A multiproxy approach of environmental changes in the last millennia reconstructed from an ombrotrophic peat archive (Frasne mire, France)

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Peatlands have stored ca. one-third of the global soil carbon stock because of low rates of plant residue decomposition due to oxygen limitation resulting from waterlogging which inhibits microbial activities. Thus, thanks to the continuous accumulation organic matter (OM), peatlands are suitable archives for the reconstruction of past environmental changes. The combination of natural climatic variations and human impacts (particularly during the late Holocene) represents a challenge for reconstructing past environmental changes from peat archives, and requires the combination of several proxies. Within the PEATWARM project (ANR-07-VUL-010), we investigated a 4 m peat profile collected in a bog located in Frasne mire (French Jura Mountains) and covering the last 7,400 years BP. We analysed peat OM composition (lignin-derived phenolic monomers, monosaccharides, lipids), testate amoebae, branched glycerol dialkyl glycerol tetraethers (GDGTs) and pollen.

Major changes in OM sources and environmental conditions were revealed at 2.5 m depth (ca. 5,000 yrs BP). Below 2.5 m depth, higher contents of lignin-derived phenolic monomers were found suggesting a predominance of vascular plants (e.g. sedges). In this deeper section, the peat composition is also characterised by (i) higher percentages of amorphous OM, (ii) lower percentages of mucilage and fungal hyphae, and (iii) lower cellulosic sugar contents and C/N ratio. In addition, at this time (around 5,000 yrs BP), pollen analysis revealed a change in vegetation with especially the disappearance of *Pinus*. Taken together, these results indicate that a rapid shift of the ecosystem functioning occurred ca. 5,000 years ago from a minerotrophic fen to an ombrotrophic *Sphagnum*-dominated peatland.

Mean annual air temperature (MAAT) and pH were reconstructed using the MBT and CBT proxies based on branched GDGTs according to Weijers et al., 2007. In parallel, testate-amoeba-based transfer function developed from sub-alpine mires (SE Switzerland; Mitchell et al., 2013) was used to infer the depth of water table (DWT). Even though the CBT overestimated pH, CBT-derived and measured pH records showed similar variations (Fig.1). The gradual decrease in pH with decreasing depth is consistent with the transition from a fen with intermediate pH to a bog with acidic conditions. GDGT-inferred temperatures ranged between 8 and 12 °C until 2.5 m depth (Fig. 1) and were higher than the average air temperature actually and currently measured (ca. 6 °C). Temperature estimates in the top part of the bog were most consistent with the mean of spring and summer air temperatures recorded in the peatland (ca. 11.5 °C), suggesting that branched GDGT-producing bacteria might be more active during the warmest months of the year (Huguet et al., 2013). Nevertheless, reconstructed temperatures showed a pronounced shift at 2.5 m depth, likely reflecting both a change in climatic conditions but also in the composition of the peat as suggested by other geochemical and palynological indicators. Indeed, although the CBT led to an overestimation of the pH, CBT-derived and measured pH records showed similar variations (Fig.1), the gradual decrease in pH with decreasing depth being consistent with the transition from a fen with intermediate pH to a bog with acidic conditions. In parallel, testate-amoebae-based transfer function was developed from sub-alpine mires (SE Switzerland; Mitchell et al., 2013) to infer the depth of water table (DWT). Drier conditions were thus indicated at the bottom of the peat core, whereas high variations in moisture conditions occurred at the upper part of the core with wetter conditions at the top. Interestingly, temperature variations inferred from MBT/CBT proxies were weakly linked with moisture variations inferred from testate amoebae until 150 cm depth ($r = -0.41$, $p = 0.06$). Therefore, the distribution of branched GDGTs might also depend on peat moisture level, in addition to air temperature and pH. Our data suggest that the joint use of MBT/CBT and testate amoebae is a promising approach to estimate past climate changes, but which needs to be further calibrated and combined with other proxies to obtain reliable paleoenvironmental data in peatlands..

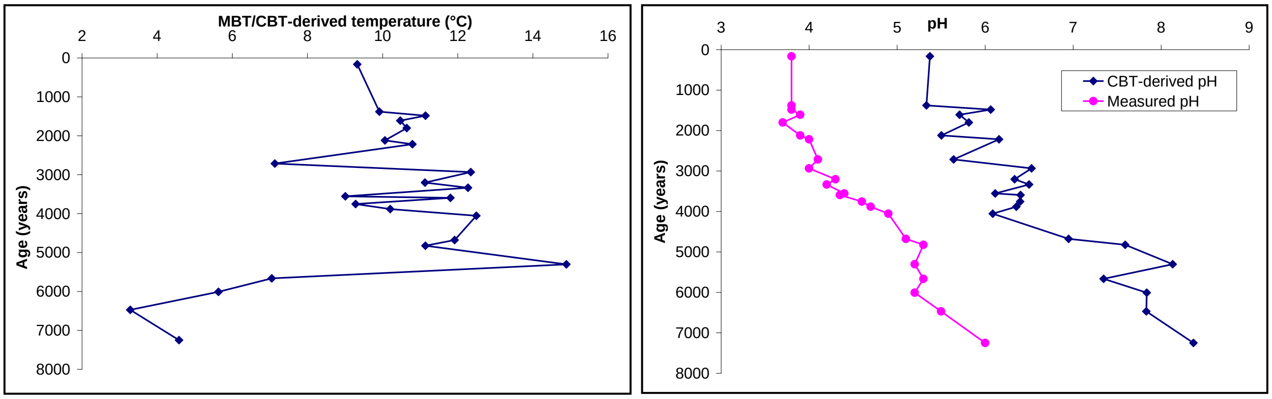

Fig. 1. Evolution during the last ca. 8 kyrs BP of estimated mean annual air temperature (left) and pH (right) reconstructed using the MBT/CBT proxies in Frasne peatland (Jura Mountains, France). Measured pH is also presented for comparison.

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