Quantitative reconstructions of vegetation cover from lake sediments: the power of multi-proxy analysis

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Résumé

Long-term ecological records from lake sediments represent a unique opportunity to understand vegetation responses to climate and disturbance changes at a temporal scale that is not accessible using field measurement or remote sensing data. These variables, however, are indirectly reconstructed using bio-proxies, such as phytolith, pollen or charcoal particles. Calibration studies are thus a critical requirement if quantitative reconstructions, in units comparable with field measurements or model output, need to be achieved. Particularly, long-term records can help disentangling the drivers of forest and savanna distribution, and of tree density within the savanna ecosystem, where both trees and grasses co-dominate. These questions represent a burning debate within the savanna community, and still no consensus has been reached even after decades of research. Phytoliths are increasingly used in tropical environments where many families produce diagnostic morphotypes. Especially, phytoliths analysis is particularly accurate in reconstructing woody cover, using the Dicotyledons to Poaceae index (D/P). In pollen analysis, the ratio of arboreal to non-arboreal pollen (AP/NAP) has been shown to precisely reconstruct woody cover in association with the D/P index. Moreover, pollen analysis enables differentiation between tree guilds, while phytolith analysis permits sub-family grasses distinction. Most calibration studies, however, have been performed on modern soil samples, but more data are needed from recent lake records, where most long-term reconstructions come from. Here we performed a multi-proxy analysis by analyzing the phytolith, pollen and charcoal content of precisely dated (210Pb) sediments from three lakes. Lacustrine sediments represent a unique way of continuous recording in tropical and sub-tropical environments. These three lakes are situated in Central African Republic and located in savanna, forest-savanna mosaics and forest.

We show that the local environment surrounding the lake is critical for interpreting current and past phytolith assemblages, and the D/P index. The presence of a riparian forest in an open environment has no impact on phytolith assemblages or the D/P index, which instead reflect both the local and regional landscapes. Contributions from a marsh, if present in a forested environment, completely dominates the phytolith records, which consequently reflect only the local environment of the lake. Preliminary pollen results show however that the AP/NAP ratio records well signal from the landscape in both riparian and marsh-surrounded lakes. Finally, the pollen analysis enables determination of the composition of trees in both forest and savanna, and the contribution of pioneers, while phytoliths inform about grass

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composition.
We also found a high correlation between Poaceae phytoliths influxes and charcoal accumulation rates for the two lakes surrounded by a riparian forest. This correlation, associated with a high proportion of burned Poaceae phytoliths, suggests that Poaceae phytoliths are mainly transported by wind in ash clouds produced by fires. We also identified that tree pollen are transported over long-distances by wind. We conclude that reconstructing vegetation from lacustrine records necessitate an analysis of taphonomic processes, especially production, transport and deposition, in order to interpret proxies source area. Therefore, multi-proxy analysis constitutes a powerful tool for reconstructing vegetation and unraveling potential taphonomic biases.

Mots-Clés: Phytolith, pollen, calibration, vegetation cover, taphonomy