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Critical comparison of peat decomposition proxies and their relationship to peat geochemistry

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Mires are known to play a major role in global carbon cycling, and there is an important link between the carbon mass balance of mires and climate. Aspects of this coupling are preserved in the peat that accumulates in mires, and in particular the record of decomposition of organic matter is used as an important proxy for reconstructing this climate-carbon coupling. The geochemical record of major and trace elements in peat is also used as a proxy for other environmental forcings, especially natural and anthropogenic atmospheric inputs on mires, such as soil dust and lead pollution, respectively. However, the geochemical composition of the peat can be influenced by changes in the decomposition of organic matter, which can potentially alter the retention and mobility of trace elements of interest, such as mercury.

To understand past climate-carbon interactions and decomposition effects on geochemistry requires quantitative assessments of decomposition. There is, however, no single measurement for decomposition, but rather a range of qualitative proxies is used to estimate mass loss and decomposition. The most common techniques include CN ratios, bulk density and light transmission following an alkaline extract. In this presentation we compare these three proxies in cores from two sites: an oligotrophic mire where we took a core transect from ($\leq$270 cm deep, ca 2400 yr), and an ombrotrophic bog where collected triplicate surface hummock cores (75 cm, ca 500 yr). In the long mire profiles, the three parameters show quite similar large-scale patterns over the length of each profile. It is clear that all three proxies co-vary and the correlations between the proxies are all highly significant ($p<0.01$). We can reasonably conclude that the three parameters reflect the same long-term qualitative changes in humification, but quantitatively the details among the proxies vary, which alter interpretations of past decomposition changes at centennial resolution. Changes in geochemistry, such as mercury, are coupled with decomposition changes. In the triplicate hummock cores, the three proxies likewise show long-term similarities, but not at finer resolution. Exploration of these proxies and their relationships to the geochemistry, based on Principal Component Analysis, suggest the 3 proxies are weakly related and respond to different factors. For example, increased bulk density is facilitated by decomposition and loss of structure, but below the water table further compaction is inhibited regardless of further changes in decomposition. CN ratios and light transmission are nearly orthogonal in PCA space, suggesting they are responding to different processes related to decomposition, as well as unaccounted for changes in plant composition. We believe that decomposition is not fully captured by any one proxy, because each proxy records different aspects of the decomposition process. Besides use of multiple cores, we suggest using more than one decomposition proxy in order to provide a more robust understanding of biogeochemical responses of peatlands to past environmental changes.