Supplementary documents

Age models

We compare $\delta^{18}O_{bf}$ records across the Eocene-Oligocene transition from Atlantic Ocean Site 522, Pacific Ocean Site 1218, and Gulf of Mexico SSQ. We use Site 522 as the standard because it has the firmest paleomagnetic age control, and we correlate the other records to this standard. We use three paleomagnetic datums at Site 522 to constrain our age models: 1) the top of Chronozone C15n (34.669 Ma, 148.88 meters below sea floor (mbsf)); 2) the base of Chronozone C13n (33.545 Ma, 133.65 mbsf); and 3) the top of Chronozone C13n (33.05 Ma, 128.54 mbsf)[1]. The time scale of Berggren and colleagues is used[2].

The $\delta^{18}O_{bf}$ increase that defines Oi-1 (earliest Oligocene) has been constrained paleomagnetically to the Chron C13r/C13n transition at Site 522, which has been confirmed at Indian Ocean Site 744[1]. The maximum $\delta^{18}O_{bf}$ value at Site 522 lies in the first normal polarity point (133.65 mbsf, C13n) above a reversed polarity point (134.05 mbsf, C13r). At SSQ, the maximum $\delta^{18}O_{bf}$ value of Oi-1 appears to occur in highest C13r. A 40 cm coring gap at Site 522 between the uppermost C13r and lowermost C13n samples allows us to reconcile the Site 522 and SSQ records, and we align the maximum $\delta^{18}O_{bf}$ value of Oi-1 at the C13n/C13r boundary.

The placement of Oi-1 relative to magnetostratigraphy is uncertain at Site 1218. Lanci and colleagues[3] did not report polarity data below 220 meters core depth (mcd) at Site 1218 (mid-C12r). The polarity history is quite clear at nearby Site 1219[3]. Carbonate data were used to correlate Site 1218 to Site 1219, and then to suggest that the lower boundary of Chron C13n at Site 1218 may be at 240.29 mcd[4]. However, this would place the Oi-1 $\delta^{18}O_{bf}$ maximum (239.51 mcd) almost 1 m above the base of Chron C13n, which is inconsistent with Site 522 and SSQ, both of which have good paleomagnetic data measured on the cores, rather than extrapolated from nearby locations (as is the case with Site 1218).

Based on this inconsistency, we revisited the correlations between Sites 1218 and 1219. Physical property data ("L* data", which is a sediment color measurement that reflects carbonate content) were collected at Sites 1218 and 1219[5]. The L* data for Sites 1218 and 1219 are very different in the uppermost Eocene sediments. The polarity change (C13n) at 176.3 mcd measured at Site 1219 is coincident with a sharp change in sediment color (L* increases from 30 to 60 in < 30 cm). In contrast, the L* record from Hole 1218C shows an intermediate phase from 242 to 240 mcd. At Holes 1218A and 1218B, the L* maximum is at 237 mcd, but both have significant core missing in this section. Because the correlations between Sites 1218 and 1219 are ambiguous at the C13n/C13r transition, we use the maximum $\delta^{18}O_{bf}$ value of Oi-1 to correlate Site 1218 to Site 522.

Within the constraints of the paleomagnetic datums at Site 522 (above), we correlate our Site 1218 and SSQ age models to

Site 522 using $\delta^{13}C$ stratigraphy (Supplementary Figure 1, Supplementary Table 1).

Supplementary Table 1. **Depths and ages used as correlation points in age models for each core.** Correlation pairs with no reference cited were established as part of this study.

Correlation point	Age (Ma)	522 depth (mbsf)	1218 depth (mcd)	SSQ depth (m)
top C13n	33.05	128.54[1]	233.88[3]	40.55[7,8]
base C13n	33.545	133.65[1]		
Oi-1	33.545	133.65	239.51	46.59
SB	33.59			46.98
SB	33.62			46.98
Ci-3	33.809	138.31	241.91	48.78
Ci-2	33.979	139.53	243.13	50.03
Ci-1	34.115	141.38	244.35	
top C15n	34.669	148.88[1]		

SB = sequence boundary

Ci = carbon isotope

Supplementary Table 2. **Stable isotopic ($\delta^{18}O$, $\delta^{13}C$) and trace element (Mg/Ca) data from St. Stephens Quarry.**

Supplementary Figure 1. **Comparisons of $\delta^{13}C$ from Site 1218[6], Site 522[1], and SSQ (this study).** We correlate our Site 1218 and SSQ age models to Site 522 using $\delta^{13}C$ stratigraphy within the constraints of the paleomagnetic datums at Site 522 (Supplementary Table 1).

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Katz SuppTable2

depth (m)	Age (Ma)	C13 PDB	O18 PDB	C13 (avg)	O18 (avg)	species	isotope reference	Mg/Ca	seafloor temp.	seafloor temp. (avg)	Species	del w
22.26	32.0183	0.50	-0.26	0.375	-0.290	C. cocoaensis	this study	5.574	17.070	17.070	16C.spp.	0.299
22.26	32.0183	0.25	-0.32			Cib. spp.	this study				+17C.pippeni	
22.87	32.0527	0.59	-0.43	0.570	-0.550	C pippeni	this study	6.788	18.880	18.880	C.pippeni	0.447
22.87	32.0527	0.55	-0.68			Cib. spp.	Miller et al. 2008					
25.55	32.2040	0.62	-0.27	0.505	-0.285	C pippeni	this study	6.961	19.110	19.110	C.pippeni	0.764
25.55	32.2040	0.39	-0.30			Cib. spp.	Miller et al. 2008					
28.05	32.3450	0.47	-0.49	0.410	-0.485	C pippeni	this study	6.630	18.660	18.660	C.pippeni	0.463
28.05	32.3450	0.35	-0.48			Cib. spp.	Miller et al. 2008					
29.27	32.4137	0.80	-0.13	0.570	-0.295	C pippeni	this study	6.560	18.570	18.570	C.pippeni	0.633
29.27	32.4137	0.34	-0.46			Cib. spp.	Miller et al. 2008					
33.72	32.6648	0.76	-0.24	0.760	-0.260	C pippeni	this study	6.222	18.080	18.080	C.pippeni	0.558
33.72	32.6648	0.76	-0.28			Cib. spp.	Miller et al. 2008					
35.98	32.7920	0.64	-0.33	0.615	-0.335	C pippeni	this study	6.503	18.490	18.490	C.pippeni	0.575
35.98	32.7920	0.59	-0.34			Cib. spp.	Miller et al. 2008					
37.32	32.8677	0.88	-0.37	0.775	-0.465	C pippeni	this study	5.892	17.580	17.580	C.pippeni	0.240
37.32	32.8677	0.67	-0.56			Cib. spp.	Miller et al. 2008					
38.54	32.9364	0.46	-0.58	0.730	-0.410	C pippeni	this study	5.872	17.550	17.550	C.pippeni	0.288
38.54	32.9364	1.00	-0.24			Cib. spp.	Miller et al. 2008					
39.33	32.9812	0.39	-0.54	0.290	-0.490	C pippeni	this study	6.221	18.080	18.080	C.pippeni	0.328
39.33	32.9812	0.19	-0.44			Cib. spp.	Miller et al. 2008					
40.46	33.0448	1.70	0.47	1.700	0.470	C pippeni	this study	5.569	17.060	17.060	C.pippeni	1.056
40.64	33.0574	0.56	0.12	0.560	0.120	C pippeni	this study					
40.79	33.0699	0.73	-0.23	0.850	-0.225	C pippeni	this study					
40.79	33.0699	0.97	-0.22			Cib. spp.	Miller et al. 2008					
41.16	33.0999	0.55	-0.55	0.550	-0.550	Cib. spp.	this study					
42.38	33.1998	0.63	-0.05	0.815	-0.125	C pippeni	this study					
42.38	33.1998	1.00	-0.20			Cib. spp.	Miller et al. 2008					
43.29	33.2748	1.41	0.14	1.410	0.140	Cib. spp.	Miller et al. 2008					
43.60	33.2998	1.33	-0.11	1.330	-0.110	Cib. spp.	Miller et al. 2008					
44.21	33.3497	1.46	-0.11	1.315	-0.035	C pippeni	this study	7.410	19.680	19.473	C.pippeni	
44.21	33.3497	1.17	0.04			Cib. spp.	Miller et al. 2008	7.081	19.267		C.pippeni	1.095
44.97	33.4122	1.47	-0.15	1.470	-0.150	Cib. spp.	Miller et al. 2008	7.383	19.650	19.650	C.pippeni	1.019
45.79	33.4797	1.72	-0.01	1.720	-0.010	Cib. spp.	Miller et al. 2008	6.643	18.681	18.681	C.pippeni	0.943
46.13	33.5071							6.741	18.816	18.816	C.pippeni	1.022
46.13	33.5071	1.29	0.04	1.294	0.038	Cib. spp.	this study					
46.25	33.5171	2.17	0.74	2.170	0.740	C pippeni	this study	5.490	16.930	17.117	C.pippeni	1.340

46.25	33.5171							5.717	17.304		C.pippeni	
46.28	33.5196	1.98	0.63	1.980	0.630	C pippeni	this study	6.021	17.780	17.969	C.pippeni	1.423
46.28	33.5196							6.274	18.158		C.pippeni	
46.37	33.5271	1.97	0.20	1.870	0.115	C pippeni	this study	4.802	15.700	15.800	C.pippeni	
46.37	33.5271	2.15	0.03			C pippeni	this study	4.906	15.900		C.pippeni	
46.37	33.5271	1.49	0.15			Cib. spp.	Miller et al. 2008					
46.59	33.5446	2.18	0.94	2.305	0.875	C. pippeni	this study	5.161	16.370	16.827	C.pippeni	1.408
46.59	33.5446	2.43	0.81			C pippeni	this study	5.704	17.284		C.pippeni	
46.65	33.5515	1.53	-0.04	1.530	-0.040	C pippeni	this study	6.086	17.880	17.862	C.pippeni	0.843
46.65	33.5515							6.063	17.843		C.pippeni	
46.65	33.5524	1.90	0.19	1.900	0.190	C pippeni	this study	6.051	17.826	17.826	C.pippeni	
46.77	33.5656	1.47	0.29	1.467	0.293	Cib. spp.	this study					
46.97	33.5884	1.85	0.27	1.850	0.270	C pippeni	this study					
47.06	33.6282	0.31	0.02	0.310	0.020	C pippeni	this study					
47.41	33.6282	1.54	0.22	1.540	0.220	C pippeni	this study					
47.44	33.6682	0.07	-0.60	0.070	-0.600	Cib. spp.	Miller et al. 2008					
47.53	33.6778	0.01	-0.67	0.000	-0.595	C. cocoaensis	this study					
47.53	33.6778	-0.01	-0.52			C. pippeni	this study					
47.68	33.6938	1.47	0.15	1.470	0.150	Cib. spp.	this study					
47.77	33.7034	0.42	-0.45	0.430	-0.415	C. cocoaensis	this study					
47.77	33.7034	0.44	-0.38			C. pippeni	this study					
47.93	33.7194	0.38	-0.37	0.375	-0.295	Cib. spp.	this study					
47.93	33.7194	0.37	-0.22			C. pippeni	this study					
48.17	33.7450	0.37	-0.44	0.450	-0.400	C pippeni	this study					
48.17	33.7450	0.53	-0.36			Cib. spp.	Miller et al. 2008					
48.20	33.7482	0.38	-0.31	0.380	-0.307	Cib. spp.	this study					
48.26	33.7546	0.33	-0.31	0.328	-0.314	Cib. spp.	this study					
48.32	33.7610	1.29	-0.08	1.290	-0.080	C pippeni	this study					
48.48	33.7770	0.30	-0.45	0.298	-0.446	Cib. spp.	this study					
48.69	33.7994	0.72	-0.20	0.722	-0.196	Cib. spp.	this study	5.392	16.767	16.767	C.pippeni	0.324
48.78	33.8091	1.20	0.00	1.200	0.000	C pippeni	this study	4.935	15.950	15.950	C.pippeni	0.332
48.87	33.8215	0.73	-0.17	0.625	-0.350	C pippeni	this study	4.995	16.070	16.070	C.pippeni	0.010
48.87	33.8215	0.52	-0.53			Cib. spp.	Miller et al. 2008					
48.90	33.8257	0.76	-0.10	0.760	-0.100	C pippeni	this study	4.920	15.927	15.927	C.pippeni	0.227
49.05	33.8464	0.72	-0.35	0.720	-0.350	C pippeni	this study					
49.36	33.8878	0.48	-0.24	0.480	-0.240	C. cocoaensis	this study					
49.39	33.8920	0.59	-0.56	0.215	-0.425	C pippeni	this study	4.844	15.784	15.784	C.pippeni	-0.131
49.39	33.8920	-0.16	-0.29			Cib. spp.	Miller et al. 2008					
49.45	33.9003	0.34	-0.44	0.340	-0.440	C. cocoaensis	this study	5.330	16.067	16.364	C. cocoaensis	-0.013

49.45	33.9003							4.996	16.660		C.pippeni	
49.66	33.9293	-0.02	-0.65	-0.020	-0.650	C. cocoaensis	this study	6.258	18.130	18.130	C. cocoaensis	0.179
49.70	33.9335	-0.05	-0.88	-0.015	-0.895	C. cocoaensis	this study	6.048	17.820	17.820	C. cocoaensis	-0.136
49.70	33.9335	0.02	-0.91			Cib. spp.	Miller et al. 2008					
50.03	33.9791	0.13	-0.40	-0.095	-0.725	C. cocoaensis	this study	7.222	19.450	19.450	C. cocoaensis	0.400
50.03	33.9791	-0.32	-1.05			Cib. spp.	Miller et al. 2008					
50.18	33.9998	0.07	-0.61	0.070	-0.610	C. cocoaensis	this study	6.979	19.130	19.130	C. cocoaensis	0.443
50.34	34.0205	0.28	-0.74	0.280	-0.740	C. cocoaensis	this study	8.403	20.840	20.840	C. cocoaensis	0.692

*The SSQ core was sampled multiple times over several years. Hence, the exact core depth of this sample is uncertain relative to those immediately above and below. It is plotted, but not connected by the line.

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