Geophysical Research Abstracts
Vol. 14, EGU2012-4748, 2012
EGU General Assembly 2012

Testing the potential of bacterial branched tetraether membrane lipids as temperature proxy in peat and immature coal deposits

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Branched glycerol dialkyl glycerol tetraether (brGDGT) membrane lipids occur ubiquitously in peat and soil. In soil, the degree of methylation and cyclisation of branched tetraethers (MBT index and CBT ratio, respectively) has shown to relate to both soil pH and annual mean air temperature (MAT). Using this relation, past annual MATs can be reconstructed by analysing brGDGTs in marine sediment records near large river outflows. More recently, the potential of this MBT/CBT proxy is also being explored in lakes. Despite being more abundant in peat than soils, however, the utility of the proxy has not yet been fully explored in peat records. Present day peat records generally extent back to the early Holocene, but if the MBT/CBT proxy were shown to be applicable in peat deposits, there is also potential to apply it to immature coal deposits like lignites, which could provide valuable snapshots of continental climate back to the early Cenozoic.

Here results are presented of analyses of different peats in south eastern Canada, showing that the pH of peat along a nutrient gradient is rather well reflected by the CBT. Annual MAT reconstructions based on the MBT/CBT soil calibration, however, tend to overestimate measured MAT. This is also the case for peat analysed from the surface of Etang de la Gruère peat bog in the Swiss Jura Mountains. Along the 6m depth profile of this bog (∼13ka), CBT-reconstructed pH is compared with in-situ measured pore water pH showing that the brGDGT composition does not reflect present-day in-situ conditions. Instead, it reflects a stratigraphic boundary between Carex and Sphagnum dominated peat at 4 m depth that is not present in the pore water profile, testifying to a 'fossil' nature of the brGDGTs down the peat bog.

Analyses of three immature coals of the Argonne Premium Coal Series reveal that branched GDGTs are present in the most immature coal, the Beulah Zap lignite (Ro = 0.25%), and only just above detection limit in the Wyodak Anderson coal (Ro = 0.32%), both of about the same age (Late Palaeocene). In the more mature Illinois #6 coal (Ro = 0.46%), brGDGTs are completely absent. In the Denver Basin, a comparison is made between outcrop and drilled core samples of Palaeocene lignites. BrGDGTs are preserved in the core samples, although in low quantities compared to peat. Outcrop samples are clearly overprinted by modern soil derived brGDGTs, despite digging a meters deep trench, which shows the need to obtain fresh non-weathered samples by coring. Reconstructed annual MAT for both the Beulah Zap and the Denver Basin lignites are several degrees higher than estimates based on leaf margin and oxygen isotope analyses from the same sites. Both reconstructions do testify, nevertheless, to the warm continental conditions during the early Cenozoic of the central U.S.A..

Although further validation is required, potentially in the form of a specific peat calibration, these results do show potential for application of the MBT/CBT temperature proxy in peat and lignite deposits.