The effect of fire intensity on alkane composition of plant and soil organic matter

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Motivation

In soils, paleosoils and terrestrial sediments frequently residues from biomass burning occur. As the biogenic source of this burnt biomass is only accessible if remains of e.g. wood or pollen are available, we tried to determine the burnt biomass and the burning environment via molecular proxies. Therefore, we initiated charring experiments and collected samples from different burning environments and analysed them for their content and distribution of lipidic compounds. Here, we show the alkane patterns of wild fires from Russia and from a re-built roman furnace and lehr, where glass was produced in roman style.

Conclusions & Outlook

Experimental results and results from recent and ancient burnt samples indicate the usability of lipidic compounds to assess not only the burning environment, but the burnt biomass additionally.
Further research is required to understand degradation mechanisms associated with thermal degradation of different biogenic sources, i.e. which degradation occurs under different temperature and oxygen regimes.

Concept

Samples were collected from several recent wild fires (fires occured <5 years before sampling on all plots) in August 2009. The sample set covered two wheat fields, two oak forests, pine forest and natural grassland.
From the Velzeke Furnace Project (a Roman style glass production furnace) were derived at temperatures of >1000°C from the furnace and from <550°C from the lehr.

left figures:
Roman furnace and glass production at Provinciaal Archeologische Museum van Velzeke (Belgium, www.pam-velzeke.be)

figures above:
In Russia, fields are commonly not tilled after harvest, but harvest residues are burnt by man. Such fires can extend to adjacent forests and natural grasslands.

Results and discussion

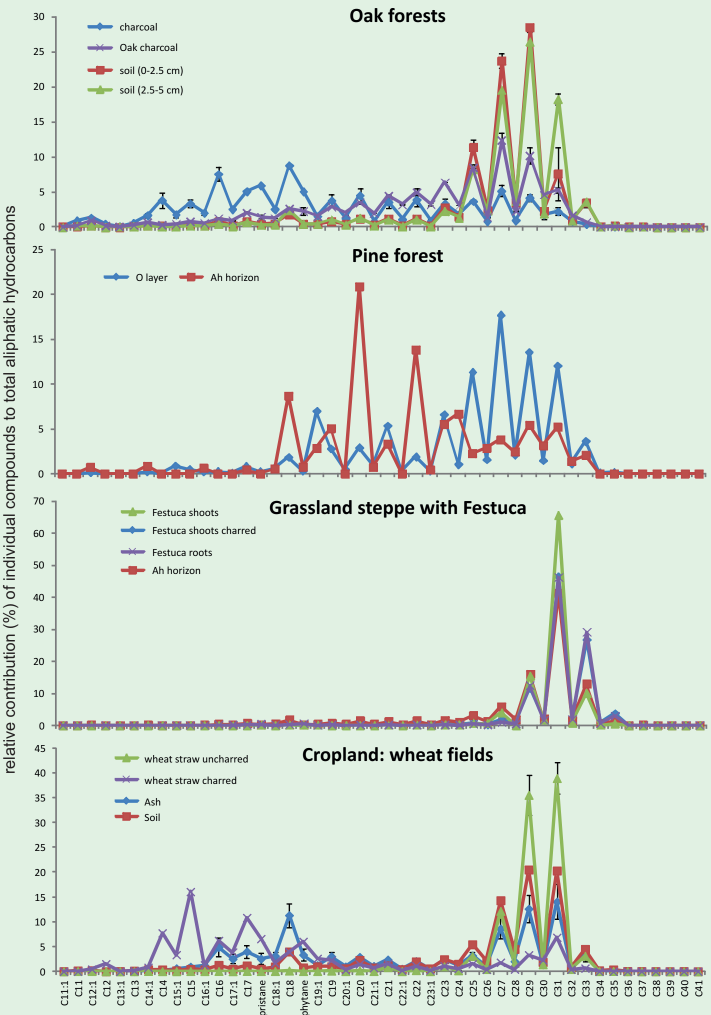

Figure 1 Aliphatic hydrocarbon composition of various sites from Russia
After burning (charring) the alkane composition of biomass is converted to a shorter carbon chain length and from a enrichment of odd long chain homologues to short chain even homologues, thus confirming literature results (Wiesenberg et al. 2009). Additionally, more monoalkenes can be observed in charred biomass, most likely deriving from breakdown of wax esters and other aliphatic compounds of biomass.
In soil a mixture of plant and charcoal derived components can be found for all sites. This argues for using alkanes as both, burning and biomass proxies in soils and sediments.

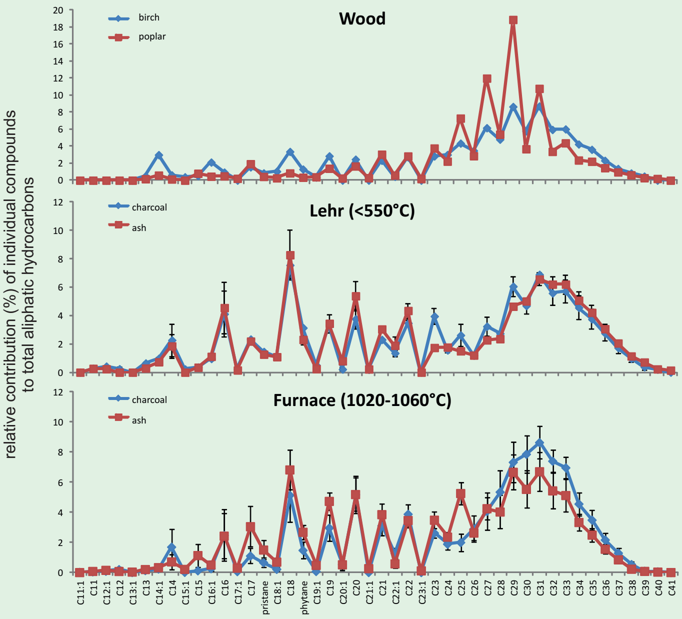

Figure 2 Aliphatic hydrocarbon composition of samples from the Velzeke furnace project
Aliphatic hydrocarbons of wood show a slight predominance of odd long chain *n*-alkanes, which was different for both tree species. After burning, any predominance of *n*-alkane homologues disappears, leading to a CPI of ~1. For the lehr oven (which is used for cooling down glasses, the pattern looks slightly different from that of the furnace. Differences, which can be related to the different temperatures can be observed e.g. in the predominance of odd short chain alkanes (higher in the lehr) and the relationship of long chain vs. short chain alkanes. Differences bewteen ash and charcoal are lower than differences between individual oven types.

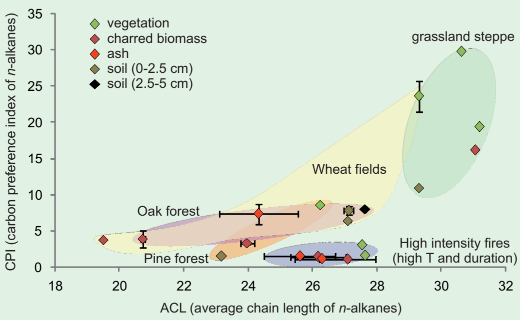

Figure 3 CPI vs. ACL of the sample set
Charring of biomass leads to a change in ACL and CPI values, which leads to a mixed signal of plant and charred residues in soil. Effects can be regarded for biomass with high CPI values (>>2), which is not observed for all analysed wood samples.

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Reference: Wiesenberg, G.L.B., Lehndorff, E. & Schwark, L. 2009. Thermal degradation of rye and maize straw: Lipid pattern changes as a function of temperature. Organic Geochemistry 40, 167-174.