Mineral transformations and bacterial diversity in As-rich waste dumps

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Weathering and mineral transformation of sulphidic waste genenerate Fe-rich secondary phases which retain metals and metalloids in metastable, nano-crystalline, or amorphous phases. Since fate and chemical stability of the pollutants are important factors for their impact on the environment, this research address microbial impact on highly weathered waste materials from the Medieval dumps in the Kaňk deposit, Kutná Hora (Czech Republic), Rotgülden-Salzburger Land (Austria) and a historical mine from Chyžné (Slovakia).

The olive-green and yellow powdery secondary mineral phases were identified using mineralogical methods, such as, powder X-ray diffraction and electron microscopy, and confirm the presence of kaňkite ($FeAsO_4 \cdot 3.5H_2O$), (para)scorodite ($FeAsO_4 \cdot 2H_2O$) bukovskýite [$Fe_2(AsO_4)(SO_4)(OH) \cdot 9H_2O$], and zýkaite [$Fe_4(AsO_4)_3(SO_4)(OH) \cdot 15H_2O$]. These minerals form in a clay-rich matrix which acts as a seal for the weathering eluate solution.

The bacterial diversity was assessed by cultivation to study the role of microorganisms in the weathering processes and their influence on the mineral transformation, thereby leading to the release of the pollutants. So far 25 bacterial and 9 fungal isolates were obtained from the deposits which show low colony forming units and hence low microbiological prevalence. The bacteria are mainly coccoid strains with slow growth rates on arsenate containing media; two aerobic, nine anearobic, ten facultative-anaerobic and the rest are neutral. Nineteen bacterial strains are gram positive and six strains are gram negative. Eighteen bacterial strains are siderophore producers and the rest are neutral. Nineteen bacterial strains are resistant to 5-, 10- and 20 mM arsenate concentrations, with 5 strains resistant to 1 M arsenate. The fungi are high spore producing isolates, and will be categorised as ascomycetes, basidiomycetes, yeasts or zygomycetes.

Establishing a biomarker from trace element incorporation patterns in abiotic and biotic magnetite

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Magnetite (nominally $Fe^{3+}{}_2Fe^{2+}O_4$) is a widespread iron oxide found at the Earth surface. It precipitates through either abiotic or biotic processes (magnetotactic bacteria, dissimilatory iron-reducing bacteria, iron-oxidizing bacteria). Magnetite provides part of the magnetic signal in various sediments such as carbonate platforms, paleosols and Banded Iron Formations. Identification of biotic magnetite in ancient sediments remains a key point to trace life evolution over geological times. Although magnetic properties allow identification of recent magnetotactic bacteria fossils, cristallographic characteristics do not appear to be suitable for unambiguous biotic magnetite identification. In this study, we propose to focus on geochemical tools to better understand the origin of fossilized magnetite. Trace elements incorporation in magnetite has been widely studied for enhancing magnetic properties but has never been explored as a potential biomarker. In the present work, we show results of both abiotic and biotic magnetite nanoparticles which were synthetized in presence of multi-elements in the precipitation media. Nanoparticles were then washed to remove adsorbed elements on magnetite surface. Magnetite were characterized using Transmission Electron Microscopy and X-Ray Diffraction. Elements incorporation was quantified with Inductively Coupled Plasma-Atomic Emission Spectroscopy and Inductively Coupled Plasma-Mass Spectrometry. Partition coefficients between solutions and magnetites were finally estimated for each element. Elemental incorporation patterns in abiotic magnetite was quantified and compared with magnetite precipitated by bacteria in order to establish criteria for biomagnetite identification. Elements of the first transition metals series show partition coefficients between mineral and fluid (normalized to Fe) close to 1 in abiotic magnetite but appear more concentrated in biotic magnetite.

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