



Calcareous nannofossils from the Santa Marta Formation (Upper Cretaceous), northern James Ross Island, Antarctic Peninsula



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ABSTRACT

This study reports on the most stratigraphically extensive nannofloras yet recovered from the Lachman Crag Member of the Santa Marta Formation, James Ross Island, Antarctic Peninsula. The productive samples are dated as early Campanian. These ages are in accord with those provided by ammonites, foraminifera, ostracods and radiolarians from the same locality. The consistent and relatively abundant presence of *Gephyrobiscutum diabolium* throughout the productive part of the section, a species that has previously only been documented from the Falkland Plateau, extends its geographic distribution to higher latitudes, at least to the Antarctic Peninsula area.

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1. Introduction

The James Ross Basin constitutes one of the most significant Mesozoic to Cenozoic sedimentary basins of the southern high-latitude region, since it is located in the northern sector of the Antarctic Peninsula and, unlike other south-polar basins, has extensive, ice-free outcrops representing more than 6000 m of Cretaceous marine deposits.

These sedimentary rocks have been interpreted as having been deposited in different marine environments, from proximal to outer shelf and prodelta lobe. In general, the sections are extensive and sediments are poorly consolidated. They contain rich faunas of ammonites, bivalves, gastropods, vertebrate remains, and also

plants that exhibit exceptional preservation at certain levels. The Cretaceous deposits are overlain unconformably either by the James Ross Island Volcanic Group (JRIVG) of Neogene to Pleistocene age, or by Neogene diamictites, generally intercalated between hyaloclastites of the JRIVG and Cretaceous sandstones or claystones.

Since the early 20th century, international polar expeditions have made significant progress in understanding the stratigraphy and palaeontology of the region. On James Ross Island, two thick sedimentary successions are recognised: the Gustav Group (Aptian-Coniacian) and the Marambio Group (Santonian-Danian) (Ineson et al., 1986; Olivero, 2012).

The biostratigraphy of the Marambio Group has been studied in fairly good detail using ammonites, which have good records in several sections on Vega, James Ross, Snow Hill and Seymour islands (Riccardi, 1980; Olivero, 1984, 1992, 2012; Macellari, 1986, 1988; Pirrie et al., 1991, 1997; Scasso et al., 1991; Olivero and Medina, 2000).

To improve the stratigraphy, palynomorphs, calcareous nannofossils and other microfossils have also been studied, providing

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different levels of resolution. They include studies on palynology by Dettman and Thomson (1987), Askin (1988), Harwood (1988), Pirrie and Reading (1988), Pirrie et al. (1991), Keating (1992), Barreda and Olivero (1993) and Carvalho et al. (2013), among others. However, micropalaeontological studies in the James Ross Basin are still scarce and are generally restricted to Mesozoic and Cenozoic foraminifera, ostracods, diatoms and radiolarians (MacFayden, 1966; Huber, 1988; Gázdicki and Webb, 1996; Concheyro et al., 1997, 2007, 2010, 2014; Bertels-Psotka et al., 2001; Fauth et al., 2003; Caramés and Concheyro, 2013; Florisbal et al., 2013).

Records of calcareous nannofossils from the James Ross Basin are concentrated in the southeast, and include late Campanian and early Maastrichtian assemblages (Concheyro et al., 1991, 1995, 2004, 2010; Robles Hurtado and Concheyro, 1995), which are impoverished, compared to coeval nannofloras from Deep Sea Drilling Project (DSDP)/Ocean Drilling Program (ODP) Legs 36, 113 and 114 (respectively, Wise and Wind, 1977; Pospichal and Wise, 1990a, b; Crux, 1991), and one core drilled in the surrounding area of the northern James Ross Island (Kulhanek, 2007).

In the northern sector of James Ross Island, Brazilian and Czech scientific expeditions have recently reported Campanian calcareous nannofossils from the Lachman Crags Member of the Santa Marta Formation (Guerra et al., 2012; Švábenická et al., 2012). The latter authors have also published a pioneering study on calcareous nannofossils from the northern sector of the James Ross Basin that include specimens recovered from five different formations from the middle Coniacian to lower Campanian, and three productive samples that belong to the Santa Marta Formation.

The study presented herein covers the upper part of the Alpha Member of the Santa Marta Formation in the Lachman Crags section, where 99 micropalaeontological samples were collected for the study of foraminifera, ostracods and radiolarians (Florisbal et al., 2013). In 17 of those samples, calcareous nannofossils have been recorded. The objectives of this study are: i) to provide a more detailed record of nannofossils from the Lachman Crags section; ii) to illustrate the moderately-preserved nannofloras recovered, highlighting their significant features; and iii) to provide independent ages to compare to those established by the other fossil groups.

2. Geological setting

The James Ross Basin, a component of the larger Larsen Basin, contains a significant upper Mesozoic to lower Cenozoic sedimentary succession related to the Gondwana break-up and subsequent development in a back-arc setting (Hathway, 2000) (Fig. 1).

The James Ross Basin hosts an extensive Cretaceous sequence unique in that the outcrops are located above 65°S latitude. On James Ross Island, the Cretaceous succession can be assigned to two major stratigraphic units: the Aptian-Coniacian Gustav Group and the Santonian-Danian Marambio Group (Olivero, 2012). The former comprises the coarse-grained, submarine fan and slope deposits of the Kotick Point and Whisky Bay formations, superposed by fan-delta deposits represented by the Hidden Lake Formation (Ineson, 1989; Buatois and López-Angriman, 1992; Medina et al., 1992; Whitham et al., 2006). Outcrops of these deposits are scattered around the northern and western sectors of James Ross Island (Ineson et al., 1986; Medina et al., 1992). These grade upwards into the finer-grained sandstones, mudstones, scarce conglomerates and bioclastic mudstones indicative of the shallow-marine deposits of the Marambio Group (Rinaldi et al., 1978; Pirrie, 1989; Crame et al., 1991; Pirrie et al., 1997; Olivero and Medina, 2000; Francis et al., 2006; Olivero, 2012).

The studied samples from Lachman Crags belong to the Santa Marta Formation, the basal unit of the Marambio Group (Rinaldi, 1982). The Santa Marta Formation was subdivided into the Alpha, Beta and Gamma members (Olivero et al., 1986). The Alpha and Beta members crop out at Brandy Bay, Col Crame and Lachman Crags, and comprise facies associations that indicate a regressive sequence (Scasso et al., 1991).

The base of the Alpha Member consists of massive or laminated, muddy-tuffaceous, fine-grained sandstones, interbedded with hard, graded tuffaceous sandstones, containing dispersed, pyritised tree trunks and carbonised plant fragments, scarce invertebrates and heteromorph ammonites, as well as specimens of *Baculites* cf. *B. kirki* Matsumoto. The upper part of the Alpha Member consists of alternations of graded, tuffaceous, sandy turbidites that preserve diverse ammonite faunas, gastropods, crinoids, solitary corals, brachiopods and bivalves.

The lower part of the Beta Member consists of tuffaceous and pebbly, or coarse-grained, sandstones, incorporating resedimented ammonites, belemnites and bivalves (Olivero, 2012). In the upper part of this member, the facies associations include fine-grained, micaceous, silty sandstones, mudstones with leaves, trunks and plant fragments, and small ammonites. Beds characterised by *Pterotrigrionia* sp. and *Cuccullaea* sp. are frequent, and bioclastic beds supported by belemnites, trigonids and scaphopods cut erosively-bioturbated beds that are overlain by cross-bedded and parallel-laminated clastic sandstones, which are composed of glass shards and pumice lapilli. The vertical stacking of these facies associations suggests the evolution of a progradational, deep-water delta system (Scasso et al., 1991; Olivero, 2012). The Alpha and Beta members contain six successive ammonite assemblages, characterised by *Baculites* cf. *B. kirki*, *Natalites rossensis* Olivero, *Natalites* spp. Group 1, *Grossouvrites occultus* Olivero and Medina, *Natalites* cf. *morenoi* Riccardi, *Natalites taylori* Spath, *Karapadites* cf. *centinallaensis* Blasco and *Natalites* spp. Group 2, all of which indicate early Campanian ages.

The Gamma Member of the Santa Marta Formation crops out at Santa Marta Cove and Dreadnought Point in the eastern sector of James Ross Island, and is dominated by sandstone beds with scarce *Neograhamites primus* ammonites, common gastropods, bivalves and coquinas. An ankylosaurian dinosaur, *Antarctopelta oliveroi* (Salgado and Gasparini, 2006), and a plesiosaur (Kellner et al., 2011) have also been recorded from the Gamma Member. The ammonites belong to Ammonite Assemblages 8 and 9 (late Campanian) of Olivero and Medina (2000) and Olivero (2012). Recently, the Gamma Member has been considered to be the base of the Snow Hill Island Formation, of late Campanian age (Olivero, 2012).

Pirrie (1989) defined two facies associations for the Santa Marta Formation and determined similar marine environmental conditions, in agreement with Olivero et al. (1986). Later, Crame et al. (1991) grouped the Alpha and Beta members into the Lachman Crags Member of the Santa Marta Formation.

The occurrence of tuffaceous sandstones in the studied section suggests that this is probably correlatable to the 'tuffs' and 'tuffaceous sediments', cemented by carbonate, described by Scasso et al. (1991) for the Alpha Member, the basal unit of the Santa Marta Formation (Olivero et al., 1986). In the scheme proposed by Crame et al. (1991), our section would be considered to be part of the Lachman Crags Member. Resting unconformably on top of the Cretaceous strata is a Miocene-Pleistocene basaltic volcanic field known as the James Ross Island Volcanic Group (JRIVG). This crops out in a wide area of James Ross Island. It is characterised by multiple lava-fed deltas, formed of topset basalt beds that overlie thicker, steep homoclinal hyaloclastite breccia foresets (Smellie, 2006). Also, unconformably resting on top of Cretaceous sediments and underlying the base of the JRIVG, or interbedded with

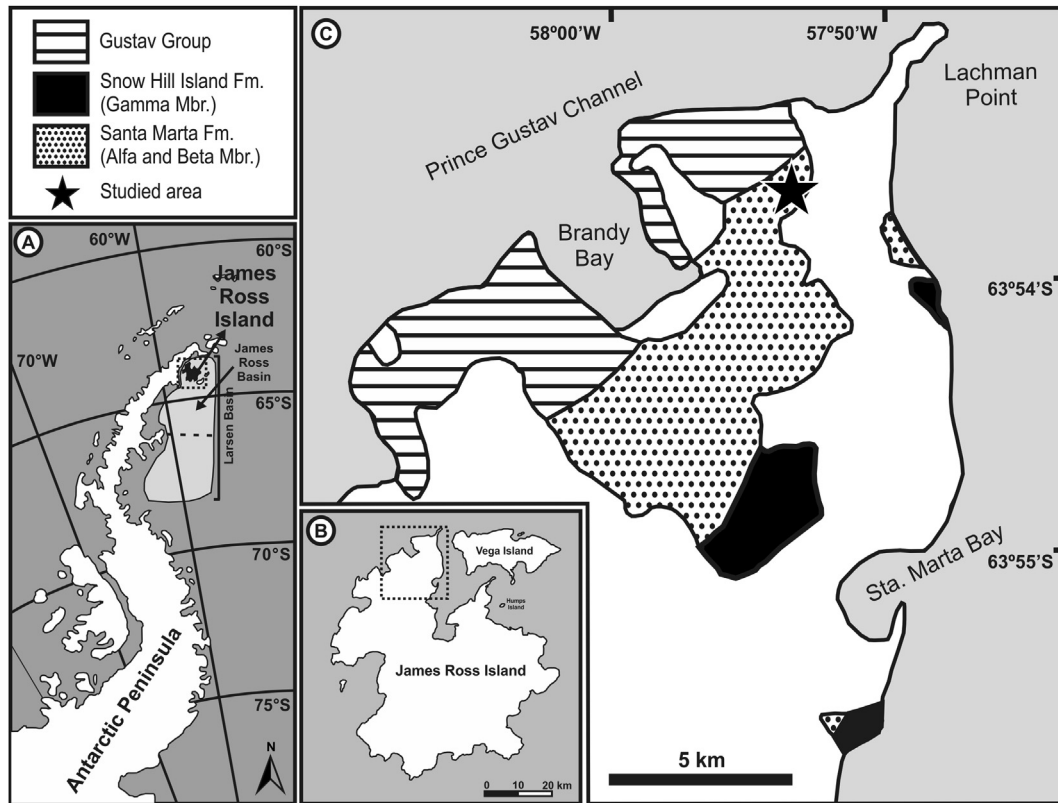


Fig. 1. Location map of the studied section, Lachman Crags, northern James Ross Island. Modified from Pirrie et al. (1991).

volcanic rocks of this group, glaciogenic sediments are exposed, and in the Lachman Crags, they belong to the Mendel Formation (Nývlt et al., 2011). These deposits have been interpreted as lodgement tills, subglacial melt-out till, glaciofluvial sands, marine sediments and glaciomarine debris-flows that contain Cenozoic marine bivalves, such as *Austrochlamys anderssoni*, and benthic foraminifera, such as *Hoeglundina asanoi* Matsunaga, *Nonionella bradii* Chapman and *Globocassidulina* sp. Strontium isotope studies developed from Lachman Crags pectinids suggest late Miocene and younger ages for the deposition of the Mendel Formation, which has an erosional contact with underlying Cretaceous deposits of the Alpha Member of the Santa Marta Formation.

3. Materials and methods

This study is based on 99 samples collected from an outcrop that comprises sedimentary rocks belonging to the Santa Marta Formation. The section was measured at Lachman Crags (63°49'44"S, 57°53'32"W), between Brandy Bay and Bibby Point, near to Col Crame, in the northern part of James Ross Island, during the project expedition *Prospecção de Fósseis do Cretáceo da Bacia de James Ross* in 2006–2007 (Fig. 1). The section comprises 126 m of very fine- to medium-grained tuffaceous sandstones, interbedded with claystones and laminated siltstones that are fossiliferous at some levels, along with rare levels of accretionary lapilli (Fig. 2). Samples were primarily selected from the siltstone and claystone beds, but some samples were also taken from the fine-grained sandstone beds (cf. tuffites cemented by carbonate sensu Scasso et al., 1991). Macrofossil content varied throughout the section, with frequent bivalves, belemnites, dispersed vegetation (stems, trunks, leaves), and rare microfossils, including Cretaceous benthic foraminifera, ostracods

and radiolarians, which occur between Samples LC28 and LC95 (Floribal et al., 2013). In general, macrofossils, where frequent at certain horizons, were contained in carbonate concretions (Fig. 2).

Samples were processed following the technique of Antunes (1997) to make the slides. We first washed each sample to remove any potential contaminants, crushed the sample and placed the powdered sediment into a test-tube previously cleaned in HCl, then rinsed. We added 40 ml of distilled water, shook the tube to mix the sediment, and waited four minutes before decantation. Some of the suspension taken with a disposable pipette from the middle of the test-tube was flooded onto a coverslip placed on a hotplate. When dry, the coverslip was affixed to a glass slide using Norland optical adhesive N° 61.

A quantitative study was performed, using a Zeiss Axio Imager A2 microscope at 1000× magnification. Because of the low abundances of calcareous nannofossils in the slides, counts were done identifying all specimens in seven longitudinal traverses, equivalent to 700 fields of view. These results are presented in the distribution chart (Table 1).

Preservation of calcareous nannofossils was evaluated using qualitative criteria to assess the degree of etching (E) and/or overgrowth (O), where E1 or O1 are relatively good - specimens exhibited little or no dissolution and/or overgrowth; E2 or O2 are moderate - specimens exhibited moderate dissolution and/or overgrowth, and were easily recognisable; and E3 or O3 are poor - specimens exhibited extreme dissolution and/or overgrowth (Roth and Thierstein, 1972; Roth, 1983).

The slides are stored in the collections of the Museu de História Geológica do Rio Grande do Sul, Universidade do Vale do Rio dos Sinos (UNISINOS), Brazil, under the curatorial numbers ULVG-11237 to ULVG-11336.

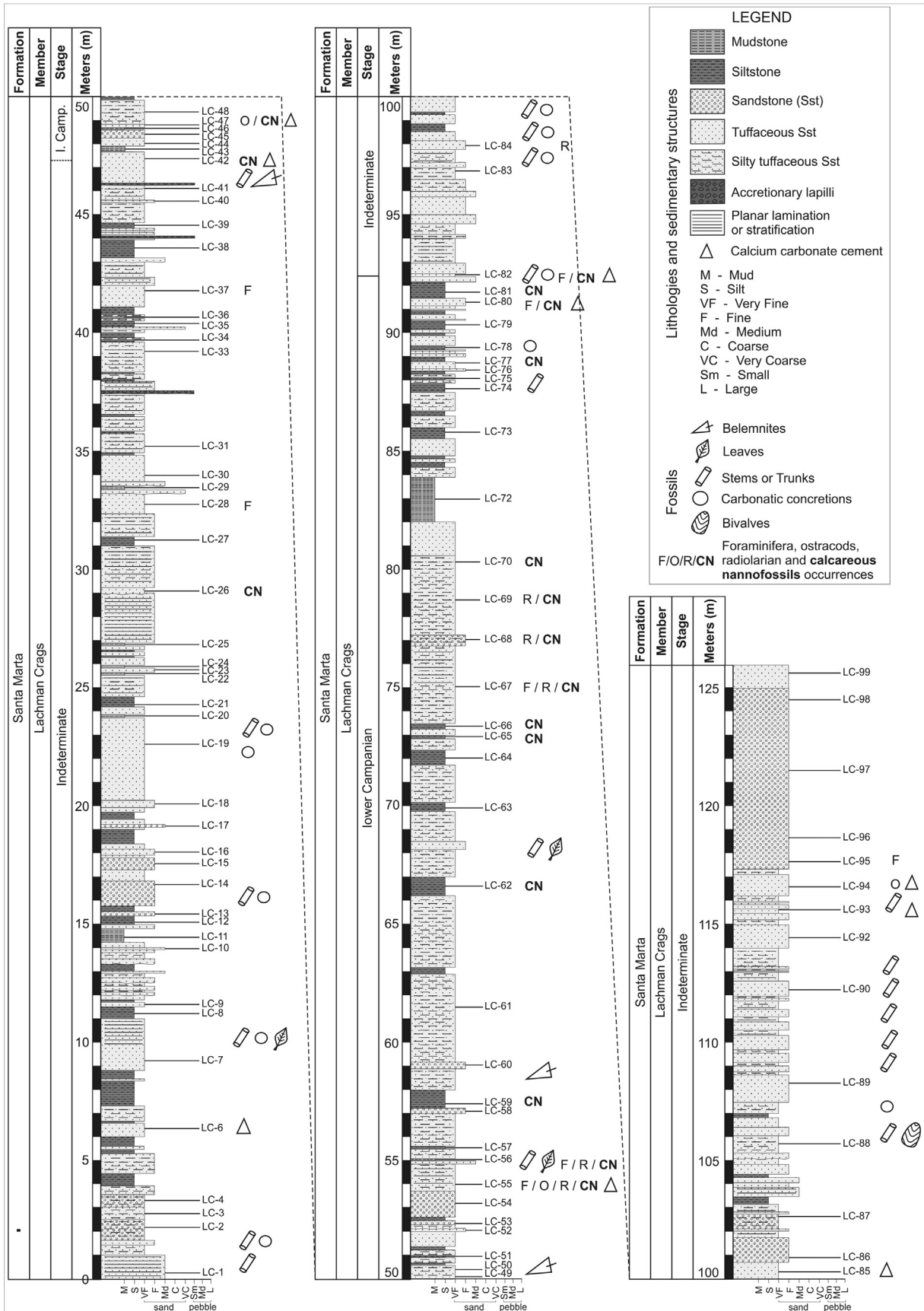


Fig. 2. Studied stratigraphic section, showing position of samples. Modified from Florisbal et al. (2013).

4. Results

The species identified in this study are recorded in Table 1, and illustrated in Figs. 3–8. Identification of the species was aided by Perch-Nielsen (1985), Burnett et al. (1998) and Nannotax3 (Young et al.).

Despite the large number of barren samples (82), the remaining 17 allowed the recognition of 52 species. The most representative genera are *Biscutum*, *Broinsonia*, *Eiffellithus*, *Gartnerago*, *Gephyrobiscutum*, *Reinhardtites*, *Staurolithites* and *Tranolithus*.

The lower part of the section is rich in silica and predominantly barren of calcareous nannofossils, except for sample LC26, which is virtually barren. In the middle part, also relatively rich in silica, 16 samples were productive, and some of these were rich in nannofossils, with *Gephyrobiscutum diabolium* and *Biscutum constans* showing high abundances, in comparison to impoverished nannofossil assemblages recovered from other Antarctic outcrops. The presence of *G. diabolium*, previously mentioned by Švábenická et al. (2012), was confirmed by our study. This species has previously

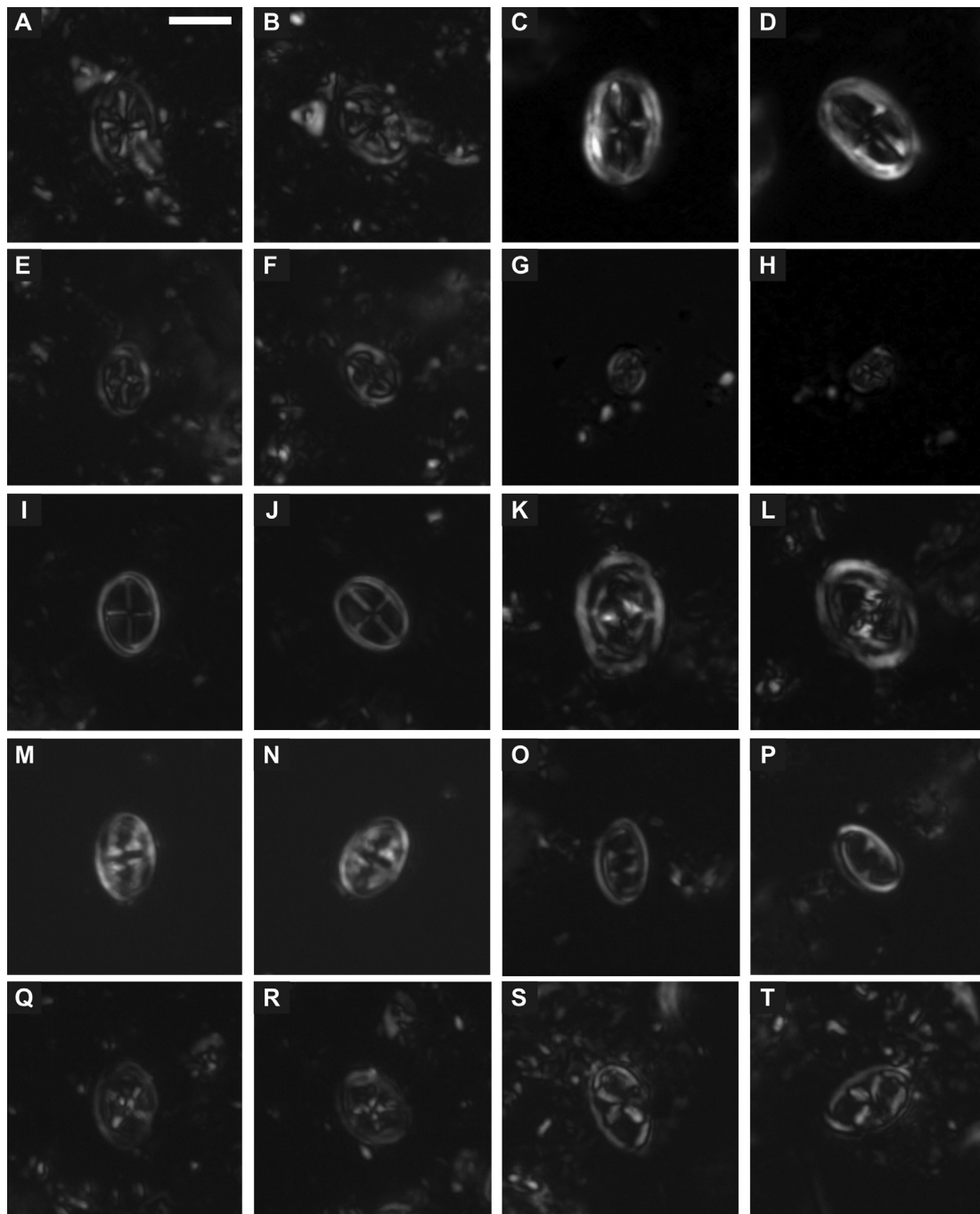


Fig. 3. A/B, *Ahmullerella octoradiata* (ULVG-11316), sample 80, 92.30 m; C/D, *Staurolithites elongatus* (ULVG-11313), sample 77, 90.20 m; E/F, *Staurolithites laffittei* (ULVG-11291), sample 55, 55.20 m; G/H, *Staurolithites minutus* (ULVG-11291), sample 55, 55.20 m; I/J, *Staurolithites* sp. (ULVG-11278), sample 42, 48.10 m; K/L, *Reinhardtites anthophorus* (ULVG-11316), sample 80, 92.30 m; M/N, *Tranolithus salillum* (ULVG-11292), sample 56, 56.30 m; O/P, *Tranolithus salillum* (ULVG-11303), sample 67, 76.20 m; Q/R, *Chiastozygus bifarius* (ULVG-11283), sample 47, 49.50 m; S/T, *Chiastozygus stylesii* (ULVG-11316), sample 80, 92.30 m. Scale bar equal to 5 μ m.

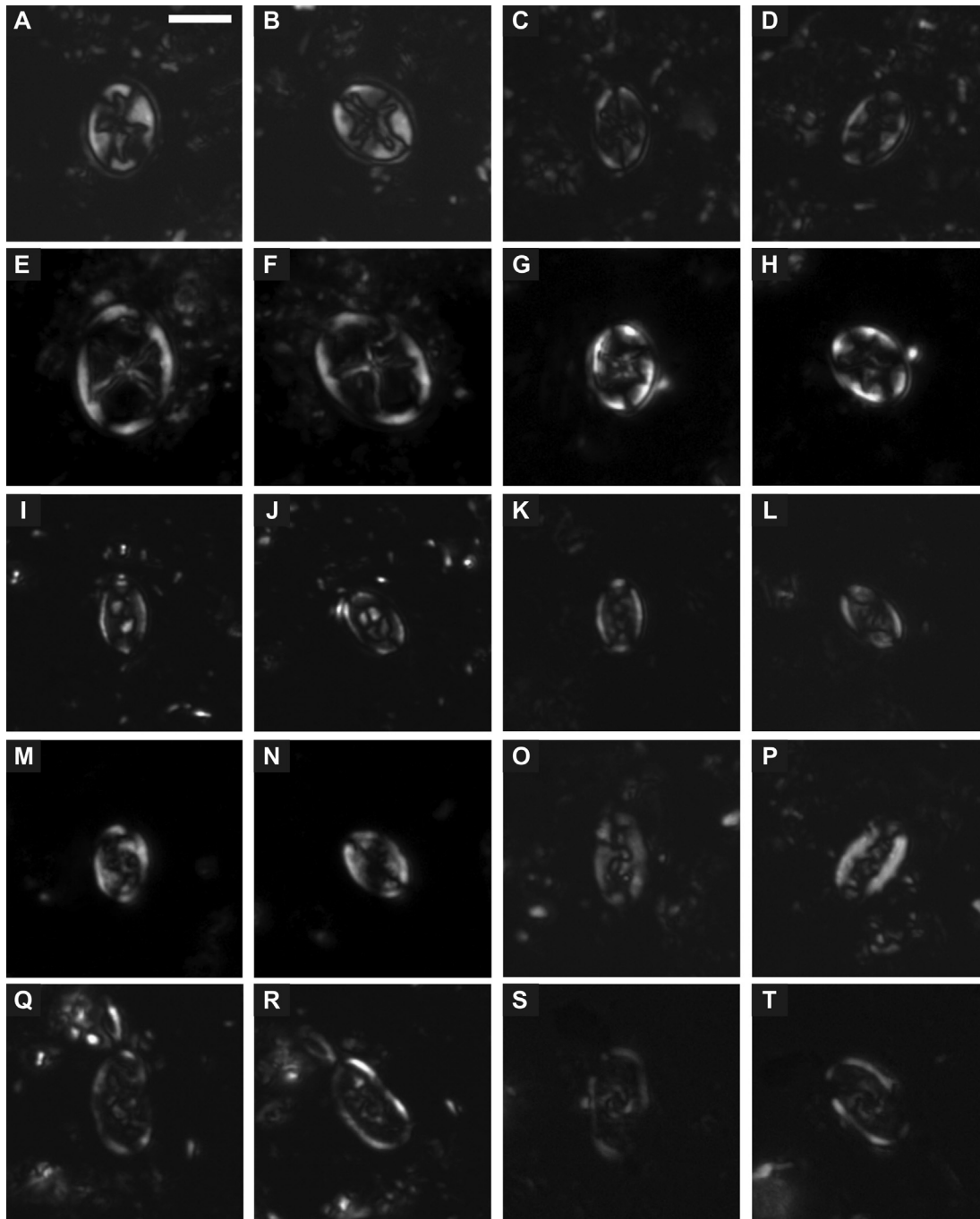


Fig. 4. A/B, *Eiffellithus eximius* (ULVG-11291), sample 55, 55.20 m; E/F, C/D, *Eiffellithus gorkae* (ULVG-11316), sample 80, 92.30 m; E/F, *Eiffellithus keio* (ULVG-11292), sample 56, 56.30 m; G/H, *Eiffellithus turrisseiffelii* (ULVG-11283), sample 47, 49.50 m; I/J, *Tegumentum lucidum* (ULVG-11283), sample 47, 49.50 m; K/L, *Percivalia fenestrata* (ULVG-11278), sample 42, 48.10 m; M/N, *Percivalia? dunkleyjonesii* (ULVG-11283), sample 47, 49.50 m; O/P, *Rhagodiscus angustus* (ULVG-11291), sample 55, 55.20 m; Q/R, *Rhagodiscus reniformis* (ULVG-11283), sample 47, 49.50 m; S/T, *Rhagodiscus* cf. *R. splendens* (ULVG-11278), sample 42, 48.10 m. Scale bar equal to 5 μ m.

only been found in the Campanian of the Falkland Plateau (Wise, 1988; Watkins et al., 1996).

4.1. Occurrences and preservation

Calcareous nannofossil assemblages are generally significantly modified through post-mortem processes acting in the water column and in the sediment, with small and delicate taxa most commonly being lost (Bown et al., 2008). The samples analysed here have clearly been deleteriously affected, as indicated by the

many barren samples and by low numbers of specimens per slide and relatively very low to low species richnesses in the productive samples (see Table 1).

Barren intervals in the lower and upper parts of the section correspond to a similar pattern exhibited by foraminifera (Florisbal et al., 2013). This could reflect unsuitable facies, as part of a regressive sequence (Scasso et al., 1991; Olivero, 2012), or a dissolution effect (Florisbal et al., 2013). This part of the studied section is particularly rich in silica, devitrified glassy shards, remains of organic material, pyrite and some heavy minerals. Tree trunks and

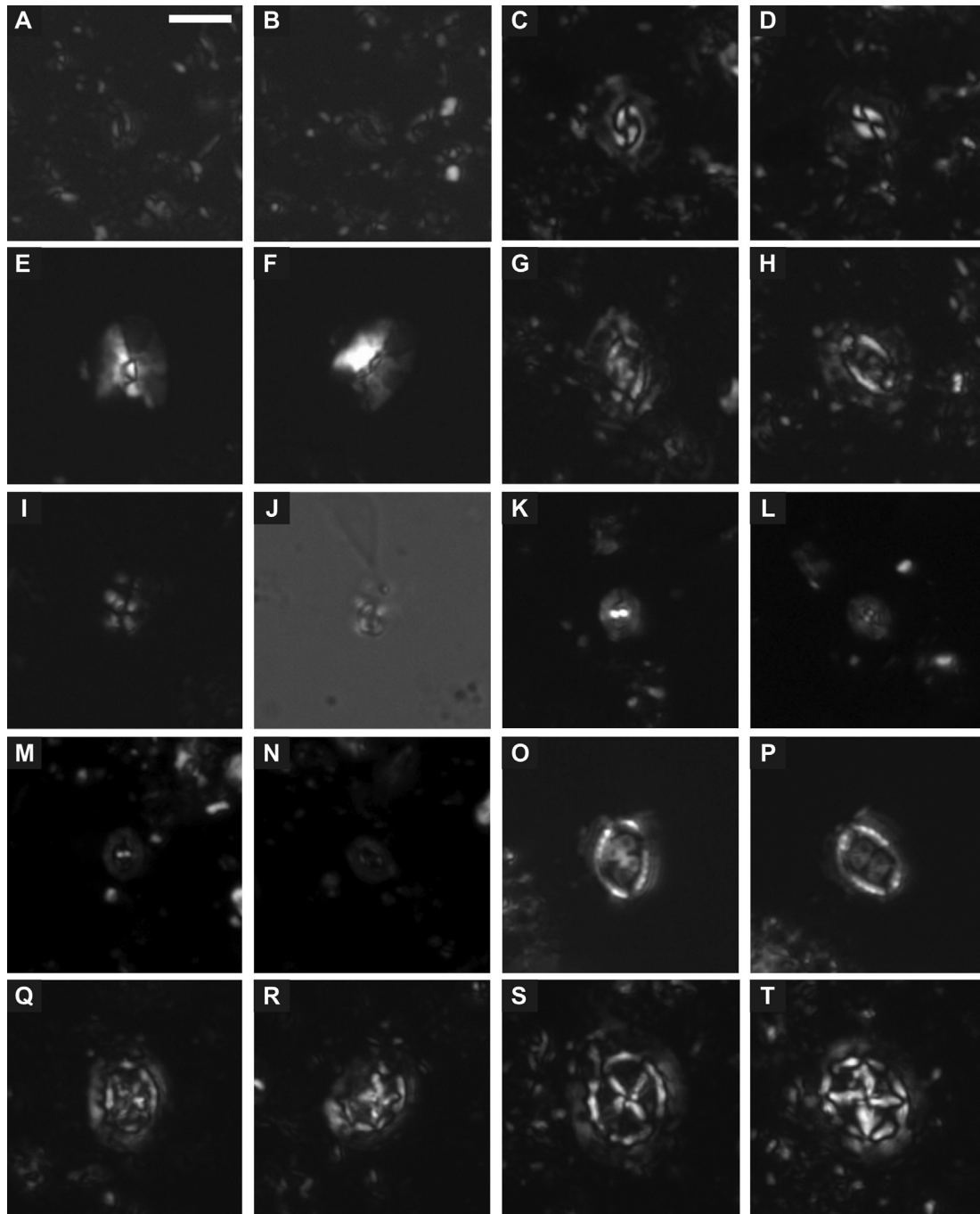


Fig. 5. A/B, *Biscutum constans* (ULVG-11283), sample 47, 49.50 m; C/D, *Biscutum* cf. *B. coronum* (ULVG-11316), sample 80, 92.30 m; E/F, *Biscutum dissimilis* (ULVG-11292), sample 56, 56.30 m; G/H, *Biscutum magnum* (ULVG-11283), sample 47, 49.50 m; I/J, *Discorhardus ignotus* (ULVG-11303), sample 67, 76.20 m; K/L, *Gephyrobiscutum diabolium* (ULVG-11283), sample 47, 49.50 m; M/N, *Gephyrobiscutum diabolium* (ULVG-11291), sample 55, 55.20 m; O/P, *Seribiscutum primitivum* (ULVG-11317), sample 81, 92.80 m; Q/R, *Prediscosphaera cretacea* (ULVG-11283), sample 47, 49.50 m; S/T, *Prediscosphaera* cf. *P. grandis* (ULVG-11316), sample 80, 92.30 m. Scale bar equal to 5 μ m.

carbonate concretions are frequent at certain levels, and the presence of belemnites in Sample LC41 provided a Mesozoic age for this interval. Coarsening- and thickening-upward, friable, tuffaceous sandy turbidites, are capped by laminated, carbonised plant fragments (Olivero, 2012).

Samples richest in nannofossils (LC55, LC56 and LC80) are from a silty, tuffaceous sandstone with carbonate cement. Besides abundant nannofossils, scarce foraminifera, ostracods and radiolarians were also found in these samples. In Samples LC55 and

LC80, there were some benthic foraminifera species, including *Gyroidinoides globulosus* Hagenow, which suggest deep neritic to upper bathyal palaeodepths, at least at these stratigraphic levels. Ostracod assemblages, composed of *Cytherella*, *Majungaella*, *Paracypris* and *Bythocypris* (Florisbal et al., 2013), provide a broad Cretaceous age for these samples. The presence of *Majungaella* particularly suggests deposition in a shelf environment with relatively warm waters and normal salinities (Piovesan et al., 2012).

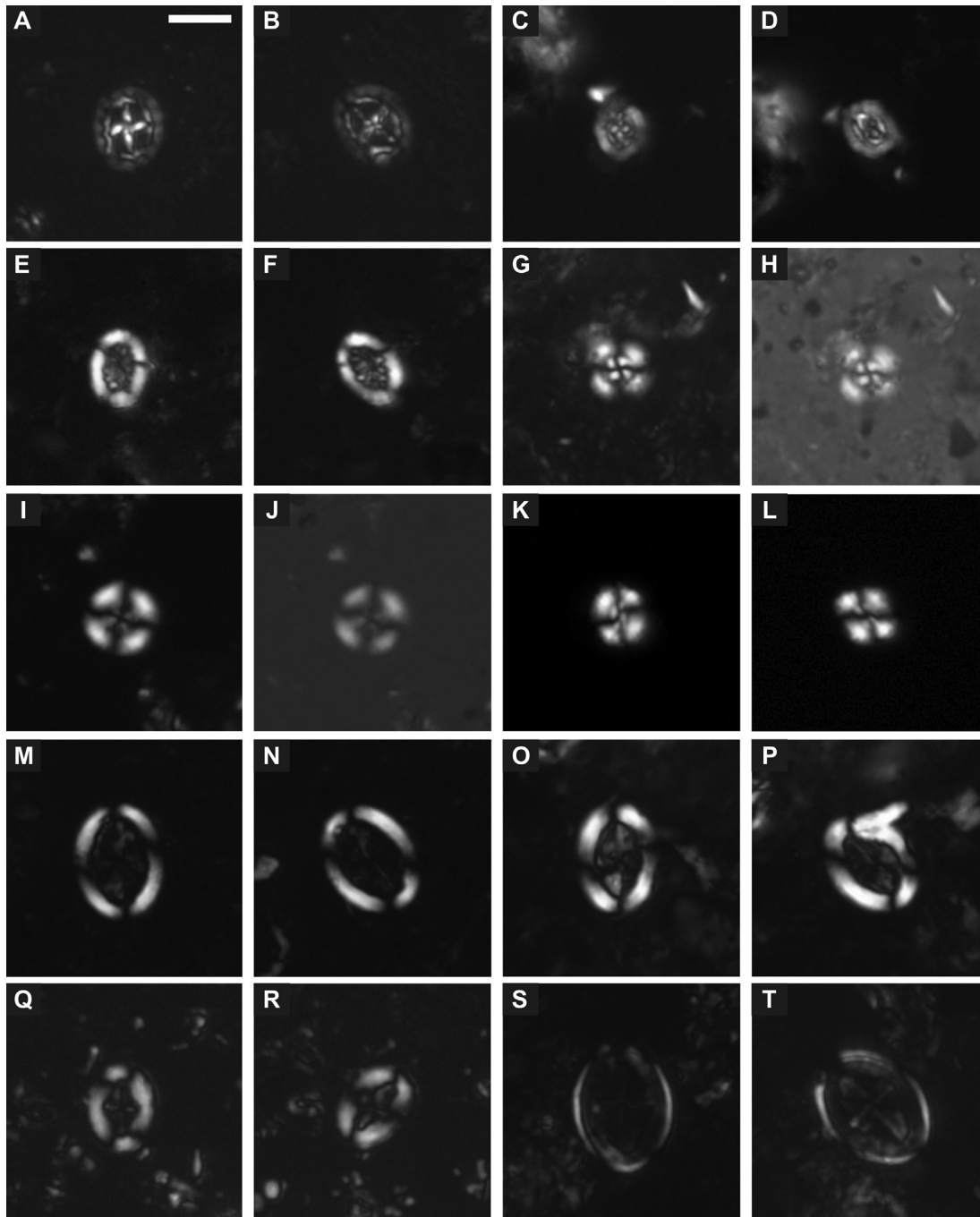


Fig. 6. A/B, *Prediscosphaera spinosa* (ULVG-11278), sample 42, 48.10 m; C/D, *Prediscosphaera stoveri* (ULVG-11283), sample 47, 49.50 m; E/F, *Retecapsa crenulata* (ULVG-11293), sample 57, 56.70 m; G/H, *Cyclagelosphaera reinhardtii* (ULVG-11317), sample 81, 92.80 m; I/J, *Cyclagelosphaera rotaclypeata* (ULVG-11316), sample 80, 92.30 m; K/L, *Watznaueria barnesiae* (ULVG-11316), sample 80, 92.30 m; M/N, *Arkhangelskiella cymbiformis* (ULVG-11313), sample 77, 90.20 m; O/P, *Broinsonia parca expansa* (ULVG-11305), sample 69, 80.50 m; Q/R, *Broinsonia signata* (ULVG-11291), sample 55, 55.20 m; S/T, *Gartnerago obliquum* (ULVG-11313), sample 77, 90.20 m. Scale bar equal to 5 μ m.

4.2. Biostratigraphy

Samples from the lower part of the section (LC1 to LC41) were barren, except for LC26, which contains three specimens representing only two species. Because of the scarcity of calcareous nannofossils in this sample, this interval (LC1 to LC41) is indeterminate in age. The upper part of the section is also barren (Samples LC83 to LC99), and its age is also indeterminate.

In the middle part of the section (Samples LC42 to LC82), 16 samples were productive, to varying degrees, allowing the

recognition of nannofossil (sub)zones (Table 1). This interval ranges between the *G. diabolum* and *Broinsonia dentata* Subzones (Lower Campanian) according to the austral scheme of Watkins et al. (1996), based mainly on the presence of *G. diabolum* and the absence of *Reinhardtites levis*. To provide a global stratigraphic context it was possible to assign this interval in the UC13 Zone (Lower Campanian) of Burnett et al. (1998), based on the presence of *Arkhangelskiella cymbiformis* and the absence of the overlying markers *Broinsonia parca parca* and *Broinsonia parca constricta* (species that occurs in other high-latitude site).

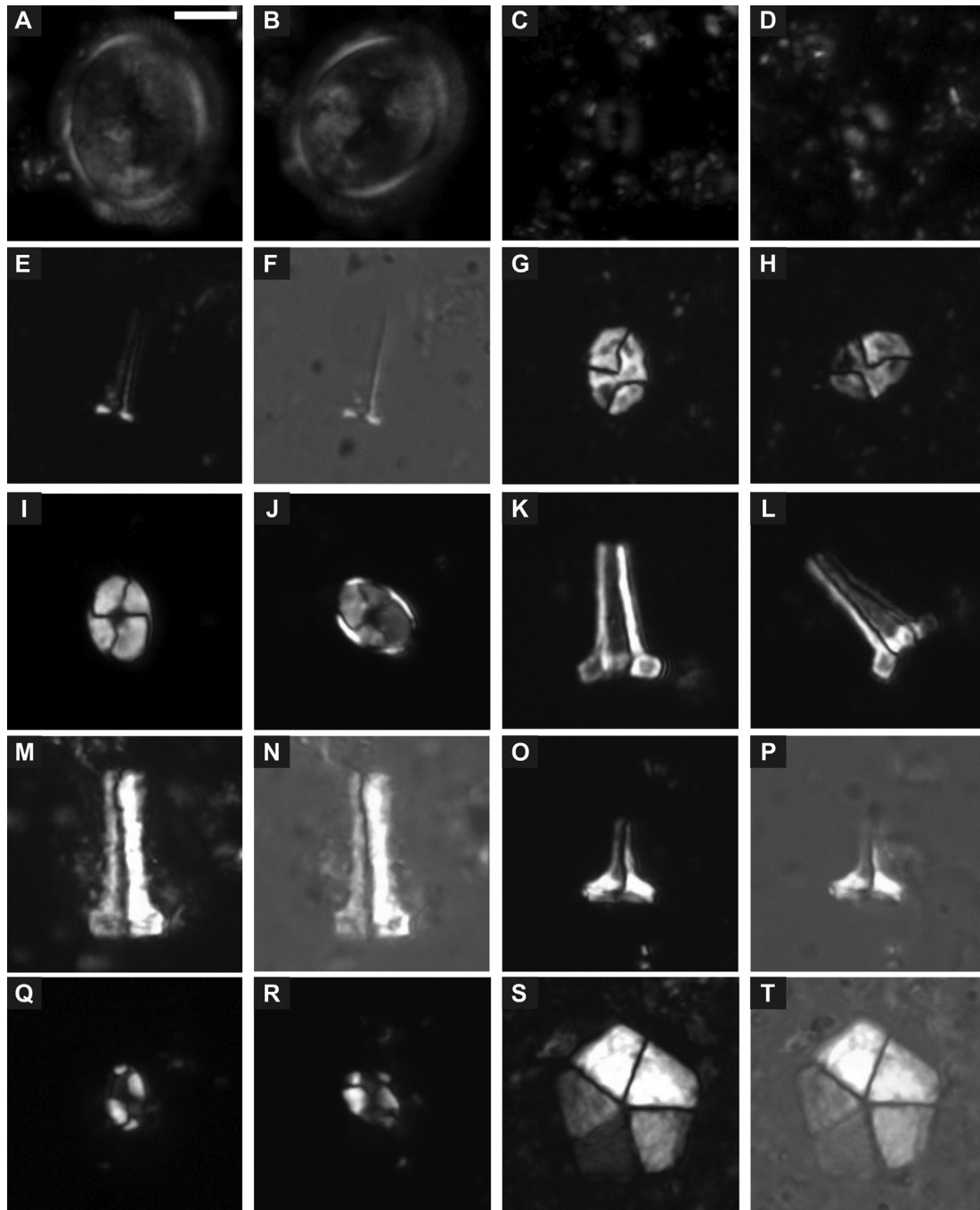


Fig. 7. A/B, *Kamptnerius magnificus* (ULVG-11291), sample 55, 55.20 m; C/D, *Repagulum parvidentatum* (ULVG-11291), sample 55, 55.20 m; E/F, *Acuturris scotus* (ULVG-11278), sample 42, 48.10 m; G/H, *Calculites obscurus* (ULVG-11283), sample 47, 49.50 m; I/J, *Calculites ovalis* (ULVG-11313), sample 77, 90.20 m; K/L, *Calculites* sp. (ULVG-11278), sample 42, 48.10 m; M/N, *Lucianorhabdus cayeuxii* (ULVG-11316), sample 80, 92.30 m; O/P, *Lucianorhabdus maleformis* (ULVG-11278), sample 42, 48.10 m; Q/R, *Octolithus multiplus* (ULVG-11316), sample 80, 92.30 m; S/T, *Braarudosphaera bigelowii* (ULVG-11305), sample 69, 80.50 m. Scale bar equal to 5 μ m.

The calcareous nannofossil ages agree well with Ammonite Assemblages 2–3 of the Santa Marta Formation, which are also Campanian in age (Olivero, 2012); previous ammonite and inoceramid studies of the Alpha Member of the Santa Marta Formation suggested a Campanian age, although the base of the formation was thought to potentially reach the uppermost Santonian (Crame, 1983; Olivero, 1984, 2012; Crame et al., 1991; Carvalho, pers. comm., 2014). Ostracods, foraminifera and radiolarians from the same samples as ours provide a broader Late Cretaceous age (Floribal et al., 2013), while palynology also suggests Campanian

(Dettmann and Thomson, 1987) and early Santonian/early Campanian (Keating, 1992; Barreda and Olivero, 1993).

5. Discussion

The nannofossil distribution and preservation data compare well with previous studies in the same general area, although we encountered more units with high species richnesses. Hradecká et al. (2011) and Švábenická et al. (2012) studied a section of the Santa Marta Formation from Col Crame. There, they found 10 fossiliferous

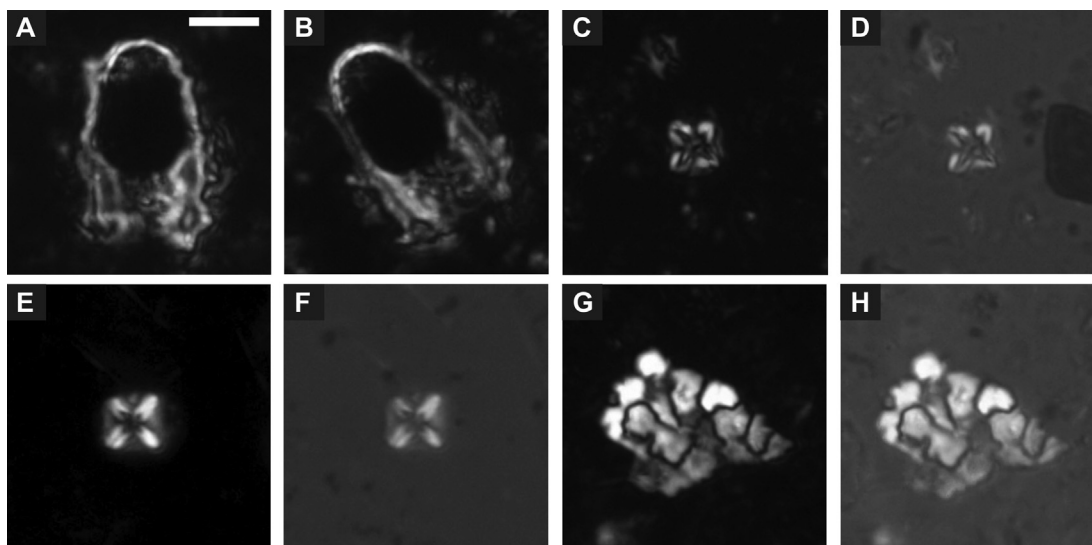


Fig. 8. A/B, *Lapideacassis mariae* (ULVG-11316), sample 80, 92.30 m; C/D, *Micula cubiformis* (ULVG-11283), sample 47, 49.50 m; E/F, *Micula staurophora* (ULVG-11293), sample 57, 56.70 m; G/H, *Cervisiella saxea* (ULVG-11305), sample 69, 80.50 m. Scale bar equal to 5 μm .

samples containing foraminifera, and only three samples yielded calcareous nannofossils. At their level KSM4, very near to the LC80 level of this study, they recovered the planktonic foraminifer *Archaeoglobigerina bosquensis* Pessagno, and in KSM4–5, Švábenická et al. (2012) found a moderately preserved nannoflora, reporting the occurrence of *G. diabolium*.

As mentioned, the samples richest in nannofossils (LC55, LC 56, and LC 80) are from a silty, tuffaceous sandstone. The abundance of these nanofossils may be due to the presence of volcanic ash. As summarized by Wise (1977), coccoliths in samples with higher amounts clay, zeolite, volcanic ash or siliceous microfossils are generally far better preserved than those in purer carbonate oozes as noted by Bukry (1971). Apparently, the presence of silica in solution inhibits the dissolution-diffusion-reprecipitation process that otherwise tends to convert nannofossils to chalk.

Although the nannofossil-productive assemblages described here are likely modified by diagenesis, we find that *G. diabolium* and *Biscutum constans* dominate the assemblages. *G. diabolium* has previously only been reported from the Falkland Plateau (e.g. Wise, 1988; Watkins, 1992; Watkins et al., 1996), so here we extend its geographic range into the Antarctic Peninsula, and suggest a broadly cooler-water ecology for this species, and perhaps also for *B. constans*. The rest of the taxa recorded in this study have cosmopolitan distributions, a finding similar to those found from southeast James Ross, Snow Hill and Seymour Islands (Concheyro et al., 1991, 1994; Concheyro, 2004), in upper Campanian-Maastrichtian strata.

6. Concluding remarks

Calcareous nannofossils were recovered from Upper Cretaceous deposits of the Santa Marta Formation of the Lachman Crags Member, James Ross Island. Although containing numerous barren intervals, this constitutes the most complete and well-documented sequence of nannofloras recovered from the northern area of the island to date. Application of both the austral zones of Watkins et al. (1996) and the global zones of Burnett et al. (1998) provides an early Campanian age for these samples. This age range is closely comparable to that provided by ammonites, and provides higher resolution than has been achieved with foraminifera, ostracods and radiolarians from the same locality.

The consistent presence of *G. diabolium* in the section, previously only recorded from the Falkland Plateau, extends its distribution to higher latitudes, at least in the Antarctic Peninsula area, and suggests a broadly cool-water ecology for this species.

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