Lignites as archives of ancient climate-biogeochemistry dynamics

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In reconstructing Earth history, continental records are essential for reconstucting climate as well as terrestrial biogeochemical feedbacks. Lignites are an archive of great but currently untapped potential, especially in deep time palaeoenvironmental research. Fossil residues in lignites reflect the temperature and precipitation regime, while geochemical signals can be used to interrogate past changes in carbon cycling. Potentially powerful climatic insight could come from the application of branched glycerol dialklyl glycerol tetraether (GDGT) lipids to develop high resolution continental temperature records. Here, we have examined MBT' and CBT ratios and reconstructed pH and temperature in a range of modern peat deposits and ancient lignites.

In five Holocene peat cores, from temperate to sub-Arctic climates, GDGTs yield relatively stable temperatures. In cold regions (Finland, Tibetan Plateua), reconstructed MBT'/CBT temperatures are significantly higher than modern annual mean. This could reflect a summer growing season for the bacterial source of the GDGTs in these climates. The pH estimates derived from CBT ratios are also higher than expected (pH of ~6 even in relatively acidic ombrotrophic bogs); they also exhibit much greater variability and appear to drive significant variations in reconstructed temperatures even when MBT' is relatively stable.

Much higher temperatures are obtained in Eocene lignites from England (Cobham) and Germany (Schoeningen), suggesting that the proxy does record higher temperatures. Intriguingly, in both settings, a change in lithology is associated with a temperature change, confirming that depositional environment has a strong control on GDGT distributions and thus the application of this palaeothermometer. Some of this variation appears to be related to the fidelity of CBT as a pH proxy. In all cases, including both modern bogs and ancient peats, substitution of a lower pH – appropriate for an ombrotrophic bog – into the MBT'/CBT calibration equation yields temperatures that are generally more stable.