geosciences

Supplementary of

Environmental and Oceanographic Conditions at the Continental Margin of the Central Basin, Northwestern Ross Sea (Antarctica) Since the Last Glacial Maximum

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Supplementary S1

Grain size data

In this section the box cores are described from the grain size point of view. The grain size raw data and the assigned clusters are reported in Table S1.

BC02

Silt is the prevailing fraction (avg 76% min 53, max 86%), while the sand content ranges from 7 to 43% with a mean value of 18%. Clay content is low and ranges between 4 and 9% with a mean value of 6%. The sediment is poorly to very poorly sorted (σ_i avg: 1.94 Φ). The skewness varies from near symmetrical to positive skewed (SK avg: 0.08) and the mean diameter (Mz) varies from 4.56 to 6.47 Φ (Mz avg 5.75 Φ, coarse silt). Sediments are mainly bimodal with primary modal diameter ranging between 4 and 7 Φ, and secondary modal diameter around 2 Φ.

BC03

Silt is the prevailing fraction ranging between 56 and 88%, with a mean content of 75.5%. Medium sand content is 18% and varies from 6 and 41%. The clay content is low (between 4 and 6%; avg: 6%). The sediment is poor sorted (σ_i avg: 1.86 Φ) and positive skewness prevails (SK avg: 0.19). The mean Mz is 5.69 Φ—coarse silt (min 4.71 Φ, max 6.27 Φ). Samples are mainly bimodal with a primary mode ranging from 4 to 6 Φ. Only one sample has the primary mode at 7 Φ (24–25 cm). The secondary mode is at 1.50 Φ.

BC04

Silt is the prevalent fraction (avg 77%, min 65% max 83%), sand varies from 11 to 31% (avg 17%) and clay ranges between 3 and 7% (avg 6%). Sediment is poor to very poor sorted (from 1.58 to 2.11 Φ—avg 1.86 Φ) with a prevailing positive skewness (SK avg 0.17). Mz varies from 4.89 to 5.95 Φ (avg 5.63 Φ—coarse silt). Sediments are mainly bimodal with primary mode at 4.50–5.50 Φ and secondary mode around 2 Φ.

Table S1. Grain size data and **s**tatistical parameters. Mz, σ_i, Sk and Kg are the mean size, sorting, skewness and kurtosis according to [1], C is the 1st percentile, M is the median, >1 mm are the particles >1 mm. The assigned cluster for each level is indicated.

Level—Cm	Sand %	Silt %	Clay %	Mz Φ	σ_i Φ	Sk	Kg	C μm	M μm	>1 mm Counts	Cluster
BC2-1	20.7	74.2	5.0	5.43	1.82	0.22	1.04	419	27.5	12	4
BC2-3	16.7	79.1	4.2	5.40	1.62	0.26	1.11	356	28.0	34	4
BC2-4	17.2	78.5	4.2	5.41	1.65	0.25	1.10	376	27.7	41	4
BC2-6	14.4	80.5	5.1	5.58	1.69	0.25	1.10	410	25.0	20	4
BC2-7	11.5	82.7	5.8	5.76	1.71	0.24	1.08	415	21.8	19	3
BC2-8	11.2	81.4	7.4	5.95	1.83	0.20	1.03	422	19.1	23	2
BC2-10	11.6	80.5	7.8	6.02	1.89	0.16	1.04	438	17.9	25	2
BC2-11	13.1	79.2	7.7	5.99	1.95	0.12	1.05	441	17.8	18	2
BC2-12	14.1	78.9	7.0	5.89	1.94	0.12	1.10	468	19.2	44	2
BC2-14	12.3	80.2	7.4	6.14	1.90	0.03	1.02	454	14.4	30	1
BC2-15	16.5	75.4	8.1	6.03	2.15	-0.04	1.08	502	15.2	45	1
BC2-16	15.5	77.3	7.1	6.02	2.12	-0.06	1.18	508	15.3	60	1
BC2-18	8.4	84.3	7.3	6.47	1.76	-0.04	1.09	412	11.0	51	1
BC2-19	12.6	79.5	7.9	6.24	2.08	-0.08	1.25	554	13.1	21	1
BC2-20	7.1	86.1	6.7	6.36	1.67	0.05	1.06	358	12.6	28	1
BC2-22	11.7	81.4	6.9	6.30	1.93	-0.10	1.14	464	12.0	27	1
BC2-23	7.8	86.0	6.2	6.27	1.67	0.06	1.05	348	13.5	33	1
BC2-24	11.0	79.8	9.2	6.44	1.97	-0.06	1.10	536	11.1	53	1
BC2-26	13.0	81.7	5.3	5.98	1.82	0.02	1.02	414	16.2	63	2
BC2-27	10.9	83.8	5.3	5.99	1.72	0.09	1.01	299	16.6	90	2
BC2-28	14.1	80.0	5.9	5.98	1.86	0.03	0.98	429	16.1	107	2
BC2-29	18.0	76.7	5.3	5.73	1.91	0.07	0.98	400	20.0	76	3
BC2-30	24.8	69.5	5.7	5.42	2.14	0.08	1.07	572	25.9	97	3
BC2-31	29.6	65.6	4.8	5.07	2.26	0.00	1.11	663	29.7	102	3
BC2-32	32.0	63.0	5.0	5.08	2.28	0.05	1.01	616	31.3	95	6
BC2-33	30.8	64.7	4.5	5.07	2.17	0.05	1.07	619	31.2	68	6
BC2-34	29.7	65.7	4.6	5.13	2.05	0.12	1.05	460	31.8	109	6
BC2-35	36.1	58.2	5.7	5.01	2.38	0.11	0.92	577	34.5	111	6
BC2-36	42.9	53.2	3.9	4.56	2.23	0.16	1.02	630	49.2	53	6
BC3-1	41.0	55.6	3.4	4.71	1.76	0.38	1.12	553	50.9	1	6
BC3-3	31.7	63.6	4.7	5.11	1.88	0.33	0.98	468	38.2	1	6
BC3-4	27.8	66.9	5.3	5.26	1.91	0.30	0.98	460	33.5	21	6
BC3-5	19.0	74.6	6.4	5.66	1.91	0.22	0.94	427	23.6	8	3
BC3-6	17.3	76.1	6.7	5.71	1.89	0.23	0.96	397	22.9	9	3
BC3-7	18.0	75.4	6.5	5.70	1.91	0.19	0.97	408	22.3	18	3
BC3-8	19.6	73.9	6.6	5.63	1.93	0.22	0.97	446	24.2	19	3
BC3-10	17.6	76.8	5.5	5.61	1.81	0.20	0.98	432	23.4	4	3
BC3-11	17.6	76.2	6.1	5.70	1.87	0.18	0.95	389	21.9	4	3
BC3-12	17.3	76.7	6.0	5.70	1.85	0.18	0.96	376	21.8	2	3
BC3-13	18.0	76.3	5.7	5.61	1.83	0.21	0.98	420	23.9	4	3
BC3-14	16.1	77.5	6.5	5.81	1.89	0.14	0.98	438	19.8	7	3
BC3-15	12.0	80.1	7.9	6.00	1.87	0.18	0.97	421	17.9	13	2
BC3-16	11.0	81.2	7.7	6.04	1.84	0.17	0.97	376	17.3	14	2
BC3-18	8.3	85.0	6.7	6.22	1.72	0.09	1.00	312	14.3	9	1
BC3-19	10.0	83.5	6.5	6.09	1.76	0.12	0.97	308	15.9	13	2
BC3-20	15.6	77.7	6.7	5.82	1.89	0.15	0.99	431	19.8	19	3
BC3-21	13.4	80.1	6.4	5.79	1.79	0.25	0.96	131	21.6	9	3
BC3-22	6.7	84.8	8.5	6.27	1.76	0.17	0.95	108	14.6	6	2
BC3-23	5.6	88.1	6.3	6.19	1.63	0.17	0.96	99	15.2	4	2
BC3-24	6.7	86.2	7.1	6.19	1.70	0.17	0.96	107	15.3	8	2
BC3-26	10.0	83.5	6.5	6.05	1.75	0.14	0.96	224	16.5	12	2
BC3-27	10.2	83.7	6.0	6.04	1.73	0.12	0.97	348	16.5	9	2
BC3-28	10.3	84.4	5.3	5.98	1.68	0.12	0.97	176	17.1	26	2
BC3-29	18.4	75.4	6.2	5.69	1.93	0.15	0.98	475	22.0	36	3
BC3-30	20.1	73.0	6.9	5.70	1.99	0.15	0.94	390	21.7	35	3
BC3-31	23.8	69.3	6.9	5.55	2.02	0.21	0.93	439	25.5	33	6
BC3-32	27.5	66.6	5.9	5.37	2.01	0.21	0.93	407	28.7	27	6
BC3-34	27.5	67.1	5.4	5.34	1.94	0.24	0.92	322	29.7	25	6
BC3-35	30.5	64.8	4.6	5.17	1.94	0.22	0.95	433	33.3	27	6
BC3-36	31.6	63.0	5.4	5.17	2.09	0.20	0.98	469	33.3	38	6

BC3-37	27.5	67.9	4.7	5.21	1.96	0.16	1.07	475	31.1	13	6
BC4-1	26.5	69.8	3.7	4.99	1.80	0.15	1.36	479	35.9	51	5
BC4-2	26.9	69.7	3.4	4.89	1.58	0.25	1.38	418	39.2	56	5
BC4-3	27.5	68.7	3.8	5.03	1.91	0.14	1.31	545	35.7	67	5
BC4-4	25.4	70.8	3.8	5.09	1.73	0.24	1.20	426	35.2	58	5
BC4-5	30.7	65.6	3.7	4.91	1.83	0.19	1.25	491	39.0	74	5
BC4-6	21.1	74.3	4.6	5.33	1.84	0.20	1.17	483	29.9	56	4
BC4-7	22.8	72.6	4.6	5.30	1.94	0.16	1.20	487	30.0	44	4
BC4-8	19.5	75.5	5.0	5.46	1.90	0.15	1.14	421	26.4	60	4
BC4-9	27.4	68.4	4.2	5.10	2.01	0.11	1.23	610	33.5	42	4
BC4-10	16.7	77.7	5.6	5.66	1.93	0.11	1.14	483	22.4	33	3
BC4-11	20.2	74.6	5.2	5.50	2.05	0.05	1.20	567	24.1	20	3
BC4-12	13.0	80.8	6.1	5.88	1.81	0.13	1.04	355	18.8	24	2
BC4-13	13.1	81.3	5.5	5.73	1.74	0.20	1.05	429	21.7	19	3
BC4-14	13.2	80.4	6.3	5.90	1.91	0.08	1.15	495	18.3	15	2
BC4-15	13.2	81.3	5.5	5.77	1.77	0.14	1.09	433	20.3	17	2
BC4-16	11.7	81.9	6.3	5.91	1.79	0.15	1.07	419	18.5	14	2
BC4-17	12.3	81.2	6.4	5.95	1.83	0.11	1.04	450	17.7	9	2
BC4-18	12.4	81.8	5.8	5.79	1.74	0.19	1.05	433	20.7	14	3
BC4-19	13.8	80.5	5.6	5.73	1.77	0.18	1.07	393	21.6	27	3
BC4-20	11.5	82.0	6.4	5.88	1.78	0.18	1.05	473	19.5	19	2
BC4-21	14.1	79.8	6.1	5.73	1.78	0.24	1.01	294	22.6	12	3
BC4-22	12.3	81.1	6.6	5.84	1.78	0.24	0.99	316	20.7	12	3
BC4-23	13.9	79.3	6.7	5.82	1.86	0.20	1.01	430	20.9	12	3
BC4-24	15.2	78.3	6.5	5.73	1.89	0.20	1.08	618	22.6	17	3
BC4-25	11.9	81.3	6.8	5.94	1.82	0.17	1.01	414	18.7	3	2
BC4-26	15.3	78.2	6.5	5.75	1.89	0.19	1.06	451	22.0	13	3
BC4-27	15.2	78.3	6.6	5.76	1.86	0.20	1.02	400	21.8	17	3
BC4-28	13.8	79.5	6.7	5.81	1.84	0.21	1.03	446	21.2	12	3
BC4-29	15.7	78.1	6.2	5.70	1.83	0.22	1.02	414	23.0	17	3
BC4-30	15.8	77.7	6.5	5.74	1.90	0.18	1.06	464	22.1	23	3
BC4-31	15.3	78.2	6.5	5.79	1.90	0.16	1.06	455	21.0	19	3
BC4-32	14.9	78.6	6.5	5.77	1.86	0.20	1.04	441	21.5	31	3
BC4-33	20.0	74.5	5.5	5.46	1.86	0.21	1.09	456	27.0	9	4
BC4-34	17.9	76.4	5.7	5.56	1.90	0.17	1.12	479	25.0	20	4
BC4-35	16.0	77.6	6.5	5.73	1.89	0.20	1.04	454	22.4	26	3
BC4-36	14.3	79.3	6.5	5.77	1.83	0.23	1.02	362	22.0	21	3
BC4-37	11.7	82.3	6.0	5.93	1.77	0.17	0.95	309	18.4	15	2
BC4-38	11.1	82.7	6.2	5.93	1.76	0.20	0.94	338	19.1	26	3
BC4-39	16.0	77.0	7.0	5.80	1.90	0.21	0.95	428	21.4	24	3
BC4-40	14.5	78.3	7.2	5.88	1.90	0.18	0.96	363	19.8	19	3
BC4-41	12.5	82.0	5.5	5.86	1.76	0.17	0.97	342	19.5	8	3
BC4-42	17.7	75.8	6.5	5.77	1.99	0.10	1.03	434	20.3	38	3
BC4-43	22.2	71.8	6.0	5.56	2.08	0.09	1.04	483	23.4	58	3
BC4-44	29.3	65.3	5.3	5.29	2.07	0.15	0.95	460	29.2	109	6
BC4-45	24.2	70.0	5.8	5.49	2.11	0.08	1.03	545	24.5	63	3

Supplementary S2

In this section we report a summary of the ecological and paleoenvironment meaning of the micropaleontological proxies used in this study.

Diatoms

The group composed of *Chaetoceros* resting spore (CRS) is used as a proxy for stratified and low salinity water related with the glacial retreat and/or ice melting. CRS is also associated with high productivity and/or upwelling [1–3]. *Eucampia antarctica* var. *recta* (the symmetric and polar forms, hereafter *E. antarctica*) lives at the ice edge [4] and is used as a proxy for meltwater from glacier and/or iceberg which release iron and promote *E. antarctica* growth [5–8]. *Thalassiosira antarctica* flourishes during the summer and forms resting spores when sea ice returns [9]. In the western Ross Sea [10] reported that *T. antarctica* was associated with the proximity of the ice shelf or sea ice edge. *Fragilariopsis curta* is used as a proxy for qualitative sea ice extension [3,11,12].

F. obliquecostata is related to cold water near the ice edge [10,13]. *F. kerguelensis* dominates in open ocean zones where sea ice is absent during the summer [9] and it is related to warm water intrusion [14,15] in the Ross Sea; it is used as an indicator of CDW [16]. The "warm water group" species, is composed of *Thalassiosira lentiginosa, T. oliverana,* and *T. gracilis*, and indicates warm water intrusion and/or open ocean condition [14].

Silicoflagellates

Open ocean group: including S*tephanocha. speculum* var. *speculum*, and var. *monospicata*, var. *bispicata*; it is found in the present-day permanently in open ocean waters or close to the winter sea ice limit [17] *S. speculum* var. *coronata* is found in the present-day sea ice dominated waters [18], *S. speculum* var. *minuta* (included in this work along with var. *coronata* because the two characters co-occur) is a cold-water indicator, typically increasing in relative abundance at higher latitudes [19–21].

Foraminifera

Neogloboquadrina pachyderma (Ehrenberg) is the only planktic foraminifera able to live in polar oceans, generally feeding on bacteria and diatoms. This species can also survive in brine channels within sea ice under hyper-saline and low temperature conditions [22–24]. The encrusted adults are related to warm-season while non-encrusted juvenile forms are related to autumn–winter season [25]. The co-presence of both growth stages of *N. pachyderma* suggests the accumulation of tests from different seasons, as already observed in a core located in the same area [26]. *Cibicides* spp., *Globocassidulina biora, G. subglobosa, Nonionella* spp., and *Trifarina earlandi* are commonly correlated to diverse sub ice shelf paleoenvironments, from a proximal to a distal position in respect to the grounding line sector (Bart et al., 2016 [27–31]. *Alabaminella weddellensis* and *Epistominella exigua* are small taxa generally occurring in the deep Atlantic and upper slope bathyal Southern Ocean under the influence of the AABW [32,33]. Furthermore, they are considered opportunistic species (r-strategist) adapted to fluctuating food supply in areas where sea ice hinders the seasonal accumulation of phytodetritus [34–36]. *E. exigua* may indicate the occasional influence of the CDW. In fact, it is thought that this species may be related to these warmer waters, as suggested by [30,37]). *Miliammina earlandi*, agglutinated taxon, is typically associated with the influence of corrosive HSSW in open water conditions [30,38].

Supplementary S3

In this section we report foraminifera data used in this study.

depth (cm) BC03	plankton/g	benthos/g	fragmentation %	*Alabaminella weddellensis*	*Astrononion antarcticus*	*Astrononion echolsi*	*Cassidulina carinata*	*Cibicides lobatulus*	*Cibicides refulgens*	*Discorbis* sp.	*Epistominella exigua*	*Fissurina marginata*	*Fursenkoina fusiformis*	*Globocassidulina biora*	*Globocassidulina subglobosa*	*Heronallenia kempii*	*Lagena* spp.	*Melonis barleeanum*	*Miliammina earlandi*	*Nonionella bradii*	*Nonionella iridea*	*Oolina* spp.	*Patellina corrugata*	*Pullenia subcarinata*	*Stainforthia concava*	*Trifarina earlandi*
1	12		57.9																							
3	1		60.0																							
4		1																	3							
8		1																	2							
12		3	21.4																11							
16		6	29.0																22							
20		2																	2							
22	1	3	27.3																10							1
24	1	4	41.9														1		11							2
25	2	7	47.3														2		13				1			6
28	24	32	28.4	9		2		1		1	21	3				1	4	2	5		3				6	22
31	818	1318	27.6	43		12	5	71	2	7	123	24	1	35	34	6	7		1	22	75	2	2	2	4	41
34	673	1227	31.4	26	1	3	3	50	1	4	81	13		32	9	4	3		2	3	44		1		2	23
36.5	500	215	20.5	12		4	4	27	5	2	56	23		43	25	2	8			4	14	8			1	39

depth (cm) BC04	plankton/g	benthos/g	fragmentation %	*Alabaminella weddellensis*	*Cyclammina orbicularis*	*Epistominella exigua*	*Fissurina marginata*	*Globocassidulina biora*	*Globocassidulina subglobosa*	*Lagena* spp.	*Miliammina earlandi*	*Oolina* spp.	*Trifarina earlandi*	*Triloculina tricarinata*
1														
6		0	50.0		1									
11		2	46.2								7			
15		1	25.0								3			
21	1	1					1			1				
25	26	4	51.3				1		5	1				
31	206	14	37.6			3		1	13	4		3		
35	145	11	63.1	3		11			15	10			1	
41	2		53.8											
45			100.0											

Figure S1.

References (S1)

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