THEME 2: THE DYNAMIC INTERFACE

Session 2.6:

Biofilms on mineral surfaces: Formation, characterisation and impact on environmental processes

CONVENED BY:
DAVID VAUGHAN (DAVID.VAUGHAN@MAN.AC.UK)
TERRY BEVERIDGE (TJB@UOGUELPH.CA)

INVITED SPEAKERS:
LESLEY WARREN (WARRENL@MCMASTER.CA)
ROY WOGELIUS (ROY.WOGELIUS@MAN.AC.UK)
GEOFF GADD (G.M.GADD@DUNDEE.AC.UK)
VERN PHOENIX (VERNON@GEOLOGY.UTORONTO.CA)

In natural environments, bacteria often grow as biofilms forming adhesive gelatinous interfaces whereby bacteria and their associated exopolymeric substances (EPS) are intermingled over inanimate surfaces, such as minerals. Depending on fluid flow, biofilms can form complex macrostructures, such as pillars and canals, which aid diffusion to the cells. As biofilms mature, they become stratified so that geochemical microenvironments of pH, redox, electrolytes, etc. are formed. Metal ions are sorbed to both cell surfaces and EPS and nano-scale mineral phases develop. Some bacteria, such as dissimilatory metal-reducing bacteria, can even respire metal-ion couples (e.g., Fe(III)/Fe(II) and Mn(II)/Mn(I)), using them as terminal electron acceptors, thereby altering the geochemical conditions under which they grow. This interdisciplinary session will cover bacterial attachment, biofilm growth and characterization, transport/fate of metals, biomineralization, and biofilm influence on fluid flow and hydrodynamics.

2.6.11

Mineral surface chemistry and conditioning films: How do biofilms begin?

R.A. WOGELIUS[1,2] AND P.M.MORRIS[1]

[1] Williamson Research Centre for Molecular Environmental Science, Department of Earth Sciences
[2] Department of Chemistry, University of Manchester, Manchester M13 9PL, UK
(Roy.Wogelius@man.ac.uk; pmorris@stud.man.ac.uk)

Regardless of environment, bacterial biofilms are ubiquitous. In soil and subsurface environments they may directly or indirectly affect reaction rates, system hydrodynamic properties, and chemical flux. Therefore, natural biofilms may alter flow and transport in a variety of systems, including such key environments as groundwater flow near radioactive waste disposal sites; landfill sites; power plant cooling systems; producing aquifers; etc. Little is known about the initial stages of biofilm formation in such environments, which typically involves the formation of an abiotic "conditioning film." Mineral surfaces display complexity equivalent to the microbial organisms which colonize them. Complexity exists in terms of surface structure, topography, and chemistry. It has been proposed that adhesion may occur through cation bridging, organic molecule bridging, or direct adsorption via macromolecules on the bacteria surface. Direct measurements are needed in order to determine which of these processes allow colonization of important rock-forming minerals.

Recent advances in surface analytical techniques (e.g. AFM) allow us to directly measure critical surface parameters such as atomic scale surface roughness. Glancing incidence synchrotron X-ray techniques also provide unique information not only about surface roughness, but also about the in-plane correlation length and the fractal nature of the surface. These parameters allow us to classify mineral surface evolution and help to predict what types of surface sites will be available for adsorption. Likewise, advances in surface spectroscopies, such as Multiple Internal Reflection Fourier Transform Infrared Spectroscopy (MIR-FTIR), X-ray absorption spectroscopy, and scanning X-ray photoelectron spectroscopy allow determination of both the mode of adsorption and the concentration of organic molecules at the surface. Imaging techniques allow structural and chemical information to be combined. This multi-faceted approach can be used to constrain the early stages of biofilm formation as proteins, glycoproteins, humics, and inorganic species are adsorbed and hence give critical information about the mineralogical controls on biofilm growth. Examples from poly-crystalline and single crystal experiments will be discussed.