KALAHARI SALT PANS AS PALEOCLIMATE ARCHIVE USING PLANT WAX-DERIVED BIOMARKERS AND STABLE ISOTOPES

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Introduction

The climate development in southern Africa since the Last Glacial Maximum (LGM) and during the Holocene is complex due to its key position between the tropics and the mid-latitudes. The semi-arid to arid western Kalahari lies within the transition zone between the winter and the summer rain in southern Africa. Due to high evaporation the region does not feature conventional continuous environmental archives like lacustrine sediments. To reconstruct hydrology and vegetation assemblage we use sediments from salt pans. Salt pans (playas) are common geomorphological structures in the Kalahari which are temporarily flooded during rainy season. The approach focuses on the reconstruction of local vegetation assemblages to identify changes in environmental conditions. This is pursued using plant biomarkers, particularly leaf wax-derived *n*-alkanes and *n*-alcohols, and their stable carbon signatures, which can be compared to existing data of southern African plants (Rommerskirchen et al., 2006; Vogts et al., 2009). Additionally, compound-specific hydrogen isotope values provide information on water availability.

Results

Most samples show bimodal distributions of *n*-alkanes and *n*-alkanols with dominating long chain homologues (C_{27}-C_{33} *n*-alkanes and C_{26}-C_{32} *n*-alkanols) and relatively high concentrations of mid chain homologues (C_{19}-C_{23} *n*-alkanes). Weighted mean $\delta^{13}C$ values of long chain *n*-alkanes (C_{27}-C_{33}) and $ACL_{27\text{-}33}$, between 29.6 and 30.8, lie within the range of southern African savannah and grassland vegetation. The range of $\delta^{13}C_{WM27\text{-}33}$ values indicates that C_4 plants play an important role in the local vegetation assemblage. This is also reflected in long chain *n*-alkane and *n*-alkanol patterns. From 26 ka BP to the LGM, an increase in inorganic carbon correlates with relatively low δD_{wax} values below -135‰, revealing conditions slightly wetter compared to today. In salt pans, high TIC and elevated $\delta^{13}C_{carb}$ and $\delta^{18}O_{carb}$ values are signs for a higher frequence of flooding events. This is followed by a period of dry conditions inferred from a very low sedimentation rate between the LGM and early Heinrich Stadial 1 (HS1, 18.5-14.6 ka BP). A steep rise in the sedimentation rate goes along with prominent shifts in *n*-alkane and *n*-alkanol distributions and compound specific carbon isotope values. These shifts point to a rapid shift towards a more grass-dominated environment around HS1, accompanied by low hydrogen isotope values of long chain *n*-alkanes and high $\delta^{13}C_{carb}$ and $\delta^{18}O_{carb}$ values suggesting relatively wet conditions. The increase of C_4 plants parallels a phase of relatively high water availability and took place in one millennium. Thus, the rising amount of C_4 plants can be explained with reclaiming of barren land by C_4 plants. During the Holocene most parameters stay constant comparable to recent values, except carbon and hydrogen isotopes. $\delta^{13}C_{WM27\text{-}33}$ values display a strong decrease indicating a more C_3 dominated vegetation during the early Holocene, which is followed by a steep rising trend towards the Late Holocene culminating at 2-3 ka

BP, while δD values show a slight decrease over the Holocene with a minimum corresponding to the $\delta^{13}C_{WM27-33}$ maximum.

Conclusion

We infer that the massive shift of plant wax composition during HS1 indicates a rapid intensification and expansion of the summer rain zone after a period of more arid conditions supporting a southward shift of the Intertropical Convergence Zone during this phase.

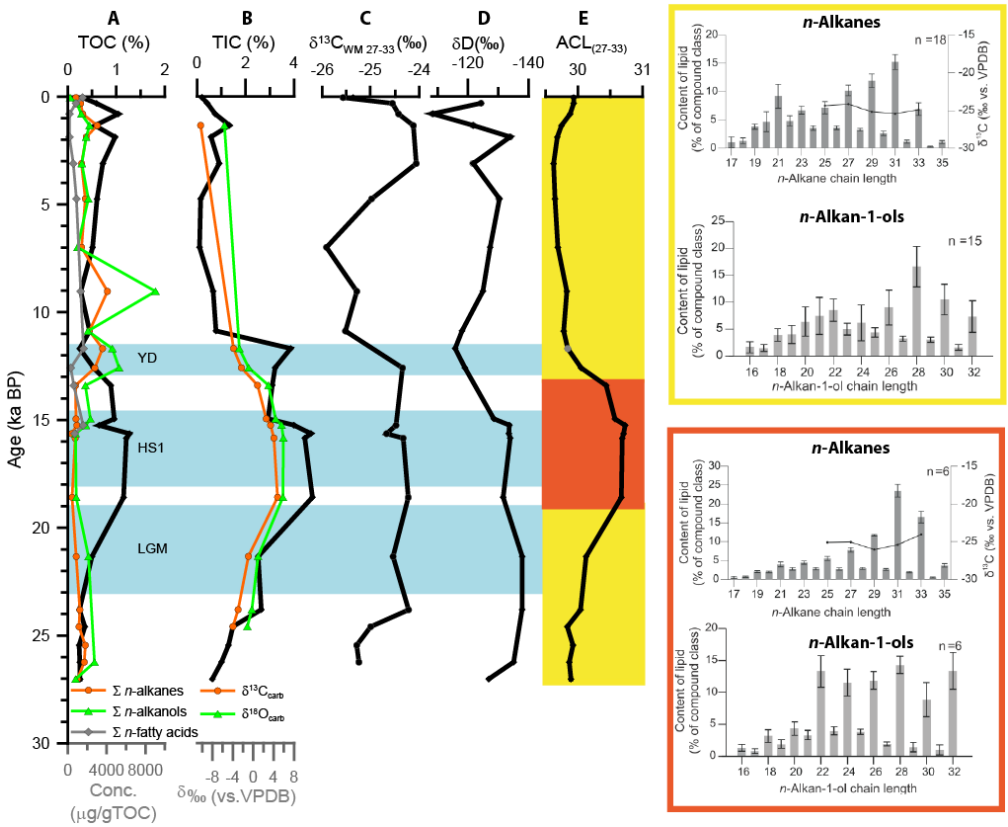

Figure 1 *Biomarker record from Omongwa Pan (western Kalahari): A. TOC, concentration of* n-*alkanes,* n-*alkanols and* n-*fatty acids; B. TIC, $\delta^{13}C_{carb}$ and $\delta^{18}O_{carb}$; C. $\delta^{13}C_{WM27-33}$; D δD_{Wax} ice corrected; E. ACL_{27-33}. Rectangles show average distribution of* n-*alkanes and* n-*alkan-1-ols in samples representing periods marked in yellow and orange in E, respectively. Blue rectangles indicate Last Glacial Maximum (LGM), Heinrich Stadial 1 (HS1) and Younger Dryas (YD).*

References

Rommerskirchen, F., Plader, A., Eglinton, G., Chikaraishi, Y., Rullkötter, J., 2006. Chemotaxonomic significance of distribution and stable carbon isotopic composition of long-chain alkanes and alkan-1-ols in C4 grass waxes. Organic Geochemistry 37, 1303-1332.

Vogts, A., Moossen, H., Rommerskirchen, F., Rullkötter, J., 2009. Distribution patterns and stable carbon isotopic composition of alkanes and alkan-1-ols from plant waxes of African rain forest and savanna C3 species. Organic Geochemistry 40, 1037-1054.