# The Effect of Seasonal Variation on the formation of Fe-Stromatolites

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NDSU Geol 428
Geochemistry
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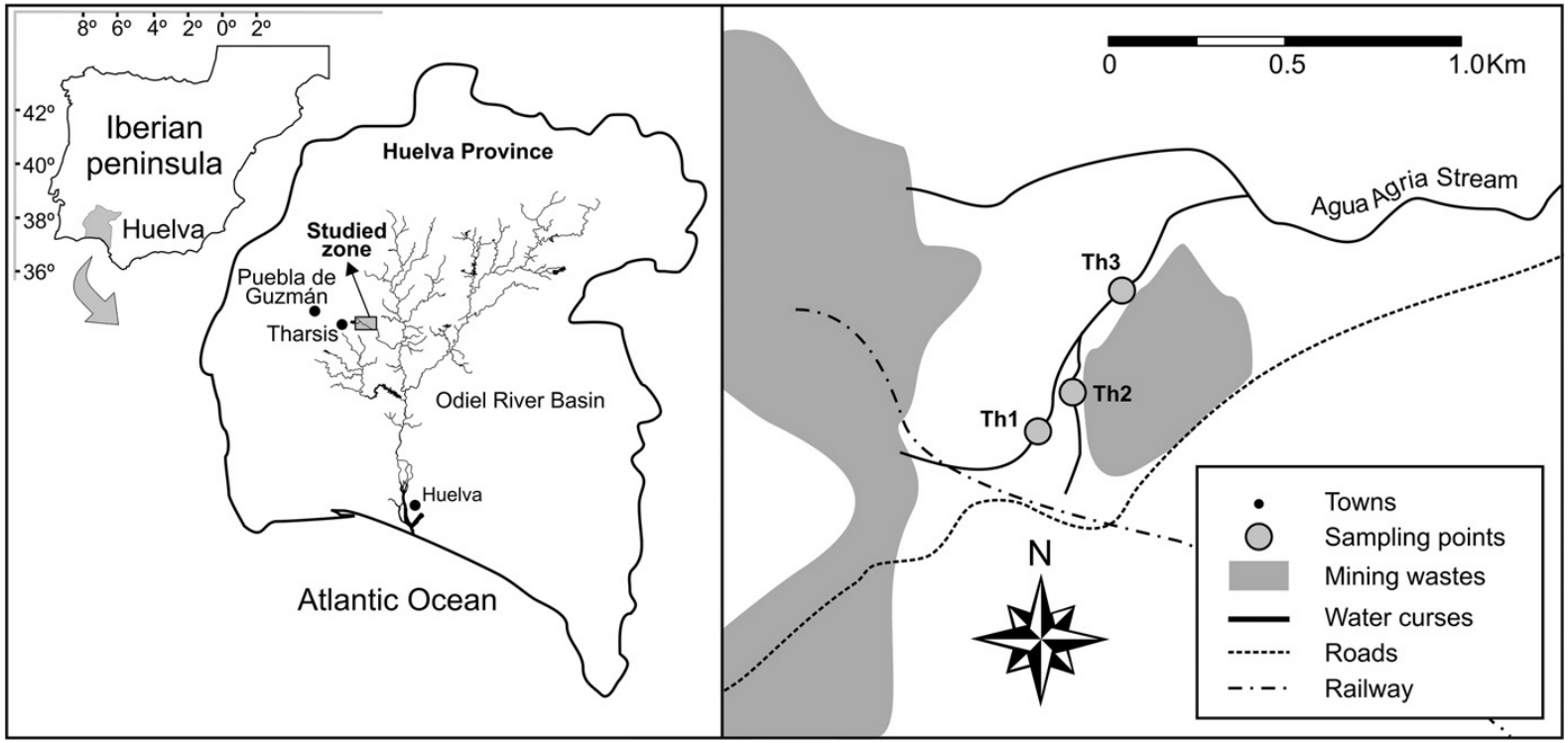
# Introduction




- Tharsis Mine originally had over 100 million tons of ore
- Main ore minerals are Pyrite, Chalcopyrite, and Sphalorite
- Also contained Galena, Arsenopyrite, and Pyrrhotite

# Introduction

- Sulfide weathering of waste piles results in Acid Mine Drainage (AMD)
- Causes drainage water to be high in metals, sulfides, acidity, and have a low pH
- The AMD from Tharsis Mine is high in Fe minerals
- The precipitation of these minerals, along with bacteria, algea, and other microbes form Fe Stromatolites in drainage streams

# Purpose

- Study the effects of seasonal variation in the composition of precipitates and their correlation with the creation of Fe stromatolites
- Three sample sites Th1, Th2, Th3
- Water samples taken during cool wet (Jun.) and warm dry (Sep.) seasons

# The Study

- Speciation Data and S.I.
- High in Al, more Fe+3 than Fe+2

| | | | | | | |
|---|---|---|---|---|---|---|
| Al | 7.612e-02 | | | | | |
| AlSO4+ | 4.851e-02 | 3.477e-02 | -1.314 | -1.459 | -0.145 | (0) |
| Al(SO4)2- | 2.114e-02 | 1.515e-02 | -1.675 | -1.820 | -0.145 | (0) |
| Fe(2) | 7.136e-04 | | | | | |
| Fe+2 | 4.032e-04 | 1.252e-04 | -3.394 | -3.902 | -0.508 | (0) |
| FeSO4 | 3.039e-04 | 3.208e-04 | -3.517 | -3.494 | 0.023 | (0) |
| Fe(3) | 3.074e-03 | | | | | |
| FeSO4+ | 2.177e-03 | 1.584e-03 | -2.662 | -2.800 | -0.138 | (0) |
| Fe(SO4)2- | 6.445e-04 | 4.764e-04 | -3.191 | -3.322 | -0.131 | (0) |

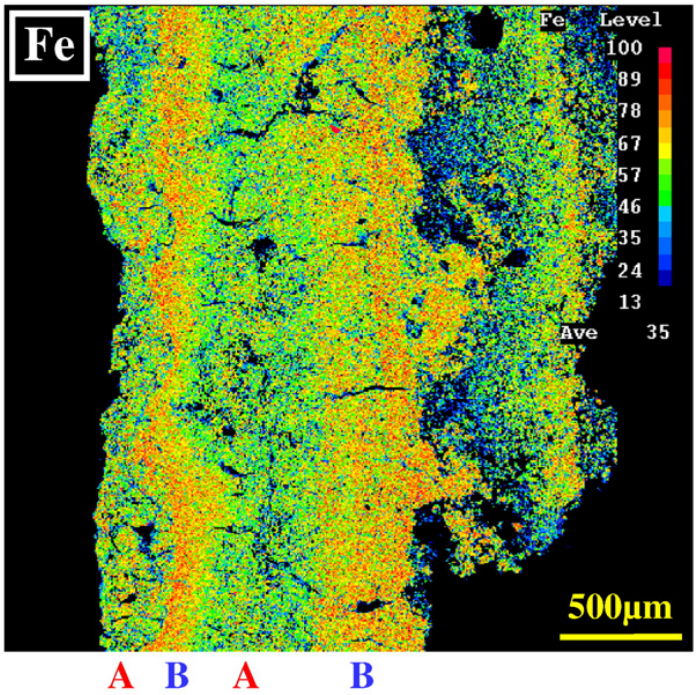
# The Study

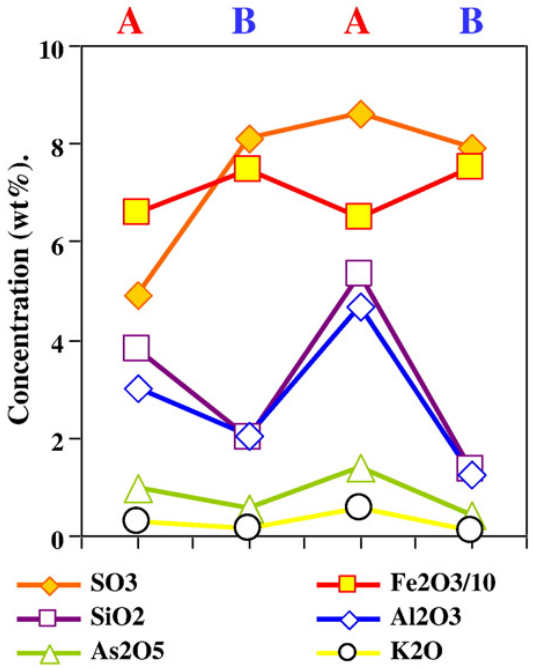
- E.C. differences from dry to wet seasons
- Jarosite saturation

| | Th1June | Th1Sept. | Th2June | Th2Sept. | Th3June | Th3Sept. |
|---|---|---|---|---|---|---|
| Temp | 20.8 | 25.8 | 19.7 | 28.3 | 19.2 | 28.3 |
| pH | 2.83 | 2.95 | 2.6 | 2.65 | 2.6 | 2.65 |
| E.C. | 5.4 | 7.98 | 6.8 | 10.6 | 6.7 | 11.4 |
| S.I. | | | | | | |
| Goethite | 2.24 | 3.01 | 3.67 | 4.03 | 3.54 | 4.03 |
| Na-Jarosite | -6.38 | -4.49 | -1.76 | -0.82 | -1.98 | -0.82 |
| H-Jarosite | -6.16 | -4.19 | -0.87 | 0.27 | -1.22 | 0.27 |
| Jurbanite | 0.77 | 0.97 | 0.74 | 0.88 | 0.7 | 0.88 |
| Quartz | 0.9 | 0.87 | 1.08 | 1.07 | 1.07 | 1.07 |

| | |
|---|---|
| Goethite | FeOOH |
| Na-Jarosite | NaFe3(SO4)2(OH)6 |
| H-Jarosite | (H3O)Fe3(SO4)2(OH)6 |
| Jurbanite | AlOHSO4 |
| Quartz | SiO2 |

# Examining Stromatolites



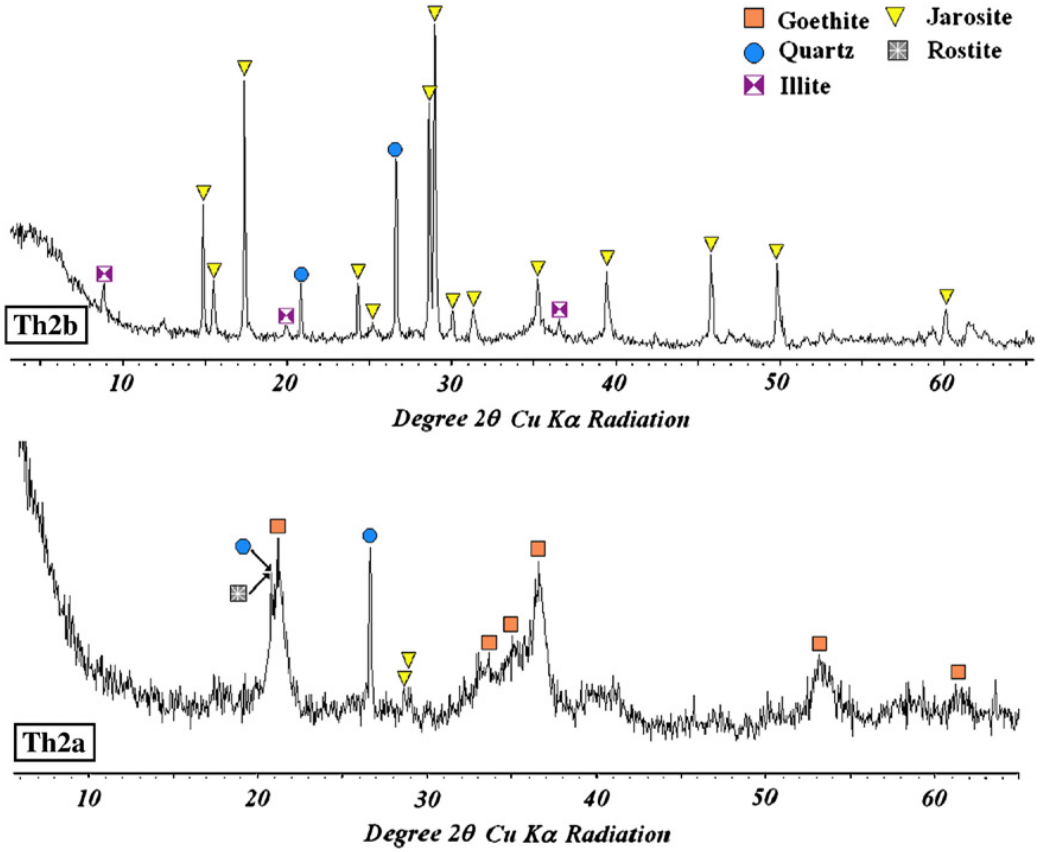

- A section of a Stromatolite from Th2
- A represents wetter time period
- B represents dryer time period
- The bright yellow-orange is Jarosite

# Jarosite

- Found in many acidic environments
- Needs water to form but only persists in more arid periods
- Decomposes in humid environments

# Examining Stromatolites

- XRD data from the Same section



# Examining Stromatolites

- The B layers are "cemented", contain diatoms and higher amounts of Fe
- The A layers lack diatoms, have lower Fe, and Higher Quarts and clay content
- Which means:
  - B layers formed in warm water
  - A layer formed in cool water

# Examining Stromatolites

- Just increasing temperature can increase Fe saturation

| | Th1June | Th1Sept. | Th2June | Th2Sept. | Th3June | Th3Sept. | Th2June | Th3June |
|---|---|---|---|---|---|---|---|---|
| Temp | 20.8 | 25.8 | 19.7 | 28.3 | 19.2 | 28.3 | 30 | 19.2 |
| pH | 2.83 | 2.95 | 2.6 | 2.65 | 2.6 | 2.65 | 2.6 | 2.6 |
| E.C. | 5.4 | 7.98 | 6.8 | 10.6 | 6.7 | 11.4 | 6.8 | 6.7 |
| S.I. | | | | | | | | |
| Goethite | 2.24 | 3.01 | 3.67 | 4.03 | 3.54 | 4.03 | 3.96 | 0 |
| Na-Jarosite | -6.38 | -4.49 | -1.76 | -0.82 | -1.98 | -0.82 | -1.12 | -11.92 |
| H-Jarosite | -6.16 | -4.19 | -0.87 | 0.27 | -1.22 | 0.27 | 0.25 | -10.18 |
| Jurbanite | 0.77 | 0.97 | 0.74 | 0.88 | 0.7 | 0.88 | 0.69 | 0.32 |
| Quartz | 0.9 | 0.87 | 1.08 | 1.07 | 1.07 | 1.07 | 0.93 | 0.93 |

| | |
|---|---|
| Goethite | FeOOH |
| Na-Jarosite | NaFe3(SO4)2(OH)6 |
| H-Jarosite | (H3O)Fe3(SO4)2(OH)6 |
| Jurbanite | AlOHSO4 |
| Quartz | SiO2 |

# Goethite

- Most Fe will precipitate into Goethite
- If the SI of Goethite decreases so does the rest of the Fe bearing minerals
- Smaller effect on Al minerals

| | Th1June | Th1Sept. | Th2June | Th2Sept. | Th3June | Th3Sept. | Th2June | Th3June |
|---|---|---|---|---|---|---|---|---|
| Temp | 20.8 | 25.8 | 19.7 | 28.3 | 19.2 | 28.3 | 30 | 19.2 |
| pH | 2.83 | 2.95 | 2.6 | 2.65 | 2.6 | 2.65 | 2.6 | 2.6 |
| E.C. | 5.4 | 7.98 | 6.8 | 10.6 | 6.7 | 11.4 | 6.8 | 6.7 |
| S.I. | | | | | | | | |
| Goethite | 2.24 | 3.01 | 3.67 | 4.03 | 3.54 | 4.03 | 3.96 | 0 |
| Na-Jarosite | -6.38 | -4.49 | -1.76 | -0.82 | -1.98 | -0.82 | -1.12 | -11.92 |
| H-Jarosite | -6.16 | -4.19 | -0.87 | 0.27 | -1.22 | 0.27 | 0.25 | -10.18 |
| Jurbanite | 0.77 | 0.97 | 0.74 | 0.88 | 0.7 | 0.88 | 0.69 | 0.32 |
| Quartz | 0.9 | 0.87 | 1.08 | 1.07 | 1.07 | 1.07 | 0.93 | 0.93 |

| | |
|---|---|
| Goethite | FeOOH |
| Na-Jarosite | NaFe3(SO4)2(OH)6 |
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| Quartz | SiO2 |

The Change in SI when Goethite is at Equilibrium

# Conclusions

- Change in season from cool and wet to warm and dry effects what Fe minerals precipitate
- Also effects how much Fe precipitates
- This correlates with the composition of the stromatolites

# Why its Important

- Attempting to understand formation of Fe stromatolites in these environments can help to understand past Fe formations

- Can also help to give clues about the environments in which they were formed

# Source

- Manuel A. Caraballo, Aguasanta M. Sarmiento, Daniel Sánchez-Rodas, José Miguel Nieto, Annika Parviainen, Seasonal variations in the formation of Al and Si rich Fe-stromatolites in the highly polluted acid mine drainage of Agua Agria Creek (Tharsis, SW Spain), Chemical Geology, Volume 284, Issues 1–2, 9 May 2011, Pages 97-104, ISSN 0009-2541

# Inquiries about the presented information?