INVESTIGATION OF THE ROLE OF HARDPANS ON THE GEOCHEMICAL BEHAVIOR OF JOUTEL MINE TAILINGS

Summary

- Introduction
- Methodology
- Results
- Final remarks
Joutel is a closed TSF since 90s (120 ha),
- Divided into two zones: North (old TSF) and South (recent TSF),
- Tailings produced during exploitation and treatment of gold ore contained in sulphide deposit,
- Sulphides are mainly pyrite and carbonates are mainly siderite and ankerite,
- Kinetics leaching and static tests classified Joutel tailings as uncertain regarding their AGP,
- Final effluent respects environmental standards (D019) (limestone drain and polishing pond),
- Acidity is formed within oxidized tailings in some located areas,
- Hardpans were observed in some located areas within Joutel’s oxidized tailings,

Blowes et al., 1998; Benzaazoua et al., 2004
Samples were collected in trench dug out in selected zones based on predefined paste pH,
Different tailing horizons were distinguished using colour contrast,
Thickness of different horizons was spatially variable.
Hardpans are defined as cementitious layers formed mainly by secondary minerals due to oxidation/neutralisation, hydrolysis reactions in mining context,

- They are formed at the neutralization interface (interface oxidized/unweathered tailings),
- It is assumed that hardpans are impermeable layers.

Alakangas et al., 2006; Blowes et al., 1991; DeSisto et al., 2011; Graupner et al., 2007; McGregor et al., 2002; Meima et al., 2007
Introduction

- Hardpan formation may limit the vertical infiltration of water and gas migration,
- Hardpan formation limits contaminants mobility (adsorption, co-precipitation...).

<table>
<thead>
<tr>
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<th>Fault Lake site</th>
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<tbody>
<tr>
<td></td>
<td>Cemented</td>
</tr>
<tr>
<td>As</td>
<td>34</td>
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<tr>
<td>Cd</td>
<td>1.4</td>
</tr>
<tr>
<td>Co</td>
<td>247</td>
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<tr>
<td>Cu</td>
<td>176</td>
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<tr>
<td>Ni</td>
<td>2940</td>
</tr>
<tr>
<td>Zn</td>
<td>27</td>
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Blowes et al., 1998
McGregor & Blowes, 2002
Methodology

Sampling of the different tailings based on paste pH of oxidized tailings (acidic zone)

Chemical, physical and mineralogical characterization

AGP assessment of oxidized and unweathered tailings

Kinetic column tests (two scenarios)

Automated mineralogy on hardpan sample (correlative mineralogy)

pH, EC, acidity/alkalinity and the chemical composition

Oxidized tailings

Unweathered tailings

16 cm

35 cm
Scenario 1 is mounted to simulate surface and sub-surface runoff,

In lab conditions, it is difficult to reproduce the hardpan,

It is assumed that when the hardpan is formed, surface and sub-surface runoff are enhanced and the vertical infiltration is negligible,

During this scenario, the leachates are reacting only with the oxidized tailings.
Scenario 2 is mounted to simulate water vertical infiltration,
Surface and sub-surface runoff are negligible comparatively to vertical infiltration,
Water is reacting with the oxidized tailings and then with unweathered tailings,
Results: Physical characteristics and static tests

- Oxidized sample showed fine PSD comparatively to unweathered sample (oxidation effect),
- NP used for the classification is the NP titrated using the method of Bouzahzah et al., 2015,
- NP calculated using carbonates method overestimate the real NP of samples due to presence of Fe-Mn carbonates,
- NP and AP of oxidized sample are almost depleted,
- Unweathered sample is located at non acid generating zone of static tests.
Sulphides and carbonates within oxidized tailings are almost depleted, 
NP calculated is overestimated due to presence of Fe-Mn carbonates, 
Hardpans present a mixture of the mineralogical composition of oxidized and unweathered tailings, 
Hardpan sample showed a different texture comparatively to tailings, (cementitious texture).
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NP calculated is overestimated due to presence of Fe-Mn carbonates,
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Results: Mineralogical composition

- The mineralogical composition of hardpan sample is deeply investigated using automated mineralogy system by Mineralogic Mining (Zeiss),
- Quantification of the modal mineralogy, mineral liberation, mineral association...
More than 50% of sulphides are associated to Fe-oxy-hydroxides,

Phenomenon of sulphides coating and passivation (precipitation of secondary phases),

About 10% of Fe-oxy-hydroxides is associated to carbonates known as carbonates passivation,

Carbonates and sulphides may be protected against further oxidation,

Most identified Fe-oxy-hydroxides are: goethite and hematite based on EDS analysis.
Results: Kinetic leaching tests

- pH of leachates from oxidized sample was acidic (steady state was reached at the beginning of the test), while leachates from the vertical infiltration scenario were neutral,

- Leaching behavior of the oxidized sample was acidic despite sulphide depletion,

- Electrical conductivity from the vertical infiltration were slightly greater than those of the surface runoff scenario,
Results: Kinetic leaching tests

- Acidity of leachates from surface runoff scenario was 14 times higher than that from the vertical infiltration scenario,
- Alkalinity of leachates from the vertical infiltration scenario was about 135 mg CaCO₃/l.
Results: **Kinetic leaching tests**

- Fe leaching was more important within leachates from surface runoff scenario than that leached from the vertical infiltration scenario,
- Fe concentrations were reduced about 100 times when the unweathered sample is added (calculated based on average concentration),
- S was more leached within the vertical infiltration scenario,
- Leaching of S within the vertical infiltration scenario is due to further dissolution of sulphides within the unweathered sample (columns dismantling).
Ca concentrations were slightly different for both scenarios, Ca average concentrations were about 552 mg/l for surface runoff scenario and 510 mg/l for vertical infiltration scenario,

Mg was more leached within the vertical infiltration scenario (carbonate dissolution) than the surface runoff scenario (Mg average concentrations were about 791 mg/l for vertical infiltration and 24 mg/l for surface runoff scenario).
Final remarks

✓ Carbonates within Joutel tailings are mainly siderite and ankerite,
✓ Hardpan mineralogical composition showed a mixture between the oxidized and unweathered tailings,
✓ Fe-oxy-hydroxides are mainly precipitated at the porosity of the tailings,
✓ Oxidized tailings are PAG despite sulphide depletion (surface runoff scenario),
✓ During the vertical infiltration scenario, the geochemical behavior is neutral,
✓ Leachates from oxidized samples are characterized by high concentrations of Fe, S and Ca due Fe-oxy-hydroxides and gypsum dissolution.
Thank you for your attention