

Figure DR1. Oxygen and carbon isotopic data for from TDP 22 plotted relative to subsurface depth. Foraminiferal zones shown to left from Huber and Petrizzo (in press). Lines go through average of values if a taxon was analyzed multiple times from the same sample. The temperature scale is appropriate for calcitic shells secreted in equilibrium with seawater having a $\delta^{18}\text{O}$ value of $-1\text{\textperthousand}$ vsmow. For aragonitic *Epistomina* spp., observed $\delta^{18}\text{O}$ of values of $-1\text{\textperthousand}$ vpdb correspond to paleotemperature estimates of $\sim 20^\circ\text{C}$. W.—*Whiteinella*; H.—*Helvetoglobotruncana*; D.—*Dicarinella*; P.—*Praeglobotruncana*; G.—*Globoheterohelix*.

Huber, B.T. and Petrizzo, in press, Evolution and taxonomic study of the Cretaceous planktonic foraminifer Genus *Helvetoglobotruncana* Reiss, 1957: Journal of Foraminiferal Research.

Additional Discussion of Turonian Timescales

To explore the differences between timescales (Fig. DR2), we calculated datum ages for planktic foraminifer zonal markers using biostratigraphic occurrence data from Caron et al. (2006) and the age model of Meyers et al. (2012) for the Cenomanian/Turonian boundary Global Stratotype, Section and Point near Pueblo, Colorado. The calibrated events are underscored and calculated ages are shown in parentheses. Non-underscored names to the right are for calcareous nannofossil zonal datum markers, which do not occur in the Pueblo section and have not been age calibrated in any other sequence.

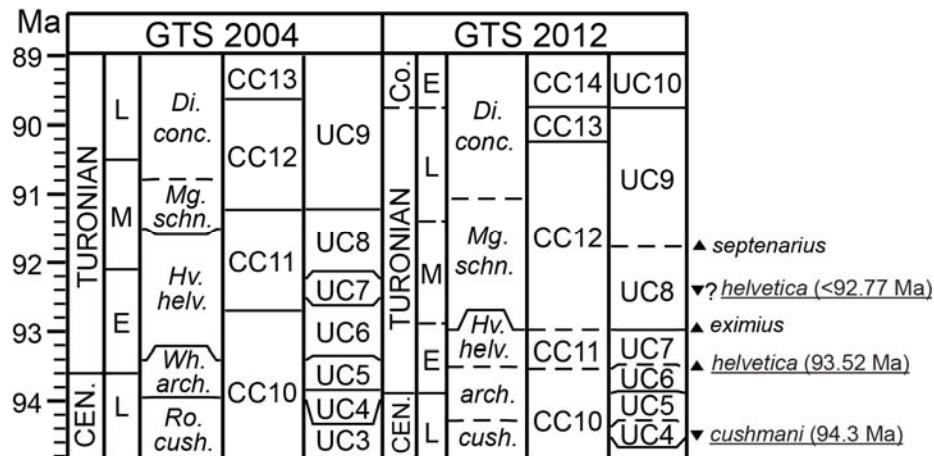


Figure DR2. A comparison of the 2004 vs. 2012 geologic time scales (GTS) of Gradstein et al. (2004, 2012) is shown. Note significant offsets in ages, particularly for the Turonian, assigned to calcareous nannofossil (CC: Sissingh, 1977; UC: Burnett et al., 1998) and planktic foraminiferal biozones. Differences are discussed below.

The Pueblo ages for the Last Appearance Datum (LAD) of *Rotalipora cushmani* (downward pointing triangles) and First Appearance Datum (FAD) (upward pointing triangles) of *Helvetoglobotruncana helvetica* show good agreement with GTS 2012. However, dates for the LAD of *H. helvetica* do not. The calculated age of the LAD for *H. helvetica* (92.77) at Pueblo, is younger than the 92.99 Ma extinction age used in GTS 2012. Further, this age is a maximum estimate since *H. helvetica* occurs to the top of the outcrop in the Pueblo GSSP section so the extinction horizon is presumably younger, and potentially much younger than suggested by GTS 2012.

The position of the CC11/CC12 zonal boundary also was placed in the lower *Marginotruncana schneegansi* Zone in GTS 2004 and was moved to the top of the *H. helvetica* Zone in GTS 2012. No explanation or documentation is provided for this change in relative timing, but the CC11/CC12 boundary does occur in the upper *H. helvetica* Zone in Tanzania (Jimenez Berrocoso et al., 2012). What is most important with respect to nannofossil age assignments for the TDP 31 sequence and correlation to the results in Bornemann et al. (2008) is that the first occurrences of the calcareous nannofossil CC11/CC12 zonal boundary marker *Eiffelithus eximius* and UC8/UC9 zonal boundary marker *Lithastrinus septenarius* all occur within the a well documented portion of TDP31. Thus, by all available data, the oxygen isotopic

data from TDP 31 spans the intervals of Turonian ice sheet growth that were proposed by Miller et al. (2004), Bornemann et al. (2008) and Galeotti et al. (2009).

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Table DR1. Core samples, subsurface depths and oxygen and carbon isotope data from TDP 22.

Table DR2. Core samples, subsurface depths, and oxygen and carbon isotope data from TDP 31.

TDP 31 core	Section	Depth interval (m)	Depth below surface (m)	<i>Berthelia berthelini</i>	<i>Lingulagavelinella convexa</i>	<i>Lenticulina</i> sp. 1	<i>Lenticulina</i> sp. 2	<i>Lenticulina</i> spp.	<i>Epistomina</i> spp.	<i>Epistomina chapmani</i>	<i>Epistomina</i> sp.2	<i>Epistomina</i> sp.3	<i>Epistomina</i> sp.4	<i>Epistomina</i> sp.5	<i>Dicarinella elata</i>	<i>Dicarinella hagni</i>	<i>Whiteinella aprica</i>	<i>Whiteinella brittonensis</i>	<i>Praeglobotruncana stephani/gibba</i>	<i>Helvetoglobotruncana praehelvetica/helvetica</i>	<i>Marginotruncana renzi</i>	<i>Marginotruncana pseudolimneiana</i>	Mixed heterohelicids	<i>Huberella praehuberi</i>	<i>Globoterebellix paraglobulosa</i>	<i>Whiteinella baltica</i>			
				$\delta^{13}\text{C}$ $\delta^{18}\text{O}$	$\delta^{13}\text{C}$ $\delta^{18}\text{O}$	$\delta^{13}\text{C}$ $\delta^{18}\text{O}$	$\delta^{13}\text{C}$ $\delta^{18}\text{O}$	$\delta^{13}\text{C}$ $\delta^{18}\text{O}$	$\delta^{13}\text{C}$ $\delta^{18}\text{O}$	$\delta^{13}\text{C}$ $\delta^{18}\text{O}$	$\delta^{13}\text{C}$ $\delta^{18}\text{O}$	$\delta^{13}\text{C}$ $\delta^{18}\text{O}$																	
19	1	2-20cm	28.11	-0.75 -2.13								1.14 -1.47										0.12 -4.13	-0.86 -4.60			-0.98 -4.66			
20	1	16-56cm	29.36	-0.29 -2.45					-1.72 -2.62												0.80 -4.47								
21	1	45-65cm	32.55	-1.64 -2.16		-1.46 -2.44															-0.12 -4.22	-0.27 -4.27	-2.23 -4.97						
21	2	74-94cm	33.84						-0.40 -2.18			2.18 -1.27									0.76 -4.76								
21	3	28-46cm	34.37	-0.35 -1.94				-0.55 -2.39	2.33 -1.27											0.59 -4.14									
22	1	2-20cm	35.11	-0.27 -1.81		-1.57 -2.41	-0.34 -2.14													0.55 -4.61	0.34 -4.40	0.14 -4.30	-2.33 -5.37						
23	1	40-60cm	38.50	-0.46 -2.08		-2.75 -2.66															-0.12 -4.58								
24	1	50-70cm	39.60				0.73 -2.03				2.75 -1.13										0.86 -4.54								
25	1	30-50cm	41.40	-0.27 -1.89			-0.12 -1.98				2.21 -1.18								0.64 -3.66		0.87 -4.18								
26	1	40-60cm	43.10	-0.02 -1.88		-1.03 -2.61	0.74 -2.06			2.04 -1.53										0.91 -4.31	1.28 -4.08	1.32 -4.28							
26	1	73-75cm	43.34	-0.19 -1.76			-0.30 -2.14			1.66 -1.42										0.33 -4.03				0.99 -4.52					
26	1	93-120cm	43.67			0.26 -2.24													0.78 -3.55		0.69 -4.32	0.73 -4.17							
27	1	40-60	44.50	-0.48 -2.00			-0.03 -2.37			1.97 -1.52										0.90 -4.43									
27	2	5-25	45.15	0.19 -1.63	0.44 -1.82				2.72 -1.16	2.21 -1.79		2.94 -1.48				1.92 -4.13	1.15 -4.17		1.36 -3.84	1.75 -4.40									
28	1	5-25cm	46.25	0.69 -1.63			-0.26 -2.21			2.91 -1.24	2.85 -1.14	2.68 -1.29																	
29	1	27-47cm	47.37	0.66 -1.69	0.49 -1.81	-0.86 -2.31	-0.25 -2.24			3.00 -1.19	2.59 -1.23			2.93 -1.20		1.84 -4.25	2.17 -4.36		1.86 -4.16	1.97 -4.33									
29	2	10-29cm	48.20	0.68 -1.73	0.71 -1.88		0.81 -2.15			2.72 -1.30						2.01 -4.06			2.19 -4.47	1.94 -4.58	1.86 -3.87								
29	3	71-93cm	49.82	0.82 -1.73	0.97 -1.83			0.18 -2.17	2.69 -1.21	3.13 -1.27						2.02 -3.92	1.94 -4.13		2.42 -4.24	2.02 -4.57	2.57 -5.07	2.16 -4.39	2.48 -4.51						
30	1	40-60cm	50.65	0.98 -1.61	0.99 -1.80	-0.84 -2.23				2.93 -1.19						2.71 -4.18	2.59 -4.15	2.61 -4.22	2.56 -4.17	2.52 -4.17			1.53 -4.94						
30	2	20-40cm	51.45	1.04 -1.67	1.10 -1.77	-0.90 -2.29				3.03 -1.12						2.49 -4.16	2.37 -3.76		2.52 -4.19	2.65 -4.18	2.37 -4.28								
31	1	34-53cm	52.59	0.98 -1.70	1.03 -1.57	-1.19 -2.18	0.68 -2.08	0.63 -2.00			2.99 -1.15	3.02 -1.00	2.83 -1.13	3.16 -1.11	3.07 -1.05				2.40 -4.16	2.18 -4.13	2.30 -4.62	2.36 -4.05	2.48 -4.30	2.28 -4.49	2.37 -4.50	1.47 -4.55	1.76 -4.66	1.45 -4.77	-0.24 -4.67
32	1	40-59cm	53.50	1.02 -1.48	1.05 -1.70		0.81 -1.67	1.67 -1.10			3.05 -1.03	2.86 -1.07						2.18 -3.97	2.63 -4.34		2.43 -4.12	2.55 -4.12							
34	1	45-65cm	56.55		1.05 -1.69		1.29 -1.88	-0.25 -2.15			3.02 -1.04	3.03 -1.16	2.86 -1.06	2.81 -1.03				1.89 -4.06	2.23 -4.09		2.43 -4.34	2.33 -4.34	2.36 -4.02	2.43 -4.43					
35	1	50-70cm	58.10	1.04 -1.55	1.01 -1.59		1.35 -1.89				2.98 -0.95									2.51 -4.13	2.63 -4.19	2.23 -4.38	2.40 -4.40						
35	2	20-40cm	58.80	1.07 -1.41	1.02 -1.47	-0.60 -2.14				3.03 -1.01		2.79 -0.87					2.18 -3.95			2.50 -3.91	2.49 -4.51			1.44 -4.53					
36	1	10-29cm	59.20	1.00 -1.49	0.97 -1.61						3.16 -0.96	2.69 -0.97			3.16 -0.99		2.17 -4.13	2.31 -4.46		2.55 -4.09	2.65 -4.62	2.42 -4.21							
37	1	49-70cm	61.10	0.97 -1.50	0.99 -1.62	-0.68 -2.08	0.16 -2.10				3.12 -1.00	2.72 -0.98		3.12 -1.07		2.17 -4.12	2.19 -4.12		2.35 -4.30	2.27 -4.48	2.38 -4.32								
37	2	15-35cm	61.75	0.99 -1.58	1.04 -1.68			-0.65 -2.20			3.12 -1.19	2.98 -0.87	2.76 -0.96	3.13 -0.91						1.88 -3.94	2.37 -4.71	2.20 -4.42							
38	1	29-49cm	62.39	0.97 -1.46	0.94 -1.72	-0.87 -2.15					3.24 -1.07		2.22 -1.66					2.06 -4.32	1.96 -4.50	2.09 -4.29	1.89 -3.97	2.45 -4.41	2.24 -4.35						
38	2	45-65cm	63.55	0.89 -1.50	0.94 -1.67	-0.42 -2.16					3.16 -1.05	2.64 -0.98		2.63 -1.15				2.22 -3.96	2.21 -4.04		2.34 -4.17	2.08 -4.27	2.36 -4.32		1.67 -4.48				
38	3	32-52cm	64.42	1.16 -1.34	1.07 -1.52	-0.59 -1.91	0.83 -1.98				3.20 -0.92	2.88 -0.93	2.97 -0.96	3.27 -1.07					2.14 -4.16		2.30 -4.20	2.48 -4.40			1.60 -4.67				

