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Pyrite surface alteration as effect of microbial activity and crystallographic orientation

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The relevance of microbial mineral leaching processes has resulted in a large number of studies by which microbial leaching of a wide variety of minerals by pure and mixed cultures of Bacteria and Archaea were experimentally examined. These lead to good understanding of biogeochemical processes that occur as effect of microbial metabolic activities. The project presented here aims to enhance our understanding of effects of parameters such as time, varied metabolism, direct or indirect leaching, and crystallographic orientation on microbial leaching of pyrite surfaces. Systematic assessment of highly characterized surfaces before and after exposure to the microbial cultures will result in quantification of the leaching processes. This will lead us to determine whether varied crystallographic orientation results in varied surface leaching features. The long-term goals of the study are to establish means that allow the controlled manipulation of pyrite and other metal sulfide surfaces. We present issues related to possible effects of crystallographic orientation of pyrite surfaces on the leaching efficacy and resulting leaching surface features as a function of microbial activity. We devise microbial leaching experiments on pyrite surfaces of different orientation, including (100), (111) and (210). The experiments are performed using strains of mesophilic Bacteria and thermophilic Archaea. Six different microbial strains were tested initially, three mesophilic Bacteria (Thiobacillus sphaeroides, Acidithiobacillus ferrooxidans, Thiobacillus prosperus) and three thermophilic Archaea (Sulfolobus metallicus, Metallosphaera sedula, Sulfolobus spp.). In addition to the crystallographic orientation and nature of microbial species, parameters such as pH, temperature, and time may affect the leaching process. Epifluorescens microscopy observations show, that some

microbial strains attach to the mineral surface whereas others remain planktonic in the liquid growth medium. Systematic studies addressing the effect of time are accomplished in time spans between one day and six weeks. Cell attachment commences after few days attaining a surface cell density that remains stable after approximately two weeks. Scanning Electron Microscopy (SEM) studies have shown that leaching effects become visible within few days of incubation. Surface alteration produces structures such as channels, inverse pyramids following crystallographic orientation, rectangular or round pits in the 10s to 100s um size range. Epifluorescens microscopy and SEM analysis has show that surface alteration as result of microbial activity occurs first at weaknesses in the surface, such as micro-scratches and possibly at crystallographic defects (e.g. screw and edge dislocations). Leaching occurs due to microbial activity, which results in lowering pH-values from 2.5 in the growth medium to approximately 1.5 in local micro-environments. To test whether microbial activity has a direct bearing on surface alteration, or whether abiotic acid leaching produces similar results, we devise experiments using sulfuric acid etching to compare features of surface alteration.