MIGRATORY PATTERNS AND STABLE ISOTOPE ANALYSIS OF THE HILL STREET SKELETONS

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OVERVIEW

- Found during the construction of Hill Street in Riverton, WY, ca. 1989-1995.
- 3 Skeletons--two males, one female.

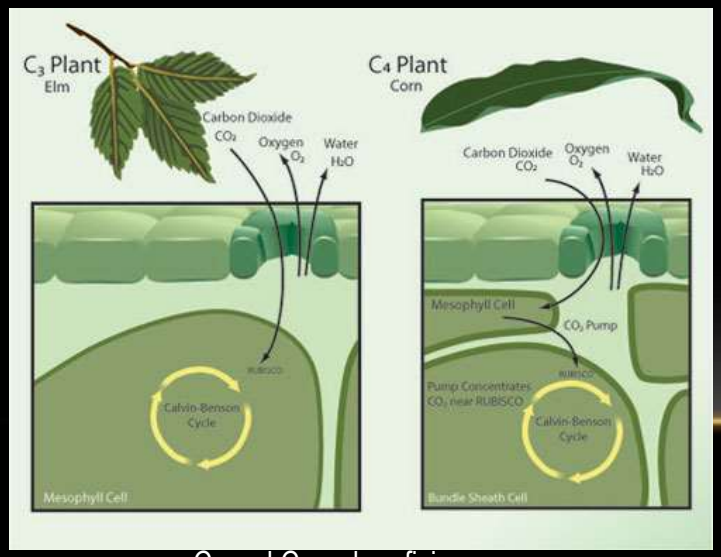
FC070-1

FC070-2

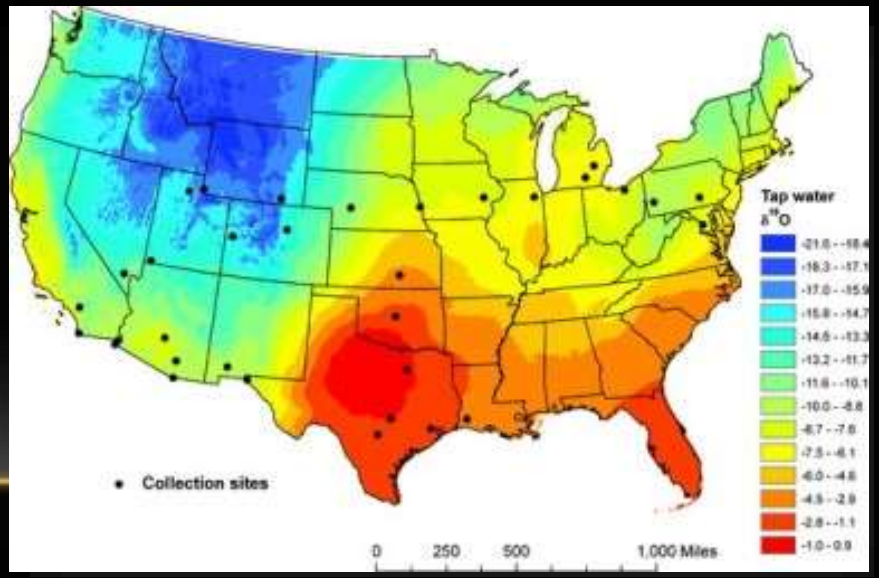
FC070-3

UTILITY OF STABLE ISOTOPES

- For the purposes of this project, δC^{13} and δO^{18} isotope ratios were analyzed.
- δC^{13} analysis provides information on the diet of the individual during their lifetime (e.g. whether diet was based more in C_3 or C_4 plants)
- δO^{18} signatures are retained from groundwater sources, which can be used to hypothesize probable long-term geographic residence or migration.
- Both of these isotopes are present in hydroxyapatite ($Ca_5(PO_4)_3(OH)$), which is the primary inorganic component of bone.



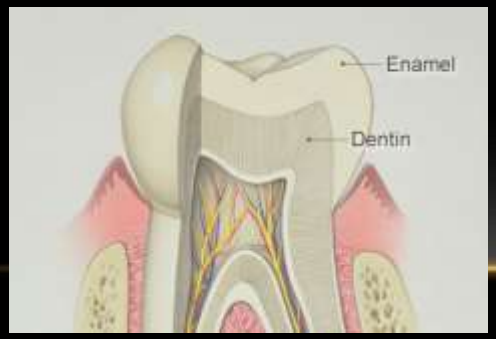
C_3 and C_4 carbon fixing processes



Map of the distribution of δO^{18} signatures in groundwater of the continental U.S.

BONE AND ENAMEL REGENERATION RATES

- Osteoclasts (“bone eating” cells) destroy old bone tissue, while Osteoblasts (“bone building” cells) construct new bone tissue.
- This process of bone regeneration occurs at predictable rates for various bones in the body, which in turn provides us with chemical signatures from varying points in the individual’s lifetime.
- For this project, δC^{13} and δO^{18} samples were taken from carbonate in tooth enamel and rib bones.
- Tooth enamel does not regenerate after initial formation—approx. 10 years of age.
- Bones of the axial skeleton (e.g. ribs, vertebrae) fully regenerate approximately every 10 years.



Human Tooth

Human Axial Skeleton

QUESTIONS

- Did these individuals come to Wyoming from a distant place? Were they homesteaders? Pioneers?

Pioneers on the Oregon Trail

Homestead Near the Wind River Mountains, WY

METHODS

- The methods used to prepare samples was that first outlined by Schoeninger, Moore, Murray, and Kingstone ca. 1989 (Schoeninger et al 1989).
- Samples were selected from broken, non-pathological bones and teeth to mitigate any destruction of potentially useful material.
- Cusps from one tooth and fragments of one rib per individual were selected based on this criteria
- Samples were prepared over a period of approximately 1.5 weeks before being sent to the Stable Isotope Facility at the U.W. Berry Biodiversity Conservation Center.

METHODS

1. Isolate the desired bone materials—enamel (teeth) and carbonate (ribs)

   Rib Bones: This is done by scraping away all of the cancellous (inner spongy) bone and the exterior fibrous sheath from the sample, leaving only the outer compact bone.

   Enamel: This is done by removing one or more cusps from the crown of a tooth and scraping away all but the exterior enamel.

2. Grind bones and enamel to a powder using an agate mortar and pestle
3. Supersonic rinse in double distilled water

Grinding Samples with Mortar & Pestle

Ground Rib Sample

METHODS

4. Soak in NaOCl (Clorox, [sodium hypochlorite]) for 48 hours to compensate for diagenetic alteration (posthumous carbonate formation) (Ambrose 2003)
5. Rinse samples back to a basic state in double distilled water
6. 2-hour soak in 0.2M acetic acid to eliminate organic components (i.e. collagen) (Garvie-Lok et al 2004).
7. Final rinse to basic
8. Freeze dry to extract all moisture
9. Mass Spectrometry analysis of samples using a Thermo Gasbench coupled to a Thermo Delta Plus XL IRMS

U.W. Thermo Finnigan Delta Plus XP, TC LC PAL Autosampler, Thermo Finnigan GasBench II at the Berry Biodiversit Concervation Center

RESULTS

SIF ID	Sample ID	$\delta^{13}C$	$\delta^{18}O$
20140046.001	HR070-2 C1 (Mand) Rt	-13.6	-5.5
20140046.002	HR070-3 Rib	-14.4	-5.1
20140046.003	HR 070-3 M2 (Mand) Lt	-13.4	-8.9
20140046.004	HR 070-1 Rib	-11.4	-9.5
20140046.005	HR 070-1 M1 (Mand) Rt	-14.6	-6.5
20140046.006	HR 070-2 Rib	-12.1	-9.1

But what does it mean?

CONVERSIONS

- The reference material used for the initial analysis was Vienna Pee Dee Belemnite (VPDB), which is a mineral that cannot be used as a basis for comparison of Oxygen isotopes in groundwater. In addition, fractionation of oxygen isotopes occurs when water is consumed and assimilated into structural carbonate (Bryant et al. 1996). Because of this, a series of three conversion equations was applied to the results which made them useable. These were:

1. Conversion from $\delta^{18}O\ c_{VPDB}$ to Vienna Standard Mean Ocean Water ($\delta^{18}O\ c_{VSMOW}$):

$$\delta^{18}O\ c_{VSMOW} = (1.0392 \times \delta^{18}O\ c_{VPDB}) + 30.92$$

Enamel

SIF ID	Sample ID	$\delta^{18}O$
20140046.001	HR070-2 C1 (Mand) Rt	25.2044
20140046.003	HR 070-3 M2 (Mand) Lt	19.2681
20140046.005	HR 070-1 M1 (Mand) Rt	24.1652

Rib

SIF ID	Sample ID	$\delta^{18}O$
20140046.002	HR070-3 Rib	25.62008
20140046.004	HR 070-1 Rib	21.0476
20140046.006	HR 070-2 Rib	21.46328

CONVERSIONS

- The fractionation of oxygen isotopes that make up structural carbonate renders them irrelevant for comparative analysis to oxygen isotopes in groundwater; however, oxygen isotopes in phosphate are generally expected to be in equilibrium with those of body water (Brown 2014), which varies linearly with (but is not in equilibrium with) groundwater (Luz et al 1984) . Because of this a second equation was employed to convert $\delta^{18}O\ c_{VSMOW}$ to $\delta^{18}O\ p_{VSMOW}$.

2. $$\delta^{18}O\ c_{VSMOW} = \frac{(8.5 + \delta^{18}O\ p_{VSMOW})}{0.98}$$

Enamel

SIF ID	Sample ID	$\delta^{18}O$
20140046.001	HR070-2 C1 (Mand) Rt	16.2003
20140046.003	HR 070-3 M2 (Mand) Lt	10.3827
20140046.005	HR 070-1 M1 (Mand) Rt	15.1819

Rib

SIF ID	Sample ID	$\delta^{18}O$
20140046.002	HR070-3 Rib	16.60769
20140046.004	HR 070-1 Rib	12.126648
20140046.006	HR 070-2 Rib	12.5340144

CONVERSIONS

- Lastly, an equation was used to compensate for the variations amongst $\delta^{18}O$ p and $\delta^{18}O$ w (groundwater):

$$3.\ \delta^{18}O\ w_{VSMOW} = \frac{(\delta^{18}O\ p_{VSMOW} - 22.70)}{0.78}$$

Enamel

SIF ID	Sample ID	$\delta^{18}O$
20140046.001	HR070-2 C1 (Mand) Rt	-8.3329
20140046.003	HR 070-3 M2 (Mand) Lt	-15.7914
20140046.005	HR 070-1 M1 (Mand) Rt	-9.6386

Rib

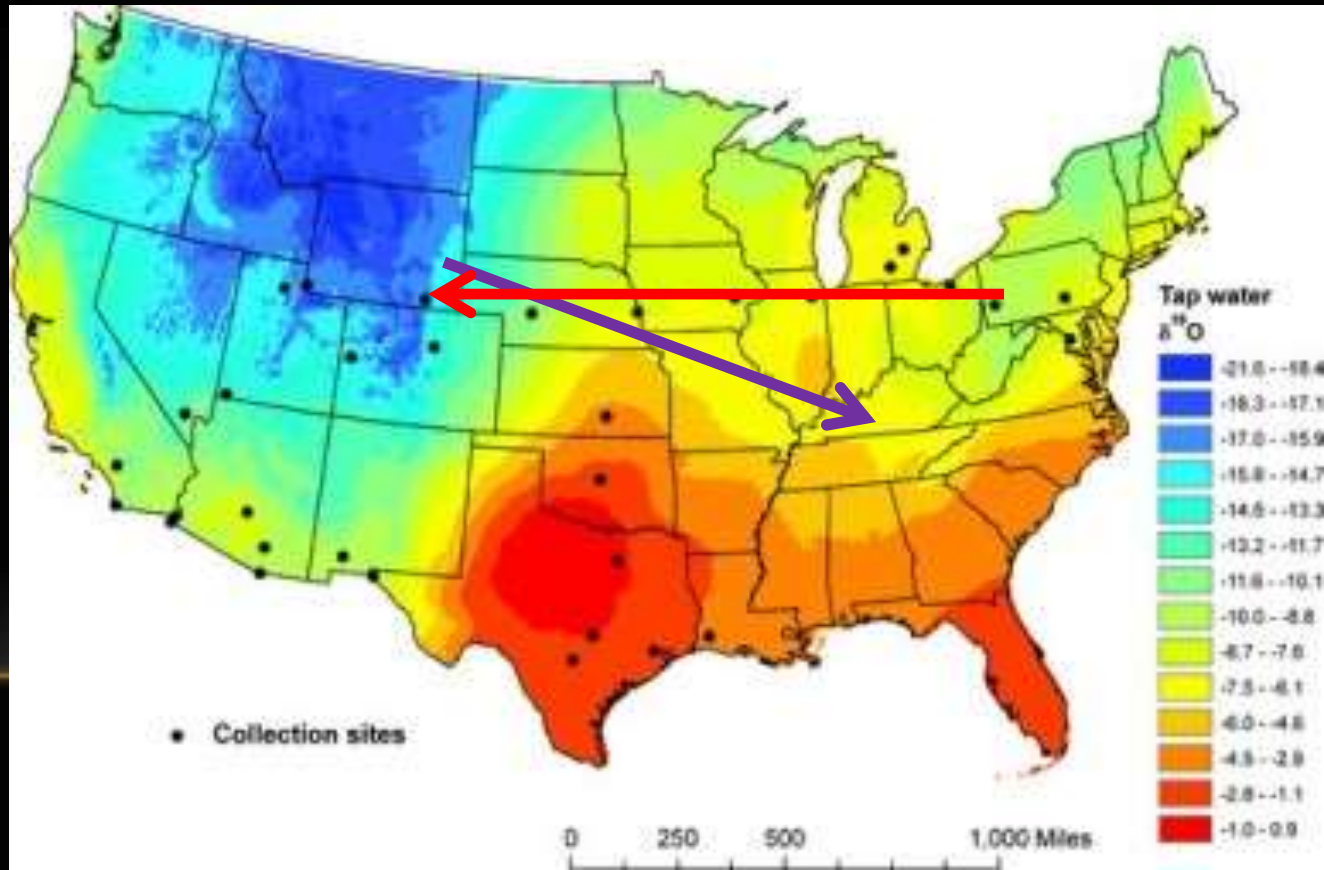
SIF ID	Sample ID	$\delta^{18}O$
20140046.002	HR070-3 Rib	-7.8107
20140046.004	HR 070-1 Rib	-13.5555
20140046.006	HR 070-2 Rib	-13.0333

INTERPRETATION

- Skeletons FC070-1 and FC070-2 display a migratory trend from east to west during their lifetimes; however, FC070-3 shows a directly opposite migratory trend from west to east.

FC070-1 and HR070-2 (-8.8 - -10.0)

FC070-3 (-15.8 - -14.7)



INTERPRETATION

- Though these numbers provide us with an indication of where these individuals lived during childhood, it is still very difficult to establish any particular trend of mobility; however, due to the time frame in which these individuals lived and died in Northwestern Wyoming, it is most likely that FC070-1 and FC070-2 were homesteaders who moved from further East.
- Between 1820 and 1916, a series of laws, including the Homestead Act of 1862, were passed that created incentives for white settlers to move westward and develop the interior of the United States (Matray 2012).
- Based on this, it would be unsurprising if familial relations existed between FC070-1 and FC070-2 (e.g. father-daughter, husband-wife, brother-sister).

FC070-1

FC070-2

INTERPRETATION

- FC070-3 stands out from the other two cases, as the oxygen isotopes from his rib samples indicate that he spent significant time further east during the final years of his life. This is likely due to pursuing either work or a university education.
- While his isotopic signatures place him further east, he was still buried alongside FC070-1 and FC070-2.
- Possible reasons for this could be: familial (e.g. brother, cousin, nephew); long term friendship; employment (e.g. farmhand, ranch worker, etc.); indentured servitude (very unlikely); no relationship at all.

FC070-3

CONCLUSION

- Overall, the data gathered provides a good index as to the migratory patterns of these individuals, however, it is still quite inconclusive.
- Further research utilizing carbon and nitrogen isotopes as well as collagen will provide information on diet
- Strontium isotopic analysis will provide more specific geographic placements

THANKS!

- Special Thanks to:
- Dr. Rick Weathermon
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IMAGES

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