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Uplifting of palsa peatlands by permafrost identified by stable isotope depth profiles

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Natural abundances of stable isotopes are a widespread tool to investigate biogeochemical processes in soils. Palsas are peatlands with an ice core and are common in the discontinuous permafrost region. Elevated parts of palsa peatlands, called hummocks, were uplifted by permafrost out of the influence of groundwater. Here we used the combination of δ^{15}N values and C/N ratio along depth profiles to identify perturbation of these soils. In the years 2009 and 2012 we took in total 14 peat cores from hummocks in two palsa peatlands near Abisko, northern Sweden. Peat samples were analysed in 2 to 4 cm layers for stable isotope ratios and concentrations of C and N. The uplifting of the hummocks by permafrost could be detected by stable isotope depth patterns with the highest δ^{15}N value at permafrost onset, a so-called turning point. Regression analyses indicated in 11 of 14 peat cores increasing δ^{15}N values above and decreasing values below the turning point. This is in accordance with the depth patterns of δ^{13}C values and C/N ratios in these palsa peatlands. Onset of permafrost aggradation identified by the highest δ^{15}N value in the profile and calculated from peat accumulation rates show ages ranging from 80 to 545 years and indicate a mean ($\pm$SD) peat age at the turning points of 242 ($\pm$66) years for Stordalen and 365 ($\pm$53) years for Storflaket peatland. The mean peat ages at turning points are within the period of the Little Ice Age. Furthermore, we tested if the disturbance, in this case the uplifting of the peat material, can be displayed in the relation of δ^{15}N and C/N ratio following the concept of Conen et al. (2013). In unperturbed sites soil δ^{15}N values cover a relatively narrow range at any particular C/N ratio. Changes in N cycling, i.e. N loss or gain, results in the loss or gain of ^{15}N depleted forms. This leads to larger or smaller δ^{15}N values than usual at the observed C/N ratio. All, except one, turning point show a perturbation in the depth profile, with most of the adjacent sampling points also indicating perturbation. This perturbation shows the changes in N cycling, in this case N loss, from these depths due to permafrost aggradation. Deeper parts of some profiles at Stordalen peatland indicate with the same approach an N gain, maybe due to lateral N input to these nutrient poor ecosystems. Most of the uppermost samples in the δ^{15}N depth profiles show no perturbation, potentially due to the adaptation of these soils to the new conditions. Both stable isotope (δ^{15}N and δ^{13}C) depth profiles are suitable to detect palsa uplifting by permafrost. The perturbation of the peat by uplifting as well as the potential nutrient input can be detected by δ^{15}N when related to the C/N ratio.

Conen, F., Yakutin, M. V., Carle, N., and Alewell, C. (2013): δ^{15}N natural abundance may directly disclose perturbed soil when related to C:N ratio. Rapid Commun. Mass Spectrom. 27: 1101-1104.