Assessment of seasonal variations in the mineralogical and geochemical features of sulfide mine tailings

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Two sulfide mine tailings impoundments with very different proportions of pyrite from the Iberian Pyrite Belt (SW Spain) have been exposed to weathering during more than forty years under semi-arid climate conditions. Therefore, the examination of their evolution may contribute to shed light on the main processes controlling the element mobility in sulfide mine tailings with a well-developed and variable vadose zone.

For this purpose, a combination of different methodologies and techniques was applied, including the characterisation of primary and secondary mineralogy by XRD and μ-XRD, SEM-EDS and μ-XRF, study of mineral geochemistry and elemental mobility by sequential extractions and determination of pore gas profiles. The evolution of pore water hydrochemistry in vertical profiles was also examined and interpreted by geochemical and reactive transport modelling. These methodologies were applied both at field scale and in complementary laboratory column experiments.

The results of this study suggest that the main factors controlling the evolution of abandoned mine tailings under semi-arid conditions are their initial mineralogy and the degree of water saturation, which is mainly determined by the grain size and by the balance between evaporation and water infiltration. These factors determine not only the input of oxygen (and, therefore, the dissolution rate of sulfide minerals and the redox conditions) but also the type of secondary minerals precipitated, which is key for the mobilization of potentially pollutant elements. For instance, the existence of pyrite amounts larger than 80% in the vadose zone of one of the studied impoundments seems to promote not only a greater sulfide dissolution but also the existence of extremely acidic pH (below 1) that hinder the formation of secondary precipitates and give the apparence of unreacted tailing. However, the extreme low pH allows the solute load to remain in solution, increasing its pollutant potential.

Development of the U-series dating technique for the EDML ice core

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Determining the absolute ages of ice within ice cores, ice sheets and glaciers remains non-trivial especially for the oldest ice (>100ka). While both insolation and Be-10 records have proven invaluable in creating ice-core timescales, neither can be used to evaluate the length of hiatuses, the extent of ice folding in ice cores, or the age of ice at the bottom sections of ice cores. U-series recoil from mineral aerosols (dust) into the ice matrix is one possible technique for determining the absolute age of ice, independent of any other parameters [1].

The well-dated upper section of the EPICA Dronning Maud Land (EDML) ice core (down to 150 ka at 2415.7 m) provides excellent constraints to verify uranium ages in a high accumulation site in the Atlantic sector of East Antarctica. In the lower 300 m the ice core climate records are disturbed due to tilting and folding of the ice. And, due to the uncertainties in flow models, it is impossible to determine if the discontinuity is resolvable (i.e., some climate record is accessible), or if the ice is too incoherent. Here, we show initial results verifying the U-series technique on samples of known age, which will allow us to apply the technique to disturbed ice in the future.

U-series recoil ages of ice samples are calculated using an age equation that includes an ejection factor, the fraction of daughter products implanted into the ice relative to the total number produced, based on the surface to volume ratio of the dust grains. This parameter is measured by specific surface area determination (BET) using a magnetically levitated balance designed at ETH [1] and manufactured by Rubotherm GmBH for the University of Michigan. Standard measurements of BAM PM103 indicate that we have achieved S_{BET} precision of better than 0.5%, equivalent precision to that of the original prototype.

Results from the well-dated section of the ice core, including surface area of dust, radiogenic and radioactive isotopic compositions of the soluble seasalt component and ^{238}U parent concentrations in the soluble component and mineral dust are applied to the U-series age equation.

[1] Aciego et al (2011) Quaternary Science Reviews **30**, 2389–2397.

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