GSA Data Repository Information

Supplementary Methods Section

Enamel was removed from *Coryphodon* teeth using a Dremel drill with diamond bits. All teeth sampled from Wyoming are canines, while all teeth sampled from Ellesmere Island are incisors. The canine teeth are typically ~50 mm in length, while the incisors are typically ~20 mm in length. In order to increase the temporal resolution of isotopic data from incisors, the sampling resolution was also increased from ~ 1 sample/5 mm to 1 sample/2 mm (see figures 2 and 3 in text). In all teeth, enamel that formed first is located at the tip of the tooth, while enamel that formed last is at the base of the tooth. For this reason, the seasons in figures 2 and 3 in the text are illustrated going backwards in time, with winter values to the left representing the youngest (most recently formed) enamel and summer values to the right representing the oldest (first formed) enamel on the tooth.

Each ~ 5 mg sample of tooth enamel was soaked for 24 hours in 0.1 N acetate-buffer solution, rinsed four times in distilled water, and dried. The $\delta^{18}O$ and $\delta^{13}C$ values of tooth enamel carbonate were measured using an automated carbonate preparation device (KIEL-III) coupled to a Finnigan MAT 252 isotope ratio mass spectrometer at the University of Arizona. Powdered samples were reacted with dehydrated phosphoric acid under vacuum at 70°C (UA) in the presence of silver foil. Isotope ratio measurements are calibrated based on repeated measurements of NBS-19, NBS-18 and in-house powdered carbonate standards. Stable isotope ratios are reported in the text as $\delta^{13}C$ and $\delta^{18}O$ values, where $\delta = (R_{sample}/R_{standard} - 1)*1000$ ‰ *versus* PeeDee Belemnite (VPDB) standard for carbon and *versus* Standard Mean Ocean Water (VSMOW) standard for oxygen.

Discussion of Diagenesis

In order to use stable isotope data to investigate behavior of ancient mammals, it is important to determine if diagenesis, defined here as the chemical alteration of bioapatite after the death of an animal, obscured original behavioural information. Unfortunately, no method described to date can provide unambiguous evidence whether isotopic alteration has or has not occurred in fossil bioapatite (Kohn and Cerling, 2002). As a result, our goal here is not to demonstrate that isotopic alteration is absent. Rather, our goal is to demonstrate that diagenesis has not entirely obscured original paleobiological information reflected in stable isotope ratios of biogenic apatite. In this case, we feel that two primary observations support this hypothesis: (1) inter-tooth patterns in isotope ratios of individual *Coryphodon* teeth are similar in each area, and in both cases significant isotopic variations occur. If isotopic alteration was extensive in any one of these formations, however, then enamel should have a uniform isotopic ratio, as isotopic exchange with ground waters or secondary precipitation of apatite during diagenesis conditions would result in near-uniform isotope ratios. (2) An isotopic offset is observed between *Coryphodon* and coexisting perrisodactyls. Again, if isotopic alteration was extensive, then no such offset should be preserved in the face of secondary mineral formation.

TABLE DR1. STABLE ISOTOPE DATA FROM BULK SAMPLES OF ARCTIC *CORYPHODON* AND PERISSODACTYLS

Specimen Number	Genus	Element*	Carbonate δ13C (‰ VPDB)	Carbonate δ18O (‰ VSMOW)
NUFV 398	*Coryphodon*	tooth frag.	-12.19	11.99
NUFV 399	*Coryphodon*	px frag.	-9.85	12.27
NUFV-18	*Coryphodon*	Mx frag.	-12.00	12.93
CMN 52851	*Coryphodon*	Incisor	-12.63	12.94
CMN 52852	*Coryphodon*	Incisor	-11.78	13.21
CMN 52853	*Coryphodon*	Incisor	-11.37	13.29
CMN 52854	*Coryphodon*	Incisor	-12.30	13.10
CMN 32249	cf *Eotitanops*	M2	-9.16	11.75

CMN 32247A	cf *Eotitanops*	mx frag.	-12.88	10.54
CMN 32283	*Thuliadanta*	M3	-9.74	12.35
CMN 30800	*Thuliadanta*	P4, M3	-11.75	10.68
CMN 30812a	*Thuliadanta*	M3	-8.36	12.38

Note: Specimens are housed in the collections of the Canadian Museum of Nature (CMN), Ottawa, Canada.

*P/p = upper/lower premolar; M/m = upper/lower molar; frag. = fragment; numbers indicate tooth position (e.g., M2 = upper second molar)

TABLE DR2. $\delta^{13}C$ AND $\delta^{18}O$ OF SEQUENTIALLY-SAMPLED ARCTIC *CORYPHODON*

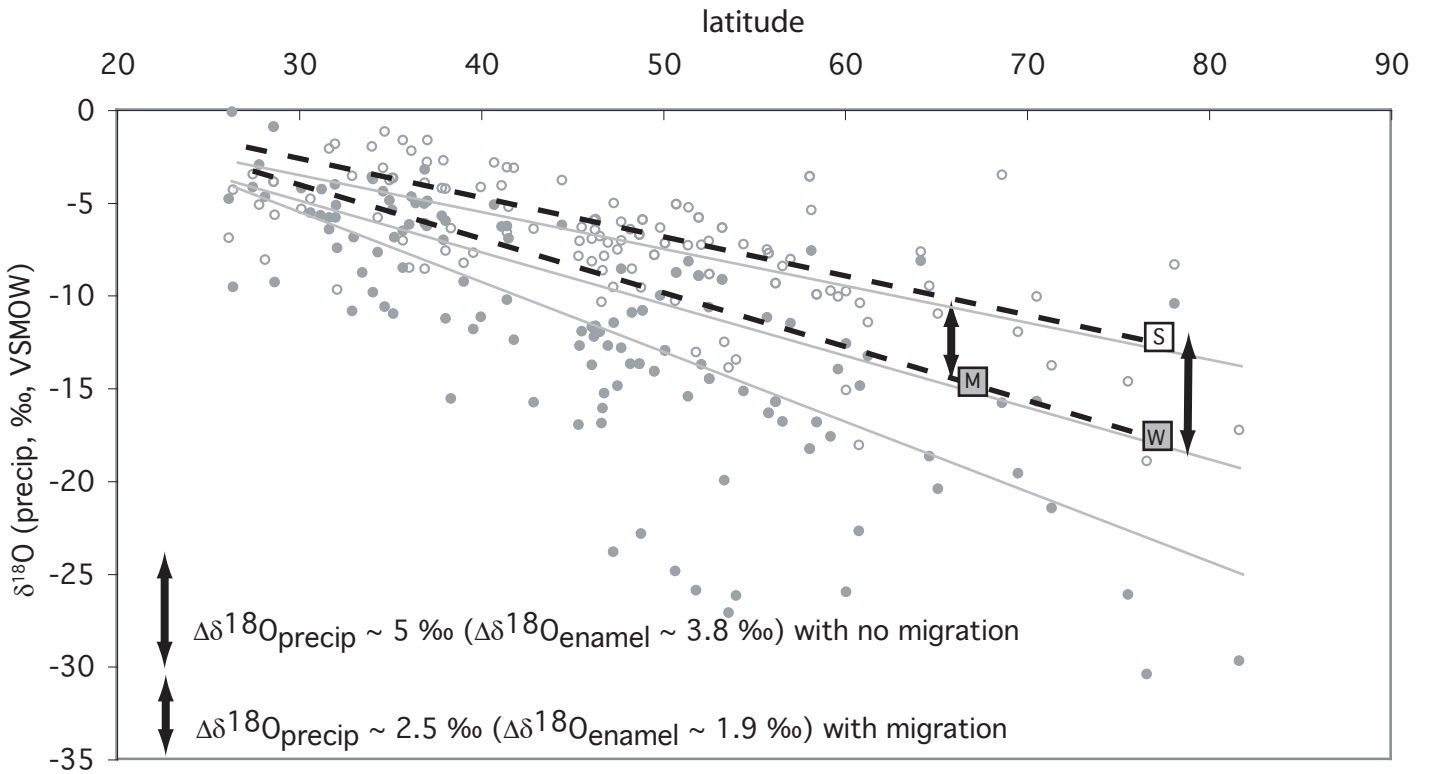
Specimen No.	Sample Position along tooth*	Carbonate $\delta^{13}C$ (‰ VPDB)	Carbonate $\delta^{18}O$ (‰ VPDB)	Carbonate $\delta^{18}O$ (‰ VSMOW)
CMN 52851	1	-11.36	-17.83	12.5
	2	-12.04	-18.62	11.7
	3	-13.33	-17.74	12.6
	4	-13.24	-17.31	13.0
	5	-12.50	-16.78	13.6
	6	-13.34	-16.30	14.1
CMN 52852	1	-10.64	-16.69	13.7
	2	-13.10	-16.49	13.9
	3	-12.08	-17.68	12.6
	4	-11.76	-17.29	13.0
	5	-11.34	-17.71	12.6
CMN 52853	1	-13.06	-16.53	13.8
	2	-10.07	-15.68	14.7
	3	-9.39	-17.05	13.3
	4	-12.22	-18.23	12.1
	5	-12.11	-17.98	12.3
CMN 52854	1	-9.78	-17.86	12.5
	2	-12.16	-18.56	11.7
	3	-12.80	-17.94	12.4
	4	-13.23	-15.95	14.4
	5	-13.54	-16.09	14.3
	6	-13.15	-16.76	13.6
CMN 52855	1	-10.42	-16.00	14.4
	2	-10.83	-17.09	13.2
	3	-10.89	-18.09	12.2
	4	-11.27	-19.72	10.5
	5	-12.08	-19.50	10.8
	6	-12.09	-17.47	12.9
CMN 52856	1	-13.28	-17.00	13.3
	2	-13.49	-17.68	12.6
	3	-13.36	-16.12	14.2
	4	-13.29	-16.09	14.3
	5	-13.28	-16.86	13.5
	6	-13.20	-16.21	14.1

Note: Specimens are housed in the collections of the Canadian Museum of Nature (CMN), Ottawa, Canada.

***** In all teeth, enamel that formed first is located at the tip of the tooth, while enamel that formed last is at the base of the tooth. With regard to sample position, sample 1 was taken nearest the base of the tooth (youngest enamel) while sample 6 was taken farthest from the base (oldest, first formed enamel).

Figure DR1. $\delta^{18}O$ of modern precipitation *versus* latitude for summer (open circles) and winter (closed circles; Fricke and O'Neil, 1999). Solid gray lines are linear regressions for modern winter (lower line), summer (upper line) and mean annual data sets (middle line; mean annual data not shown for sake of clarity). Dashed black lines are estimated latitudinal gradient in $\delta^{18}O$ of Eocene precipitation. They were made using the predicted range in $\delta^{18}O$ of environmental water for Arctic regions during the Eocene (Jahren and Sternberg, 2008) as high-latitude tie points, and extrapolating back to lower latitude $\delta^{18}O$ values that are (1) assumed to be ~ 1 ‰ higher than at present due to late Cenozoic ice sheet formation (Miller et al., 1987) and (2) consistent with estimated $\delta^{18}O$ of low latitude river water during that time (Fricke, 2003). Precipitation $\delta^{18}O$ that would have been ingested by *Coryphodon* during summer months is illustrated with 'S'; precipitation $\delta^{18}O$ that would have been ingested during winter months if *Coryphodon* did not migrate is illustrated with 'W'; and precipitation $\delta^{18}O$ that would have been ingested if *Coryphodon* migrated south during winter is illustrated with 'M'. Seasonal difference in $\delta^{18}O$ of precipitation available to *Coryphodon* ($\Delta\delta^{18}O$) is reduced in half from ~ 5 to 2.5 ‰. Because range is dampened another ~25% when recorded by tooth enamel, non-migratory *Coryphodon* should have intra-tooth ranges in $\delta^{18}O$ of ~3.8 ‰, while migratory *Coryphodon* should have ranges in $\delta^{18}O$ of ~1.9 ‰. The former is observed (Fig. 4).

Figure DR1


latitude
20
30
40
50
60
70
80
90
0
-5
-10
-15
-20
-25
-30
-35
δ18O (precip, ‰, VSMOW)
S
M
W
Δδ18Oprecip ~ 5 ‰ (Δδ18Oenamel ~ 3.8 ‰) with no migration
Δδ18Oprecip ~ 2.5 ‰ (Δδ18Oenamel ~ 1.9 ‰) with migration

REFERENCES CITED

Fricke, H.C., 2003, $\delta^{18}O$ of geographically widespread mammal remains as a means of studying water vapor transport and mountain building during the early Eocene: Geological Society of America Bulletin, v. 115, p. 1088-1096.

Fricke, H.C. and O'Neil, J.R., 1999, The correlation between 18O/16O ratios of meteoric water and surface temperature: its use in investigating terrestrial climate change over geologic time: Earth and Planetary Sciences Letters, v. 170, p. 181–196.

Jahren, A.H., and Sternberg, L.S., 2008, Annual patterns within tree rings of the Arctic middle Eocene (ca. 45 Ma): isotopic signatures of precipitation, relative humidity, and deciduousness: Geology, v. 36, p. 99–102.

Kohn, M.J. and Cerling, T.E., 2002, Stable isotope compositions of biological apatite: Review of Mineralogy, v. 48, p. 455-488.

Miller, K.G., Fairbanks, R.G., and Mountain, G.S., 1987, Tertiary oxygen isotope synthesis, sea level history, and continental margin erosion: Paleoceanography, v. 2, p. 1–19.