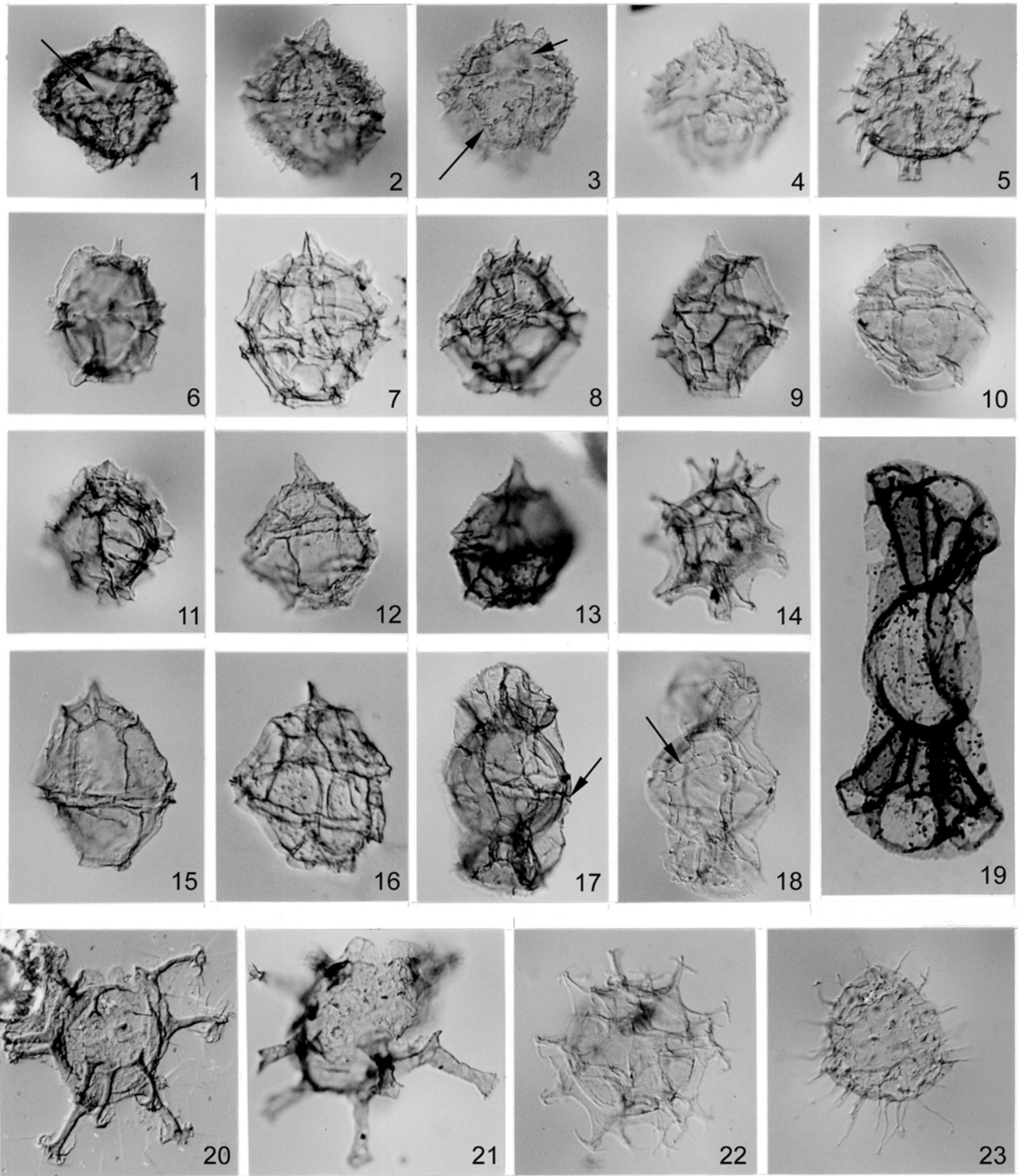
40 μ m

PLATE 2

Dinoflagellate cysts from the Scisti a Fuocidi Formation cored at Piobbico.

(1-4) *Damassadinium chibane*, samples PP-34, PP-44 and PP-45. Arrows indicate the single-plate precingular archeopyle and details of the parasutural arrangement of the ornamentation. (5) *Coronifera* sp. (6) *Carpodinium granulatum*. (7-8) *Pterodinium?* *cornutum*. (9-10) *Stanfordella?* *cretacea*. (11) *Pterodinium cingulatum*. (12-13) *Wrevittia helicoidea*. (14) *Rottnestia wetzelii*. (15-16) *Leptodinium?* *hyalodermopse*. (17-18) *Codoniella psygma*, samples PP-46 and PP-37 respectively. Arrows indicate the well expressed cingular paratabulation which distinguishes this species from *C. campanulata*. (19) *Codoniella campanulata*. (20) *Oligosphaeridium complex*. (21) *Oligosphaeridium totum*. (22) *Spiniferites* spp. (23) *Kiokansium unituberculatum*.

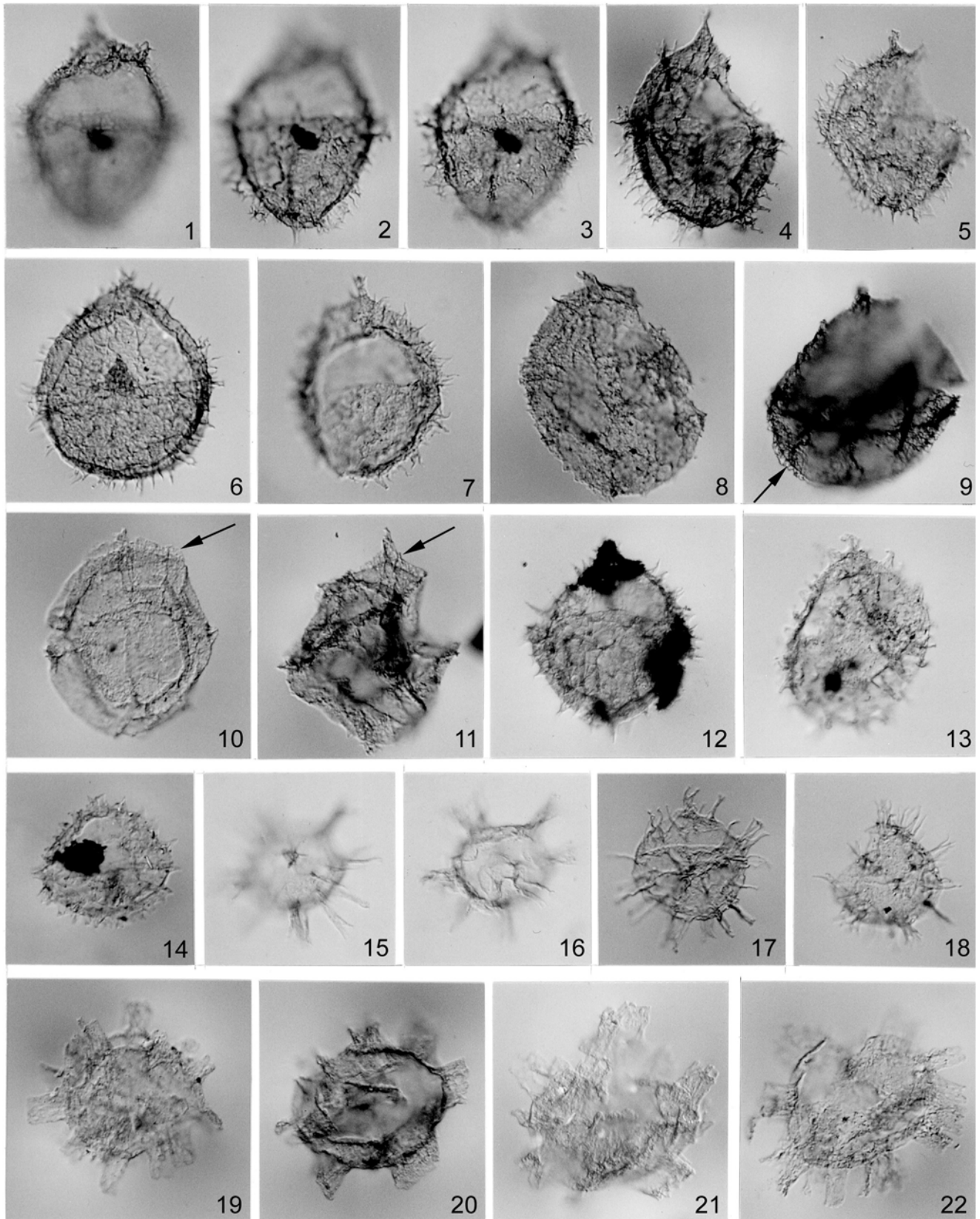
40 μm 

PLATE 3

Dinoflagellate cysts from the Scisti a Fucoidi Formation cored at Piobbico.

(1-3) *Tehamadinium mazaganense*, sample PP-10, slide A29937, same specimen at different focus levels showing the double-plate precingular archeopyle and details of parasutural rows of interconnected spines. (4-5) *Tehamadinium mazaganense*. (6-8) *Tehamadinium coummia*. (9-11) *Tehamadinium sousense*, samples PP-46 and PP-47 respectively. Arrows indicate details of irregularly and finely fenestrate parasutural septa. (12-14) *Pervosphaeridium brevispinum*. (15-16) *Pervosphaeridium truncatum*. (17-18) *Pervosphaeridium pseudhystrichodinium*. (19-22) *Systematophora?* sp. MAZ sensu Below (1984).

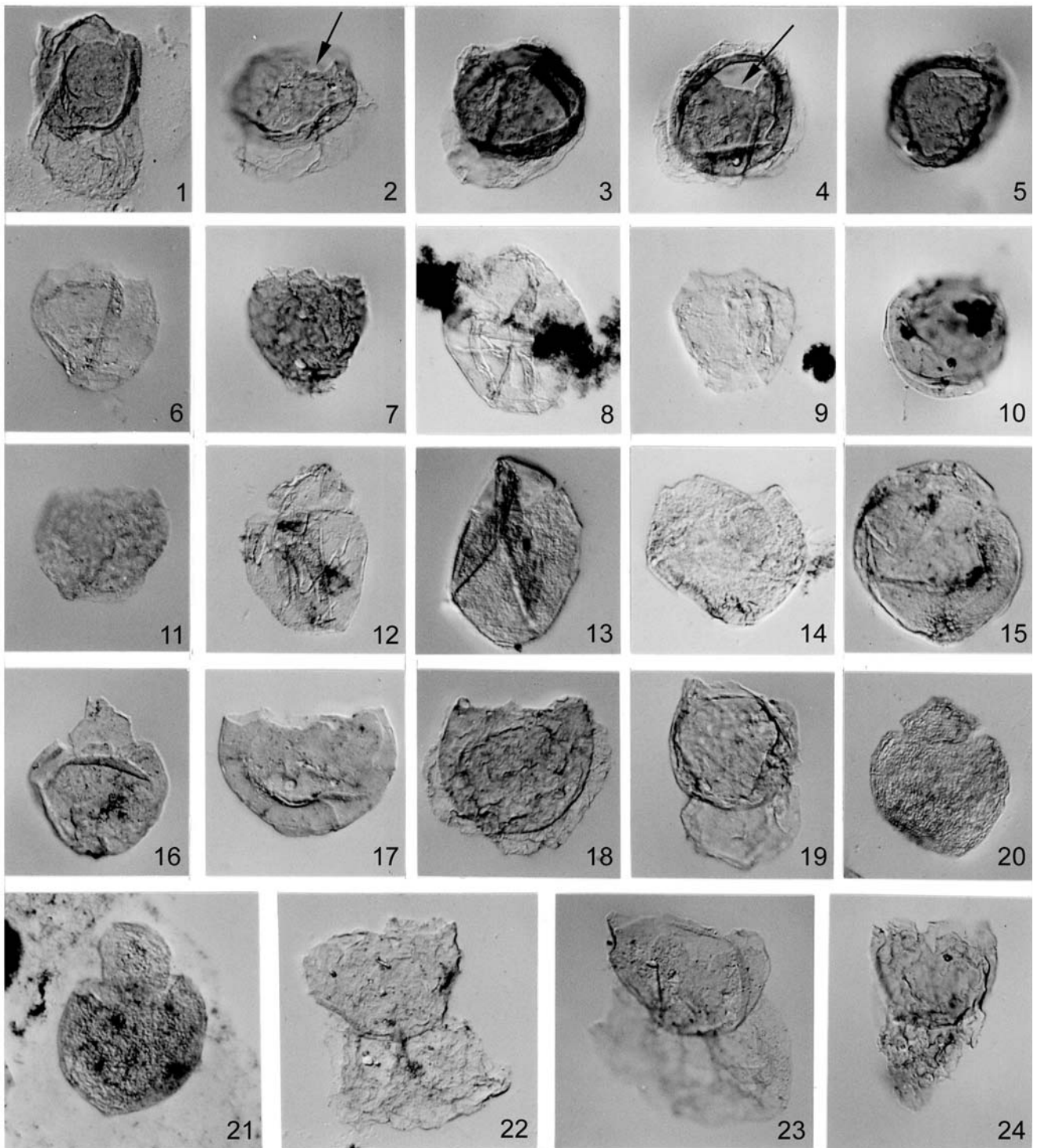
40 μm 

PLATE 4

Dinoflagellate cysts from the Scisti a Fuocidi Formation cored at Piobbico.

(1-5) *Ovoidinium* sp. A sensu Davey (1979); arrows indicate the strongly indented archeopyle margin which distinguishes this taxon from *L. defloccata*. Note the highly variable cyst cavation. (6-9, 11) *Ovoidinium scabrosum*. (10) *Ascodinium ovatum*. (12-15) *Ovoidinium implanum*. (16-17) *Ovoidinium incomptum*. (18-19) *Leberidocysta defloccata*. (20-21) *Ovoidinium diversum*. (22-24) *Forma A*.

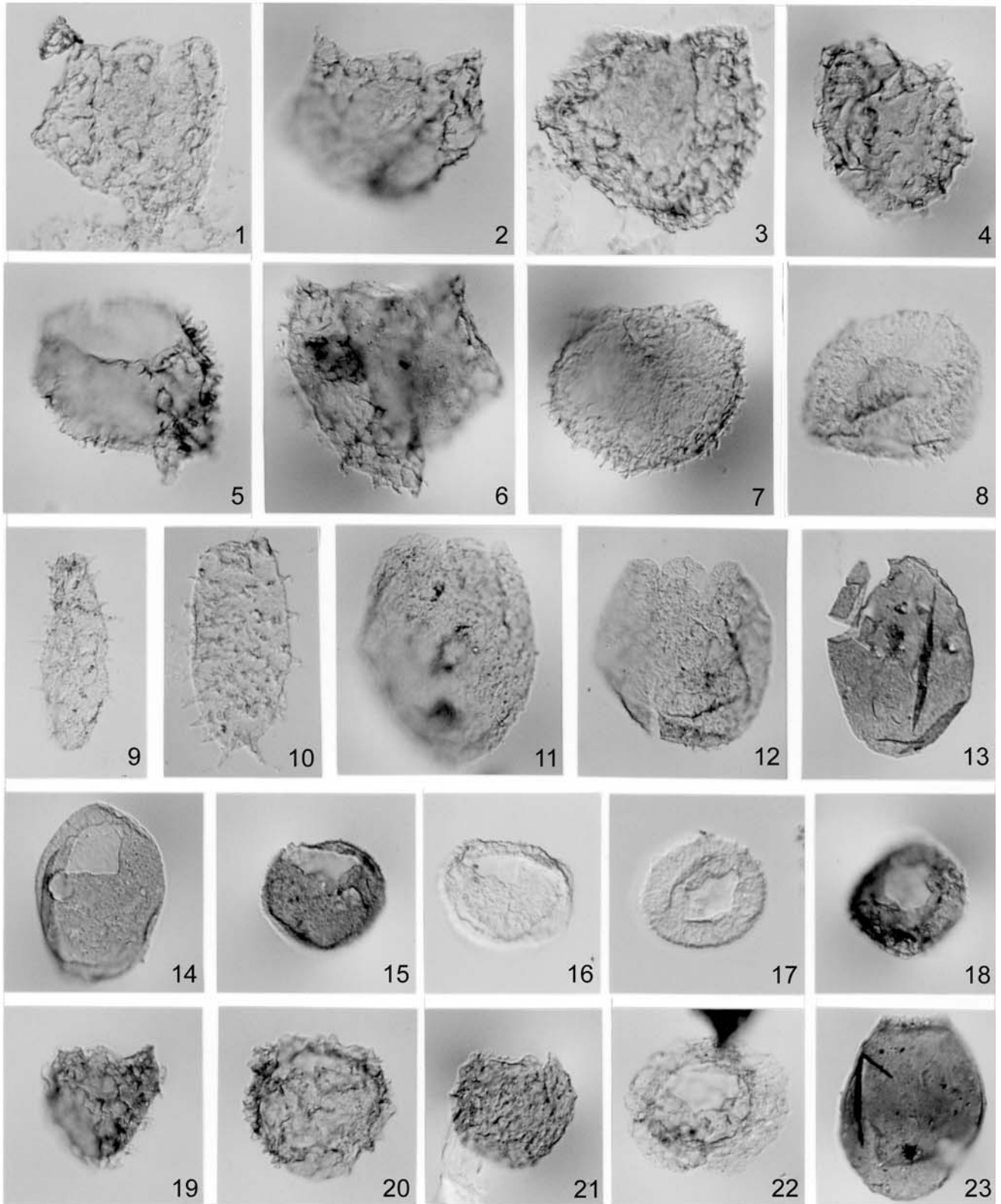
40 μ m

PLATE 5

Dinoflagellate cysts from the Scisti a Fucoidi Formation cored at Piobbico.

(1-2) *Pseudoceratium eisenackii*. (3-4) *Cyclonephelium compactum*. (5-6) *Aptea* aff. *polymorpha*. (7-8) *Cyclonephelium brevispinatum*. (9-10) *Prolixosphaeridium conulum*. (11-12) *Batiacasphaera granulosa*. (13-14) *Chytroeisphaeridia?* *scabrata*. (15-16) *Batiacasphaera saidensis*. (17-18) *Cassiculosphaeridia reticulata*. (19-21) *Valensiella tazadensis*. (22) *Membranilarnacia polycladiata*. (23) *Fromea amphora*.

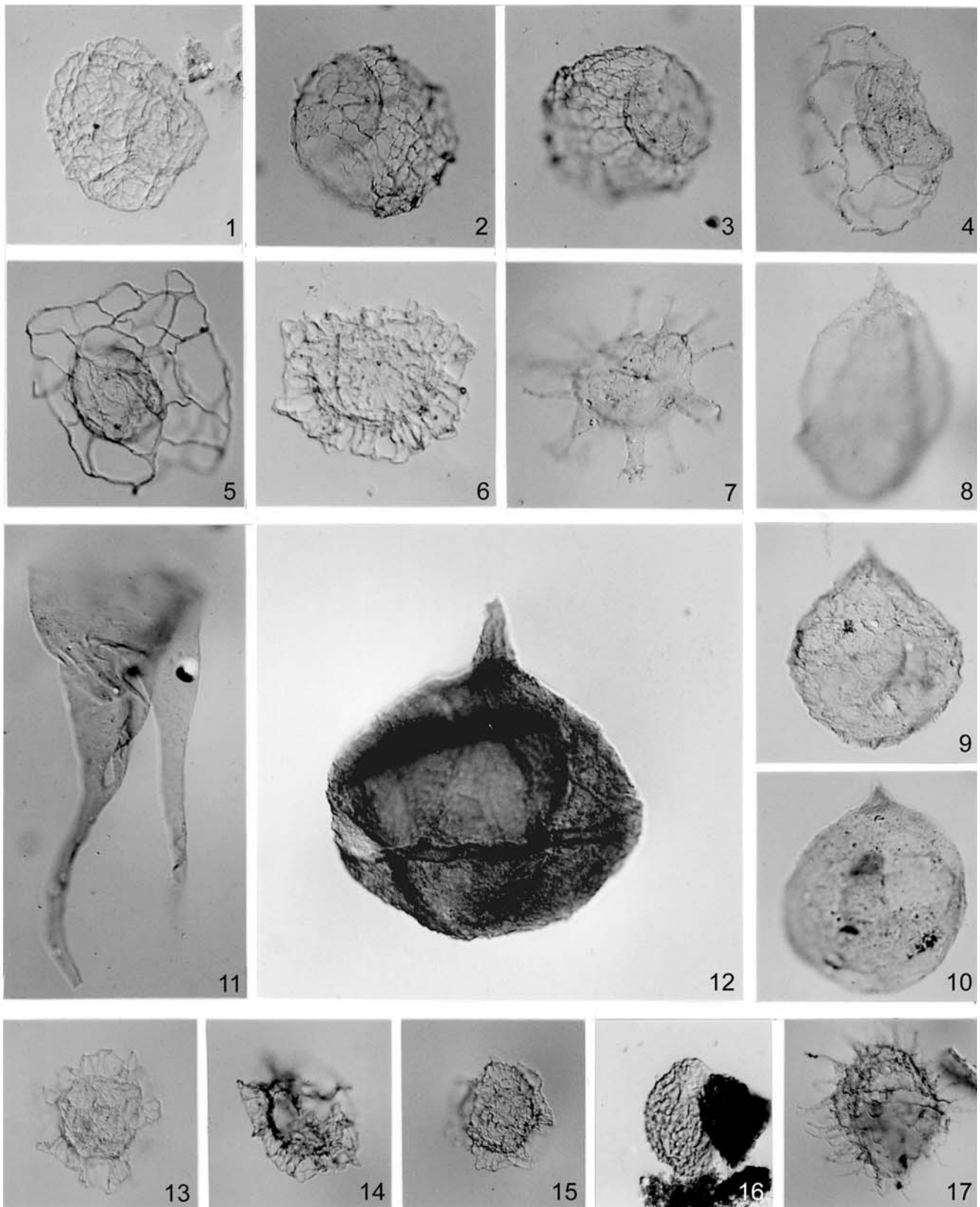
40 μm 

PLATE 6

Dinoflagellate cysts from the Scisti a Fucoidi Formation cored at Piobbico.

(1-3) *Hapsocysta dictyota*, samples PP-10 and PP-2. (4-5) *Hapsocysta peridictya*. (6) *Adnatospaeridium tutulosum*. (7) *Florentinia stellata*. (8-10) *Apteodinium* sp. (11) *Odontochitina operculata*. (12) *Cribroperidinium tensiftense*. (13-15) *Nematospaeropsis singularis*. (16) *Ellipsodinium rugulosum*. (17) *Hystrihodinium pulchrum*.

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Appendix: annotated species list

Alphabetical listing of dinoflagellate cyst and acritarch taxa recovered from the Piobbico core. The number in parentheses refers to the taxon position in the distribution chart (Fig. 2) and taxa illustrated are followed by plate and figure references. The generic allocation and species authorship follow Williams et al. (1998).

- Adnatosphaeridium tutulosum* (Cookson & Eisenack, 1960) Morgan, 1980 (52, Pl. 6, fig. 6)
- Aptea* aff. *polymorpha* Eisenack, 1958 (80, Pl. 5, figs 5-6)
- Aptodinium* sp. (79, Pl. 6, figs 8-10)
- Ascodinium ovatum* Prössl, 1990 (57, Pl. 4, fig. 10)
- Batiacasphaera granulosa* (Cookson & Eisenack, 1974) Jansonius, 1989 (13, Pl. 5, figs 11-12)
- Batiacasphaera saidensis* Below, 1981 (1, Pl. 5, figs 15-16)
- Carpodinium granulatum* Cookson & Eisenack, 1962 (42, Pl. 2, fig. 6)
- Cassiculosphaeridia reticulata* Davey, 1969 (2, Pl. 5, figs 17-18)
- Chlamydroporella nyei* Cookson & Eisenack, 1958 (56, Pl. 1, fig. 29)
- Chytroisphaeridia? scabrata* Pocock, 1972 (14, Pl. 5, figs 13-14)
- Codoniella campanulata* (Cookson & Eisenack, 1960) Downie & Sarjeant, 1965 (29, Pl. 2, fig. 19)
- Codoniella psygma* Davey, 1979 (15, Pl. 2, figs 17-18)
- Cometodinium* spp. (16)
- Coronifera oceanica* Cookson & Eisenack, 1958 (30)
- Coronifera* sp. (58, Pl. 2, fig. 5)
- Cribroperidinium exilicristatum* (Davey, 1969) Stover & Evitt, 1978 (72)
- Cribroperidinium tensiftense* Below, 1981 (31, Pl. 6, fig. 12)
- Cyclonephelium brevispinatum* (Millioud, 1969) Below, 1981 (49, Pl. 5, figs 7-8)
- Cyclonephelium compactum* Deflandre & Cookson, 1955 (53, Pl. 5, figs 3-4)
- Cyclonephelium paucimarginatum* Cookson & Eisenack, 1962 (32)
- Damassadinium chibane* (Below, 1981) Fensome et al., 1993 (5, Pl. 2, figs 1-4)

- Dapsilidinium duma* (Below, 1982) Lentin & Williams, 1985 (71, Pl. 1, fig. 27)
- Dapsilidinium laminaspinosum* (Davey & Williams, 1966) Lentin & Williams, 1981 (73)
- Dapsilidinium multispinosum* (Davey, 1974) Bujak et al., 1980 (33)
- Dapsilidinium? pumilum* (Davey & Williams, 1966) Lentin & Williams, 1981 (70, Pl. 1, figs 21-26)
- Remarks. Some of the specimens observed in this study fit with the annotation made by Davey (1979) that Albian specimens are slightly bigger, with fewer processes and thicker wall than the Cenomanian type-material.
- Dapsilidinium warrenii* (Habib, 1976) Lentin & Williams, 1981 (17, Pl. 1, fig. 28)
- Ellipsodinium rugulosum* Clarke & Verdier, 1967 (83, Pl. 6, fig. 16)
- Exochosphaeridium phragmites* Davey et al., 1966 (34)
- Eyrea nebulosa* Cookson & Eisenack, 1971 (6)
- Florentinia cooksoniae* (Singh, 1971) Duxbury, 1980 (67)
- Florentinia mantellii* (Davey & Williams, 1966) Davey & Verdier, 1973 (48, Pl. 1, fig. 1)
- Florentinia radiculata* (Davey & Williams, 1966) Davey & Verdier, 1973 (82)
- Florentinia stellata* (Maier, 1959) Below, 1982 (74, Pl. 6, fig. 7)
- Forma A* (75, Pl. 4, figs 22-24)

Remarks. This is a spheroidal to ovoidal dinoflagellate cyst species with a single-layered smooth to finely scabrate wall. The archeopyle is apical, type tA. Well-marked accessory sutures along the archeopyle margin are the only evidence of paratabulation on the cyst. Numerous filaments, with a tangled hair appearance, extend from the antapex; they are sometimes longer than the diameter of the main cyst body. Overall width: 43-55 µm; overall length: 62-70 µm. Only four specimens have been found in sample PP-14 (13.35 m), within the *B. breggiensis/T. praeticinensis* foraminifer Zone and the NC 9b nannofossil Zone, Upper Albian. This species has already been reported as *Desmocysta plekta* from the Upper Albian of NE Greenland

- (Nøhr-Hansen 1993, pl. 7, figs. 11, 12) and as cf. *Desmocysta plekta* from the Upper Albian of the Southern Alps (Torriceili 2000, pl. 3, fig. 5).
- Fromea amphora* Cookson & Eisenack, 1958 (18, Pl. 5, fig. 23)
- Hapsocysta*? cf. *bentae* Nøhr-Hansen, 1993 (60)
- Hapsocysta dictyota* Davey, 1979 (78, Pl. 6, figs 1-3)
- Hapsocysta peridictya* (Eisenack & Cookson, 1960) Davey, 1979 (35, Pl. 6, figs 4-5)
- Hystriochodinium pulchrum* Deflandre, 1935 (4, Pl. 6, fig. 17)
- Kiokansium unituberculatum* (Tasch, 1964) Stover & Evitt, 1978 (7, Pl. 2, fig. 23)
- Kleithrisphaeridium atlatense* (Below, 1982) Torricelli, 2001 (36, Pl. 1, figs. 2-9)
- Remarks.** The single-plate precingular nature of the archeopyle which led to transfer this species to the genus *Kleithrisphaeridium* is strikingly evident in the well preserved material from Piobbico. The considerable morphological variability in size, width of processes and striations are also well documented in the material investigated.
- Leberidocysta defloccata* (Davey & Verdier, 1973) Stover & Evitt, 1978 (50, Pl. 4, figs 18-19)
- Remarks.** This species resembles *Leberidocysta chlamydata* except for the lack of ornamentation on the inner body wall which is instead present in *L. chlamydata*.
- L. defloccata* also resembles *Ovoidinium* sp. A sensu Davey (1979) except for the shape of the apical archeopyle margin that is irregular in the former and strongly indented in the latter. These close resemblances could have originated in the literature as misleading records.
- Leptodinium?* *hyalodermopse* (Cookson & Eisenack, 1958) Stover & Evitt, 1978 (19, Pl. 2, figs 15-16)
- Leptodinium millioudii* (Sarjeant, 1963) Sarjeant, 1969 (43)
- Litosphaeridium arundum* (Eisenack & Cookson, 1960) Davey, 1979 (61, Pl. 1, figs 10-14)
- Litosphaeridium* cf. *arundum* sensu Below 1984 (68, Pl. 1, fig. 20)
- Litosphaeridium conispinum* Davey & Verdier, 1973 (77, Pl. 1, figs 15-18)
- Membranilarnacia polycladiata* Cookson & Eisenack in Eisenack, 1963 (37, Pl. 5, fig. 22)
- ?*Microdinium crinitum* Davey, 1969 (62)
- Nematosphaeropsis singularis* Davey, 1979 (44, Pl. 6, figs 13-15)
- Odontochitina ancala* Bint, 1986 (20)
- Odontochitina operculata* (Wetzel, 1933) Deflandre & Cookson, 1955 (10, Pl. 6, fig. 11)
- Oligosphaeridium albertense* (Pocock, 1962) Davey & Williams, 1969 (65)
- Oligosphaeridium complex* (White, 1842) Davey & Williams, 1966 (3, Pl. 2, fig. 20)
- Oligosphaeridium djenn* Below, 1982 (45)
- Oligosphaeridium totum* Brideaux, 1971 (12, Pl. 2, fig. 21)
- Ovoidinium diversum* Davey, 1979 (55, Pl. 4, figs 20-21)
- Ovoidinium implanum* Davey, 1979 (64, Pl. 4, figs 12-15)
- Ovoidinium incomptum* Duxbury, 1983 (63, Pl. 4, figs 16-17)
- Ovoidinium scabrosum* (Cookson & Huges, 1964) Davey, 1970 (69, Pl. 4, figs 6-9, 11)
- Ovoidinium* sp. A sensu Davey, 1979 (59, Pl. 4, figs 1-5)
- Remarks.** Following Davey (1979), the presence of a strongly indented margin, reflecting an apical-intercalary combination archeopyle, allows to distinguish this taxon from *L. defloccata* which is otherwise similar in pericoel development.
- Palaeoperidinium cretaceum* Pocock, 1962 (9)
- Pervosphaeridium brevispinum* (Norvick & Burger, 1975) Below, 1982 (21, Pl. 3, figs 12-14)
- Pervosphaeridium pseudhystriochodinium* (Deflandre, 1937) Yun, 1981 (38, Pl. 3, figs 17-18)
- Pervosphaeridium truncatum* (Davey, 1969) Below, 1982 (76, Pl. 3, figs 15-16)
- Prolixosphaeridium conulum* Davey, 1969 (46, Pl. 5, figs 9-10)
- Prolixosphaeridium parvispinum* (Deflandre, 1937) Davey et al., 1966 (51)
- Protoellipsodinium seghire* Below, 1981 (11)
- Pseudoceratium almohadense* (Below, 1984) Lentin & Williams, 1989 (47)
- Pseudoceratium eisenackii* (Davey, 1969) Bint, 1986 (81, Pl. 5, figs 1-2)
- Pterodinium cingulatum* (Wetzel, 1933) Below, 1981 (23, Pl. 2, figs 10-11)
- Pterodinium?* *cornutum* Cookson & Eisenack, 1962 (22, Pl. 2, figs 7-8)
- Rottnestia wetzelii* (Deflandre, 1937) Slimani, 1994 (39, Pl. 2, fig. 14)
- Spiniferites* spp. (24, Pl. 2, fig. 22)
- Stanfordella?* *cretacea* (Neale & Sarjeant, 1962) Helenes & Lucas-Clark, 1997 (25, Pl. 2, figs 9-10)
- Subtilisphaera perlucida* (Alberti, 1961) Jain & Millepieid, 1973 (26)
- Systematophora?* sp. MAZ sensu Below, 1984 (40, Pl. 3, figs 19-22)
- Remarks.** This striking taxon, characterised by fibrous tubiform processes, was left by Below (1984) in open nomenclature because of the unknown arrangement of processes and type of archeopyle. Neither of these features is identifiable in the Piobbico core material, hence this form is reported following the original denomination proposed by Below (1984). Although in the present study it has a narrow stratigraphic occurrence in the basal Albian, this taxon was previously reported also from the Aptian, the uppermost Albian and the Cenomanian (Below 1984, Masure 1988).
- Tehamadinium coummia* (Below, 1981) Jan du Chene et al., 1986 (41, Pl. 3, figs. 6-8)
- Tehamadinium mazaganense* (Below, 1984) Jan du Chêne et al., 1986 (66, Pl. 3, figs. 1-5)
- Tehamadinium sousense* (Below, 1981) Jan du Chene et al., 1986 (27, Pl. 3, figs. 9-11)
- Valensiella tazadensis* (Below, 1981) Lentin & Williams, 1993 (8, Pl. 5, figs. 19-21)
- Walloodinium inflatum* (Habib, 1969) Habib, 1970 (54)
- Wrevittia helicoidea* (Eisenack & Cookson, 1960) Helenes & Lucas-Clark, 1997 (28, Pl. 2, figs 12-13).

