Sequestration of labile organic carbon in Alaskan permafrost soils

MUELLER CARSTEN W.[1]; KAO-KNIFFIN JENNY[2]; RETHEMEYER JANET[3]; LÖPPMANN SEBASTIAN[1]; HINKEL AND KENNETH[4]; BOCKHEIM JAMES[5]

[1]Lehrstuhl für Bodenkunde, TU München, Freising-Weihenstephan, 85356 Germany, carsten.mueller@wzw.tum.de
[2]Cornell University, Department of Horticulture, Ithaca, NY 14853, USA, jtk57@cornell.edu
[3]University of Cologne, Institute of Geology and Mineralogy, Cologne, 50674, Germany, janet.rethemeyer@uni-koeln.de
[4]University of Cincinnati, Department of Geography, Cincinnati, Ohio, 45221, USA, hinkelkm@ucmail.uc.edu
[5]University of Wisconsin-Madison, Department of Soil Science, Madison, WI 53706, USA, bockheim@wisc.edu

Permafrost affected soils of the Northern circumpolar region represent 50% of the terrestrial soil organic carbon (SOC) reservoir and are most strongly affected by climatic change. Although a large number of studies revealed the overall C cycles in this region, there is only scarce knowledge about the quantitative and qualitative properties of organic matter compartments and their potential stability. To unravel chemical and physical properties of SOC in permafrost soils we combined the physical soil fractionation with the evaluation of the chemical composition using nuclear magnetic resonance spectroscopy (NMR) and microscopic techniques as nano-scale secondary ion mass spectrometry (NanoSIMS).

Approximately 50-75% of Alaska's Arctic Coastal Plain is covered with thaw lakes and drained thaw lakes that follow a 5,000 yr cycle of development (between creation and final drainage), thus forming a natural soil chronosequence. The drained thaw lakes offer the possibility to study SOM dynamics affected by permafrost processes over millennial timescales. In April 2010 we sampled 16 soil cores reaching from young drained lakes (0-50 years since drainage) to ancient drained lakes (3000-5500 years since drainage).

We can show that up to over 25 kg SOC per square meter were stored as mostly labile organic matter particles rich in carbohydrates. In contrast only 9.7 ± 2.3 kg OC per square meter were sequestered as presumably more stable mineral associated OC dominated by aliphatic compounds. The formation of soil aggregates, comparable to soil aggregation in temperate soils, was proved by physical fractionation and microscopic evidence. Here we show that significant amounts of labile SOC are stored in permafrost soil layers which soon could be degraded due to the deepening of the active layer resulting from climatic change.

Unraveling cooling histories using Fe-Mg zoning of exsolution lamellae in a garnet pyroxenite from the Granulitgebirge, Saxony, Germany

THOMAS MUELLER[1], HANS-JOACHIM MASSONNE[2] AND ARNE P. WILLNER[2]

[1]Institut für Geologie, Mineralogie und Geophysik; Ruhr-Universität Bochum; D-44801 Bochum; Germany; thomas.mueller-1@rub.de
[2]Institut für Mineralogie und Kristallchemie; Universität Stuttgart; D-70174 Stuttgart, Germany

The exchange of elements such as Fe-Mg between co-existing ferromagnesian minerals is a consequence of changing external (intensive) variables, such as temperature and/or pressure and proceeds via a series of kinetically controlled processes. Compositional zoning patterns of co-existing mineral pairs can thus be used to model the incomplete diffusive equilibration process if diffusive parameters and the partition coefficient are known as a function of P and T. Unraveling such zoning patterns is the key tool to decipher the nature of measured temperatures using geothermobarometry and are thus potential recorders of cooling and exhumation processes on various timescales.

The studied sample is a garnet pyroxenite from the Granulitgebirge, Germany. The rock contains remarkable exsolution textures from former megacrysts that produced up to mm-wide, alternating lamellae of garnet (grt) and clinopyroxene (cpx). Compositional profiles of Fe and Mg measured with the electron microprobe perpendicular to the grt-cpx interfaces reveal almost flat, but often slightly zoned patterns with increasing Fe from the grt center towards the interface and decreasing Fe (from core to rim) in the adjacent cpx.

We present data from a numerical finite difference scheme that simulates diffusive exchange between grt and cpx along a virtual cooling path. The model assumes local equilibrium at the interface and diffusive fluxes are constraint by mass balance. Preliminary modeling results suggest very efficient compositonal resetting even for very fast cooling rates at temperatures above 1000 °C, so that no record of the growth of the lamellae is preserved. Nevertheless, the presence of slight chemial zoning can successfully be used to estimate P-T conditions of lamellae formation as well as cooling / exhumation rates in the temperature range between 700 – 1000 °C. Finally, modeling results indicate fast cooling rates of >> 100 °C/Ma in agreement with published estimates for the crystalline complex of the Granulitgebirge based on geochronology.

DOI:10.1180/minmag.2013.077.5.13