Vertical profiles of peat pore water chemistry in a northern peatland reveal dynamic element cycles

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Northern peatlands are globally important, carbon-rich ecosystems, and studies of peatland water chemistry have often been used to identify important biogeochemical processes that regulate nutrient availability and dissolved carbon export. However, patterns in peat pore water chemistry have rarely been examined at a high spatial or temporal resolution. We measured depth profiles (to 3 m) of pore water chemistry weekly from August to November 2013 at 17 locations across an 8.1-ha black spruce-Sphagnum bog at the Marcell Experimental Forest (northern Minnesota). Ten of these locations will be experimental plots for SPRUCE, an ecosystem-scale climate change experiment. The SPRUCE experiment will manipulate temperature and CO_2 concentrations inside replicated, 12-m diameter, open-topped chambers beginning in 2015. These pore water chemistry data characterized the baseline biogeochemical conditions prior to the start of the SPRUCE experiment, and also helped infer how biogeochemical cycles may change in response to warming.

There were striking patterns in the depth profiles of peat pore water chemistry. Pore water in the surface peat was highly acidic (mean pH across plots=3.8), had high total organic carbon (TOC) concentrations (66.3 mg/L), and low nutrient concentrations (ammonium=0.25 mg/L, nitrate=0.005 mg/L, phosphate=0.04 mg/L). Pore water in deeper peat was vastly different, with a pH of 5.5 (a 200+ fold increase in H+ concentration), much lower TOC concentrations (28.7 mg/L), and much higher ammonium concentrations (3.43 mg N/L) than in the surface peat. Pore water chemistry also varied spatially across the bog, but the differences across plots were much smaller than the changes in chemistry with depth within any particular plot. The depth profiles from plots in the north end of the bog were distinct from the profiles in the south end, as plots in the north end had higher pH, and TOC and nitrate concentrations. Similarly, depth profiles in plots closer to the edge of the bog (near the transitional zone from the bog to the surrounding upland soils) had higher ammonium concentrations than plots closer to the middle of the bog.

In summary, there were large gradients in pore water chemistry with depth, and smaller variation across the 17 study plots. The low TOC concentrations and high ammonium concentrations in deep peat likely reflect the inherently different chemical and biogeochemical setting of deeper peats. With warming, evapotranspiration is projected to increase and draw down the water table, and deeper peats may become more hydrologically and biogeochemically connected to peatland ecosystem responses.