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Stable carbon isotopes as indicators for micro-geomorphic changes in palsa peats

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Global climate change is significantly threatening stability and functioning of permafrost soils in extended areas of the northern latitudes and / or at high altitudes. A thawing of permafrost soils will most likely result in a positive feedback mechanism due to accelerated degradation of soil organic matter. The latter will not only induce release of substantial amounts of carbon into the atmosphere but also thermokast erosion and thus degradation of these unique systems. As such, biodiversity and functioning of these ecosystems are under immediate threat. One very unique northern ecosystem type are palsa peats, also called palsa mires. Palsa mires are a type of peat land typified by characteristic high mounds (called hummocks), each with a permanently frozen core. The freezing of the underlying horizons uplift these hummocks out of the groundwater saturated zone. Between the hummocks are wet depressions called hollows, which develop where the ground surface is frozen only for part of the year. Palsa mires are common in the former USSR, Canada and parts of Scandinavia and characterized by a unique geochemistry and biodiversity. If these sensitive ecosystems are exposed to environmental change, not only hydrology and vegetation composition but also degradation and mineralisation patterns of soil organic matter will change. The latter should be reflected in stable carbon isotope depth profiles.

We investigated the depth distribution of stable carbon isotopes in Palsa mires of northern Sweden (Stordalen and Storflaket near Abisco, Lapland). Our data indicate that stable isotope depth profiles are influenced by environmental change and/ or soil forming processes in space and time. We find a consistent difference between depth profiles of hummocks and hollows. Hollows which are influenced by thermokarst erosion and are thus affected by thawing, breaking and submerging of peat chunks into the hollows, differ in their isotope depth profile from undisturbed hollows. The new supply of hummock peat material in the hollows might increase mineralisation processes in the hollows.

From eight investigated hummocks six show a very clear pattern: an increase of d13C isotope profiles up to a certain depth and then a decrease to more lighter values in the deeper horizons. The increase with depth in the upper horizons corresponds to d13C increases with depth of mature, well drained soils where aerobic decomposition favours selective loss of 12C. Interestingly, the increase in 13C with depth is regardless of the peak depth always around d13C = 3.3 %■. The deeper horizons of the investigated hummocks follow more the pattern expected in hollows with low degradation rates. The latter might indicate that at a certain point in time the permafrost lifted hollow peat material out of the groundwater level zone. Isotope patterns reflect this change from anaerobic to aerobic degradation.

We conclude that the difference in depth profile between hollows in Storflaket and Stordalen might indicate the difference in site disturbance due to climate change or due to the different hydrology of the sites (less groundwater movement in Storflaket compared to Stordalen). The most likely explanation for the turning points is a change in hydrology (likely followed by vegetation changes) due to permafrost uplifting.