Master Thesis in biology, microbiology.

Title: Enrichment and characterization of microbial communities in moderate to severe acid mine drainage sites associated to Arctic coal mining in Svalbard.

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Research group:
Geomicrobiology

Description

Coal deposits contain variable (generally 1–20%) amounts of "pyritic-sulfur" (a generic term that includes other iron sulfide minerals) as well as organic sulfur. As a consequence of the mining, these sulfidic deposits are exposed to the combined action of water and oxygen, accelerating their oxidation to sulfuric acid and acidophilic iron- and sulfur-oxidizing microorganisms greatly enhance this acid-producing oxidation. This acid mine drainage (AMD) is extremely detrimental to the environment as it reduces the water quality of receiving streams. The acid also reduces the pH of soil and sediment and solubilizes many potentially toxic metals. The result is that the soil can no longer support plant growth and the mine site is left unprotected by plant cover and subject to severe erosion.

Acid mine drainage however varies significantly from site to site and it is highly controlled by different environmental variables such as climate regime. In cold climates acid mine drainage generation possess a remarkable seasonal trend. The heat generated due to the oxidation of sulfides (an exothermic process) is high enough to keep the ore warm despite the permafrost. Consequently, weathering processes continue year-round within the ore rock and weathering products accumulate during winter because of the lack of water to flush them out and the outer permafrost layer. These are only released upon thawing of the soil in the spring as runoff of highly metal-containing water. This trend has been detected by measuring the metal transport and water flow in both Arctic latitudes and sub-alpine to alpine altitudes (>2,000 m over the sea level). Nonetheless nothing is known about the microbial activity in these systems and the role that they play in the generation of the acid drainage.

Under psychrophilic conditions, chemical and biological reactions proceed much slower than under mesophilic conditions. In fact most of the acidophiles detected in AMD are mesophilic or moderate thermophilic. Actually at low temperature, chemical oxidation is even slower and without biological catalysis, acid generation would be almost imperceptible. However only one psychro-tolerant bacterium has been isolated and described so long, although different iron and sulfur oxidizing microbes are known to adapt and grow at 4C in lab culture.

Knowledge about the native microbial communities controlling the weathering is therefore essential to evaluate the impact on the ecosystem and make appropriate decision about the remediation and management. Moreover, some metabolic reactions with possibilities for the treatment of mine waste waters become thermodynamically more favorable as temperature decreases, indicating the biotechnological potential of these communities.

The aims of the proposed M.Sc. thesis are:

1) Enrichment, isolation and characterization of psychrophilic microorganisms from moderate and severe acid mine drainage areas associated to coal mining in Arctic latitudes (Svalbard).
2) Analyze the microbial community in the enrichments and native samples and monitor their spatial and temporal shifts.
3) Integrate the information to propose a model of acid mine drainage generation and possible attenuation strategies.

The photos show two different AMD-impacted sites located in the vicinity of Longyearbyen (Svalbard).

Working plan

1) Some samples were collected during August 2010 by Lise Øvreås and Antonio García-Moyano during a visit to Spitsbergen (Svalbard). Different mining areas were visited and samples of both water and sediments collected and brought back for later enrichment and DNA work.
    a. Geochemistry on site (pH).
    b. Geochemistry in the lab (Fe, sulfate and ICP-MS for trace elements).
    c. Samples of water and sediments both fresh and with RNA later.
2) Set up enrichments for iron- and sulfur-oxidizing microorganisms using different strategies such as silica-based plates, biphasic gradient tubes or liquid culture. Follow the evolution of the enrichments by measuring some geochemical parameters, microscopy and with fingerprinting (PCR-DGGE).
3) Characterization of the enrichment/isolates.
4) Discovery and characterization of iron hydroxide deposits/structures by SEM work on the native samples and enrichments.
5) Construct a PCR based 16S rRNA gene library for diversity analysis.
6) Use the sequence information retrieved to design primers/probes for the microorganisms detected on the native samples.
7) Quantification of microorganisms by qPCR or hybridization (FISH) techniques.
8) PCR and phylogeny reconstruction (and/or qPCR for real time expression analysis) of functional markers of key metabolic processes.

Financing

This thesis will be linked to the research group in Geomicrobiology and Centre for Geobiology. We will also apply for additional funding through Bergen Forskningsttiftelse and the Meltzer Foundation.

Working place

Geomicrobiology research group, Centre for Geobiology and Department of Biology (Thormøhlensgate 53B).