

DISSOLUTION MECHANISMS OF JAROSITE UNDER DIFFERENT CONDITIONS: AN AFM STUDY

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As a result of the oxidation of FeS_2 in brown coal open pit mines, toxic elements are released and then partly fixed in secondary minerals, e.g. in jarosites $[(\text{K}, \text{H}_3\text{O})\text{Fe}_3(\text{SO}_4)_2(\text{OH})_6]$. Dissolution reactions of jarosite are of great environmental importance for the reason that flooding a pit possibly results in release of sulfate and toxic elements due to the limited stability of jarosites in a relatively narrow range of acidic conditions. Therefore an understanding of its dissolution behavior is critical to any model of the dynamics of water–dump interaction. Only a few studies have sought to elucidate the dissolution process from a bulk chemical perspective (BARON & PALMER, 1996). Thus mechanisms are still unknown. The dissolution process is influenced by mineral chemistry, surface microtopography and structure. That is why atomic force microscopy (AFM) is used to study at real time mineral surface reactions by monitoring its microtopography during dissolution. The primary advantage of Fluid Cell AFM are *in situ* observations of nanoscale processes at the mineral–water interface, offering unique and complementary features to commonly used techniques.

Synthetic jarosite (012) surfaces grow by a spiral mechanism. The spirals form a single plane like a “staircase” with monolayer steps of about 5 Å in height ($d_{012} \cong 5.1$ Å) originating around a screw dislocation. It could be expected that screw dislocations provide a source of energetically favoured edge sites for dissolution, but neither in acidic solution (HCl, pH 2), in pure water nor in alkaline solution (KOH, pH 10), step retreat has been observed. Spiral breakdown on (012) faces starts at the outcrop of the screw dislocation by a dissolution process reverse to that of spiral growth. But the dominant dissolution process remains the displacement of steps by terrace vacancies, thus removing the topmost layer. It seems that dissolution mechanisms do not depend on the type of solvent (acidic, alkaline or containing complexing agents). The changes of morphology in the presence of an iron complexing agent occur at a significantly faster rate than in pure water and we suggest that the formation of thin iron oxyhydroxide layers by the interaction with water may retard dissolution kinetics. This might be of importance in coal dump sediments containing iron complexing agents like humic acids.

Ex situ AFM observations indicate biologically catalyzed sulfate reduction under anaerobic conditions. Sulfate reducing bacteria settled on jarosite surfaces. Decomposition of jarosite is proved by the formation of black FeS layers and strong morphological changes due to microbial activity. Runs under identically but bacteria free conditions did not reveal black covers and growth spirals remain almost unchanged. Thus laboratory experiments clearly show that bacteria are able to reduce sulfate from a solid phase.

References

BARON, D. & PALMER, C. (1996). *Geochim. Cosmochim. Acta*, **60** (2): 185–195.