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Thermodynamic constrains on the flux of organic matter through a peatland ecosystem

Fred Worrall (1), Catherine Moody (2), Gareth Clay (3), Nick Kettridge (4), and Tim Burt (5)

(1) University of Durham, Earth Sciences, Durham, United Kingdom (Fred.Worrall@durham.ac.uk), (2) University of Leeds, Geography, Leeds, UK., (3) University of Manchester, Geography, Manchester, UK., (4) University of Birmingham, Geography, Birmingham, UK., (5) University of Durham, Geography, Durham, UK

The transformations and transitions of organic matter into, through and out of a peatland ecosystem must obey the 2nd law of thermodynamics. Beer and Blodau (Geochimica Cosmochimica Acta, 2007, 71, 12, 2989-3002) showed that the evolution of CH4 in peatlands was constrained by equilibrium occurring at depth in the peat as the pore water became a closed system. However, that study did not consider the transition in the solid components of the organic matter flux through the entire ecosystem.
For this study, organic matter samples were taken from each organic matter reservoir and fluvial transfer pathway and analysed the samples by elemental analysis and bomb calorimetry. The samples analysed were: above- and below-ground biomass, heather, mosses, sedges, plant litter layer, peat soil, and monthly samples of particulate and dissolved organic matter. All organic matter samples were taken from a 100% peat catchment within Moor House National Nature Reserve in the North Pennines, UK, and collected samples were compared to standards of lignin, cellulose, and plant protein. It was possible to calculate ΔH_fOM ΔS_fOM and ΔG_fOM for each of the samples and standards. By assuming that each thermodynamic property can be expressed per g C and that any increase in ΔG_fOM can be balanced by the production of CO_2, DOM or CH4 then it is possible to predict the consequences of the fixation of 1 g of carbon in a peatland soil.
The value of ΔG_fOMincreases from glucose to components of the biomass: 1g of C fixed as glucose by photosynthesis would result in 0.68 g C as biomass and 0.32 g C as CO_2. The transition from biomass to litter could occur spontaneously but the transition from surface to 1m depth in the peat profile would release 0.18 g C as CO_2 per 1 g of carbon entering the peat profile. Therefore, for every 1 g of carbon fixed from photosynthesis then 0.44g of C would be released as CO_2 and 0.54 g C would be present at 1 m depth. Alternatively, if DOM only were released in transition down the peat profile then for every 1 g of carbon fixed by photosynthesis 0.32 g C would be released as CO_2 and 0.22 g C would be lost as DOM and leaving 0.46 g C as residual peat at 1m depth. If the variation in ΔG_fOM of the DOM were considered then for every 1 g of C produced as DOM then between 0 and 0.57g C would be lost as CO_2. At median value of DOM loss then for every 1g of carbon fixed as photosynthesis 0.39 g C would be lost as CO_2 and 0.15 g lost as DOM with 0.46 g C as residual peat. Alternatively, if CH4 only were released down the soil profile then no organic matter would be left in the peat profile, i.e. CH4 is not an efficient method of transferring Gibbs free energy. The measured carbon budget for this catchment is that 1 g C fixed as photosynthesis resulted in 0.42 g C as CO_2; 0.29 g C as DOM; 0.04 g C as CH4 and 0.24 g C as residual peat at 1m depth.