Smouldering fires and environmental reconstructions using ombrotrophic peat cores

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Peatlands are the soil organic matter-rich ecosystem most affected by fire. When they burn, the dominating phenomenon is not flaming but rather smouldering combustion. Recent estimates suggest that mean annual greenhouse gas emissions from smouldering peat fires are equivalent to 15% of global anthropogenic emissions. Furthermore, warmer temperatures at high latitudes are already resulting in unprecedented permafrost thaw, leaving large organic C pools exposed to fires for the first time in millennia.

Much of our knowledge of past fire events is based on the abundance of charcoal particles in fossil and sub-fossil records. The combustion of char by the smouldering process implies that the record of past fires in peat cores may be entirely hidden.

Three *Sphagnum* peat columns (26 cm deep) having different initial moisture contents (MC, in dry weight basis), i.e., 50, 100 and 200%MC, were prepared for this study. In a previous work, we tried to identify palaeofires by the physical and chemical signature that they leave behind in the soil profile. In the present one, we employ solid-state Nuclear Magnetic Resonance (NMR) and Isotope-Ratio Mass Spectroscopy (IRMS) characterization of peat organic matter, as well as results regarding and measure polycyclic aromatic hydrocarbons (PAH) production and metal concentration changes following smouldering fires.

The ^{15}N spectrum of fresh peat (FP) used as control shows only an amide signal, which is in agreement with the ^{13}C NMR spectrum where mainly signals of carbohydrates and alkyl C can be observed. Further signals can be observed in the aromatic region, most probably due to lignin derivatives. Following the smouldering event, selected peat samples from both the 50% and 100% MC series show signals supporting the occurrence of fire. In detail, the ^{15}N-signals between -200 and -250 ppm are typical for pyrrole or indole type N. This is in accordance with the ^{13}C NMR spectra showing considerable intensity in the aromatic region, most likely from char residues.

The isotopic signature of δ^{13}C seems to be slightly affected by smouldering, although the information about vegetational changes are preserved, whereas the δ^{15}N shows a trend positively correlated with the relative N enrichment observed in smouldered peat samples, as also supported by ^{15}N NMR.

Compared to flaming fires, smouldering fires produce much lower concentrations of PAH. Furthermore, PAH detected in peat following smouldering fires consist mainly of those with lower molecular weights (i.e., naphthalene, acenaphthene and fluorene).

Finally, although concentrations of As, Hg, and Pb increase compared to the FP, their enrichment, relative to Ti, decreases. Such a trend regards mainly the surface layers.

These data that suggest smouldering fires may be an important cause of variations observed in peat cores.