Geomicrobiology and geochemistry in the Jöri lake catchment and in the mineral springs of the Lower Engadine and the Albula region

Field trip to geomicrobial ecosystems in the Swiss Alps for Participants of the Course „Evolution and Ecology of Microorgansims“ at the University of Zürich, and guests
on Thursday, October 11 and Friday, October 12, 2007

Jöri catchment

Locations

During this geomicrobiological field trip we will learn how to evaluate concepts of microbial ecology as they appear to us in nature. We will also be confronted with a few essentials about hydrochemistry, which we will relate to basic chemical knowledge, and to the mineralogy and the geology of the areas visited.

Jöri: alpine microbial habitats, low-nutrient life strategies, cold-adapted microorganisms, microbially mediated geochemical cycling of Fe, Mn, S, P, relations to alpine geology, alpine water cycle.

Tarasp-Scuol: subsurface geo-hydro-microbiology in the „Lower Engadin Window“, Trias evaporites, Dolomite, Bündnerschiefer, mineral dissolution and carbonate ice precipitation, surface reactivities of sedimentary rocks.

Alvaneu: chemolithotrophy, biosphere-hydrosphere-lithosphere interactions, gypsum containing dolomite at Alp Weissenstein.

Guide

Kurt Hanselmann, University of Zürich

Travertine terracetts at Clüs

Geysir precipitats

Fuschna, carbonate ice

Objectives

Geomicrobiology: Often the solutes present in spring water not only represent the water soluble mineral components of the rocks, they also carry a signature of microbiological processes which have taken place in the subsurface. The presence of certain reduced chemicals can be due to the activity of anaerobic chemoorganotrophic bacteria and archaea in the deep subsurface. Aerobic chemolithotrophs at the spring mouth can make a living by oxidizing them.

Bio-geo-chemical cycles: We will see surface phenomena which relate to underground and surface geochemical cycles of iron, manganese, sulfur and phosphorus (Alvaneu, Jöri). Often ferrous iron and sulfide oxidizing bacteria develop in masses at the anoxic-oxic transition zone. We will study the conditions that must prevail to select specifically for the kind of bacteria, which are present in these aquatic habitats.

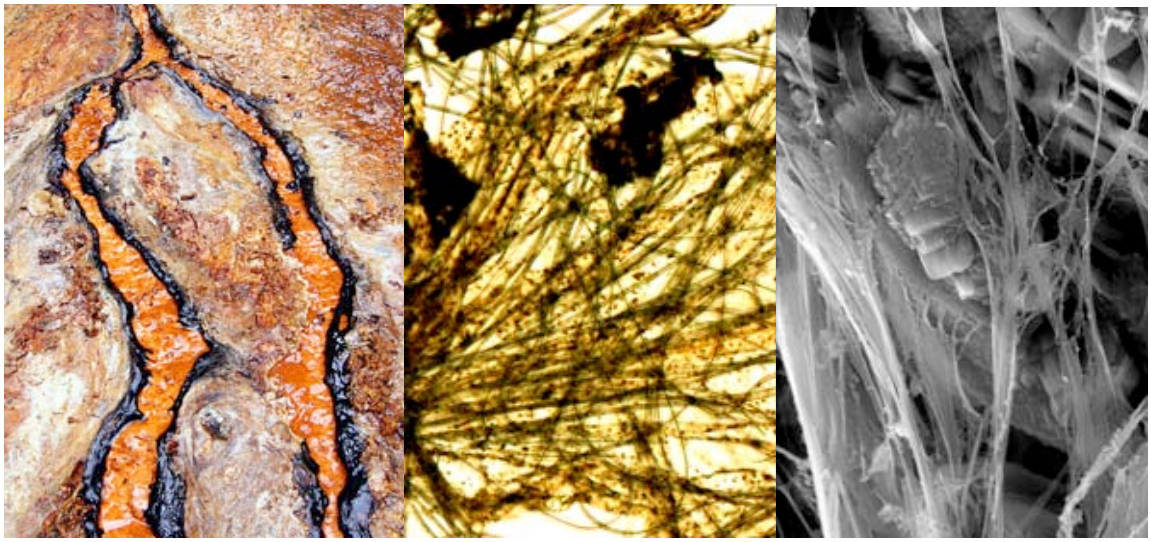
Hydrobiochemistry: We will illustrate the quality of the water when it arrives as rain or snow in the Alps, how it gets stored and transported and how its chemical composition changes while it percolates through different rock formations (Rauwacke, Gypsum, Bündnerschiefer). These topics will be illustrated at different locations in the upper catchment of the Rhine and Inn rivers (Rothenbrunnen, Alvaneu, Scuol-Tarasp). We will focus on the chemical composition of a variety of spring waters and follow how this can create a diversity of ecosystems for microorganisms.

High altitude research: In collaboration with other institutions, the Microbial Ecology Group is studying how microorganisms respond and adapt physiologically to the complex interactions between chemical, geological and atmospheric determinants in the Jöri lakes, in snow and on ice. The studies are aimed at understanding evolutionary processes in ecosystems research and the microbial diversity in cold-extreme environments.

Hydrology: The terrestrial hydrological cycle, which begins in the central European mountains distributes water by 4 major river systems across much of the continent. We will cross the divide between the Rhine and and the Danube catchments. Millions of people in Europe depend on water, which originates in these alpine regions for drinking water, power generation, transport, industrial purposes and recreation.

Field trip stops

(might change depending on weather and time)
1. High alpine Jöri lakes (Klosters / Davos) – 2. Mineral springs and travertine formation (Lower Engadine, Scuol-Tarasp) – 3. Gypsum containing dolomitic outcrop (Alp Weissenstein, Albula) and carbonate-lake Palpuogna (Preda / Bergün) – 4. Sulfur and iron springs (Alvaneu) – 5. Iron fountain (Rothenbrunnen).



Key topics at stops

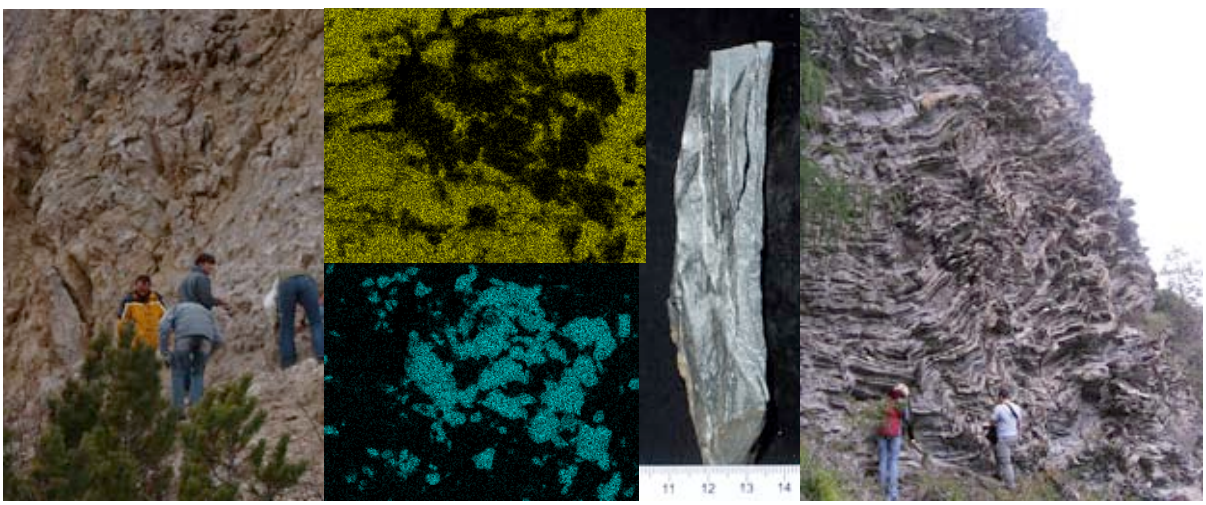
1. High alpine Jöri lakes, Klosters / Davos: The University of Zürich maintains a High Mountain Research Station at Jöri Lake XIII, upper Vereina valley/GR. Research topics are „Microbial life strategies under harsh environmental conditions" and "Geochemical nutrient scavenging in nutrient-poor environments". High mountain lakes and glacial ice offer ideal conditions for the study of adaptations of organisms to a variety of environmental extremes: water temperatures are often near freezing, darkness under snow and ice lasts for many months, UV radiation is strong during the summer months and nutrients are scarce. One wonders how life has adapted to these challenges over time and yet is constantly amazed at the strategies microbes have developed to cope with these extreme conditions.

2. Mineral springs, Scoul Tarasp Vulpera: Spring water composition reflects the mirror image of the underground geology and is dependent on the contact time between water and rock. At the mouth of the springs the waters contain the dissolved solutes from the rock minerals. Dangerously large amounts of gaseous CO_2 are formed in enclosed areas and underground. When the bicarbonate saturated aqueous solution reaches the surface it equilibrates with the CO_2 of the atmosphere. This can lead to the formation of carbonate ice and small travertine terraces.

3. Gypsum containing dolomitic outcrop, Alp Weissenstein: At Igls Plans (2044 m asl) a gypsum containing dolomitic outcrop offers a window into what is buried in the subsurface on most other locations. They are evaporitic rocks, which are easily eroded and dissolved. Endolithic phototrophic communities find habitats in near surface rock layers.
Carbonate-enriched Lac da Palpuogna, Preda: This and other lakes, which are located just below a dolomitic outcrop reflect the consequences of elevated concentrations of dissolved minerals on algal growth and primary productivity.

4. Sulfur and iron springs, Alvaneu: The „rust" in the outflow of the iron spring consists of badly soluble iron(III)-oxides and iron(III)-hydroxides which dominate the habitats of ferrous iron oxidizing bacteria. The sulfur in the springs and fountains is formed by hydrogensulfide oxidizing chemolithotrophs, mostly *Thiothrix spp.* with intracellular sulfur deposits, which are highly enriched under the sulfidic conditions.

5. Iron spring Rothenbrunnen: For centuries highly mineralized spring waters were used for healing purposes; today they are mostly bottled and marketed as mineral enriched drinking water after de-ironing the original spring water. Bacteria which colonize the fountain catalyze the ferrous iron oxidation (e.g. *Gallionella ferruginea*). They protect themselves from being completely encapsulated with „rust" by forming an extracellular sheath from which the cells can „escape" as soon as exchanges of metabolites by diffusion becomes limiting.



Discussions

include aspects to (depending on interest):

- Geochemical cycling of nutrients in cryosphere ecosystems
- The role of the iron cycle for nutrient accumulation
- Geochemical nutrient scavenging in oligotrophic high-mountain lakes
- Self-trophication – a phenomenon of specialized low nutrient environments
- Adaptation to low temperatures, intensive solar radiation and long periods of darkness
- Regulation of community diversity by changing habitat conditions
- Microbial adaptation to extreme environments: psychrophilic lifestyles
- Microbial mats & biofilms in nutrient poor flowing and stagnant mountain waters
- Chemolithotrophic microbiota in mineral springs
- Chemical and microbially mediated subsurface mineral weathering
- Carbonate ice and travertine formation at mineral springs
- Alpine (and polar) microbial ecosystems

Research

Participants are invited to choose from 7 research topics, which are offered for this course. There are research topics, which can accommodate 1 student and those, which are suitable for a group of maximally 2 students. Please organize yourself.

Samples for course work will be collected at the following sites:

1. Jöri lake XIII, microbial communities in the water column (2 students)
2. Jöri lake XIII, bloom degradation communities (1 student)
3. Jöri lake I or XIX, biofilms (1 student)
4. Mineral springs Fuschna and Bonifacius: Cyanobacteria and carbonate ice communities (2 students)
5. Outcrop Weissenstein: endolithic microbes (1 student)
6. Alvaneu, sulfur and iron-sulfur springs: hydrogensulfide chemolithotrophs (2 students)
7. Rothenbrunnen, iron fountain: ferrous iron chemolithotrophs (1 student)

The samples will be conserved at the collection site and investigated during the practical section of the course. Please document the conditions at the site from which the samples are collected.

For each ecosystem (site visited) investigate the following five aspects:

1. Which microorganisms are present?
2. Describe the site as a habitat.
3. Define the living conditions.
4. Discuss the microbial life styles, which are possible in the ecosystem.
5. Address questions, which relate to “your” research topic.

Aspect 1 will mostly be carried out in the laboratory after the field trip, 2 is based on your observations and the discussions at the location in the field and 3 needs to be supplemented with background information from the literature and from the lectures. Aspects 4 and 5 will be based on the contents of the lecture and discussion periods during weeks 2 to 4.

Reporting

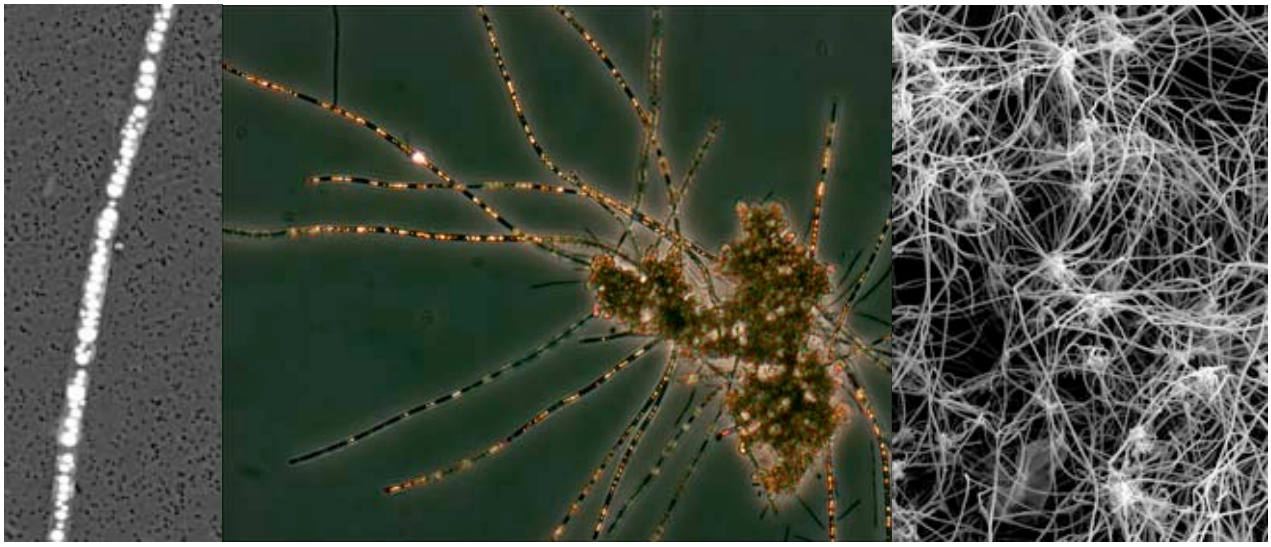
Each participant will choose scientifically related topics for investigation from the ones offered, search for background information and summarize and present the findings together with the on-site experiences in the form of a well documented power point presentation during the first two weeks of the course. The results of the laboratory investigation shall be included in the final presentation and in the course report.

Field trip program **October 11 (Thursday)**

07.50	Assemble at the Botanical Garden, Zollikerstrasse 107
08.00	Departure with minibus and private car.
10.30	Wägerhus, begin climb to Jöri lakes
12.00	Arrival at Research station lake XIII: geochemical Fe-, Mn-, P-cycles *Sampling lake water from different depths for course work*
14.30	Lake I: highly turbid lake, biofilms of Cyanobacteria. *Sampling for course work*
15.00	Lake II: iron rich swamp
15.30	Lake XIV: Glacial sedimentation field, fractionation of erosion particles
16.30	Glacial lakes XVI – XXII
17.00	Cryoconite holes on Jöri glacier, depends on snow cover
17.30	Winterlücke, begin descent
18.30	Departure at Wägerhus
19.00	Arrival at Davos
19.00	Dinner and overnight stay at „Time Out“, Davos Platz (Tel. +41-81- 415 36 72)
20.00	Presentations and discussions about topics of the next day

October 12 (Friday)

07.20	Breakfast at „Time Out“
08.00	Departure from Davos
09.00	Mineral springs at Scuol-Tarasp-Vulpera: Bonifazius. Have a drinking cup with you. We will taste different mineral waters along the way.
10.00	Clozza drinking fountain, *Sampling for course work*, formation of travertine terracetts at Clüs.
10.30	Lischana: High magnesium water.
11.00	Carola, Luzius, Emerita, „Geysir“, Sfondraz, high mineralization, CO_2 formation and escape.
11.30	Fuschna, cyanobacterial mats and carbonate ice formation. *Sampling for course work*
14.00	Albula Pass, Alp Weissenstein, dolomitic outcrop, endolithic microbial habitats. *Sampling for course work*
15.00	Carbonate-rich Lake Palpuogna near the Albulapass road
16.00	Alvaneu: Walk along the Albula river to the iron and sulfur springs, which are rich in chemolithotrophic microbes. *Sampling for course work*. A few words about the use of the sulfidic waters for health.
17.30	Continue via Surava - Tiefenkastel: Bündnerschiefer outcrop
18.00	Rothenbrunnen (N-13 to exit Rothenbrunnen), iron spring, de-ironing of water to make bottled mineral water. *Sampling for course work*.
18.30	N13, begin trip back to Zürich
20.30	ca. arrival in Zürich



Clothing etc.

Sturty walking shoes are a must since we will traverse rough montainous terraine and glacial ice. Be prepared for snow. Backpack for provisions and samples; bag for overnight utensils. The weather can change abruptly in the mountains. Please be equiped with sun glasses and protective lotion, hat and rain gear and have extra dry cloths with you.

We will take collecting vials for bacteria with us. Take a note book to record the information collected in the field and a camera with you if you intend to take pictures of the sites which we will visit.

Most of the excursion can take place regardless of the weather forecast if you are equiped accordingly. But we might decide on the spot to change the program in case the weather or the conditions should demand it.

Fitness

In the mountains we will walk on well marked paths. The highest elevation that we will reach is 2800 m asl, the maximum altitude difference will be 600m but the walks will not be strenuous.

Travel

By private cars and mini-bus

Route

Day 1: Zürich – Landquart – Klosters – Wägerhus – Jöri – Davos.
Day 2: Davos – Flüela Pass – Scuol-Tarasp – Albula Pass – Alvaneu – Tiefenkastel – Thusis – Rothenbrunnen – Zürich.

Costs

Fr. 75 for the full 2-day-field trip per person. Included are transportation, lodging at Davos (room and board for 1 night, half pension (not the drinks), occupancy 4 persons per room, no sleeping bags required). Backpack lunches for the 2 days are the particpant's responsibility. The expenses will be collected during the trip. Students who are registered at the University of Zürich can apply for a 30% cost reduction.

Insurance

is the responsibility of the participant. The tour guides cannot be held liable for damages or lost items. Please make sure that your accident insurance policy covers mountain rescue operations by helicopter (REGA in Switzerland, www.rega.ch, tel. ++41 (0)844 834 844). Please do not leave the group in the mountains since you might get lost or get yourself into danger.

Signing up

There are 16 places available. For the housing at the „Time Out" in Davos we had to make reservations far in advance.

Information

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Participants

Course students: Alex Georg Bösch, Gisela Brand, Ester Eckert, Nadine Hermann, Martin Meyer, Jasmine Ritschard, Jörg Villiger, Susanne Wild, Florian Zapf, Yannick-Serge Zimmermann
Guests: Jakob Pernthaler, Thomas Posch

We are looking forward to having interested students and guests on this geomicrobiology excursion to the beautiful Jöri Lakes and the mineral springs in the Canton of Graubünden. You will learn a lot and it will be an eye-opener for those who are interested in seeing natural microbiological and geochemical features. The field trip is mandatory for course participants. They will investigate the samples collected from the sites during the following weeks of the course. If the weather allows, we will have opportunities to enjoy the beautiful landscapes with great views of the Alps. Don't forget your camera!