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New molecular marker and spectroscopic tools for reconstructing wildfire history

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Wildfire regimes have been changing during the late Quaternary under the influence of changing climate and vegetation, and by anthropogenic impact. Wildfires are an important parameter in the biosphere-climate system and affect the carbon cycling. Thus, reconstructing their history helps to understand palaeoenvironmental conditions and is essential to project future biosphere-climate interactions and associated carbon cycles.
Late Quaternary wildfire reconstruction has mainly been based on dated lake sediment cores, where the number of microscopically detected charcoal particles has served as the raw data for assessing the past fire frequency. Quantifying (microscopically) visible charcoal may reflect the relatively large and structurally sound charcoal particles from forest fires. However, this technique is less likely to quantify submicroscopic charcoal fractions derived from grasses – probably the main contributor of charcoal in the world's vast savannas and open grassy woodlands.
Therefore, we are developing a new methodology to infer past wildfires from lacustrine sediments by using molecular marker and spectroscopic tools. Such geochemical methods could assess the whole size range of charred fire residues in sedimentary records and could yield additional information about the burned vegetation when only microscopically invisible fire residues are present. In particular, we are adapting a geochemical marker method (benzene polycarboxylic acids (BPCA)) for this task. BPCA have been used for almost a decade as unambiguous molecular markers for the presence of fire-derived organic matter in soil, and in a recent laboratory ring trial have been proven to be a robust tool for the quantification of charred fire residues. So far, however, this geochemical marker method has not been adapted to quantify fire residues in lake sediment cores.
In order to calibrate and validate the BPCA method for sedimentological fire reconstruction, we use well characterized lake sediment cores from Australia. They exhibit distinct wildfire histories (charcoal counting method) – data, that can be compared to the results of the BPCA method. In addition, we are examining these cores with MIR-PLS (Mid InfraRed spectroscopy with Partial Least Square analysis), which is another geochemical method that can detect charred organic material independent of its particle size. We are using it as a screening method to locate interesting sections of the cores and it should provide another independent dataset of fire residue contents, to which the BPCA molecular marker analysis can be compared.
Taking into account the standard (charcoal particle counting), molecular marker (BPCA) and spectroscopic (MIR-PLS) methods, the palaeofire data acquistion could generally become more quantitative and wildfire history in grassland ecosystems could be better assessed.