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Can oxygen isotopes from turtle bone be used to reconstruct paleoclimates?

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ABSTRACT

A substantial complication to using the oxygen isotope composition ($\delta^{18}O$) of vertebrate bioapatite in paleoclimate studies is the need to distinguish variation due to temporal changes in the $\delta^{18}O$ of surface waters from that due to temperature-dependent fractionation during biomineralization. One solution is multiple-taxon comparisons using data from coexisting homeothermic and heterothermic animals. Fossil emydid turtles have been suggested to be potentially useful as functional homeotherms because (1) modern emydids employ behaviors, such as basking, to restrict skeletal growth to a narrow temperature range; (2) their aquatic habitat constrains the isotopic variability of dietary inputs; and (3) emydids have a dense fossil record. But because turtles lack teeth and therefore tooth enamel, sampling must focus on bone, which is potentially more susceptible to diagenetic alteration. This study examines the $\delta^{18}O$ of carbonate ($\delta^{18}O_c$) and phosphate ($\delta^{18}O_p$) in hydroxylapatite from co-occurring emydids and heterotherms (crocodilians and gars) from the Paleocene–Eocene of the Clarks Fork Basin, Wyoming. Previous isotopic studies of this area provide an extensive data set for comparison with the results of this study. Bone and enamel $\delta^{18}O_c$ values measured here exhibit a greater range (16‰–32‰ Vienna Standard Mean Ocean Water) than previously observed, suggesting alteration, while the range of $\delta^{18}O_p$ values (9‰–15‰) is within that predicted by presumably unaltered mammalian tooth enamel $\delta^{18}O_c$. While high crystallinity indices (0.28–0.55) and a lack of covariation between $\delta^{18}O_c$ and $\delta^{18}O_p$ suggest alteration of one or both of these constituents, a strong correlation between crocodilian enamel and bone $\delta^{18}O_p$ suggests bone phosphate may be reliable.[1]

[1]Stable carbon and oxygen isotopic ratios reported in this paper follow the conventional δ-notation:

$$\delta \text{ value} = [(R_{sample}:R_{standard}) - 1] \times 1000,$$

where R = $^{13}C:^{12}C$ or $^{18}O:^{16}O$, and standard is Vienna Pee Dee Belemnite (VPDB) for carbon and Vienna Standard Mean Ocean Water (VSMOW) for oxygen. The δ values are given in parts per thousand (‰).