

## Characterization of the microbe-biotite interface on field samples from a mine site, Derome, Sweden

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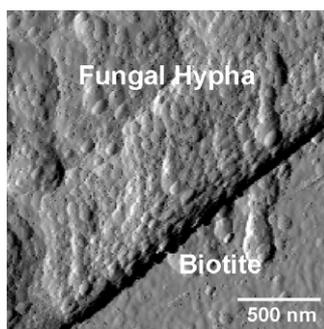
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Biological processes, specifically mediated by fungal hyphae and biofilms, play a major role in mineral weathering and facilitating nutrient uptake. This study examines field samples of biotite from an abandoned mine site that was naturally re-vegetated by a mixed conifer and hardwood forest. We hypothesized that hyphal-sized etched channels formed on biotite surfaces by the weathering action of fungal hyphae under protective biofilm cover. Biotite surfaces were examined with atomic force microscopy (AFM) and environmental scanning electron microscopy (ESEM) in their natural state and after removing the biological material from the mineral surfaces [1, 2].

The AFM and ESEM images show extensive hyphal colonization and biofilm cover of the entire biotite surface. Fungal hyphae also grew between layers of the biotite sheets exhibiting an intensive exploration of the available weatherable surfaces. The biofilm that also covers the hyphae shows unique globular features of diameter 10-100 nm on all surfaces (Figure 1).

Force spectroscopy mode of AFM showed that both biofilm and hyphal surfaces are hydrophobic with hyphal surfaces providing higher adhesive forces. However, removal of the biological material resulted in smooth and non-etched surfaces indicating that regardless of the strong surface attachment, etching of the basal surface is not the main mechanism for base-cation nutrient acquisition in these natural biotite samples.



**Figure 1:** An AFM contact mode deflection image of the globular features of the biofilm layer covering the fungal hypha on a sample of biotite.

- [1] Balogh-Brunstad *et al.* (2008) *GCA* **72**, 2601–2618.  
[2] Buss *et al.* (2003) *Geomicrobiol J* **20**, 25–42.

## Precipitation and surface complexation in systems containing Cu(II), As(V) and goethite

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The main objective of the present study has been to establish a model for equilibria in the four component system  $H^+$ - $HAsO_4^{2-}$ - $Cu^{2+}$ -goethite ( $\alpha$ - $FeOOH$ ). Before the complete four component system can be tackled, equilibria in the different subsystems must be known. Due to the scarce information available in the literature on interactions between Cu (II) and As (V), the possible formation of complexes involving Cu (II) and As (V) in aqueous solution, as well as formation of solid phases were studied. All experiments were performed in 0.1 M NaCl ionic medium. Potentiometric titrations at different Cu to As ratios gave no evidence for the existence of Cu (II)-As (V) complexes in solution below pH of the precipitation boundaries ( $pH \approx 4$ ). Mixing of solutions of Cu (II) and As (V) at different proportions and adjusting pH to values ranging from 4 to 9 resulted in precipitation of five different solid phases. The elemental composition of the solids was analysed using XPS and SEM. The average Cu/As ratio was determined by dissolving the solids and analyzing of aqueous solutions. Two of the solids contained significant fractions of  $Na^+$ . Stability constants for the five solid phases have been calculated.

The co-adsorption of copper (II) and arsenate onto the surface of goethite were studied by potentiometric titrations and batch uptake experiments. A surface complexation model was developed to describe the experimental results. Models for the binary systems Cu (II) -goethite and As (V)-goethite were acquired separately and the parameters were included together with the stabilities of copper-arsenate solid phases. The adsorption of copper (II) could best be described with four different surface complexes. The surface complexes of As (V) on goethite were best modelled invoking a monodentate coordination of arsenate ions to singly coordinated surface hydroxyls and the arsenate ions are hydrogen-bonded to neighboring triply coordinated surface sites. In the case of co-adsorption of copper (II) and arsenate, the adsorption could not be described by applying the combined model from the two binary systems only. Two ternary copper- arsenate-goethite surface complexes were required.