Paleoenvironmental Reconstruction of Two Paleoindian Sites in North-Central New Mexico

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THE UNIVERSITY OF NEW MEXICO

Introduction

Hypotheses

Carbon

H_0: The C_3 and C_4 grasses ratio remained stable between the Younger Dryas and the Early Holocene

H_1: The ratio of C_4 grasses to C_3 grasses was higher in the Early Holocene than in the Younger Dryas

Oxygen

H_0: $\delta^{18}O$ will remain stable between the Younger Dryas and the Early Holocene

H_1: $\delta^{18}O$ will differ between the Younger Dryas and the Early Holocene

Carbon

Carbon exists in two stable forms in nature (^{12}C and ^{13}C)

Plants have evolved different photosynthetic pathways for observing carbon from the atmosphere depending on the habitat

- C_3, C_4, and CAM
  - Bison do not feed on CAM (crassulacean acid metabolism) Plants (e.g., succulents)

Oxygen

Oxygen exists in three naturally occurring stable isotopes (^{18}O, ^{17}O, and ^{16}O)

- ^{17}O is not used in paleoenvironmental analyses

^{16}O is the most common isotope

^{18}O to ^{16}O ratios can provide proxy evidence for an animal's environment

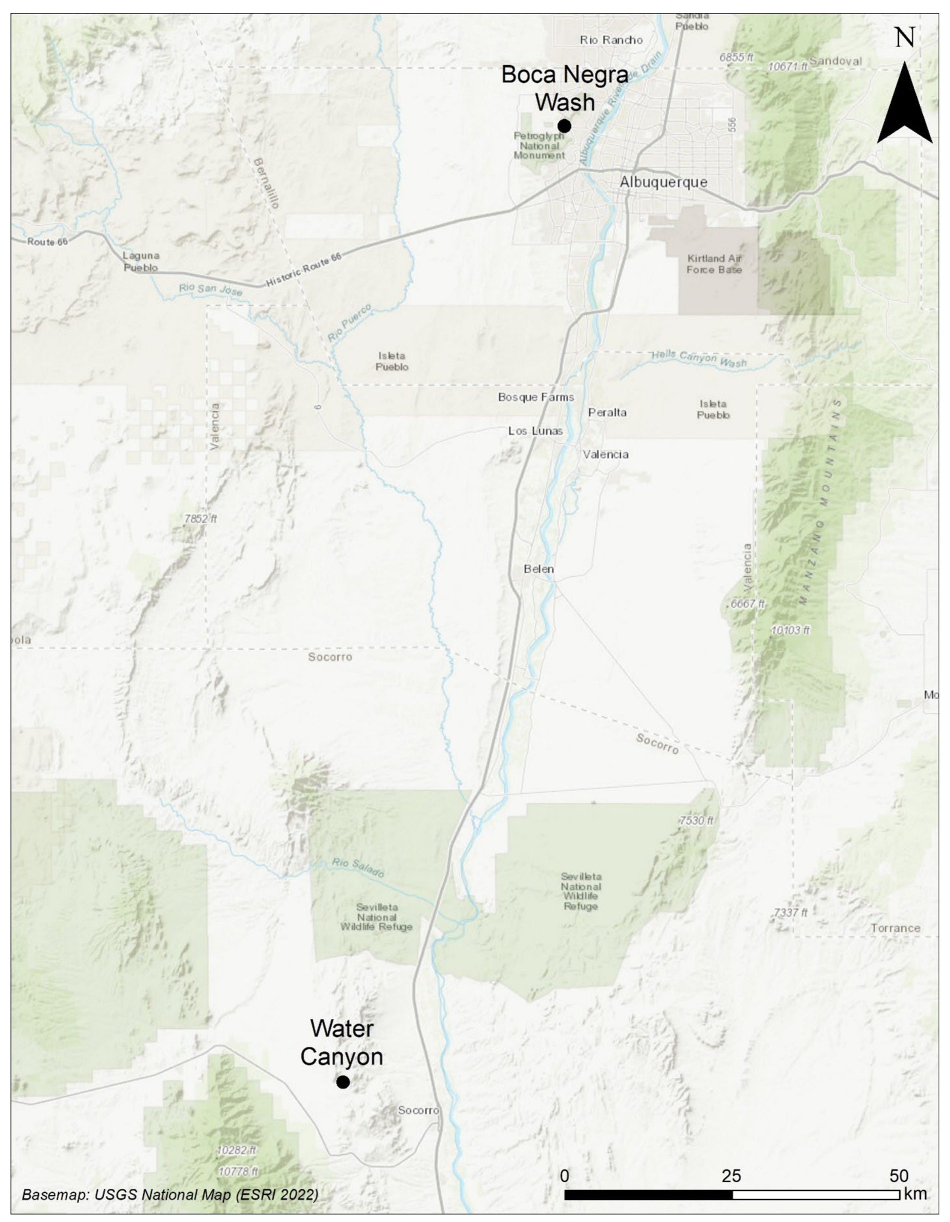
There is no specific fractionation factor to determine an environment based on $\delta^{18}O$

Environmental factors affect the value:

- Precipitation, temperature, altitude, latitude...

Lakes will have an average $\delta^{18}O$ across the seasons while $\delta^{18}O$ in rivers varies seasonally

Background



Map showing Boca Negra Wash and Water Canyon

The Stable Isotopes

^{12}C vs ^{13}C

- These are taken up at a different rate by C_3 and C_4 plants based on the environment

^{18}O vs ^{16}O

- A higher ratio of ^{16}O to ^{18}O may indicate a wetter climate

Carbon = Habitat

Oxygen = Climate

Methods

Center for Stable Isotopes

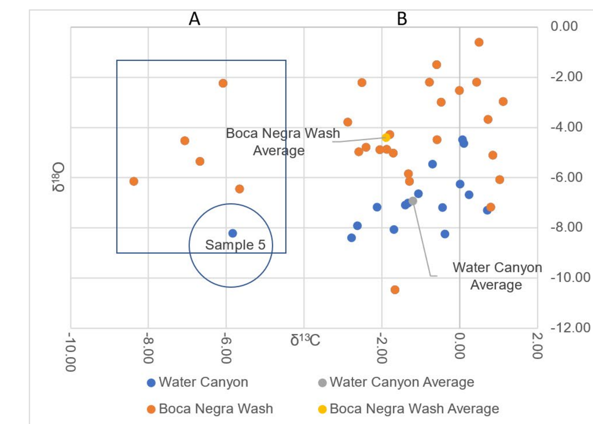
1. Dr. Atudorei from the Department of Earth and Planetary Sciences performed the mass spectrometer
2. He loaded the samples in a 12 mL borosilicate exetainer and flushed them with helium
3. The samples were reacted for 24 hours
4. The CO_2 was measured by the continuous flow Isotope Ratio Mass Spectrometry
5. Reproducibility was better than 0.15‰ for both the $\delta^{13}C$ and $\delta^{18}O$ based on repeat of lab standards
6. I present the isotopic ratios in the per mill (‰) notation

Bison tooth before and after drilling of the surface

Results

Sample Number	FS Number	Project	LA Number	weight (mg)	$\delta^{13}C$‰	$\delta^{18}O$‰
1	5029	41.901	134764	6.468	-0.44	-7.18
2	5121	WC field school	134764	6.212	-2.63	-7.91
3	5171	UNM field school	134764	6.561	-0.70	-5.47
4	5140	WC field school	134764	6.114	-1.07	-6.64
5	5080	41.901	134764	6.336	-5.83	-8.22
6	5140	WC field school	134764	6.242	-2.78	-8.40
7	5102	41.901	134764	6.428	-0.38	-8.24
8	5118	41.901	134764	6.994	-1.40	-7.09
9	5125	WC field school/41.901	134764	6.178	0.71	-7.29
10	5037	41.901	134764	6.45	0.01	-6.25
11	5055	WC field school	134764	6.499	0.11	-4.64
12	5013	41.901	134764	6.896	-1.69	-8.07
13	5145	WC field school	134764	6.075	-1.33	-7.00
14	5148	WC field school	134764	6.261	0.07	-4.49
15	5151	WC field school	134764	6.575	-1.46	-5.47
16	1198	WC 2012	134764	5.184	-2.13	-7.17
17	1276	WC 2012	134764	6.89	0.24	-6.67

Sample 15 was removed from further analysis due to possible contamination.



Isotopic analysis results comparing the bison at Water Canyon (blue) and Boca Negra Wash (orange) in ‰

The average and range for $\delta^{13}C$ and $\delta^{18}O$ values for bison at Water Canyon and Boca Negra Wash

	Average		Range	
	$\delta^{13}C$	$\delta^{18}O$	$\delta^{13}C$	$\delta^{18}O$
Water Canyon	-1.20‰	-6.92‰	-5.83‰ – 0.71‰	-8.40‰ – -4.49‰
Boca Negra Wash	-1.89‰	-4.41‰	-8.38‰ – 1.12‰	-10.47‰ – -0.60‰

Statistics

Carbon		Oxygen	
Mann-Whitney U	202	Mann-Whitney U	55.5
z	0.52455	z	4.0991
p	0.5999	p	< 0.01

Population A vs. B from Boca Negra Wash

Carbon	
Mann-Whitney U	0
z	3.4191
p	< 0.01

Results comparing Boca Negra Wash vs Water Canyon

The statistics show that the $\delta^{13}C$ values for both sites are similar, while Water Canyon has more negative $\delta^{18}O$ values than Boca Negra Wash on average. The statistics also show that sample 5 from Water Canyon clusters with five samples from Boca Negra Wash. At Boca Negra Wash, only fragmentary enamel samples were analyzed due to preservation, so individual teeth could not be identified precisely. This same problem occurred at Water Canyon, with several samples too fragmentary to identify a specific tooth type.

Gadbury et al. (2000), documented that the M1 teeth of ungulates had a “light” δ18O compared to the M2 and M3 of the same animal, most likely due to the M1's utero enamel formation. I created Population A and B based on where they fell on the scatter plot and ran a Mann-Whitney *U*.

C_3-browsers vs C_4-grazers according to Cerling et al. 2015

Water Canyon

- 53% C_4 grazers and 47% C_3/C_4 grazers

Boca Negra Wash

- 52% C_4 grazers and 48% C_3/C_4 grazers

Results

Carbon

H_0: The C_3 and C_4 grasses ratio remained stable between the Younger Dryas and the Early Holocene

~~H_1: The ratio of C_4 grasses to C_3 grasses was higher in the early Holocene than in the Younger Dryas~~

Oxygen

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H_1: $\delta^{18}O$ will differ between the Younger Dryas and the Early Holocene

Conclusion

Carbon

Statistically similar

Water Canyon:

- 53% C_4-grazers and 47% mixed C_3/C_4-grazers

Boca Negra Wash:

- 52% C_4-grazers and 48% mixed C_3/C_4-grazers

C_3 and C_4 grasses habitat remained unchanged from the Younge Dryas into the Early Holocene

Oxygen

Statistically different

Water Canyon had “lighter” $\delta^{18}O$ compared to Boca Negra Wash

Bison had a different source of water during the Younger Dryas and Early Holocene

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References Cited