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4. Data Report: Late Pleistocene and Holocene Sedimentation on the Marion Plateau: Data from Precruise ODP Leg 194 Site Survey Gravity Cores[1]

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ABSTRACT

Biostratigraphic, sedimentologic, and geochemical analyses of hemipelagic periplatform sediments from shallow gravity cores taken during the Ocean Drilling Program Leg 194 site survey reveal that, despite the strong currents and almost infilled intraplatform bathymetric depressions, recent sedimentation at the location of the Leg 194 drill sites recorded glacial–interglacial cycles. Sediment analyses included determination of sediment type, carbonate content, bulk stable oxygen isotope composition, and calcareous nannofossil zones. Glacial periods, identified by elevated bulk $\delta^{18}O$, are characterized by darker sediment color, coarser grain size, and lower carbonate content, whereas interglacial periods yield lighter-colored, finer, and carbonate-rich sediments. These data from the shallowmost few meters of Marion Plateau sediments complement the subsurface information of Leg 194 holes, in which the top few meters have not been analyzed in such a high-resolution fashion. In addition, these gravity cores are more likely to have recovered the sediments closest to the sediment/water interface as compared to the hydraulic piston cores collected during Leg 194.

[1]Heck, P.R., Anselmetti, F.S., and Isern, A.R., 2004. Data report: Late Pleistocene and Holocene sedimentation on the Marion Plateau: data from precruise ODP Leg 194 site survey gravity cores. *In* Anselmetti, F.S., Isern, A.R., Blum, P., and Betzler, C. (Eds.), *Proc. ODP, Sci. Results,* 194, 1–13 [Online]. Available from World Wide Web: <http://www-odp.tamu.edu/publications/194_SR/VOLUME/CHAPTERS/006.PDF>. [Cited YYYY-MM-DD]
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INTRODUCTION

In addition to performing a multichannel seismic survey campaign, the site survey cruise AGSO 0209, FR03/99 (April/May 1999) for Ocean Drilling Program Leg 194 collected a series of gravity cores, with a maximum length of 4 m, at the future sites of the proposed Marion Plateau drill sites. Two years later, during Leg 194, scientists cored several hundred-meter-thick successions of Neogene sediments at these locations. The almost undisturbed water/sediment interface in the short cores of the site survey cruise offer the opportunity to analyze the modern sedimentation at a high-resolution scale and comparison with the Leg 194 results from the deeper subsurface.

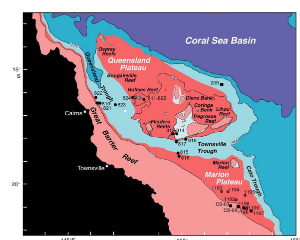
Sediment geometries seen on the seismic data revealed that in the modern environment, the bathymetric depression between the two Marion Plateau carbonate platforms is infilled, the topography is flattened, and strong currents are sweeping the plateau surface (Isern and Anselmetti, 2001). Consequently, it is not obvious whether sedimentation is still ongoing or whether the modern depositional pattern differs from the Neogene situation, where a morphologic depression was present.

Coring sites are located on a seismic line imaging the Southern Marion Platform (SMP) and its adjacent slope/plateau areas (Table **T1**; Fig. **F1**). Deeper-water depositional environments northwest and southeast of the SMP are composed of hemipelagic periplatform sediments in modern water depths from 320 to 343 m. Seafloor photographs (Isern, Anselmetti, Blum, et al., 2002) show no (sites CS-03 and 1197/CS-08) to moderate (sites CS-09 and 1198/CS-05) sediment ripples, reflecting differing degrees of current activity.

Site survey gravity cores were used to characterize the composition of seafloor and subseafloor sediments, a requirement for the operational planning of Leg 194. The sediments collected were also used to characterize the modern depositional regime, based on carbonate and organic carbon data, stable oxygen and carbon isotopic data from bulk sediment, and biostratigraphic information using calcareous nannofossils. These data are presented in this report.

T1. Gravity core sampling locations, p. 11.

F1. Map showing Queensland Plateau and Marion Plateau, p. 7.



METHODS

Sediment samples were taken at each proposed drill site to characterize the nature of the seafloor and shallow subsurface, using pipe dredges, chain dredges, a Van-Veen grab, and a 1-ton gravity corer with 10-cm-diameter barrels. Gravity cores collected during the cruise were examined on a Geotek multisensor track at the Swiss Federal Institute of Technology (ETH) in Zurich, Switzerland, prior to splitting. This instrument measures gamma ray attenuation (GRA) bulk density, *P*-wave velocity, and magnetic susceptibility. Data were empirically calibrated using aluminum and water standards.

After measuring physical properties, core liners were cut in two halves and examined visually. Sediment color was determined using a color chart, major lithologies were recorded using the Dunham classification of carbonates as modified by Embry and Klovan (1971), and primary sedimentary structures were indicated (Heck et al., 1999). Smear slide analysis was used to determine grain and mud content of the sediment. Nannofossils from three cores were studied to obtain age information of the cored sediments at an average frequency of four to five smear slides per core. Smear slides were examined visually with a microscope at 1000× magnification. Nannofossils were identified and counted on a randomly chosen 40-mm-wide band. A total number of 100 fossils per slide was counted.

Total carbon and inorganic carbon (IC) contents were measured using a CO_2 coulometer attached to either an autosampler furnace for total carbon or an acidification module for inorganic carbon. Bulk sediment was powdered using an agate mortar, and 12 mg was placed into 0.15-mL Sn capsules. Samples were loaded into an autosampler wheel, where they were combusted at 950°C.

Sample acidification was performed with $HClO_4$ (2 N) and measured according to standard coulometric techniques (see Shipboard Scientific Party, 2002). IC was subtracted from total carbon to obtain total organic carbon (TOC) concentrations. With the coulometric methods described above, a standard deviation of 0.2 wt% was obtained both for IC and TOC content. A fingertip of the dried powdered sediment prepared for coulometric analysis was used for stable isotope measurement. Carbonate isotope standards are measured with a typical standard deviation of 0.06‰.

RESULTS

Gravity Core Lithology

All sediments collected consist mainly of unlithified, weakly to strongly bioturbated foraminifer wackestone or packstone as well as unlithified mudstone of yellowish gray to light olive-gray color. Shell fragments and also complete shells of gastropods and pteropods are found in coarse layers. The mud fraction (<0.03 mm) mainly consists of calcareous nannofossils, foraminifers, bryozoans, and sponge and tunicate spicules (Heck et al., 1999). Physical property data do not show important variations within and among the cores and are therefore not shown here.

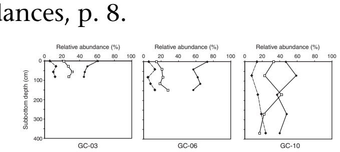
Nannofossils

Nannofossils constrain the age of the sediments. In the three cores examined for calcareous nannofossils (GC-10, GC-06, and GC-03), at least 12 genera were identified and grouped according to size into 33 different categories (Table T2). *Florisphaera profunda* (40%–70%) is by far the most abundant species in all samples, followed by *Emiliania huxleyi* (15%–40%) and *Gephyrocapsa* (5%–24%). *Umbilicosphaera* is present in nearly all samples but only in minor quantities (1%–4%). *Gladiolithus flabellatus* and *Thorosphaera flabellata* were found in almost all samples (0%–7%).

T2. Major nannofossil abundances, p. 12.

E. huxleyi is present in all samples and at all core depths. This places the recovered sediments in the *E. huxleyi* nannofossil Zone NN21 and therefore sets an upper age of ~270–290 ka (Brown, 1998). In the deepest part (370 to ~300 cm) of the longest core (GC-10; site CS-03), *Gephyrocapsa* is more abundant than *E. huxleyi*. This dominance reversal from *Gephyrocapsa* to *E. huxleyi* (Fig. F2) may represent the start of the *E. huxleyi* acme Zone in the upper part of Zone NN21. To confirm this hypothesis, more fossil counts (>400 per smear slide) would be required; however, the clear trend based on the 100 counts per slide indicate that this reversal zone correlates as suggested in our age model. The *E. hux-*

F2. Major nannofossil abundances, p. 8.



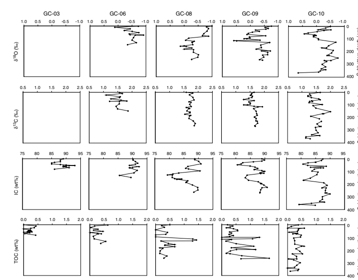
leyi acme zone starts at ~85 ka in tropical and subtropical waters (Thierstein et al., 1977). Because the dominance reversal is only identified in the longest core GC-10, the other two cores can be assigned a maximum age of the start of the acme Zone at ~85 ka. Not enough nannofossils were counted to observe significant size/core-depth relationships among different categories of the same genus (i.e., small *Gephyrocapsa* <2 µm, large *Gephyrocapsa* >5 µm).

Inorganic and Organic Carbon Content

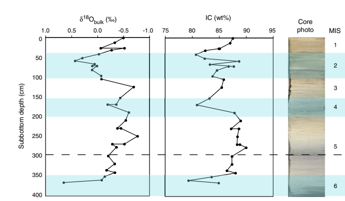
IC content in the cores ranges from 79 to 93 wt% with a mean of 87 wt% (Table T3). A relatively small amount of TOC was measured in the collected sediments (0–1.7 wt%; mean = 0.4 wt%), which is typical for high-carbonate sediments in general. Only two cores have higher than 1 wt% TOC concentrations at the following sample depths: GC-08 at 112, 120, and 127 cm and GC-09 at 111, 169, 195, and 264 cm (Fig. F3). No correlation with any other measured parameter in the core has been found. IC content is usually lower in darker-colored lithologies (Fig. F4).

T3. Carbon content of gravity cores, p. 13.

F3. Bulk sediment carbon content, p. 9.



F4. $\delta^{18}O$ and inorganic carbon profiles, p. 10.



Marine Isotope Stages

Based on the nannofossil data, three cores (GC-03, GC-06, and GC-10) seem to be younger than marine isotope Stage (MIS) 8, which is known to coincide with the start of Zone NN21 (*E. huxleyi* Zone). Based on the dominance of *E. huxleyi,* cores GC-03 and GC-06 likely correlate with the *E. huxleyi* acme Zone (Thierstein et al., 1977) and, consequently, are likely to be younger than MIS 5b and 5a. According to the tentative nannofossil dates, MIS 5b and 5a should be located at ~3 m in core GC-10. This must be confirmed with further stable oxygen isotope data.

The $\delta^{18}O$ values vary between –1.2‰ and 0.6‰. Because $\delta^{18}O$ data are from bulk sediment, different isotope effects are superimposed on the measured signal and therefore this signal is relatively "noisy" as compared to foraminifer species-specific $\delta^{18}O$ data. However, several maxima in the downhole trends can be recognized (Fig. F3). For instance, in the longest core (GC-10), three local minima can be detected near 60 cm, 170 cm, and the base of the core at 360 cm (Fig. F4). Using the correlation shown in Figure F4, the base of the core is interpreted to be the beginning of MIS 6 (130–140 ka) and the two minima higher in the core represent stages 4 and 2, respectively. This postulated chronology for core GC-10 inferred from $\delta^{18}O$ isotopes is in accordance with ^{14}C ages of the same core (M. Page, pers. comm., 2003).

DISCUSSION AND CONCLUSIONS

Our $\delta^{18}O$, inorganic carbon, and nannofossil data suggest that the oldest sediments in core GC-10 are from MIS 6 (130–140 ka; Fig. F4), whereas all other cored sediments are within the *E. huxleyi* acme Zone and are thus younger than 85 ka. The proposed age model based on nannofossil and isotope data correlates well with carbonate content and sediment color, which fits into a depositional model reflecting glacial–interglacial cycles. All glacial stages (2, 4, and 6) in core GC-10 (Fig. F4) coincide with low carbonate contents and darker sediment color. This matches other studies in periplatform slope settings (e.g., Betzler et al., 1999; Isern and Anselmetti, 2001), where sea level lowstands resulted in a relative increase in siliciclastic input because carbonate production was reduced.

The sedimentation rate for core GC-10 is 3 m per 85 k.y. or 3.5 cm/k.y. The other gravity cores have average rates as low as 2.6 cm/k.y. Because the longest core (GC-10) was taken at a location that was not drilled during Leg 194, no direct comparison can be made with the sedimentation rates of the underlying Neogene section. However, these values approximately match the youngest sedimentation rate values obtained from nearby Sites 1192 (~20 m/m.y.) and 1198 (~50 m/m.y.) (Isern, Anselmetti, Blum, et al., 2002). This indicates that the overall sedimentation pattern has not changed as a result of infilled morphology and/or modern current patterns.

ACKNOWLEDGMENTS

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Figure F1. Map showing the Queensland Plateau (north) and the Marion Plateau (south) with sampling sites of Leg 194 site survey (solid boxes), Leg 194 (solid circles), and Leg 133 (open circles).

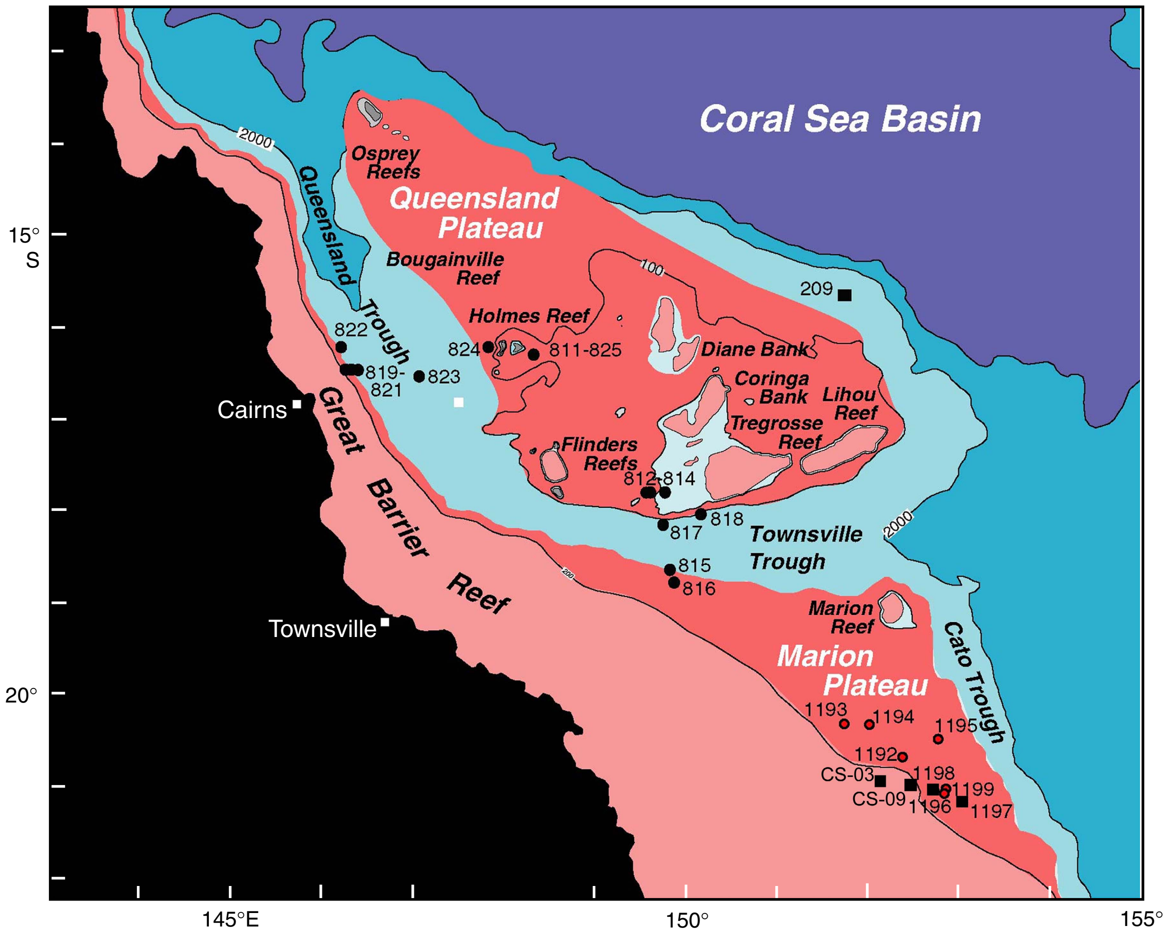

Figure F2. Major nannofossil abundances of *Gephyrocapsa*, *Emiliania huxleyi,* and *Florisphaera profunda* in gravity cores.

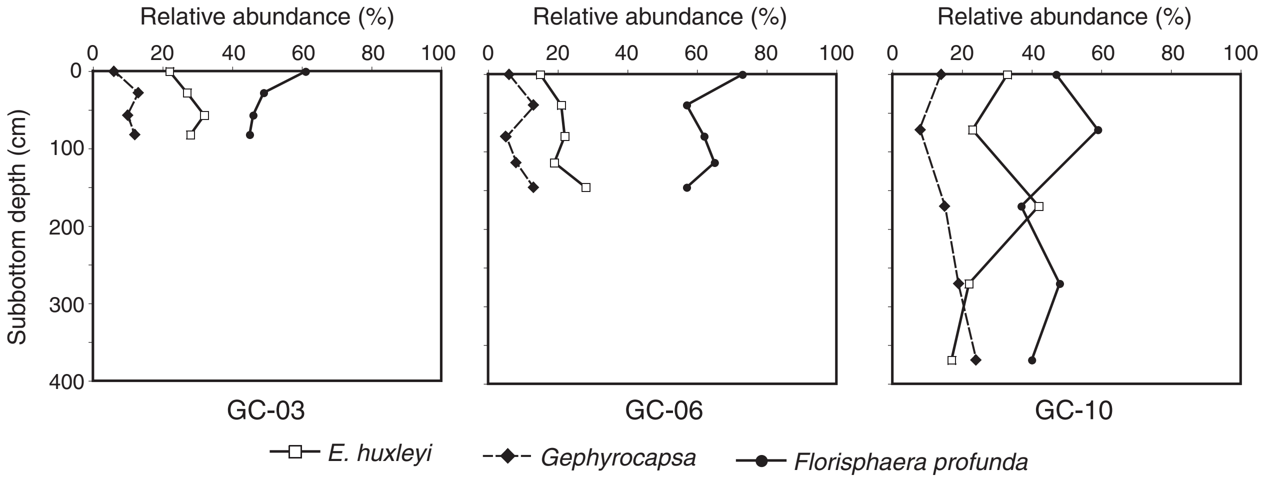

Figure F3. $\delta^{18}O$, $\delta^{13}C$, inorganic carbon (IC), and total organic carbon (TOC) on bulk sediment for cores GC-03 (only IC and TOC), GC-06, GC-08, GC-09 and GC-10. 1σ errors are 0.06‰, 0.04‰, 0.2 wt%, and 0.2 wt%, respectively.

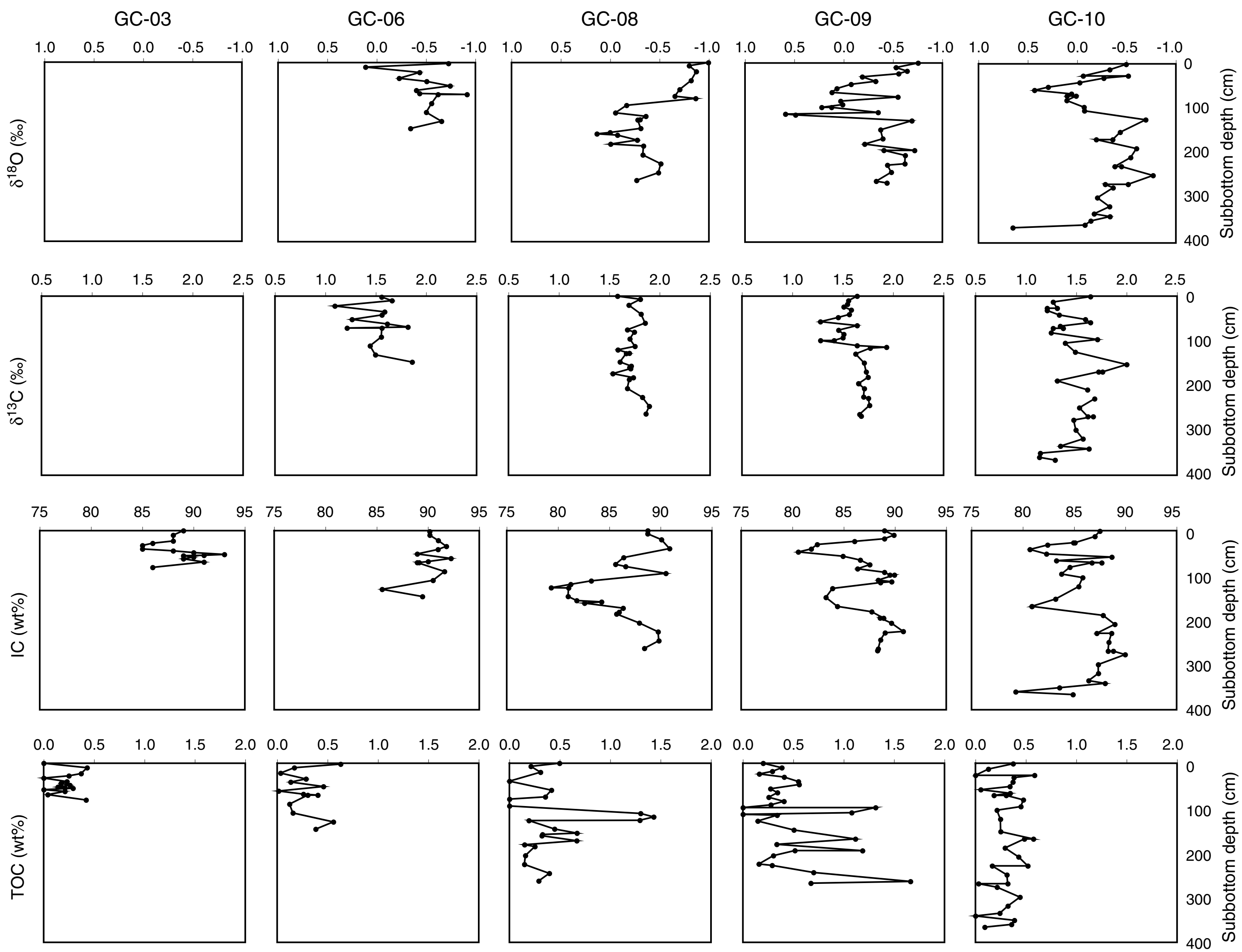

Figure F4. Correlation of δ^{18}O and inorganic carbon (IC) profiles with sediment color of largest sediment core GC-10 (site CS-03). Shaded regions are interpreted as glacial periods represented by marine isotope stages (MIS) 2, 4, and 6, which are characterized by higher δ^{18}O values, lower IC content, and darker sediment color. Our nannofossil age, start of *E. Huxleyi* acme Zone at ~300 cm subbottom depth, is indicated with a dashed line. 1σ errors are 0.06‰ for δ^{18}O and 0.2 wt% for IC.

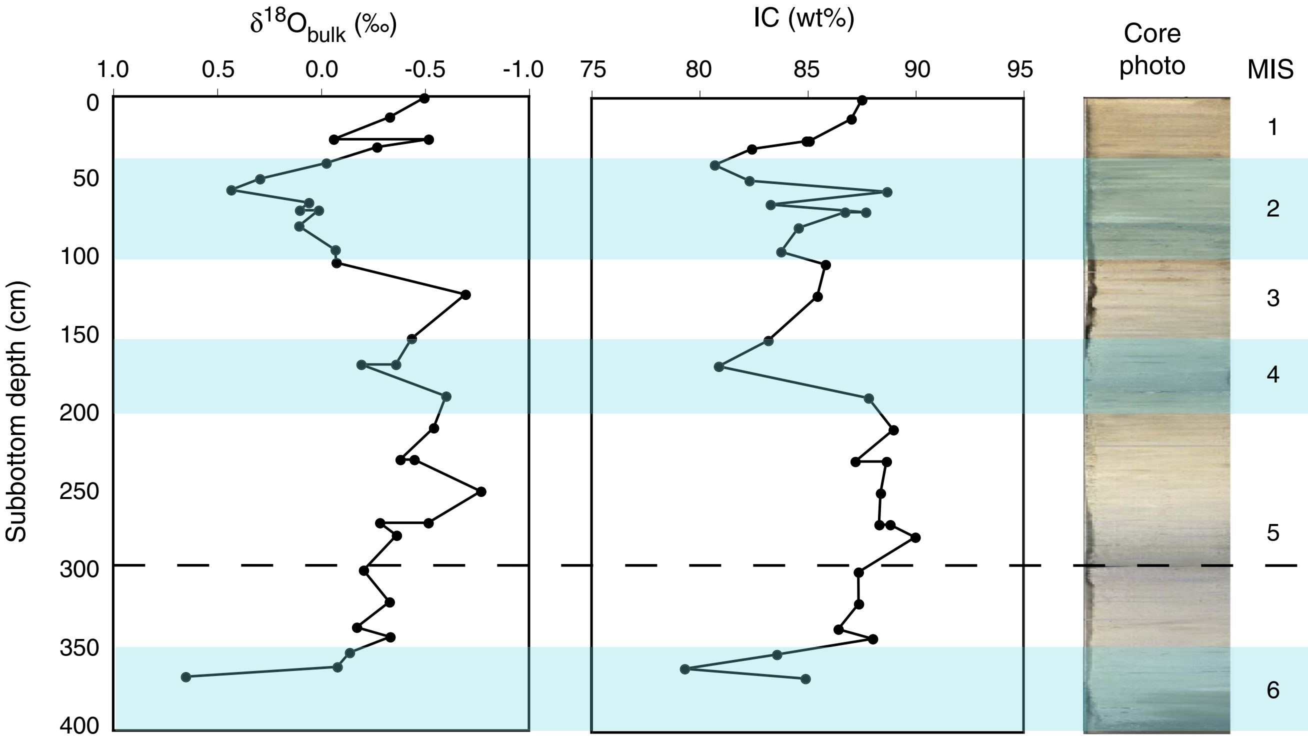

Table T1. ODP Leg 194 site survey gravity core sampling locations on Marion Plateau.

Site	Water depth (m)	Global positioning system position	Core	Core length (m)
CS-08/1197	343	21°4.566′S, 153°3.968′E	GC-03	0.84
CS-05/1198	327	20°57.018′S, 152°43.003′E	GC-06	1.48
CS-09	325	20°54.641′E, 152°35.049′E	GC-08	2.73
CS-03	320	20°47.544′S, 152°16.520′E	GC-09	2.70
CS-03	320	20°47.576′S, 152°16.459′E	GC-10	3.73

Table T2. Major nannofossil abundances in three gravity cores.

Core	Subbottom depth (cm)	*Emiliania huxleyi* (%)	*Gephyrocapsa* (%)	*Florisphaera profunda* (%)
GC-10	0.5	33	14	47
	72.0	23	8	59
	170.5	42	15	37
	270.5	22	19	48
	369.3	17	24	40
GC-06	0.5	15	6	73
	40.0	21	13	57
	80.3	22	5	62
	114.3	19	8	65
	146.3	28	13	57
GC-03	0.5	22	6	61
	28.0	27	13	49
	57.0	32	10	46
	82.0	28	12	45

Table T3. $\delta^{18}O$, $\delta^{13}C$, inorganic carbon and total organic carbon of four gravity cores.

Core	Subbottom depth (cm)	$\delta^{18}O$ (‰)	$\delta^{13}C$ (‰)	IC (wt%)	TOC (wt%)
GC-03	0.0			89.0	0.0
	10.0			88.0	0.4
	23.0			88.0	0.4
	28.0			86.0	0.3
	33.0			85.0	0.0
	41.0			85.0	0.2
	45.0			88.0	0.2
	49.0			90.0	0.3
	53.0			93.0	0.1
	55.0			91.0	0.2
	56.0			89.0	0.3
	59.0			90.0	0.0
	63.0			89.0	0.2
	70.0			91.0	0.0
	82.0			86.0	0.4
GC-06	2.0	–0.73	1.56	90.2	0.6
	10.0	0.11	1.66	90.2	0.2
	22.0	–0.43	1.09	91.0	0.0
	35.0	–0.23	1.59	91.8	0.3
	42.0	–0.51	1.56	91.0	0.1
	52.0	–0.74	1.26	88.9	0.5
	62.0	–0.4	1.61	92.2	0.0
	69.0	–0.43	1.82	90.0	0.3
	71.1	–0.91	1.21	89.1	0.4
	71.1	–0.62	1.56	88.9	0.3
	91.1	–0.55	1.55	91.6	0.1
	111.1	–0.5	1.44	90.5	0.2
	131.1	–0.66	1.50	85.5	0.6
	147.1	–0.34	1.86	89.4	0.4
GC-08	0.0	–0.99	1.58	88.7	0.5
	7.0	–0.8	1.81	88.7	0.2
	20.0	–0.87	1.69	90.1	0.3
	40.0	–0.82	1.81	90.9	0.0
	60.0	–0.7	1.86	86.4	0.4
	75.0	–0.65	1.68	85.6	0.4
	80.0	–0.86	1.75	86.6	0.0
	95.5	–0.16	1.70	90.5	0.0
	112.0	–0.05	1.75	83.2	1.3
	120.0	–0.36	1.58	81.2	1.4
	127.3	–0.3	1.70	79.3	1.3
	128.0	–0.28	1.67	81.0	0.2
	147.0	–0.31	1.61	81.0	0.4
	156.0	0.00	1.72	81.8	0.7
	159.0	0.14	1.70	84.2	0.3
	162.0	–0.07	1.71	82.6	0.3
	173.0	–0.27	1.53	86.3	0.7
	182.0	0.00	1.74	86.0	0.2
	186.0	–0.34	1.70	85.7	0.3
	206.0	–0.33	1.68	87.9	0.2
	226.0	–0.51	1.83	89.8	0.1
	246.0	–0.49	1.90	89.8	0.4
	263.0	–0.27	1.86	88.4	0.3
GC–09	0.0	–0.75	1.64	89.0	0.2
	10.0	–0.53	1.56	89.9	0.4
	18.0	–0.64	1.55	89.0	0.3
	24.0	–0.56	1.51	86.1	0.2
	31.0	–0.19	1.58	82.4	0.4
	41.0	–0.32	1.56	81.8	0.6
	47.5	–0.07	1.45	80.6	0.6
	57.0	0.07	1.28	84.9	0.3
	65.7	0.12	1.64	86.6	0.3
	76.0	–0.55	1.46	87.5	0.3
	85.0	0.03	1.51	86.3	0.4
	93.0	0.01	1.50	89.0	0.3
	99.0	0.22	1.41	89.5	0.0
	99.0	0.12	1.28	89.9	1.3
	110.5	–0.35	1.64	88.4	1.1
	114.0	0.59	1.93	89.7	0.0
	116.0	0.49	1.77	88.6	0.3
	129.0	–0.69	1.63	83.9	0.1
	149.0	–0.37	1.71	83.3	0.5
	169.0	–0.4	1.73	84.4	1.1
	181.0	–0.21	1.75	87.7	0.3
	195.3	–0.72	1.66	88.9	1.2
	195.0	–0.41	1.66	88.5	0.5
	206.5	–0.62	1.71	89.6	0.3
	225.0	–0.62	1.71	90.8	0.2
	228.0	–0.44	1.75	89.0	0.3
	244.0	–0.48	1.76	88.6	0.7
	264.0	–0.33	1.67	88.4	1.7
	267.9	–0.44	1.68	88.3	0.7
GC-10	1.0	–0.5	1.64	87.5	0.4
	13.0	–0.33	1.27	87.0	0.1
	27.0	–0.06	1.31	85.1	0.0
	27.0	–0.52	1.21	84.9	0.6
	32.0	–0.27	1.21	82.4	0.4
	42.0	–0.02	1.33	80.7	0.4
	52.0	0.29	1.59	82.3	0.3
	59.0	0.43	1.64	88.7	0.1
	67.0	0.06	1.34	83.3	0.3
	71.8	0.10	1.37	87.7	0.2
	71.8	0.01	1.27	86.7	0.3
	81.8	0.11	1.25	84.6	0.5
	96.8	–0.07	1.71	83.8	0.5
	104.8	–0.07	1.39	85.8	0.2
	124.8	–0.69	1.49	85.4	0.2
	152.7	–0.44	2.00	83.2	0.3
	169.1	–0.36	1.76	80.9	0.6
	169.1	–0.19	1.72	80.9	0.5
	189.1	–0.6	1.31	87.8	0.3
	209.1	–0.54	1.61	89.0	0.4
	229.1	–0.38		87.2	0.5
	229.1	–0.45	1.68	88.7	0.2
	249.1	–0.77	1.53	88.4	0.3
	268.9	–0.52	1.61	88.3	0.3
	268.9	–0.28	1.67	88.8	0.0
	276.9	–0.36	1.47	90.0	0.2
	298.9	–0.2	1.50	87.4	0.4
	318.9	–0.33	1.57	87.4	0.3
	334.9	–0.17	1.34	86.4	0.2
	340.9	–0.33	1.63	88.0	0.0
	350.9	–0.14	1.14	83.6	0.4
	359.9	–0.08	1.13	79.3	0.4
	366.1	0.65	1.29	84.9	0.1

Notes: IC = inorganic carbon, TOC = total organic carbon. 1σ errors are 0.06‰, 0.04‰, 0.2 wt%, and 0.2 wt%, respectively.