Late Campanian-Maastrichtian *Kamptnerius magnificus* acme in the South Atlantic section of the Southern Ocean, ODP Holes 690C and 700B

Rodrigo M. Guerra[1], Andrea Concheyro[2], Sherwood W. Wise Jr[3] and Gerson Fauth[1]
[1] *Instituto Tecnológico de Micropaleontologia (itt Fossil), Universidade do Vale do Rio dos Sinos, Brazil*
email: rmguerra@unisinos.br; rodrigomguerra1@gmail.com; gersonf@unisinos.br
[2] *Laboratório de Bioestratigrafía de Alta Resolución, IDEAN-CONICET, Universidad de Buenos Aires, Argentina*
email: andrea@gl.fcen.uba.ar
[3]*Department of Earth, Ocean and Atmospheric Sciences, Florida State University, USA*
email: swise@fsu.edu

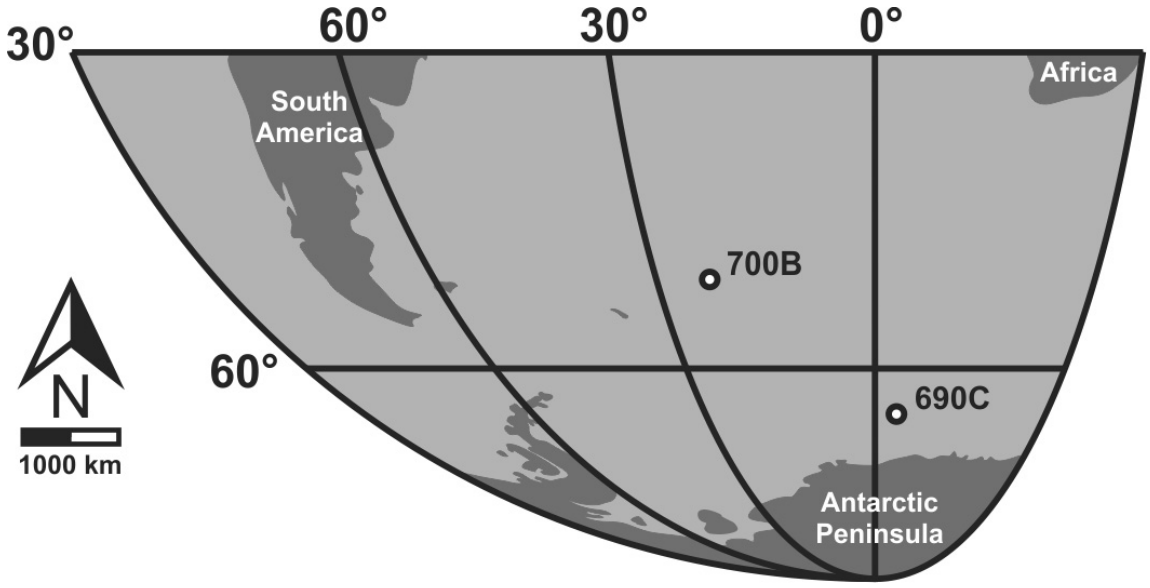
ABSTRACT: Coccolithophores are organisms with distribution largely controlled by temperature and availability of nutrients. For extinct calcareous nannofossils there are some uncertainties in assigning ecological preferences of taxa, however sometimes species occurrences exhibits striking high abundances showing clear preferences for certain environment, the so-called acme events. During quantitative analyses on samples from the South Atlantic section of the Southern Ocean (Holes 690C and 700B) a notable *Kamptnerius magnificus* acme was documented. This is the first time that such bioevent is described for the South Atlantic Ocean. Preliminary analysis indicates that this event probably is related to the cooling in sea-surface temperatures during the Late Campanian-Maastrichtian.

Keywords: Calcareous nannofossils; Southern Ocean; Campanian-Maastrichtian; Paleoecology; Paleoceanography.

INTRODUCTION

Calcareous nannofossil intervals characterized by sudden increases in the occurrences of *Kamptnerius magnificus* were observed in two ODP holes (690C and 700B) in the South Atlantic section of the Southern Ocean. In their original reports on these austral high-latitudes, Pospichal and Wise (1990) for Hole 690C, and Crux (1991) for Hole 700B, showed abundant occurrences of *Kamptnerius magnificus*, but did not point out the striking increase in abundance and the possibility to be considered as an acme zone. However, there is another report of a similar acme pattern described by Thibault et al (2015) in a Upper Campanian-Maastrichtian section of Denmark.

The purpose of this study is to consider and describe for the first time this acme of *Kamptnerius magnificus* in the austral high-latitudes and to suggest its importance for biostratigraphy and paleoceanography.



TEXT-FIGURE 1
Location map of sites selected for this study.

ODP Leg 113 - Hole 690C

Sample	Depth (mbsf)	Preservation	Nº Field of view	Species Richness	Total	Biological events	Biostratigraphy based on the SAH zonation Guerra et al., 2016	
15-4 (120-122 cm)	247.60	M	6	22	327		SAH1	Late Maastrichtian
15-5 (73-75 cm)	249.63	M	5	22	325		SAH1	Late Maastrichtian
15-6 (78-80 cm)	251.18	M	6	23	306		SAH1	Late Maastrichtian
15-7 (20-22 cm)	252.10	M	3	20	313		SAH1	Late Maastrichtian
16-1 (71-73 cm)	253.20	M	7	20	331		SAH1	Late Maastrichtian
16-2 (72-74 cm)	254.72	M	5	22	317		SAH1	Late Maastrichtian
16-3 (72-74 cm)	256.22	M	6	23	315		SAH1	Late Maastrichtian
16-4 (50-52 cm)	257.50	M	10	26	305		SAH1	Late Maastrichtian
17-1 (73-75 cm)	262.52	M	8	25	312		SAH1	Late Maastrichtian
17-2 (77-79 cm)	264.07	M	6	21	364	*P. stoveri* acme	SAH1	Late Maastrichtian
17-3 (74-76 cm)	265.54	M	12	22	322		SAH2	Early/Late Maastrichtian
17-4 (5-7 cm)	266.35	M	6	27	336		SAH2	Early/Late Maastrichtian
18-1 (78-80 cm)	272.18	M	12	23	339		SAH2	Early/Late Maastrichtian
18-2 (72-74 cm)	273.62	M	11	24	303		SAH2	Early/Late Maastrichtian
18-3 (73-75 cm)	275.13	M	16	23	318		SAH2	Early/Late Maastrichtian
18-4 (72-74 cm)	276.62	M	16	30	326		SAH2	Early/Late Maastrichtian
18-5 (40-42 cm)	277.80	M	11	30	333	Lo *B. magnum*	SAH3	E. Maast.
19-1 (72-74 cm)	281.82	M	7	51	329	Lo *R. levis*	SAH4	Late Campanian / Early Maastrichtian
19-2 (72-74 cm)	283.32	G	9	52	329		SAH4	Late Campanian / Early Maastrichtian
19-3 (73-75 cm)	284.83	G	7	46	333		SAH4	Late Campanian / Early Maastrichtian
19-4 (76-78 cm)	286.36	M	11	42	310		SAH4	Late Campanian / Early Maastrichtian
19-5 (72-74 cm)	287.82	M	11	45	322		SAH4	Late Campanian / Early Maastrichtian
19-6 (72-74 cm)	289.32	M	11	39	326		SAH4	Late Campanian / Early Maastrichtian
19-7 (11-13 cm)	290.21	M	17	36	340		SAH4	Late Campanian / Early Maastrichtian
20-1 (70-72 cm)	291.50	G	8	45	330		SAH4	Late Campanian / Early Maastrichtian

Calcareous nannofossils species

Sample	*Acuturris scotus*	*Ahmuellerella* spp.	*Arkhangelskiella* spp.	*Biscutum magnum*	*Biscutum* spp.	*Broinsonia parca constricta*	*Calculites obscurus*	*Centosphaera barbata*	*Cervisiella spp.*	*Chiastozygus* spp.
15-4 (120-122 cm)	X	1	49							
15-5 (73-75 cm)	X	X	18							
15-6 (78-80 cm)	X	X	26						1	
15-7 (20-22 cm)	X		29							
16-1 (71-73 cm)	X		36						2	
16-2 (72-74 cm)	X		23						X	X
16-3 (72-74 cm)	X		20		X					X
16-4 (50-52 cm)	X		65		X				X	X
17-1 (73-75 cm)	X		54		X				X	
17-2 (77-79 cm)	X	1	24						2	
17-3 (74-76 cm)	X		78		X				X	
17-4 (5-7 cm)	X	2	45		X				4	
18-1 (78-80 cm)	X		53							X
18-2 (72-74 cm)	X	X	35		X			X	X	
18-3 (73-75 cm)	X		26		X			X	1	
18-4 (72-74 cm)	X		15		2		X		1	
18-5 (40-42 cm)	4		7	X	6				2	
19-1 (72-74 cm)	6	4	34	39	18		6	X	7	2
19-2 (72-74 cm)	8	9	40	34	2	X	10	X	3	2
19-3 (73-75 cm)	15	6	10	40	17		8	X	2	1
19-4 (76-78 cm)	2	7	4	79	4	X	7		3	3
19-5 (72-74 cm)	4	6	5	80	24		16	X	4	3
19-6 (72-74 cm)	11	6	10	66	14		20	X	X	1
19-7 (11-13 cm)	14	2	11	72	7		35		2	X
20-1 (70-72 cm)	2	19	41	51	10		2	X	6	3

Sample	*Cretarhabdus conicus*	*Cribrosphaerella* spp.	*Crucibiscutum* sp.	*Cyclagelosphaera reinhardtii*	*Eiffellithus* spp.	*Gartnerago* spp.	*Helicolithus* spp.	*Kamptnerius magnificus*	*Lapideacassis* spp.	*Lithraphidites carniolensis*
15-4 (120-122 cm)		10			3	X		61		
15-5 (73-75 cm)		15			7	X	X	19	X	
15-6 (78-80 cm)		17			1	X		23	X	
15-7 (20-22 cm)		14			5			41	X	
16-1 (71-73 cm)		9			2		X	74	X	
16-2 (72-74 cm)		7			10		X	44	X	
16-3 (72-74 cm)		2			6	X		45	X	
16-4 (50-52 cm)		10			7	X		91	X	
17-1 (73-75 cm)		7			4	X		86	X	
17-2 (77-79 cm)		11			7	X		58		
17-3 (74-76 cm)		7			8			154		
17-4 (5-7 cm)		11			10	3		54	X	
18-1 (78-80 cm)		2			14	X		113	X	
18-2 (72-74 cm)		X			15			161		
18-3 (73-75 cm)		7			17			166		
18-4 (72-74 cm)		8			13	X		135	X	
18-5 (40-42 cm)		5	X		24	X		120		
19-1 (72-74 cm)	1	6			15	1	1	45	X	
19-2 (72-74 cm)	X	8		X	13	1		42	X	
19-3 (73-75 cm)		2			11	3		28	3	X
19-4 (76-78 cm)		12	X		18	X	1	35	X	
19-5 (72-74 cm)	X	3	X		8	X		29	X	
19-6 (72-74 cm)	X	7			6			21	X	
19-7 (11-13 cm)		11			14	X	X	23		
20-1 (70-72 cm)		5			13			25	X	

Sample	*Loxolithus armilla*	*Lucianorhabdus arcuatus*	*Lucianorhabdus cayeuxii*	*Markalius inversus*	*Micula* spp.	*Misceomarginatus pleniporus*	*Monomarginatus quaternarius*	*Neocrepidolithus watkinsii*	*Nephrolithus* cf. *N. corystus*	*Nephrolithus corystus*
15-4 (120-122 cm)			53		X					
15-5 (73-75 cm)	X		44		12					
15-6 (78-80 cm)			X	X	X					
15-7 (20-22 cm)			X	X	X					
16-1 (71-73 cm)			6	X	4					
16-2 (72-74 cm)			3		1					
16-3 (72-74 cm)			36	X						
16-4 (50-52 cm)			35	X						
17-1 (73-75 cm)			76	X	X					
17-2 (77-79 cm)			2	1	X					
17-3 (74-76 cm)			11	1	X					
17-4 (5-7 cm)			21		X					
18-1 (78-80 cm)			29		1	X				
18-2 (72-74 cm)			39	X						X
18-3 (73-75 cm)			55	3	1	X				X
18-4 (72-74 cm)			38		2	1	2			X
18-5 (40-42 cm)			32	X		X	4			X
19-1 (72-74 cm)		X	27			X	7		X	19
19-2 (72-74 cm)		X	28		1	X	X	X	X	43
19-3 (73-75 cm)		X	48		X	X	3	X		38
19-4 (76-78 cm)			21		X	6		X		46
19-5 (72-74 cm)		X	27		2	2	X			39
19-6 (72-74 cm)		X	90		X	2				26
19-7 (11-13 cm)		3	62		1	X	1	X		39
20-1 (70-72 cm)			12		1	6	X	8		45

Sample	*Nephrolithus frequens*	*Nephrolithus* sp.	*Octocyclus magnus*	*Petrarhabdus copulatus*	*Pharus simulacrum*	*Placozygus fibuliformis*	*Prediscospahera* spp.	*Prediscosphaera stoveri*	*Psyktosphaera firthii*	*Reinhardtites anthophorus*
15-4 (120-122 cm)	42					X	47	57		
15-5 (73-75 cm)	50					X	44	116		
15-6 (78-80 cm)	25					3	66	144		
15-7 (20-22 cm)	16					X	32	176		
16-1 (71-73 cm)	33					X	25	136		
16-2 (72-74 cm)	67					X	25	124		
16-3 (72-74 cm)	39					2	28	124		
16-4 (50-52 cm)	37					X	34	23		
17-1 (73-75 cm)	21					X	18	39		
17-2 (77-79 cm)	29					X	39	188		
17-3 (74-76 cm)	12					X	40	11		
17-4 (5-7 cm)	15					1	85	61		
18-1 (78-80 cm)	55					7	26	32		
18-2 (72-74 cm)	14					X	35	X		
18-3 (73-75 cm)	3					2	21	X		
18-4 (72-74 cm)	32					32	17	17	2	
18-5 (40-42 cm)	48					21	40	14		
19-1 (72-74 cm)		X	X			3	14	13	16	
19-2 (72-74 cm)						3	10	16	16	X
19-3 (73-75 cm)						4	22	26	1	
19-4 (76-78 cm)		X					20	18	5	
19-5 (72-74 cm)				X			31	19	3	
19-6 (72-74 cm)					X	X	11	6	X	
19-7 (11-13 cm)		X					16	5	2	
20-1 (70-72 cm)			X				26	8	9	

Sample	*Reinhardtites levis*	*Retecapsa* spp.	*Rucinolithus* sp.	*Staurolithites* spp.	*Teichorhabdus ethmos*	*Tranolithus salillum*	UFO	Watznaueria spp.	*Zeugrhabdotus* spp.
15-4 (120-122 cm)		3							
15-5 (73-75 cm)		X							
15-6 (78-80 cm)		X						X	
15-7 (20-22 cm)		X						X	
16-1 (71-73 cm)		4							
16-2 (72-74 cm)		13			X				
16-3 (72-74 cm)		13		X				X	
16-4 (50-52 cm)		3		X	X		X	X	
17-1 (73-75 cm)		6		1					
17-2 (77-79 cm)		2			X			X	
17-3 (74-76 cm)		X			X				X
17-4 (5-7 cm)		21		3	X				X
18-1 (78-80 cm)		7		X	X				
18-2 (72-74 cm)		3						1	
18-3 (73-75 cm)		16							X
18-4 (72-74 cm)		6							3
18-5 (40-42 cm)		1			X			1	4
19-1 (72-74 cm)	17	10		X	X		X	1	17
19-2 (72-74 cm)	10	8	X	X			1	X	21
19-3 (73-75 cm)	8	4		1	X			28	4
19-4 (76-78 cm)	7	3		1	X		X		8
19-5 (72-74 cm)	2	3		1	X				11
19-6 (72-74 cm)	14	4		X	X			1	10
19-7 (11-13 cm)	8	6			1				5
20-1 (70-72 cm)	22	X		4	1	X	X	3	8

Ahmuellerella spp. = *A. octoradiata* and *A. regularis*; Arkhangelskiella spp. = *A. confusa*; *A. cymbiformis*, *A. maastrichtiensis* and *A. specillata*; *Biscutum* spp. = *B. constans*, *B. dissimilis*, *B. melaniae* and *B. notaculum*; *Cervisiella* spp. = *C. operculata* and *C. saxea*; *Chiastyozygus* spp. = *C. amphipons*, *C. garrisonii* and *C. literarius*; *Cribrosphaerella* spp. = *C. daniae* and *C. ehrenbergii*; *Eiffellithus* spp. = *E. gorkae*, *E. parallelus* and *E. turriseiffelii*; *Gartnerago* spp. = *G. obliquum* and *G. segmentatum*; *Helicolithus* spp. = *H. anceps* and *H. trabeculatus*; *Lapideacassis* spp. = *L. asymetrica*, *L. mariae* and *L. tricornus*; *Micula* spp. = *M. cubiformis*, *M premolisilvae* and *M. staurophora*; *Prediscosphaera* spp. = *P. arkhangelskyi*, *P. cretacea*, *P. grandis* and *P. spinosa*; *Retecapsa* spp. = *R. crenulata*, *R. ficula* and *R. surirella*; *Staurolithites* spp. = *S. flavus* and *S. imbricatus*; *Watznaueria* spp. = *W. barnesiae*, *W. fossacincta* and *W. ovata*; and *Zeugrhabdotus* spp. = *Z. bicrescenticus*, *Z. embergeri*, *Z. praesigmoides* and *Z. sigmoides*.

X - species identified after the count

K. magnificus acme

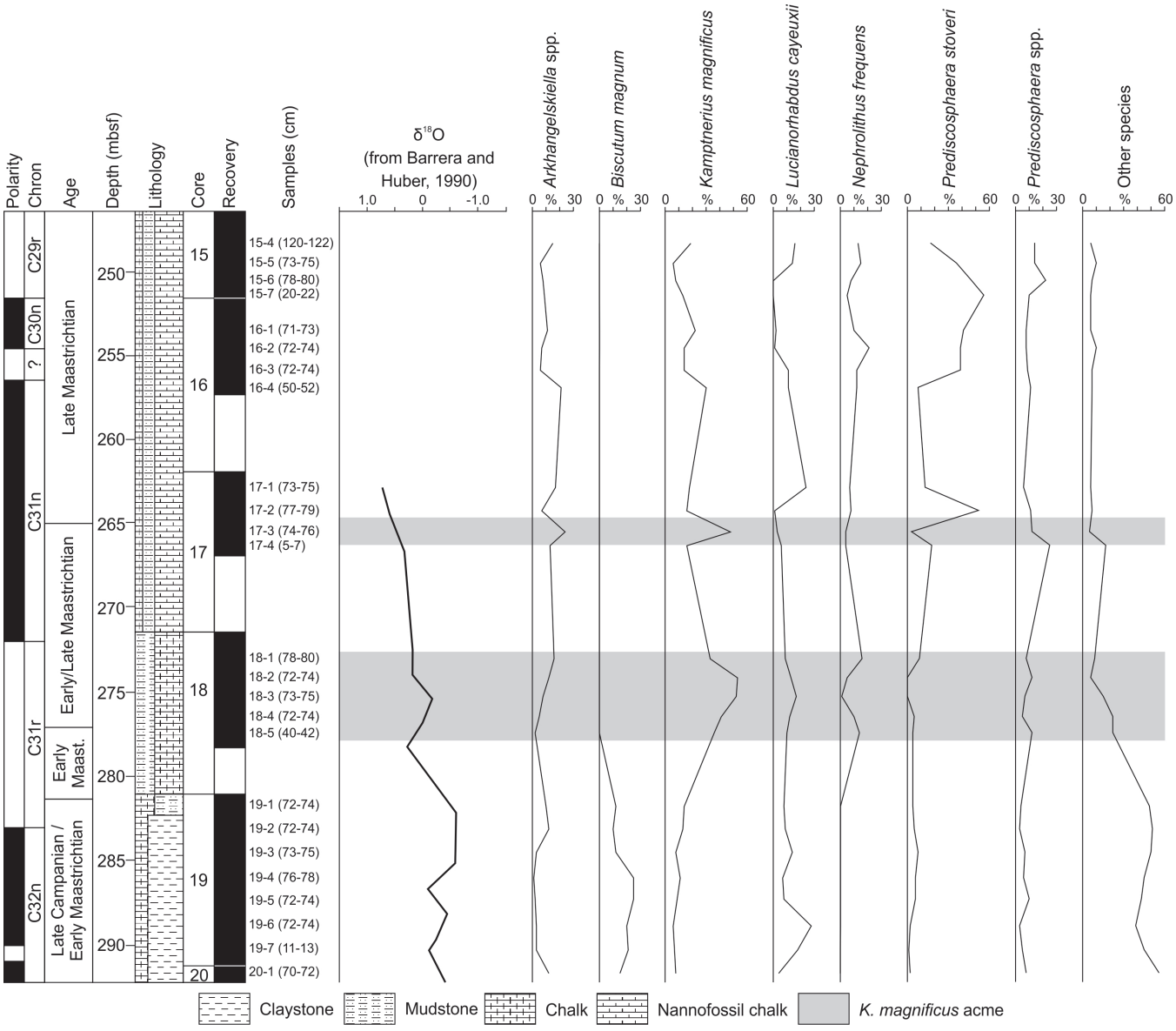
TEXT-FIGURE 2
Range-chart showing calcareous nannofossil distribution and biostratigraphical interpretation for Hole 690C.

ODP Leg 114 - Hole 700B						Calcareous nannofossils species																																				Biostratigraphy based on the SAH zonation of Guerra et al., 2016	
Sample	Depth (mbsf)	Preservation	Nº Field of view	Species Richness	Total	*Ahmuellerella octoradiata*	*Arkhangelskiella* spp.	*Biscutum magnum*	*Biscutum* spp.	*Broinsonia* (small)	*Cervisiella* spp.	*Chiastozygus* spp.	*Cretarhabdus conicus*	*Cribrosphaerella* spp.	*Cylindralithus* spp.	*Eiffellithus* spp.	*Gartnerago* spp.	*Kamptnerius magnificus*	*Lapideacassis mariae*	*Lapideacassis* sp.	*Lithraphidites carniolensis*	*Lucianorhabdus cayeuxii*	*Markalius inversus*	*Microrhabdulus decoratus*	*Micula* spp.	*Monomarginatus quaternarius*	*Nephrolithus corystus*	*Nephrolithus frequens*	*Placozygus fibuliformis*	*Prediscosphaera* spp.	*Prediscosphaera stoveri*	*Reinhardtites anthophorus*	*Reinhardtites levis*	*Retecapsa* spp.	*Staurolithites mielnicensis*	*Teichorhabdus ethmos*	*Watznaueria* spp.	*Zeugrhabdotus* spp.	Biological events		
37-1 (70-71 cm)	331.40	M	14	19	312		52		1			X		15		1		67				3			2		X	42		32	93			3			1				SAH1	Late Maast.
37-2 (74-75 cm)	332.94	M	19	25	303		21				3	X		2		X		110	1	X		4			X		X	50	3	12	94			2		1	X		*P. stoveri* acme		
38-1 (73-74 cm)	336.23	M	14	26	305	X	63		X		1			X	X	3		171				X	X		17		X	X		28	16			2		1	3			SAH2	Early/Late Maastrichtian
38-2 (72-73 cm)	337.72	M	31	26	302		31			X	2			X	X	1		213				20		X	18		X	3	4	6	2			1		1	X	X			
38-3 (71-72 cm)	339.21	M	78	25	312		38		X		1			X		2		184				43			13		X	11	X	18				1		X	1				
38-4 (70-71 cm)	340.70	M	79	25	302		34		X		3	X		X		3		189				19			10		X	9		28				2		1	3	1			
38-5 (71-72 cm)	342.21	M	29	25	305		11		2		1			4		2	X	130			X	57		X	2	X	X	12		81				3			X	X			
39-1 (72-73 cm)	345.72	M	71	30	300	6	28		1		3		X	3	X	4	X	152			X	46			X	X	X	9		40	X			6	1	1	X	X			
39-2 (73-74 cm)	347.23	M	40	30	303		16	1	1		5			4	X	11		149	1			63			5	1	X	15	19	6	1			2		1	X	2	Lo *B. magnum*		
39-3 (71-72 cm)	348.71	M	98	24	318		19	12			X			7		16	5	180				8			5	1	X	28	18	10	5					3	1			SAH3	Early Maast.
39-4 (74-75 cm)	350.24	M	147	15	359		X	19	X		1			X				331				3			1		X	2		2						X	X	X			
40-1 (70-71 cm)	355.20	M	110	16	307		28	31			X			4				234				X			2	X		2		6			X	X				X	Lo *R. levis*		
40-2 (71-72 cm)	356.71	M	134	19	301		12	36	2		3					1		233				2			3			1		3	1			4	X		X	X			
40-3 (73-74 cm)	358.23	M	111	19	303		12	40			X					1		228				3	X		5	X				1				9	2			1	1			
40-4 (70-71 cm)	359.70	M	86	17	319		31	37	2		2			1		1		198				38			X				X	X		1	3	2				3			SAH4	Late Campanian / Early Maastrichtian
40-5 (71-72 cm)	361.21	M	202	16	301		9	89	2		X			X		1		92				94			X			2		3	X			2				7			
41-1 (71-72 cm)	364.71	M	93	28	300	2	2	121	2			X		1		X	1	36				94			X	X	X	1	X	2	6		9	1	X	1		18			
41-2 (74-75 cm)	366.24	M	97	26	301	X	14	118	6		1			3		1	1	51				93			1	6	X		X	1	X		5			X		X			

Arkhangelskiella spp. = *A. confusa*; *A. cymbiformis* and *A. maastrichtiensis*; *Biscutum* spp. = *B. constans*, *B. dissimilis*, *B. melaniae* and *B. notaculum*; *Cervisiella* spp. = *C. operculata* and *C. saxea*; *Chiastyozygus* spp. = *C. bifarius* and *C. literarius*; *Cribrosphaerella* spp. = *C. daniae* and *C. ehrenbergii*; *Cylindralihus* spp. = *C. biarcus* and *C.* serratus; *Eiffellithus* spp. = *E. gorkae* and *E. turriseiffelii*; *Gartnerago* spp. = *G. obliquum* and *G. segmentatum*; *Micula* spp. = *M. cubiformis*, *M. staurophora* and *M. swastica*; *Prediscosphaera* spp. = *P. arkhangelskyi*, *P. cretacea* and *P. spinosa*; *Retecapsa* spp. = *R. crenulata* and *R. surirella*; *Watznaueria* spp. = *W. barnesiae* and *W. manivitiae*; and *Zeugrhabdotus* spp. = *Z. bicrescenticus*, *Z. praesigmoides* and *Z. sigmoides*.

X - species identified after the count ▭ *K. magnificus* acme

TEXT-FIGURE 3
Range-chart showing calcareous nannofossil distribution and biostratigraphical interpretation for Hole 700B.



TEXT-FIGURE 4
Abundance of selected species at Hole 690C are reported against chronostratigraphy, age, lithology and oxygen isotope values.

MATERIAL AND METHODS

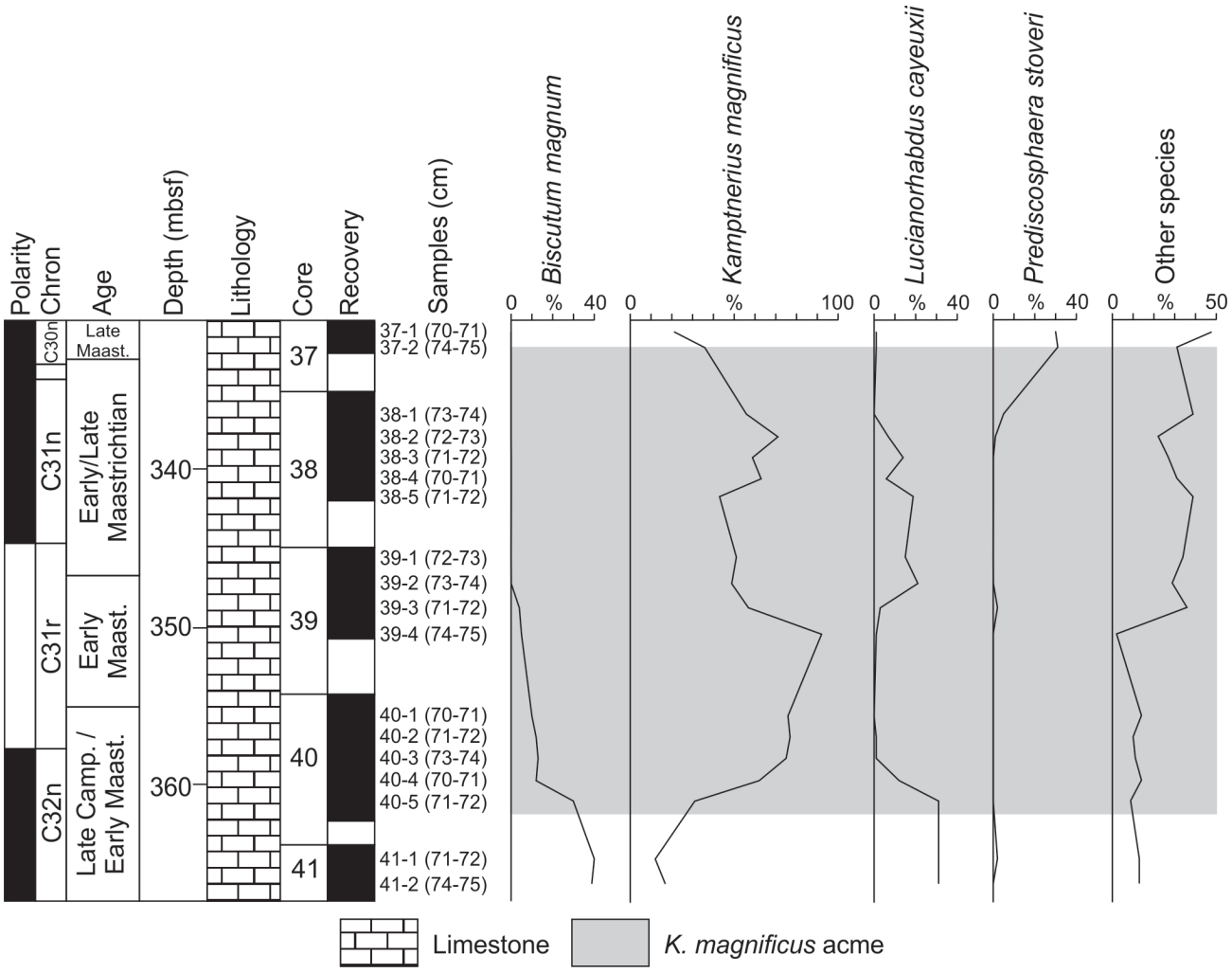
Holes 690C and 700B were drilled by Ocean Drilling Program (ODP) in 1987 in the South Atlantic section of the Southern Ocean (text-figure 1). Twenty-five samples were taken from the Upper Campanian-Maastrichtian section at Hole 690C composed of foraminifer-bearing muddy nannofossil chalk, muddy nannofossil chalk, calcareous claystone, clayed chalk, and muddy chalk. At Hole 700B 18 samples were taken from micritic limestone, clay-bearing micritic limestone, and limestone.

One sample was taken per section, corresponding to a sampling resolution of ~1.5 meters. The total of 43 samples were prepared following the standard smear-slide technique described in Bown and Young (1998).

A quantitative study was performed using a Zeiss Axio Imager A2 microscope at 1000x magnification. At least 300 specimens were counted per sample, followed by the scanning of three more longitudinal traverses (~300 fields of view) for rare taxa missing in the initial counts, indicated in our range charts by "X". Sometimes, important markers were identified after the counting, denoting species present but do not represent only one specimen.

RESULTS

The biostratigraphic analysis at Holes 690C and 700B showed a significant increase in *Kamptnerius magnificus* abundances starting between the Late Campanian and Early Maastrichtian stages. Most of the specimens identified are large to very large in size and have a small flange (Plate 1, Figures A-B, F-J). Also



TEXT-FIGURE 5
Abundance of selected species at Hole 700B are reported against chronostratigraphy, age and lithology.

some specimens are broken (Plate 1, Figures H-I), and just a few specimens with medium to large flanges were identified (Plate 1, Figures C-E).

At Hole 690C the acme interval of this species is located between Samples 18-5 and 17-3 (277.80 to 265.54 mbsf), corresponding to ~12.26 m, while at Hole 700B this interval occurs between Samples 40-5 and 37-2 (361.21 to 332.94 mbsf) measuring ~28.27 m.

The range-charts with the species distribution along both sections are presented in text-figures 2 and 3. Some species were grouped into higher taxonomic levels, such as *Ahmuellerella* spp., *Arkhangelskiella* spp., *Biscutum* spp. *Cervisiella* spp., *Chiastozygus* spp., *Cribrosphaerella* spp., *Cylindralithus* spp., *Eiffellithus* spp., *Gartnerago* spp., *Helicolithus* spp., *Lapideacassis* spp., *Micula* spp., *Prediscosphaera* spp., *Retecapsa* spp., *Staurolithites* spp., *Watznaueria* spp., *Zeugrhabdotus* spp. The biostratigraphic framework for the two holes has been taken from Guerra et al. (2016).

In text-figures 4 and 5 the percentages of the most abundant species were plotted against chronostratigraphy, age, lithology and oxygen isotope values (when available). At Hole 690C *K. magnificus* shows a percentage ranging from 6-30% before/after the acme interval and increases to 33-52% during the acme interval (text-figure 4), whereas at Hole 700B the percentage before/after the acme ranges between 12-21% and during the acme a striking 31-92% (text-figure 5).

DISCUSSION

A significant increase in abundance of some species has been used as biostratigraphic and paleoceanographic markers. According to Lees (2002), since the first occurrences and last occurrences of the stratigraphically useful, widely-correlatable Upper Cretaceous nannofossil taxa are now fairly well constrained, the next generation of improvements is likely to depend more on identifying widely-correlatable abundances of certain taxa.

Despite its wide global distribution, the occurrences of *Kamptnerius magnificus* have been associated to cool water temperatures (Thierstein 1976, 1981; Gardin and Monechi 1998; Gardin 2002; Lees 2002; Thibault and Gardin 2006, 2007; Thibault et al. 2010; Sheldon et al. 2010; Linnert et al.

2011; Thibault et al. 2015; Thibault and Husson, 2016), mainly because of its preference for high-latitudes.

Thibault et al. (2015) was the first study to report a *Kamptnerius magnificus* acme interval similar to the one described herein. The authors analyzed an Upper Campanian-Maastrichtian section from Denmark and reported two possible acmes of *K. magnificus*, interpreted as cooling of sea-surface temperatures (SST). At Hole 690C the beginning of the increase in *K. magnificus* coincides with the same level where the $\delta^{18}O$ suddenly increases (close to sample 18-5, see text-figure 4), a pattern that probably indicates cooling of the SST. As well as Thibault et al. (2015) some previous studies used sudden small increases in *K. magnificus* abundances (and other high-latitude taxa) to characterize intervals of cooling (Thibault and Gardin, 2006; 2007; Sheldon et al., 2010).

The biostratigraphic value of this acme was not proven in the South Atlantic section of the Southern Ocean, because this bioevent seems to be somewhat diachronous between the two holes analyzed in this study. At Hole 690C the increase in abundances of *K. magnificus* starts in the middle part of Chron C31r (Early Maastrichtian), while at Hole 700B this phenomenon starts in the middle part/top of Chron C32n (Late Campanian/Early Maastrichtian) (see text-figures 4 and 5).

CONCLUSION

This study documents for the first time the presence of an *Kamptnerius magnificus* acme in the South Atlantic section of the Southern Ocean. The increase in abundance of this specie is attributed to cooling in sea-surface temperature during the Late Campanian-Maastrichtian in the high-latitudes. This description is the first step in the record of this sort of biovent. We intend to make new C^{13} and O^{18} isotope analyses for each site, as well as different trace-elements analyses to better understand the main factors that lead to these notable acme events.

ACKNOWLEDGMENTS

The authors thanks the staff of Itt Fossil, Universidade do Vale do Rio dos Sinos (UNISINOS). David K. Watkins is thanked for the critical revision of this manuscript. This study constitutes part of the Ph.D. thesis of the first author at Universidade do Vale do Rio dos Sinos (UNISINOS), São Leopoldo - Brazil, partially supported by Padre Milton Valente scholarship. Rodrigo M. Guerra thanks Conselho Nacional de Desenvolvimento Científico e Tecnológico (CAPES - Proc. BEX 10863/14-1) by the supporting to a internship at Florida State University (FSU). This paper is the contribution number R-180 of Instituto de Estudios Andinos "Don Pablo Groeber" (IDEAN-CONICET). This work was partially supported by grant ANPCYT, PICTO-DNA 2010-00112.

REFERENCES

BOWN, P.R., and YOUNG, J.R., 1998. Techniques. In*:* Bown, P.R., Ed., *Calcareous Nannofossil Biostratigraphy.* British Micropalaeontological Society Series. London: Chapman and Hall/Kluwer Academic Publishers, pp. 16-28.

CRUX, J.A., 1991. Calcareous nannofossils recovered by Leg 114 in the Subantarctic South Atlantic Ocean. *Proceedings of the Ocean Drilling Program, Scientific Results,* 114: 155-177.

GARDIN, S., 2002. Late Maastrichtian to early Danian calcareous nannofossils at Elles (Northwest Tunisia): A tale of one million years across the K/T boundary. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 178(3-4): 211-231.

GARDIN, S., and MONECHI, S., 1998. Paleoecological change in middle to low-latitude calcareous nannoplankton at the Cretaceous/Tertiary boundary. *Bulletin de la Societe Geologique de France,* 169(5): 709-723.

GUERRA, R.M., CONCHEYRO, A., WISE JR, S.W., KENDER, S., and FAUTH, G., 2016. New latitude-based nannofossil zonations for the Campanian-Maastrichtian of the South Atlantic Ocean and its paleoceanographic implications. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 452: 55-67.

LEES, J.A., 2002. Calcareous nannofossil biogeography illustrates palaeoclimate change in the Late Cretaceous Indian Ocean. *Cretaceous Research,* 23: 537-634.

LINNERT, C., MUTTERLOSE, J., and HERRLE, J.O., 2011. Late Cretaceous (Cenomanian-Maastrichtian) calcareous nannofossils from Goban Spur (DSDP Sites 549, 551): Implications for the palaeoceanography of the proto North Atlantic. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 299: 507-528.

POSPICHAL, J.J., and WISE, S.W., 1990. Maestrichtian calcareous nannofossil biostratigraphy of Maud Rise, ODP Leg 113 Sites 689 and 690, Weddell Sea. *Proceedings of the Ocean Drilling Program, Scientific Results,* 113: 465-487.

SHELDON, E., INESON, J., and BOWN, P.R., 2010. Late Maastrichtian warming in the Boreal Realm: Calcareous nannofossil evidence from Denmark. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 295: 55-75.

THIBAULT, N., and GARDIN, S., 2006. Maastrichtian calcareous nannofossil biostratigraphy and paleoecology in the Equatorial Atlantic (Demerara Rise, ODP Leg 207 Hole 1258A). *Revue de Micropaleontology,* 49: 199-214.

———, 2007. The Late Maastrichtian nannofossil record of climate change in the South Atlantic DSDP Hole 525A. *Marine Micropaleontology,* 65: 163-184.

THIBAULT, N., and HUSSON, D., 2016. Climatic fluctuations and sea surface water circulation patterns at the end of the Cretaceous era: calcareous nannofossil evidence. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 411(1): 152-164.

THIBAULT, N., GARDIN, S., and GALBRUN, B., 2010. Latitudinal migration of calcareous nannofossil *Micula murus* in the Maastrichtian: Implications for global climate change. *Geology,* 38(3): 203-206.

THIBAULT, N., ANDERSKOUV, K., BJERAGER, M., BOLDREEL, L.O., JELBY, M.D., STEMMERICK, L., and SURLYK, F. 2015. Upper Campanian-Maastrichtian chronostratigraphy of the Skaelskor-1 core, Denmark: correlation at the basinal and global scale and implications for changes in sea-surface temperatures. *Leth*aia, 48(4): 549-560.

THIERSTEIN, H.R., 1976. Mesozoic calcareous nannoplankton biostratigraphy of marine sediments. *Marine Micropaleontology* 1: 325-362.

———, 1981. Late Cretaceous Nannoplankton and the change at the Cretaceous-Tertiary boundary. *SEPM Special Publication* 32: 355-394.

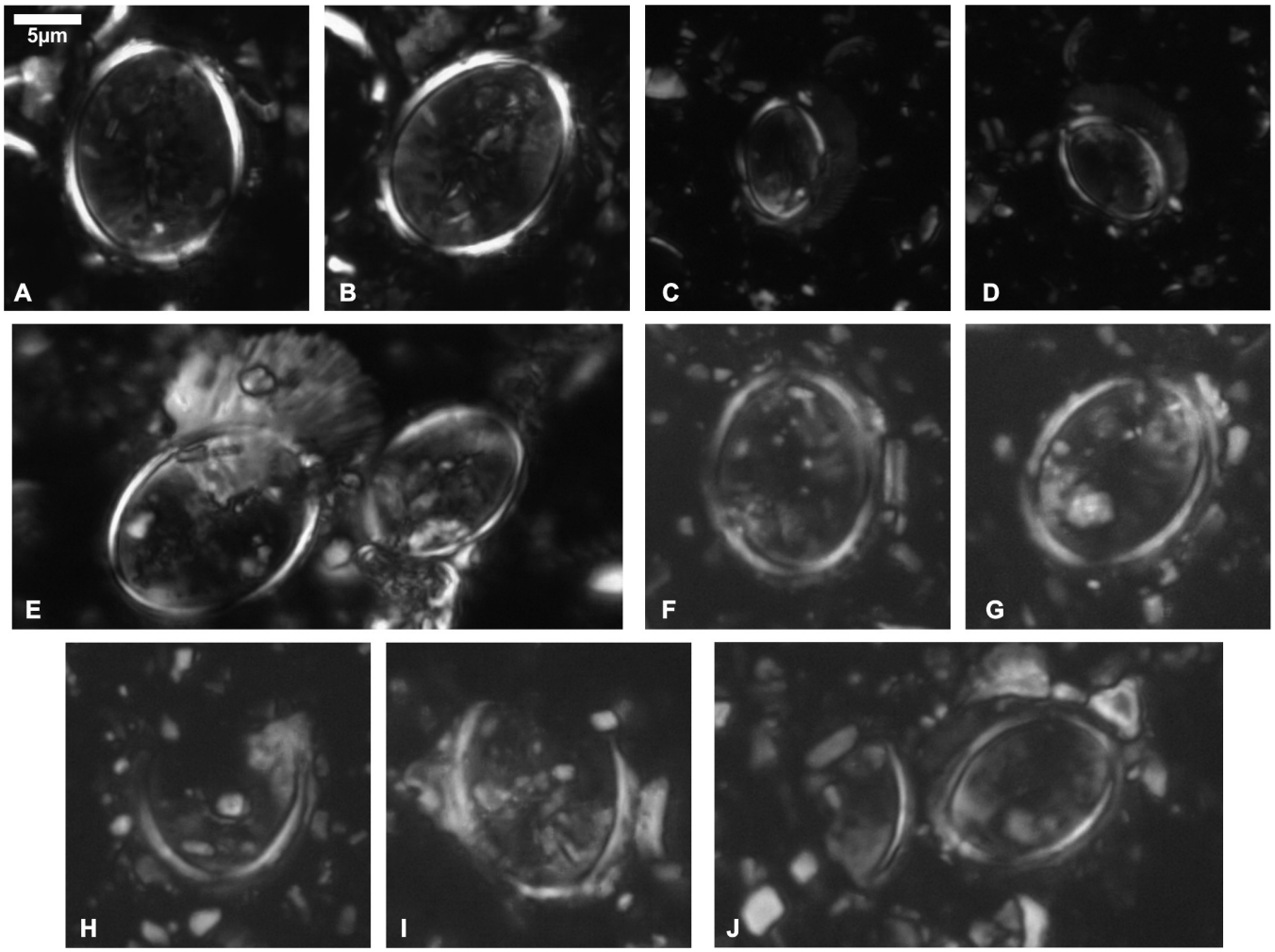


PLATE 1

A-B	Hole 690C Sample 18-4 (276.62 mbsf)	F-G	Hole 700B Sample 40-1 (355.20 mbsf)
C-D	Hole 690C Sample 18-1 (272.18 mbsf)	H-I	Hole 700B Sample 40-2 (340.70 mbsf)
E	Hole 690C Sample 17-3 (265.54 mbsf)	J	Hole 700B Sample 40-4 (332.94 mbsf)