Weathering and neoformation of minerals in carbonate soils affected by pyrite tailings

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The pollution
We have studied the oxidation of the tailings spilled when a retention wall of a pond containing the residues from a pyrite mine in Anael collar (southern Spain) broke open, as well as the effects on the weathering and neoformation of minerals in carbonated soils (CaCO₃ = 7.1%; pH = 7.9). The climate of this area is typically Mediterranean.

The pollution evolution

Initial contamination

On spreading over the soil surface the tailings were saturated in water and therefore reducing conditions predominated and the sulphide particles remained stable.

In the first step, when drying took place (10 days after the spill), the soluble elements in the tailings rose by capillary action to the surface, precipitating and forming a white salty layer.

As a result of drying and consequently aeration of the tailings, sulphides oxidized to sulphates, the pH markedly fell due to the formation of sulphuric acid, while the pollutants solubilized.

Infiltration of the acidic pollutant solution: soil alteration

With the rainwater, the acidic pollutant solution (1) and the salts that had previously formed on the surface of the tailings (2) infiltrated the soil.

Infiltration of the acidic pollutant solution: mineral neoformation

The acidic solutions, when penetrating the soil, produced the precipitation of salts and the neoformation of minerals.

The SO₄²⁻ ions in the acidic pollutant solution precipitated in the reddish-yellow band, primarily as gypsum (CaSO₄) and... also, as needle-like crystals of iron oxihydroxide (FeOOH)... projecting from a mass of sulphate complexes with Zn, Fe and Mn, as well as needle-like crystalline formations of a aluminium sulphate (probably alunite = A)... and aggregated microcrystals of iron and potassium sulphates (jarosite = J).

Infiltration of the acidic pollutant solution: soil contamination

The Al which had dissolved in the acidic solution, although precipitated partially in the form of aluminium sulphate in the first 12 mm, almost precipitated as amorphous hydroxyl Al-oxides between 12 and 14 mm... in depth (pH = 6.0) adsorbing the Cu dissolved in the acidic solution. The Zn and Cd also accumulated mainly at pH = 6.8 (12-20 mm in depth).

Elemental composition of the tailings

<table>
<thead>
<tr>
<th>Element</th>
<th>g/kg</th>
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<th>g/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>337.0</td>
<td>Pb</td>
<td>11.0</td>
<td>Mg</td>
<td>6.4</td>
<td>Sb</td>
</tr>
<tr>
<td>Fe</td>
<td>364.0</td>
<td>Zn</td>
<td>9.6</td>
<td>Ca</td>
<td>4.1</td>
<td>Bi</td>
</tr>
<tr>
<td>Al</td>
<td>16.2</td>
<td>Cu</td>
<td>7.2</td>
<td>Cr</td>
<td>0.06</td>
<td>Cd</td>
</tr>
</tbody>
</table>

Soluble metals in the tailings over time.

A, Q, P, SO, M = sampling points.