C.4 Microbial Ecology of Anaerobic Sulfate- and Iron-Reducing Bacteria in Sulphidic Mine Tailings

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Microbial ecology of anaerobic sulfate- and iron-reducing bacteria in sulfidic mine tailings

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What do we know about sulfidic mine tailings?

- They contain large amounts of pyrite and pyrrhotite
- They often oxidize and generate acid-mine drainage
- Fe- and S-oxidizing bacteria play a significant role in the oxidation of sulfides minerals at low pH
- Very little is known about the activity of anaerobic bacteria, such as sulfate-reducing bacteria (SRB) and iron-reducing bacteria (IRB)

Microbial ecology of SRB

- SRB generally prefer reduced conditions, neutral pH and use simple electron donors, such as acetate, formate, lactate, H_2, etc.
- However SRB have been identified in acidic mining lakes and they have been recovered in Cu-Zn and Au tailings, but they appear to be only active in Cu-Zn tailings
- Microbial sulfate reduction leads to the formation of metal (Fe) sulfides and generates alkalinity

Microbial ecology of IRB

- They require reduced conditions and can sustain slightly acidic conditions, even though they prefer neutral pH
- They can use acetate, glucose, H_2, etc. as electron donors
- They can reduce various forms of Fe(III)-oxides
- IRB have been recovered from mining lakes and streams affected by mine drainage, but not (so far) in sulfidic tailings.
- Microbial iron reduction generates soluble Fe(II) and alkalinity

Why do we study IRB and SRB?

- They directly affect the mobility (fate) of Fe and S in mine tailings
- Microbial sulfate and iron reduction both generate *in situ* alkalinity
- *In situ* formation of diagenetic Fe-sulfides and reduction of sulfate levels
- They both have an impact on the mineralogical and chemical stability of the tailings

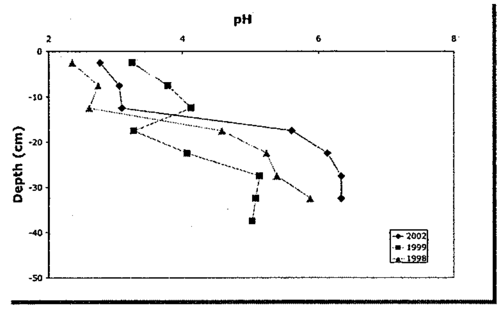
Objectives

- Assess the presence of SRB and IRB in two types of sulfidic tailings (acidic and alkaline tailings)
- Link their presence to porewater chemistry
- Determine the *in situ* rate of sulfate reduction
- Determine the factors affecting their presence and activity

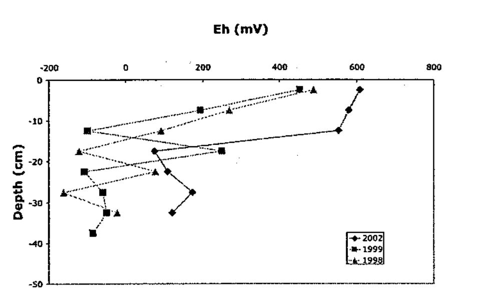
Methodology

- One acidic and oxidized site in Northern Ontario (PO-01) and one alkaline site near Ottawa (organic-rich) (CA-01)
- Samples taken along a 50-cm deep profile every 5 cm
- IRB and SRB assessed by MPN with growth media adjusted to the *in situ* pH and containing various electron donors
- Porewaters extracted from the tailings and also collected with peepers
- Analysis of dissolved Fe(II), Fe (total), SO_4, HS^-, DOC/DIC, pH, Eh, etc.
- *In situ* rates of sulfate reduction (^{35}S core-injection technique)

PO-01



PO-01



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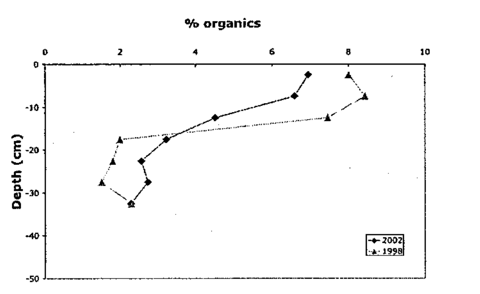

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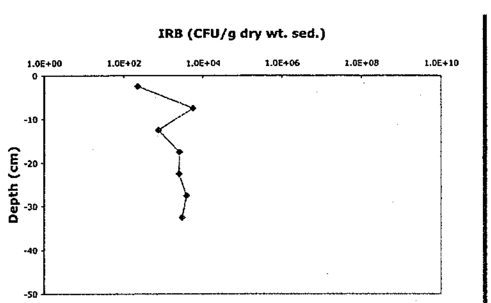

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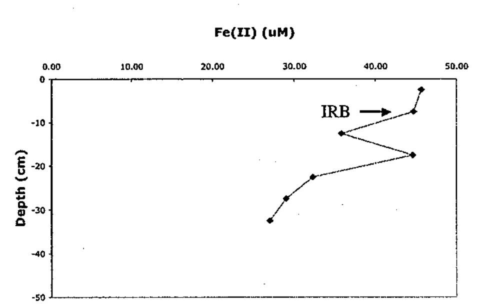
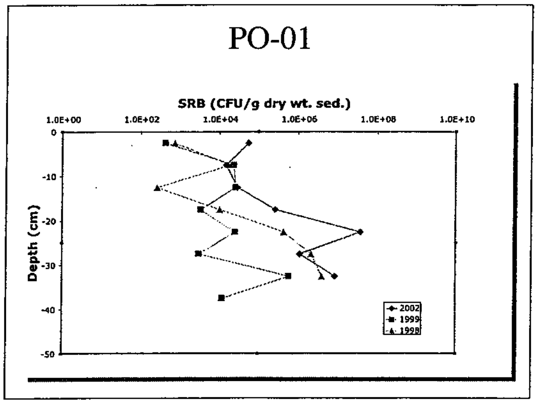
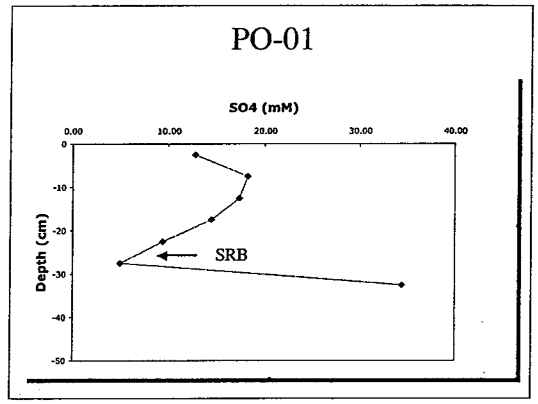
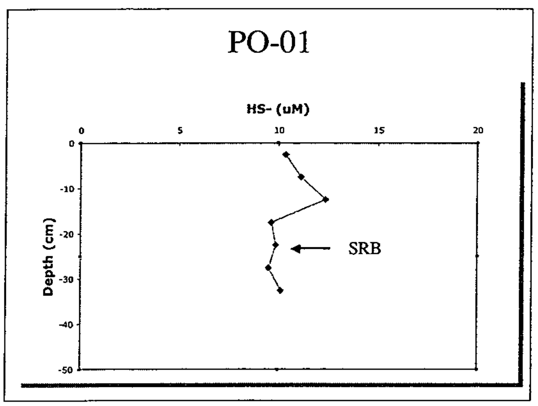
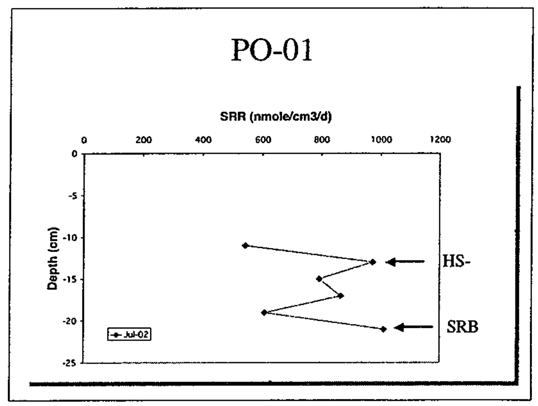
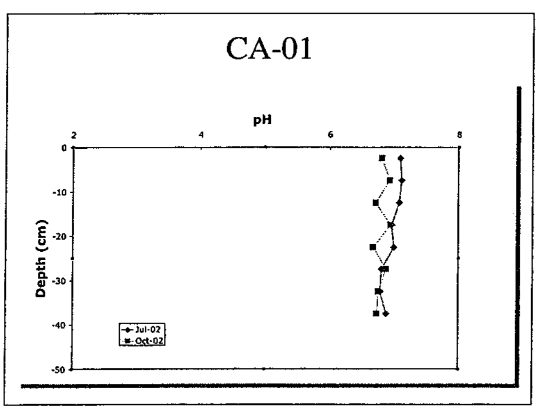


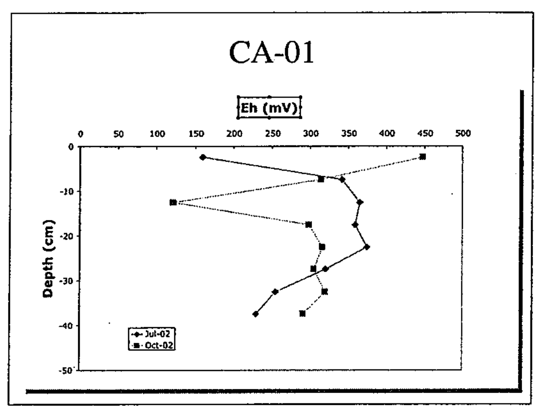

PO-01
SRB (CFU/g dry wt. sed.)
1.0E+00
1.0E+02
1.0E+04
1.0E+06
1.0E+08
1.0E+10
Depth (cm)
0
-10
-20
-30
-40
-50
2002
1999
1998


PO-01
SO4 (mM)
0.00
10.00
20.00
30.00
40.00
Depth (cm)
0
-10
-20
-30
-40
-50
SRB

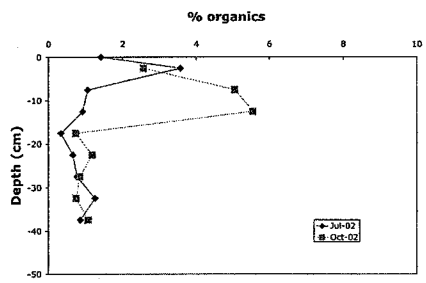

PO-01
HS- (uM)
0
5
10
15
20
Depth (cm)
0
-10
-20
-30
-40
-50
SRB


PO-01
SRR (nmole/cm3/d)
0
200
400
600
800
1000
1200
Depth (cm)
0
-5
-10
-15
-20
-25
Jul-02
HS-
SRB


CA-01
pH
2
4
6
8
Depth (cm)
0
-10
-20
-30
-40
-50
Jul-02
Oct-02


CA-01
Eh (mV)
0
50
100
150
200
250
300
350
400
450
500
Depth (cm)
0
-10
-20
-30
-40
-50
Jul-02
Oct-02

CA-01



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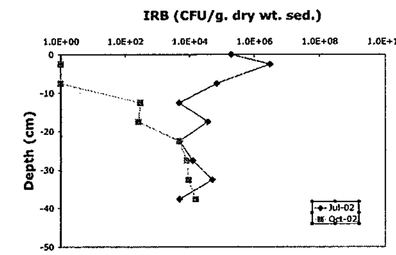

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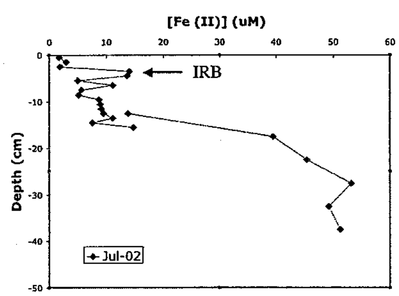

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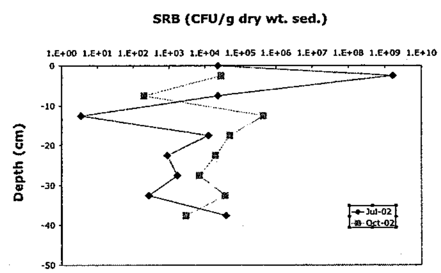

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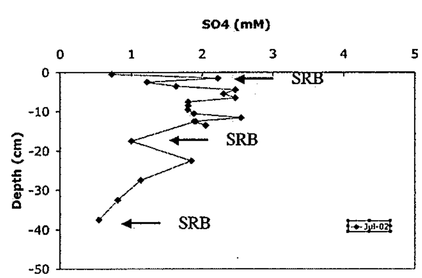

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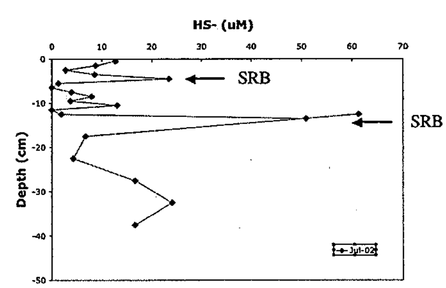

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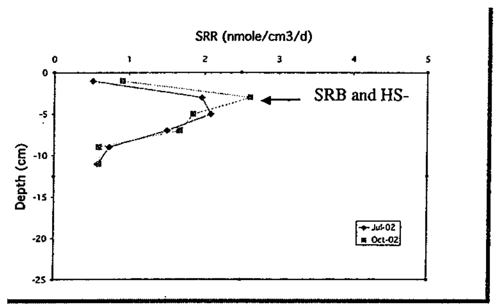

Discussion

- IRB and SRB present and active at both sites
- SRR higher in acidic tailings containing large amounts of sulfide minerals
- Active zones of sulfate reduction vary with depth and seasons in the alkaline tailings
- Sulfide and Fe(II) concentrations both controlled by microbial activity and chemical reactions (abiotic reduction of Fe(III)-rich minerals by HS^-)
- Microbial Fe(III) and sulfate reduction partially responsible for pH increase in sub-surface

Acknowledgements

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