Mid-Pliocene environment of Zanda Basin in southwestern Tibet: Paleo-elevation implications

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Introduction

A mid-Pliocene fauna containing a primitive woolly rhino was recently discovered in the Zanda Basin in western Himalaya, at an elevation of about 4200 m above sea level (Deng et al., 2011). These fossil materials are archives of paleoenvironments. Specifically, carbon and oxygen isotopic compositions of fossil tooth enamel and bones contain valuable information about the diet and water isotopic composition, and paleotemperature. Fossil shells on the other hand are a recorder of lake water isotopic composition and temperature, which are controlled by regional hydrology and climate. In this study, we analyzed the carbon and oxygen isotopic compositions of enamel samples from a diverse group of fossil and modern herbivores as well as the oxygen and hydrogen isotopic compositions of precipitation and stream waters from the Zanda Basin to examine the diet and environmental changes in the area since the mid-Pliocene. We also estimated paleo-temperatures in the basin in the mid-Pliocene using two different paleo-temperature methods – the carbonate clumped isotope thermometry and a fossil-based oxygen isotope temperature proxy.

Results

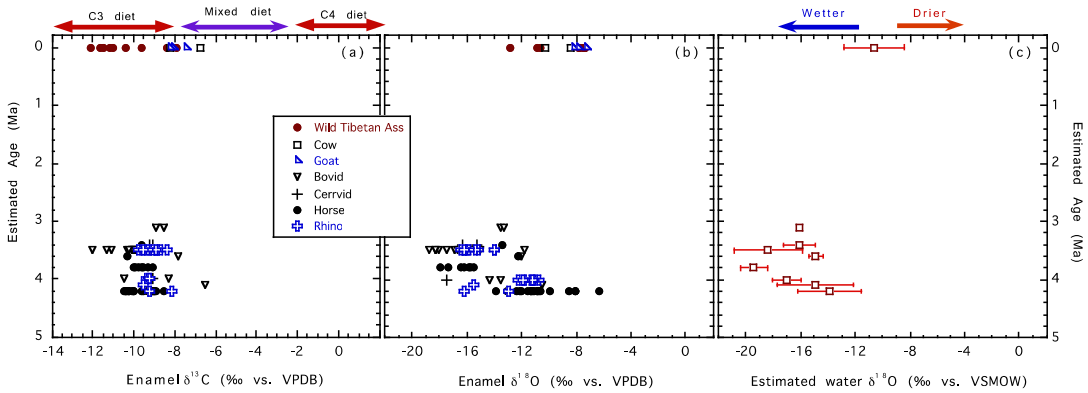

Fig. 1. Temporal variations of bulk enamel-$\delta^{13}C$ (a) and $\delta^{18}O$ values (b) of herbivores, and (c) $\delta^{18}O$ of local water estimated from the enamel $\delta^{18}O$ values of large mammals except deer in SW Tibet since ~4.2 Ma. The uncertainty in the water $\delta^{18}O$ estimates corresponds to 1 sigma (1σ) standard deviation in $\delta^{18}O$ of enamel. The data show that herbivores in the Zanda Basin have had C_3-based diets since ~4.2 Ma, except one 4.1 Ma bovid and two modern domesticated animals (a cow and a goat) that may have consumed a small amount of C_4 plants. The positive shift in the estimated $\delta^{18}O$ of local water likely indicates a shift in climate to much drier conditions after ~3-4 Ma.

Conclusions

Our carbon isotope data reveal that the mid-Pliocene mammalian fauna in the Zanda Basin, like modern herbivores in the area, fed primarily on C_3 vegetation and lived in an environment dominated by C_3 plants. The lack of significant C_4 plants in the basin suggests that the elevation of the area in the mid-Pliocene was higher than 2.5 km. The estimated $\delta^{18}O$ values of paleo-water in the mid-Pliocene Zanda Basin were lower than those of modern surface waters in the basin, most likely indicating a shift in climate to much drier conditions after ~4-3 Ma. Paleo-temperatures estimated using two different methods suggest that the Zanda Basin had a warmer climate and was at a similar or slightly lower elevation at 4.2-3.1 Ma than today.

References

[1] Deng, T., Wang, X.M., Fortelius, M., Li, Q., Wang, Y., Tseng, Z.J.J., Takeuchi, G.T., Saylor, J.E., Saila, L.K., Xie, G.P., 2011. Out of Tibet: Pliocene Woolly Rhino Suggests High-Plateau Origin of Ice Age Megaherbivores. *Science* 333, 1285-1288.