MOLTER final report exchange grant 3695 to F. Peterse

Tracing soil-ocean carbon transfer dynamics using membrane lipids of soil bacteria

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Exchange candidate:	Host institution:
Dr. ir. Francien Peterse	Dr. Christopher Moy
ETH Zürich	University of Otago
Geological Institute	Geology Department
Sonneggstrasse 5	360 Leith Walk
8092 Zürich	Dunedin 9054
Switzerland	New Zealand

1. Purpose of the visit

Terrestrial organic carbon (OC) is an important dynamic component of the global carbon cycle. The amount of OC held within the terrestrial biosphere and soils is almost three times the atmospheric carbon reservoir, with soils accounting for the majority of this terrestrial carbon. A large fraction of terrestrial OC is continuously mobilized and transported primarily by rivers to the ocean, where it may be sequestered in marine sediments, comprising a long-term sink for atmospheric CO_2 fixed via terrestrial photosynthesis. However, our understanding of the magnitude, transport and dispersal patterns, and especially the timescales over which terrestrial OC is transported to the oceans is far from complete. The major goal of this project is to utilize branched glycerol dialkyl glycerol tetraether (brGDGT) lipids, which are membrane lipids of soil bacteria, as tracers of soil OC as a means to probe its fate and dynamics within a range of river systems.

The South Island of New Zealand is divided by a mountain chain, which results in large differences in environmental parameters (e.g. precipitation, slope steepness and erosion rate, temperature, vegetation) between the east and west side of the chain. Comparison of two adjacent river basins on either side of the mountain range will enable in-depth assessments of drainage basin controls on soil OC discharge within a narrow latitudinal range. The visit was used to collect samples from several river basins at both sides of the mountain chain. Analysis of the abundance, distribution, and age of the brGDGTs in these samples should contribute to our understanding of the residence time of soil OC within the drainage basins, help to assess the factors that control these reference times, and to examine the transformations in soil OC during its journey from land to sea. Furthermore, an incubation experiment using soil and river water from different parts of the river basins was designed to set up at the University of Otago to investigate the biodegradability of the soil OC that is transported by the rivers in more detail.

2. Description of the work carried out during the visit

The work that was carried out during the visit consisted of 1) sample collection in different river basins, and 2) setting up the incubation experiment at the University of Otago in Dunedin, New Zealand.

2.1. Sample collection

Water and sediment samples were collected from four river basins: Haast River and Whataroa River on the West coast, and Rangitata River and Rakaia River on the East coast (Fig. 1). In each river basin, five sites were visited, following the river downstream from its headwaters to the river mouth at the coast. To address to the research questions, the following samples were collected at each sampling site:

- River bank sediment for brGDGTs and other biomarkers analysis;

- River water for δD analysis;
- River suspended OC (filtering 5-30 liter) for brGDGTs, total OC, and other biomarkers analysis.

Also the water temperature, pH, oxygen content, and conductivity were measured at each site. Additionally, the following samples were collected per river basin:

- Soil for brGDGTs and other biomarkers;
- Water for Sr isotopes analysis at the headwaters and the river mouth;
- River water from tributaries for δD analysis;
- A large sample of river suspended OC at the river mouth (filtering 70-100 liters of river water) for ^{14}C analysis.

The collected samples have been shipped to the ETH Zürich, Switzerland, where all analyses will be carried out.

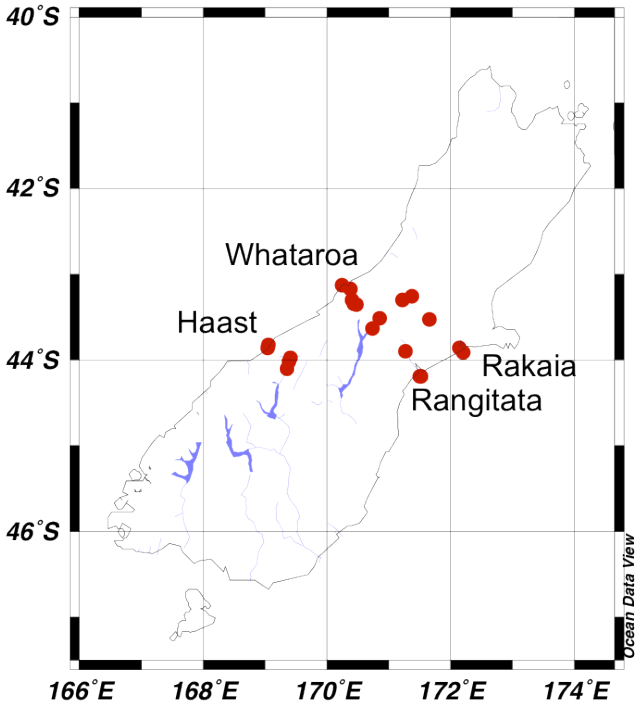

Fig. 1. South Island of New Zealand with selected rivers and sample locations.

2.2. Incubation experiment

The incubation experiment was set up with a soil from the Rakaia River basin, using Rakaia River water and ocean water from close to the Rakaia River mouth as microbial inoculum. The soil was sieved through a 2 mm mesh to remove plant debris and coarse material, after which 42 incubation bottles were filled with 10 g of sieved soil each. 2 bottles were immediately frozen at -20°C to serve as control sample (t=0 days). The remaining bottles were placed on a shaker table after addition of 100 ml of ocean water (to 16 bottles), 100 ml of Rakaia River water (to 16 bottles), 100 ml of distilled water (wet control, 4 bottles), or nothing (dry control, 4 bottles). The bottle necks were plugged with cotton wool in order to create a (semi-)aerobic environment and to prevent contamination of the samples by e.g. dust or other particles falling in.

The incubation experiment is monitored by the collaborators at the University of Otago in New Zealand. Parts of the experiment are periodically stopped by freezing the bottles according to

the following time schedule:

t=1 day	2x river water, 2x ocean water
t=1 week	2x river water, 2x ocean water
t=2 weeks	2x river water, 2x ocean water
t=1 month	2x river water, 2x ocean water
t=3 months	2x river water, 2x ocean water, 2x dry control, 2x wet control

After these three months, the frozen samples will be shipped to ETH Zürich, where they will be analyzed. Depending on the results of this first suit of samples it will be decided if the experiment will be continued or not, and if so, for how long.

3. Description of the main results obtained

The differences between the rivers on the East coast and West coast became very clear in the field during the sampling campaign. The rivers on the West coast have a steeper gradient, receive more precipitation, and have a different vegetation cover than the East coast rivers. Also the sediment load of the rivers on the West coast (i.e. Haast and Whataroa) was higher than in the Rangitata and Rakaia Rivers on the East coast, and the quantity of water that was needed to collect enough material on a filter was higher on the East coast than on the West coast. Next to the difference between coasts, there was also an increasing trend in sediment load from headwaters to the coast (Fig. 2).

The river basin samples (filters, soils, river bank sediments) that were collected during the visit have recently arrived at ETH Zürich and are stored frozen and are waiting to be freeze dried prior to be analyzed. The samples from the incubation experiment will be send to the ETH after the last sample moment at t=3 months (see section 2.2 on the incubation experiment).

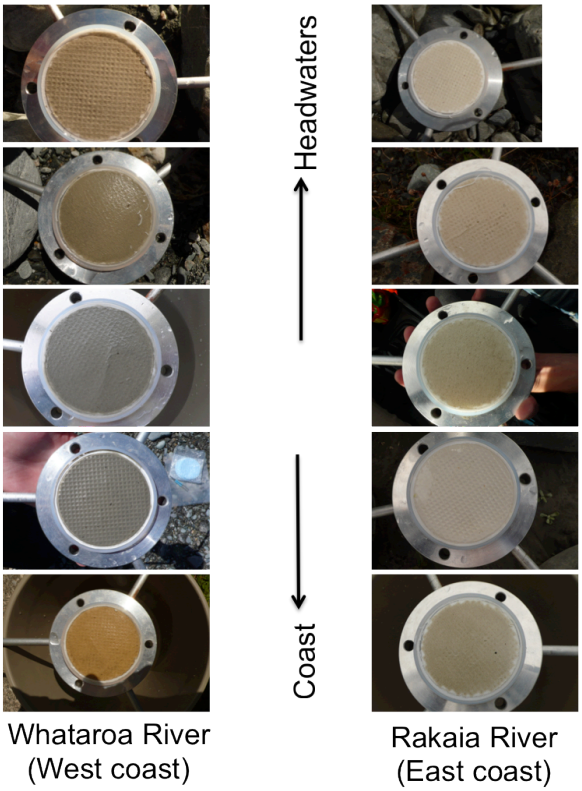

Fig. 2. Filters with river suspended material from the Whataroa River on the West coast, and the Rakaia River on the East Coast. Filters are arranged from headwaters land inwards at the top to the coast at the bottom.

4. Future collaboration with host institution

Potential future projects that have been discussed during the visit include (monthly) monitoring of (one of) the selected river basins to study the influence of seasonality or specific weather events on the transport of soil OC by these rivers. A second project may be the collection of a marine sediment core close to one of the river mouths in order to reconstruct the paleoclimate of the catchment area by applying the paleotemperature proxy based on brGDGTs (the so-called 'MBT-CBT proxy'), and to verify whether this reconstruction is influenced by the residence time of brGDGTs in the catchment. The data that will be generated from the samples collected during this visit should give an indication of the significance of the latter project.

5. Projected publications / articles resulting or to result from the grant

The data that will be generated from these samples will likely be presented at the *Gordon Research Conference on Organic Geochemistry* in Holderness, NH, USA (August 2012) and at the *5th International Workshop on Soil and Sedimentary Organic Matter Stabilization and Destabilization* in Ascona, Switzerland (October 2012). After completion of the dataset, a manuscript on the transport of soil OC from land to sea by rivers as traced by brGDGTs, as well as a manuscript on the degradation and transformation of soil OC during river transport (evolving from the incubation experiment), will be prepared for publication in a peer-reviewed journal.