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Role of trace elements in biotic and abiotic oxidation of natural pyrites

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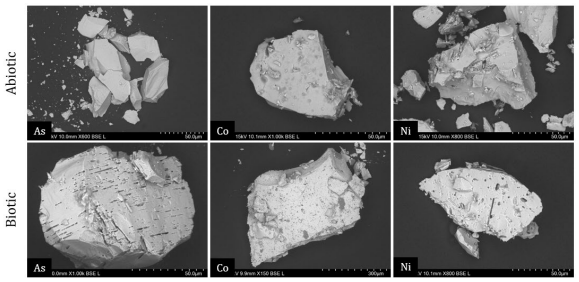


Fig. 1 : SEM images of (bio-)altered pyrite grains

Pyrites (FeS_2) are abundantly present in museum collections. Their sensitivity to oxidation is a significant conservation challenge, further complicated by the diversity of parameters controlling the degradation. For instance, pyrite can incorporate trace elements (TEs) of varying nature and concentration [1] that may explain the intrinsic differences of reactivity between samples [2], even stored in identical environments. Among extrinsic controls, microorganisms and particularly iron and sulphur-oxidising bacteria are known to significantly increase reaction kinetics [3]. There are neither studies on the influence of TEs on microbial nor atmospheric oxidation of pyrite. Our work aims at elucidating the role of TEs in museum conditions, with and without bacterial strains able to oxidise pyrite.

Three natural pyrites with different TE content (Co, As, Ni; concentrations ranging from 1000 to 4000 ppm) were bio-altered in the presence of the model strain *Acidithiobacillus ferrooxidans*. Due to the lack of atmospheric bioalteration protocols in the literature, two different experiments in aqueous bacterial culture were first designed and conducted. A first round of experiments was dedicated to 2-month bio-alteration experiments in closed reactors while a second round took place for 1 month in an open-system bioreactor with continuous medium renewal. Monitoring of the degradation was performed using Raman spectroscopy, SEM and ICP-OES.

All experiments showed a clear variation of reactivity among pyrites, with the As-bearing sample being the most stable. Iron concentration in the alteration solution was the lowest for this pyrite in abiotic conditions ($[Fe]_{As}$: 250 ppm; $[Fe]_{Ni}$: 540 ppm; $[Fe]_{Co}$: 720 ppm). SEM and ICP-OES evidenced that bacterial presence greatly increased the oxidation of all pyrites, and that this increase depended on their TEs. SEM images revealed very different patterns of bioalteration depending on the composition of the pyrites (Fig. 1). By exacerbating the oxidation and allowing abundant Fe oxides precipitation, bioreactors confirmed to be a promising set-up for further experiments on the role of TEs. We hope to carry these results onto future works in atmospheric conditions.

[1] Abraitis et al. (2004), *International Journal of Mineral Processing* 74, 41-59.

[2] Lehner & Savage (2008), *Geochimica et Cosmochimica Acta* 72, 1788-1800.

[3] Nordstrom (1982)