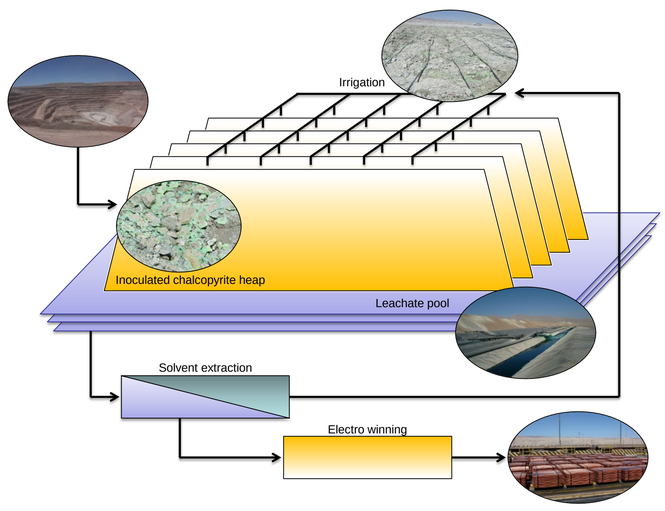
Systems Biology of Acidophile Biofilms for Efficient Metal Extraction (SysMetEx)

Introduction and aims

The very long lag phase typically encountered in the initiation of large-scale industrial bioleaching operations is considered to be one of the major drawbacks of bioleaching as an economically interesting technology.

One of the major time determining factors in bioleaching heaps is suggested to be the speed of mineral colonization by the acidophilic microbes.

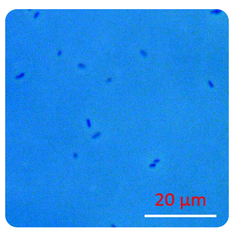
The aim of this study is to identify key elements in the formation of acidophile biofilms on the copper mineral chalcopyrite ($CuFeS_2$), and to investigate the effects of biofilms in bioleaching environments.



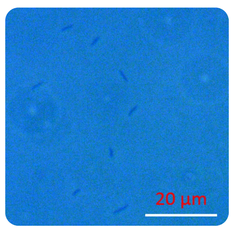
Schematic Illustration of Heap Leaching

Microorganisms

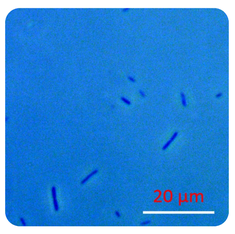
The bacterial species used in this study have been chosen according to their ability to dominate various bioleaching environments, their preferred substrate, the availability of full genome sequences, and their growth optimum in moderately thermophile conditions.



Acidithiobacillus caldus
Sulfur-oxidizer, capable of adapting to a wide range of pH conditions (1.2-2.5). Obligate autotroph.



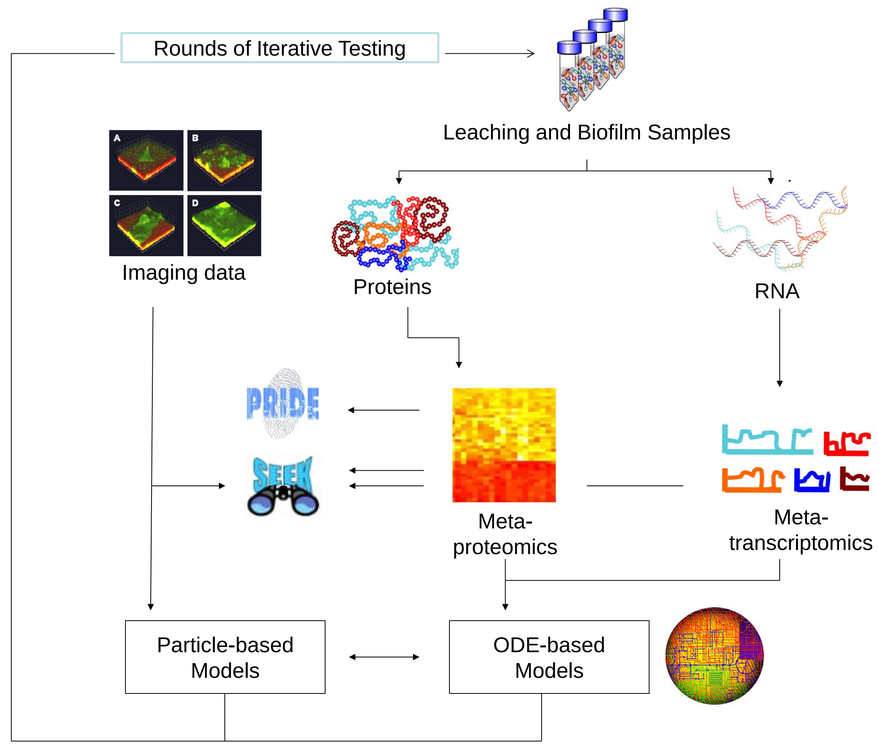
Leptospirillum ferriphilum
Most dominant iron-oxidizer under low pH (1.3-1.6) and high redox potential conditions. Obligate autotroph.



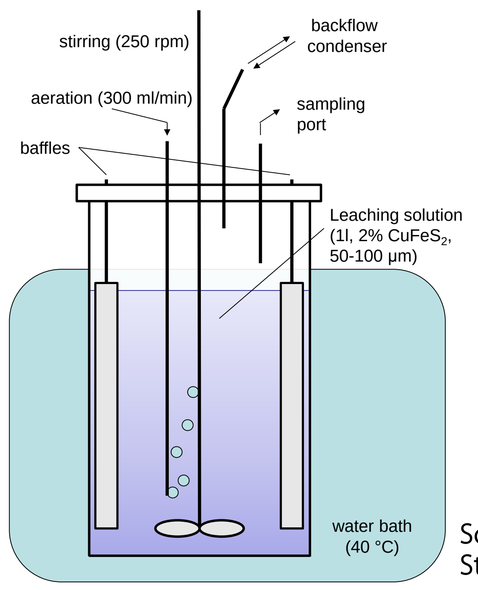
Sulfobacillus thermosulfidooxidans
Iron- (primarily) and sulfur-oxidizer. Prefers relatively high pH conditions (1.8-2.2). Mixotroph and facultative anaerobe. Spore former.

Approach

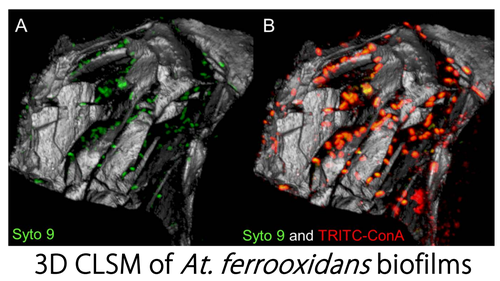
By applying confocal microscopy, metatranscriptomics, metaproteomics, bioinformatics, and computer modeling we will investigate processes leading up to, and influencing bacterial attachment to the mineral surface. Three moderately thermophilic sulfur- and/or iron-oxidizing species will be used: *Sulfobacillus thermosulfidooxidans, Leptospirillum ferriphilum* & *Acidithiobacillus caldus*.



Stirred tank reactors containing chalcopyrite concentrate, inoculated with these species, allows investigation of the effects of various inoculation orders and proportions on the lag phase and rates of metal release. Meanwhile, confocal microscopy of cell attachment to chalcopyrite, as well as metatranscriptomics and metaproteomics of the forming biofilms further increase the so far limited understanding of the attachment process and help to develop a model thereof.



Schematic Illustration of a Stirred Bioleaching Reactor



3D CLSM of *At. ferrooxidans* biofilms on a pyrite grain (~50 µm size)*

**Vera et al., 2013. Appl Microbiol Biotech 97:7529*

Impact

The models created by this study will valorize systems biology knowledge and will be used to predict and manipulate biofilm development to reduce the lag time between heap initiation and onset of copper solubilization. Decisively, the project will transfer this knowledge into maximal application by including end user companies actively carrying out biomining and other biotechnological applications, hopefully making this environmentally friendly technique more attractive to mining companies.

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