Iron-, sulfur-, nitrogen- and carbon-cycling microbial communities in an abandoned acidic metal sulfide mine

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Microbial life in an abandoned metal sulfide mine in the Harz mountains (Rammelsberg, Lower Saxony, Germany) occurs in stalactites, slimes, streamers and biofilms on mineral surfaces. Comprehensive geochemical and mineralogical analyses of the samples were undertaken. Microbial analyses targeting Archaea, Bacteria and Eukarya comprised cultivation-based as well as cultivation-independent methods based on RNA and DNA. The mine samples were characterized by low to moderate acidic pH (2.5 – 5.0). Organic carbon levels were relatively low in all samples, but nitrate and ammonium contents indicated the occurrence of active microorganisms involved in the nitrogen cycle. Total soluble iron concentrations in the liquid samples were rather low due to pH values above 3.0, but elevated concentrations of sulfate and zinc were detected. Iron was the main metal in most solid samples accompanied by aluminium, manganese, arsenic and sulfur. Organisms from all three domains of life could be detected in high numbers in the mine samples. The microbial iron-cycle was most prominent mediated by the autotrophic iron-oxidizers "*Ferrovum myxofaciens*", *Leptospirillum* spp. and *Acidithiobacillus ferrooxidans.* Iron reduction (goethite, amorphous ferric minerals, dissolved ferric ions) was performed by e.g. *Acidithiobacillus ferrooxidans* and possibly members of the *Thaumarchaeota,* which were enriched from mine samples in acidic media. According to the low numbers of active sulfur-metabolizing microorganisms detected, the microbial sulfur-cycle only plays a minor role, dominated by various sulfur-oxidizing bacteria and sulfate-reducing *Desulfosporosinus* sp.. The most abundant organisms in the archaeal group clustered with the *Thaumarchaeota*, which are proposed to contribute to the nitrogen-cycle by ammonia-oxidation, while bacteria contribute by nitrogen fixation. The carbon cycle in the mine is mediated by *Eukarya* (mainly fungi) as well as mixotrophic/heterotrophic members of the *Euryarchaeota, Alphaproteobacteria, Acidobacteria* and CO_2-fixing bacterial species.