Reynard, L.M., et al., Stable isotopes in yellow-bellied marmot (*Marmota flaviventris*) fossils reveal environmental stability in the late Quaternary of the Colorado Rocky Mountains, Quaternary Research, http://dx.doi.org/10.1016/j.yqres.2014.12.006

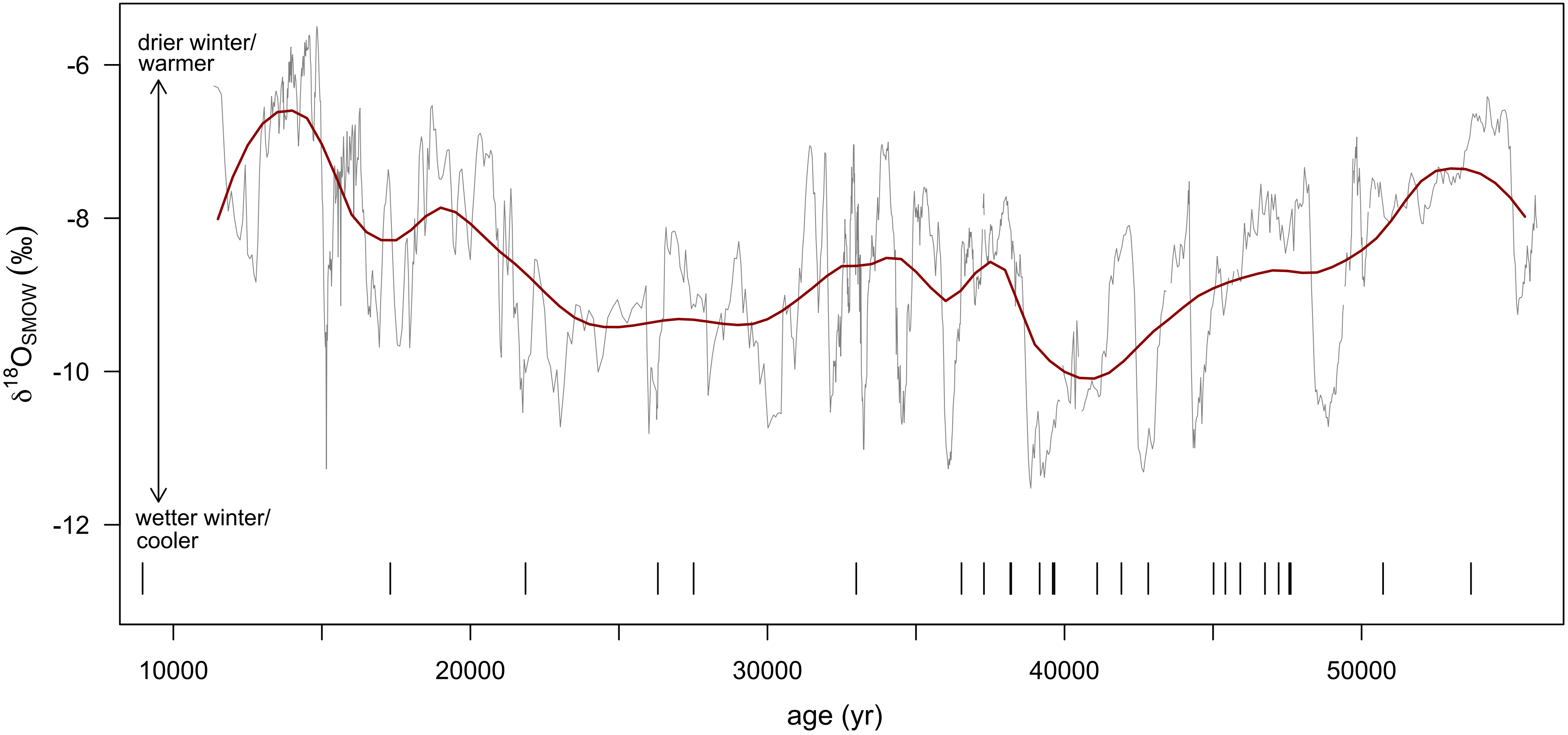

Figure S1. $\delta^{18}O$ for Fort Stanton Cave, New Mexico (Asmerom et al., 2010), as a function of time. The thick line is the smoothed data using the loess function in R (span=0.2, R Team, 2009). The lower plot shows the density of marmot radiocarbon dates (cal yr BP).

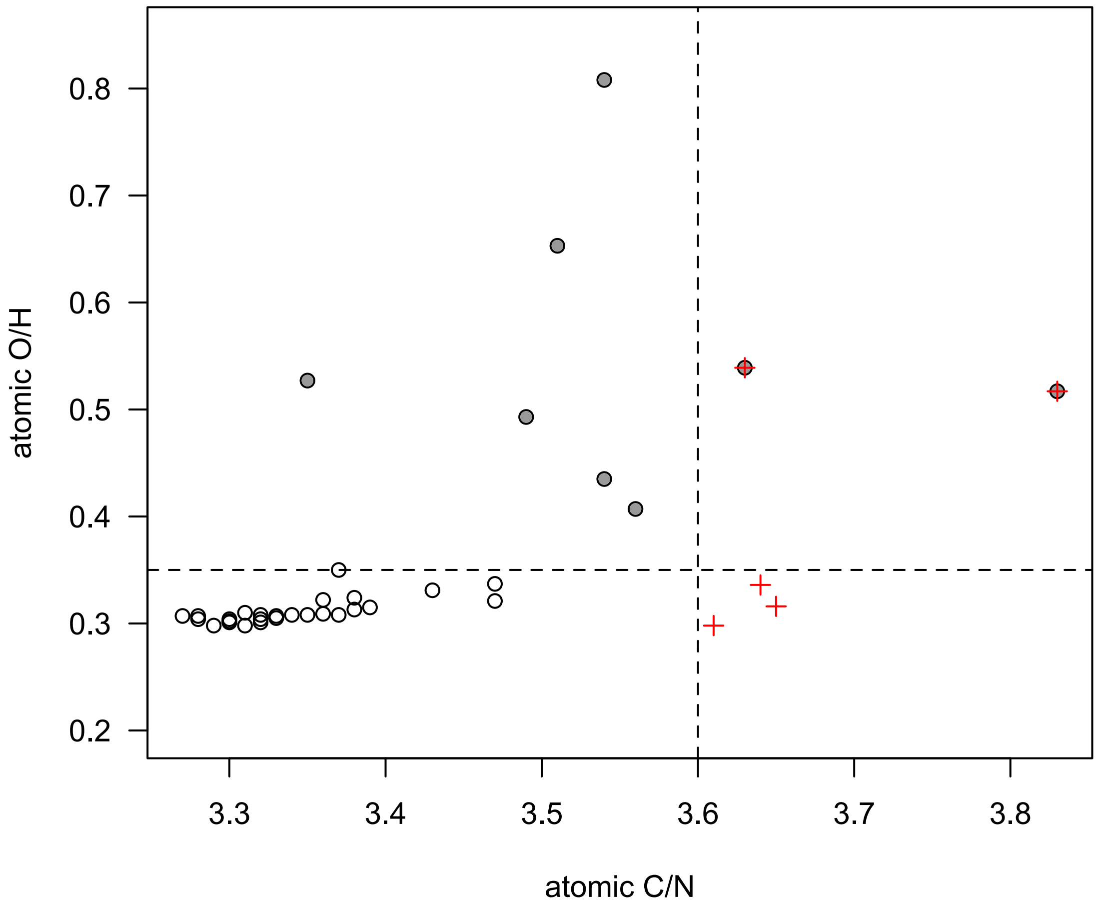

Figure S2. Atomic O/H vs. atomic C/N for Cement Creek collagens. We reject from further analysis samples with C/N > 3.6 (to the right of the vertical line, marked by crosses) and O/H greater than 0.35 (above the horizontal line, shaded points).

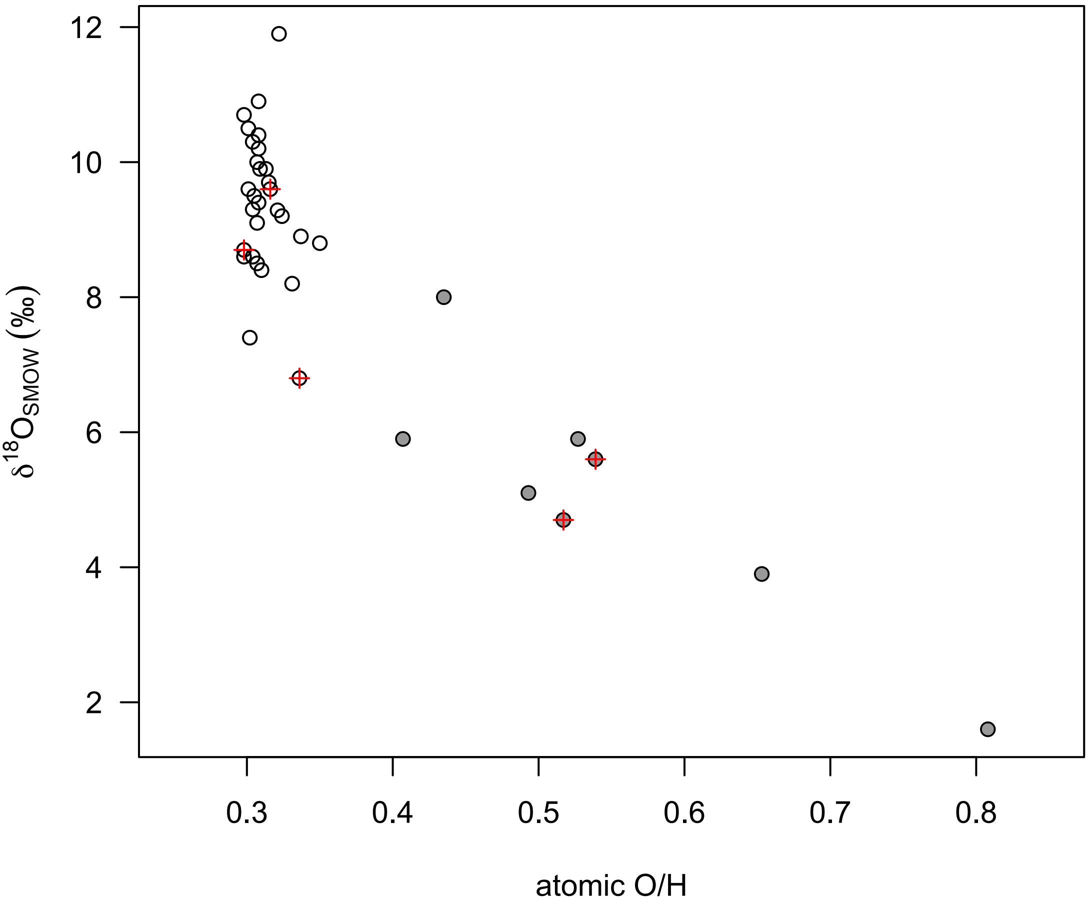

Figure S3. $\delta^{18}O_{SMOW}$ (‰) vs. atomic O/H for Cement Creek collagens. Shaded points show samples with O/H > 0.35; these data show a trend to much lower $\delta^{18}O$ with increasing O/H. Crosses indicate samples that were rejected based on high C/N ratios (n=5).

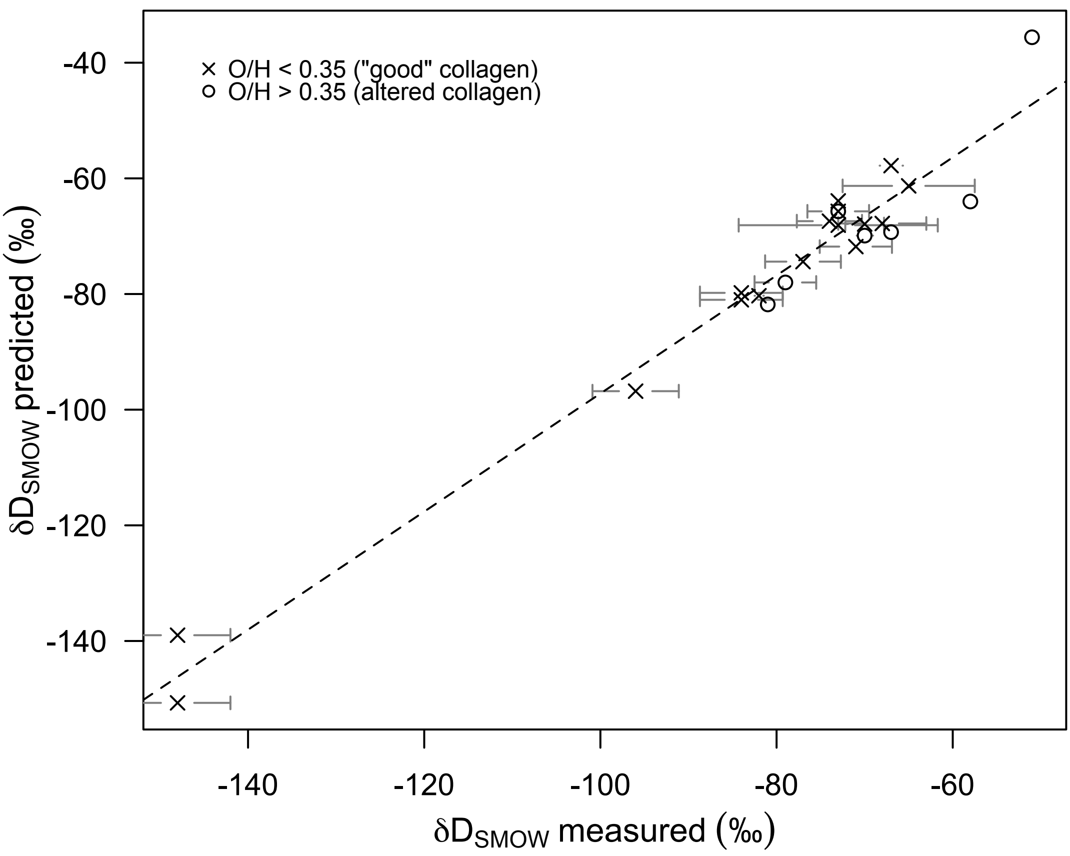

Figure S4. $\delta D_{predicted}$ vs. $\delta D_{measured}$ for collagens from the water exchange experiment. The regression line is $\delta D_{predicted} = 1.02\ \delta D_{measured} + 4.9$ ‰ with r^2=0.96.

Supplemental Material

Collagen-water exchange experiment

We performed a water exchange experiment to test the change in measured δD when collagen was exposed to waters of three distinct isotopic compositions (δD =596 ‰, -46 ‰, -450 ‰). Three separate aliquots of ~500 mg of collagen were each placed in 350 mL water in a capped ultra-centrifuge tube and left at room temperature for 24 hours. The samples were then freeze dried, and as quickly as possible transferred to silver capsules and sealed in the zero-blank autosampler. Transfer of a whole batch took ~ 1 hour. Table S1 shows the resulting total δD for each aliquot, as well as the regression slope, intercept, and correlation coefficients for δD measured vs. δD exchange water.

The slopes varied from 0.02-0.11 (with one sample repeat at 0.17), indicating that in reasonable ranges of water δD, exchange with environmental water makes negligible difference to the total measured δD: a 50 ‰ water δD difference would result in 1-5 ‰ change in measured collagen δD, which is within experimental error. All samples were processed with in-house deionized water (the mid-range δD water), and any small variation in the lab atmospheric water's isotopic composition over time should have insignificant effect on the results here.

Using the slope and intercept for each sample, we calculate the collagen δD at the in-house lab water's δD value (-46 ‰), and compare this to the total δD measured in a separate experimental runs that form the bulk of the data (Table 1). These are highly correlated (r^2=0.96), with $\delta D_{predicted}$ = 1.02 $\delta D_{measured}$ + 4.9 ‰ (Fig. S4), with the largest individual difference of 15 ‰ (mean 4 ‰). The exchange experiment reveals a systematic behavior that is consistent with the 'simple' total measured δD runs. Changes in $\delta^{18}O$ were not systematic, but showed variation of 0.9 ‰ on average, between collagen exchanged with high, mid, and low $\delta^{18}O$ water (63 ‰, -7 ‰, -56.3 ‰), and we therefore posit no major effect of environmental water on collagen $\delta^{18}O$ values.

Table S1. Measured collagen δD (‰) and $\delta^{18}O$ (‰) for the collagen-water exchange experiment

	collagen δD (‰)			slope	intercept	r^2	$\delta D_{predicted}$	$\delta D_{measured}$		atom	collagen $\delta^{18}O$ (‰)		
	(water = 596 ‰)	(water = -46 ‰)	(water = -450 ‰)							O/H	(water = 63 ‰)	(water = -7 ‰)	(water =-56.3 ‰)
CC2-5-38	-39	-90	-139	0.094	-92.5	0.986	-97	-96	4.9	0.298	8.7	8.6	7.4
CC2-3-8	11	-51	-107	0.111	-52.7	0.990	-58	-67	1.3	0.301	10.6	11.3	9.4
CC2N-23-28	-2	-84	-112	0.107	-69.5	0.980	-74	-77	4.3	0.302			
CC2-17-40	-9	-57	-114	0.099	-63.4	0.967	-68	-70	2.2	0.304			
CC2-12-11	-3	-72	-115	0.107	-66.9	1.000	-72	-71	4.1	0.307	9.5	8.5	8.3
CC2-13-12	-14	-65	-99	0.081	-61.9	1.000	-66	-73	3.5	0.308			
CC2-18-41	-16	-61	-90	0.071	-58.0	1.000	-61	-65	7.5	0.309	10.0	10.0	10.0
CC2N-21-27	-23	-85	-111	0.085	-75.8	0.990	-80	-84	4.7	0.315	10.3	10.2	9.9
CC2N-18-25	-20	-65	-101	0.077	-64.6	0.996	-68	-73	11.3	0.322	12.4	12.5	11.7
CC2-16-14	-9	-68	-95	0.083	-60.1	0.993	-64	-73		0.324	9.5	9.0	8.9
CC2-23-19	-40	-82	-106	0.063	-78.1	0.999	-81	-84	4.7	0.332	9.5	9.1	8.7
CC2-32-23	-55	-77	-100	0.042	-78.4	0.980	-80	-82	0.5	0.336			
CC2-18-17	-30	-66	-92	0.059	-64.7	0.999	-67	-74	3.7	0.337			
CC2N-36-48	-19	-66	-100	0.077	-64.2	0.999	-68	-68	5.0	0.350	9.8	10.1	9.5
CC2-17-16	1	-36	-58	0.057	-33.0	1.000	-36	-51		0.435			
CC2-25-43	-54	-68	-81	0.026	-68.7	0.984	-70	-70	0.9	0.493			
CC2N-11-45	-53	-74	-97	0.041	-76.1	0.972	-78	-79	3.5	0.517			
CC2-16-15	-26	-70	-87	0.059	-63.0	0.986	-66	-73		0.527	8.2	8.7	7.6
CC2-2-7	-45	-82	-105	0.057	-79.1	1.000	-82	-81		0.539			
CC2N-34-47	-41	-67	-89	0.045	-67.2	0.994	-69	-67		0.653			
CC2-31-22	-34	-60	-86	0.049	-61.7	0.984	-64	-58		0.808			
bison	-38	-148	-224	0.177	-142.6	0.999	-151	-148	6.0	0.295	-0.5	-3.4	-4.3
bison	-62	-146	-181	0.115	-133.7	0.990	-139	-148	6.0	0.295			