Insights into the evolution of the Great Plains grassland ecosystem over the last 5 million years from paleotemperature and paleovegetation records

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Over the last 10 million years (m.y.), the Great Plains transitioned to the modern grassland ecosystem which is dominated by C_4 grasses. Well-preserved late Miocene to Holocene fossils and paleosols make the Meade Basin in southwest Kansas, USA a unique place to determine how paleoenvironmental conditions changed during C_4 grassland evolution. $\delta^{18}O$ values of paleosol carbonates in the Meade Basin ($\delta^{18}O_{carb}$) decreased from the Miocene to Holocene while $\delta^{13}C$ values increased; these trends were interpreted as an increase in temperature and/or in aridity coincident with an increase of C_4 grass biomass on the landscape [1]. However, estimating temperature from $\delta^{18}O_{carb}$ is complicated by the role of source water $\delta^{18}O$ values in $\delta^{18}O_{carb}$ values. Thus, we used carbonate clumped isotope (Δ_{47}) thermometry of paleosol carbonate nodules to develop independent paleotemperature estimates and estimated $\delta^{18}O_{water}$ by combining temperature and $\delta^{18}O_{carb}$ values.

Preliminary temperature estimates (5-1.8 Ma) in the Meade Basin range from 17°C to 24°C with no systematic change through time, when compared to the modern mean annual (14°C) and warm season (24°C) temperatures [1]. In contrast, $\delta^{18}O_{water}$ values increase through time. We preliminarily suggest that local/regional temperature change was not the primary factor that drove grassland ecosystem evolution here, while increasing $\delta^{18}O_{water}$ values suggests increased aridity may have been a bigger influence on C_4 biomass and faunal changes, although we cannot rule out pCO_2 changes. In addition, Δ_{47} temperatures and $\delta^{18}O_{water}$ may reflect numerous factors besides air temperature and aridity changes, respectively, including depositional environment differences, soil type/depth, and source water changes. Additional analyses and detailed organic biomarker records currently underway will help further constrain the roles of paleoenvironmental factors in C_4 grassland expansion.

[1] Fox, D.L., Honey, J.G., Martin, R.A., and Peláez-Campomanes, P., (2012a), GSA Bulletin 124, 431-443.