ARD Treatment in a Case Study on a Millennium of Mining

Falu Gruva, Sweden

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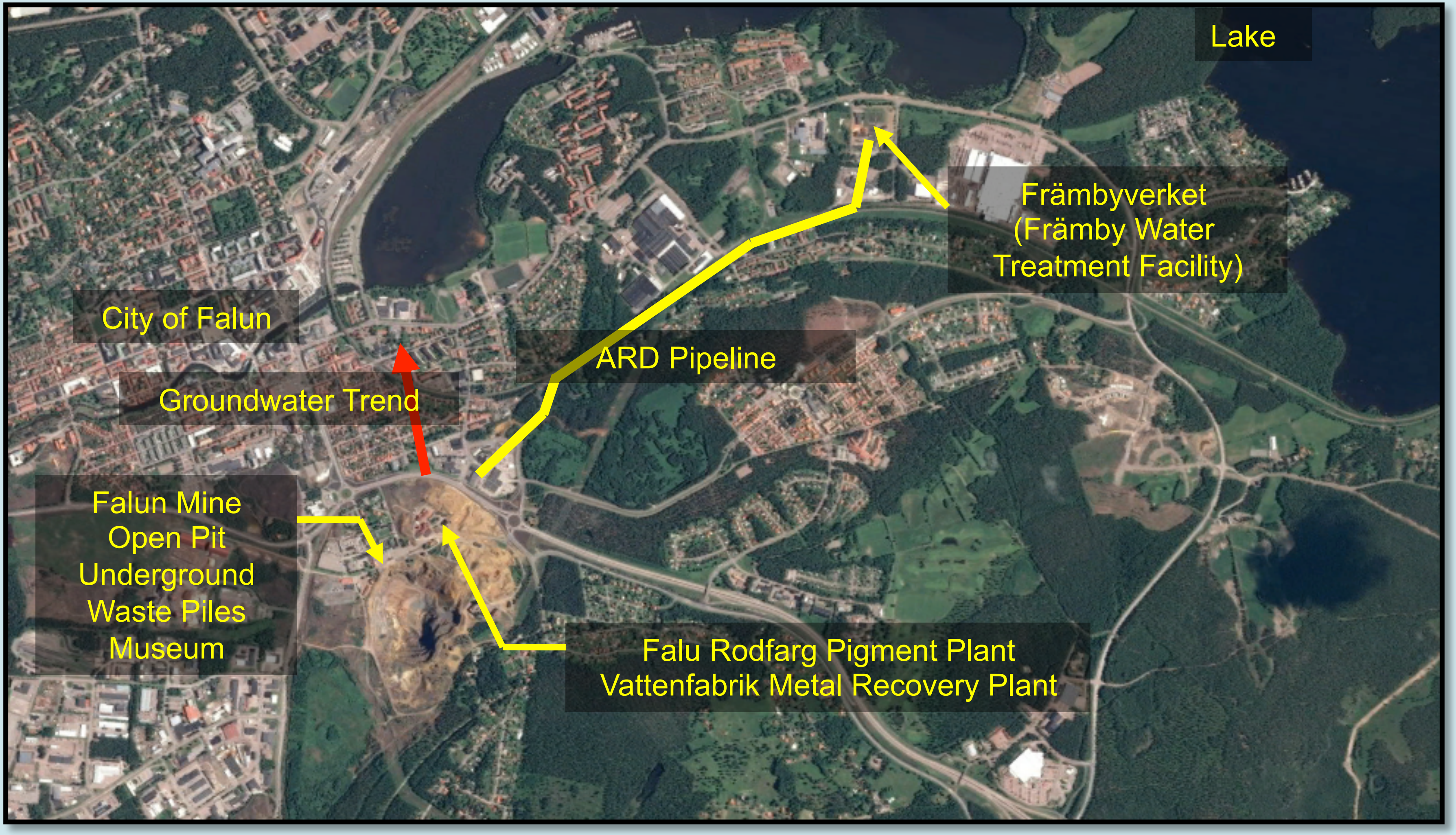
Presentation Outline

- Historical Site
- ARD Reservoir
- ARD Treatment Results
- ARD Valorization
- Future Work

Site History - Falu Gruva

- UNESCO World Heritage Site
- Operations began somewhere 850-1000 AD
- 1347 Stora Kopparberget Charter is the origin of share ownership – same owner today (Stora-Enso)
- Met about 2/3 of Europe’s copper demand in the 16th -18th centuries
- Fire-setting/Water Quenching was the main extraction method through the19th century
- Production reached its maximum in 1650 at 3,000 tonnes of copper
- Substantial cave-in occurred on Midsummer’s Eve 1687 – No deaths due to celebrations
- Copper mining ceased in 1992
- Today produces the renown red paint which has coated Swedish buildings for centuries – Falu Rodfarg

Site Overview



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Historical Pump Buildings

- Historically minewater was discharged without treatment

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Historical Shaft with Hewn Wood Staving

Old workings are characteristic of fire-setting/quenching; accessible by public tour

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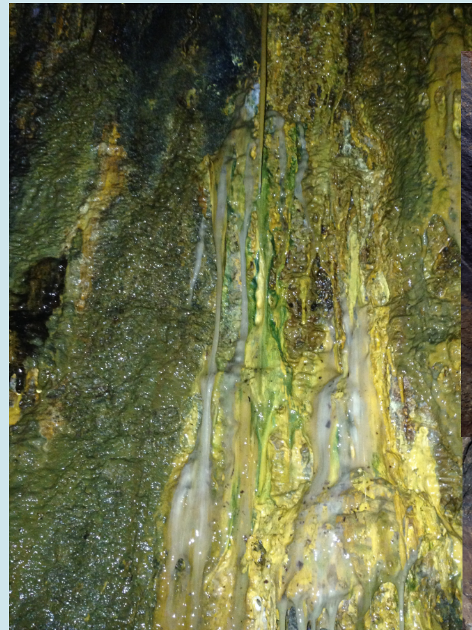
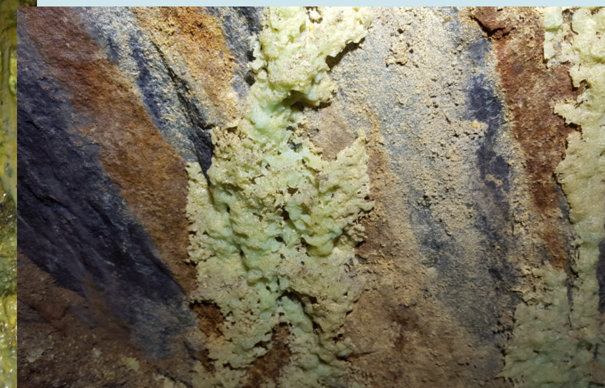
ARD Sources

- Waste Dumps on surface drain to workings
- Pit Walls
- Historic tailings dumped on surface and in pit
- Modern tailings deposited as slurry underground (est. 700 tpd operation)
- Acid plant operating from mid 1800's to 1993 produced 570,000 m^3 "pyrite ash" which was treated with lime, and deposited underground
- HDS sludge was deposited on ash, part o rehabilitation (1995-2006)
- Paint plant wastes periodically deposited underground, including waste linseed oil

Geochemist’s Playground

- Melanterite (iron (II) sulphate) on the walls underground
- Rising mine levels led to rising ARD tenor (5 to 10 g/L Fe)
- Heaps of pyrite ash with gypsum evaporates
- Denser, high strength ARD at depth
- pH, Eh controls
- Dilution (seasonal effects) of surface waters by precipitation and groundwater inputs

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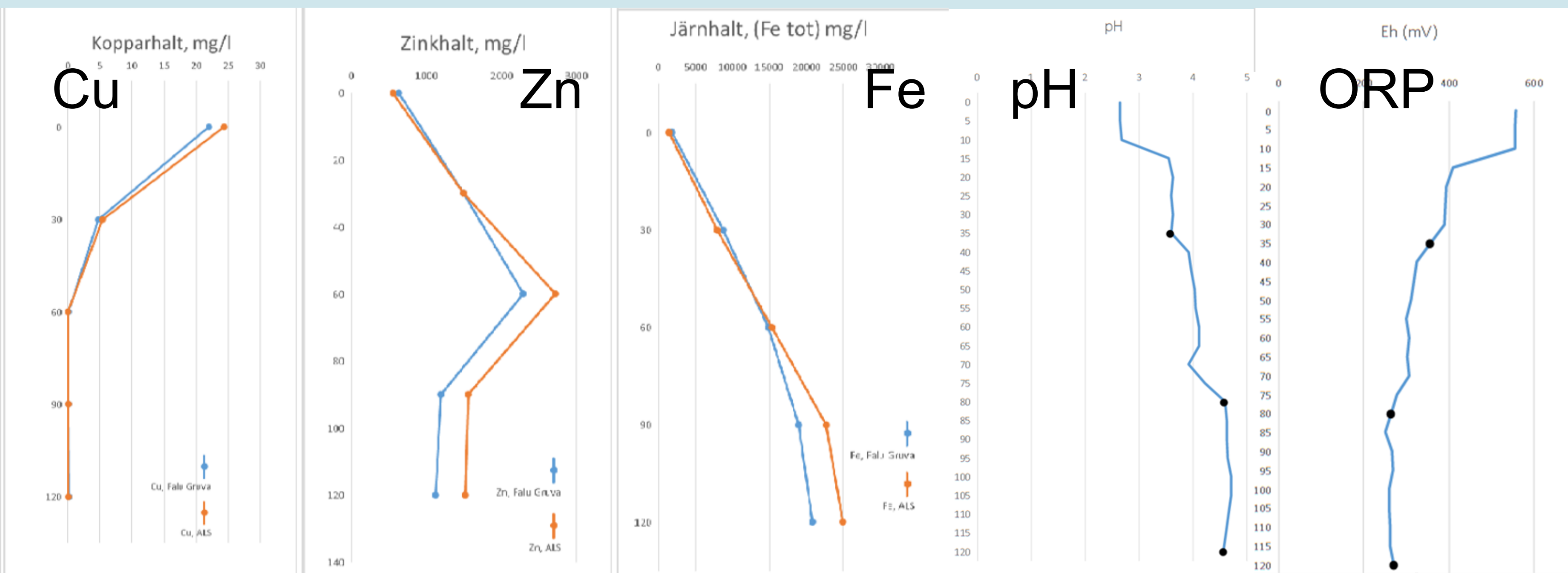
Mine Water Quality with Depth

- Cu is highest at surface (25 mg/L) then drops to < 1 mg/L at 45m
- Zn peaks at 2.5 g/L at 75m, then drops with depth
- Fe varies from 2 g/L near surface to 20 g/L at 120m depth
- pH varies from 2.5 at surface to 4.5 at depth, ORP drops from +500 mV to as low as +30



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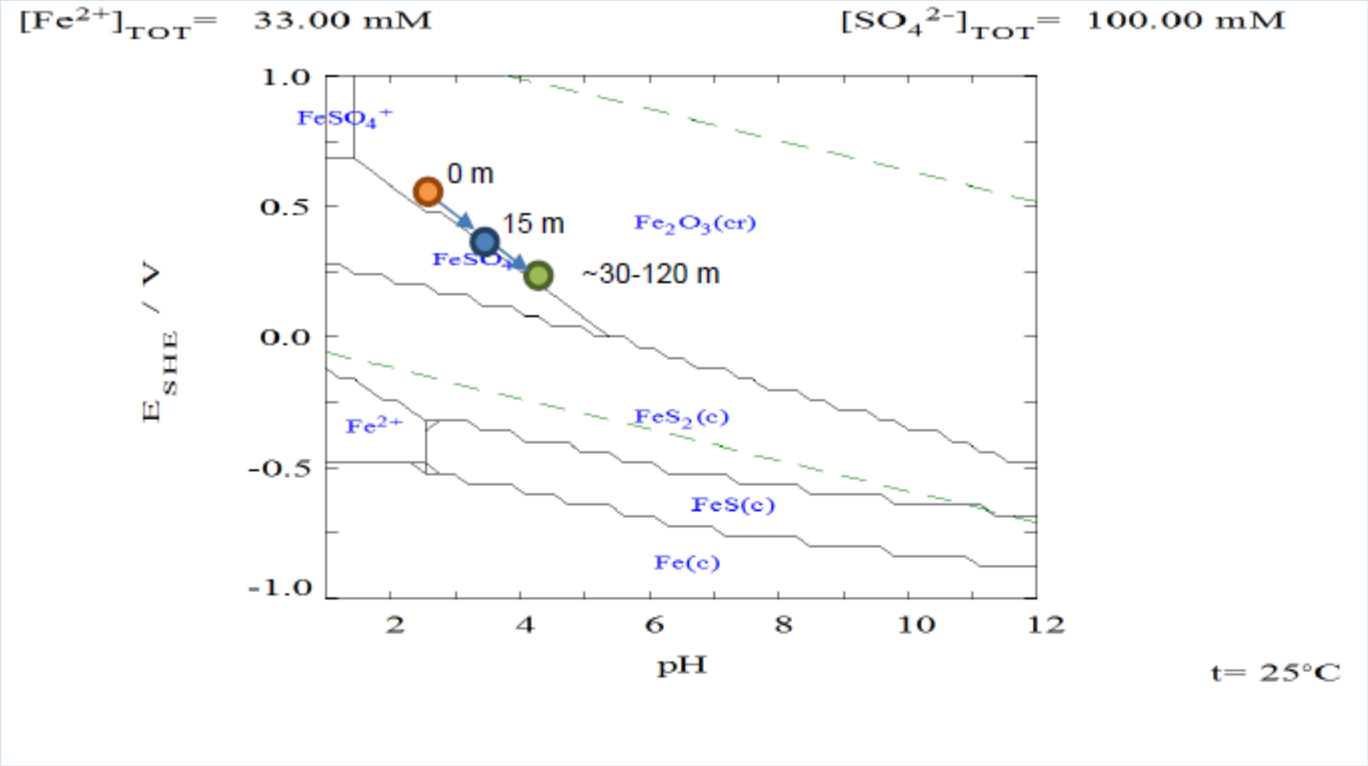
Pourbaix Diagram for Fe-S

- Iron is controlled by oxidation of ferrous ion to ferric, hydrolysis, and precipitation of ferrihydrites
- Higher ORP at surface, slow oxidation of Fe(II) at low pH



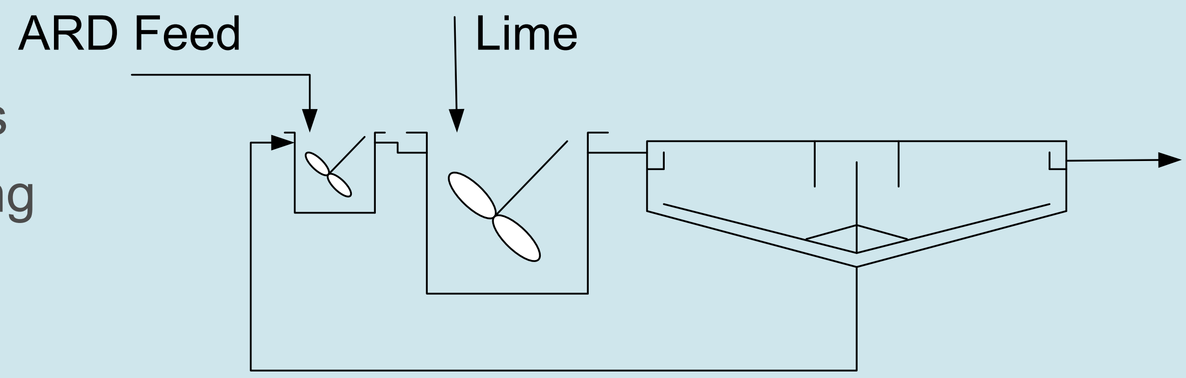
ARD Mine Water Treatment Changes

Simple Changes to ARD treatment process resulted in major improvements in plant capacity

Conversion

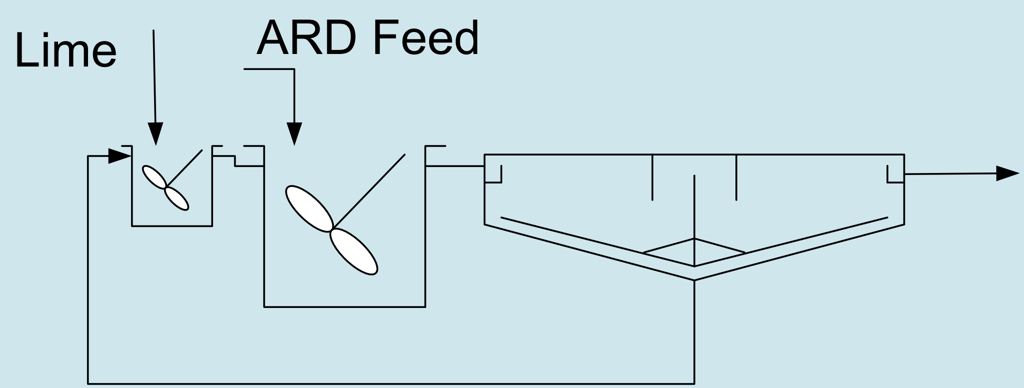
From: GECO HDS Process

- Inferior sludge dewatering
- Poor settling
- Better lime utilization



To: Conventional HDS

- Throughput increased 10x
- Sludge water content decreased



Sludge Dewatering Comparison

- High strength ARD currently produces ~ 60 tpd (dwb) sludge at 50% moisture (from thickener at 30% underflow density)
- Sludge dewatering is a continuous, un-manned operation
- Sludge is trucked to a landfill site

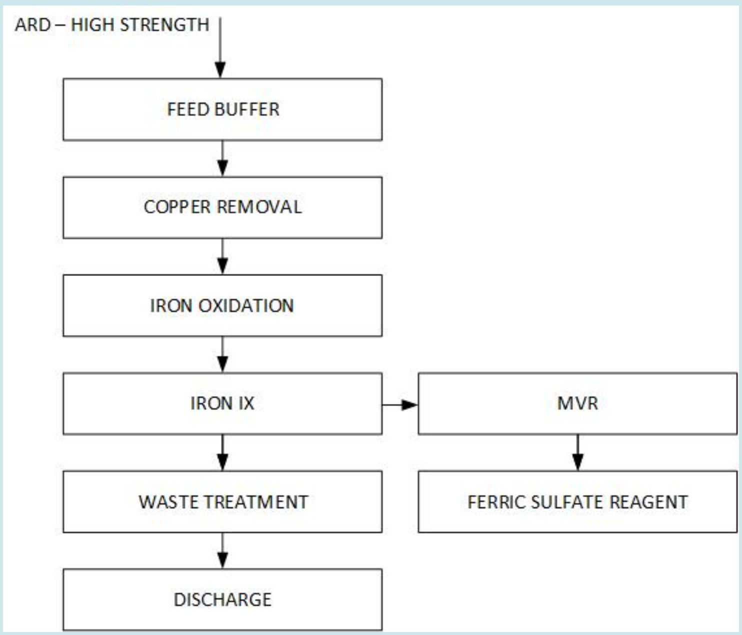
Vacuum Drum Filter

Improved sludge

GECO sludge

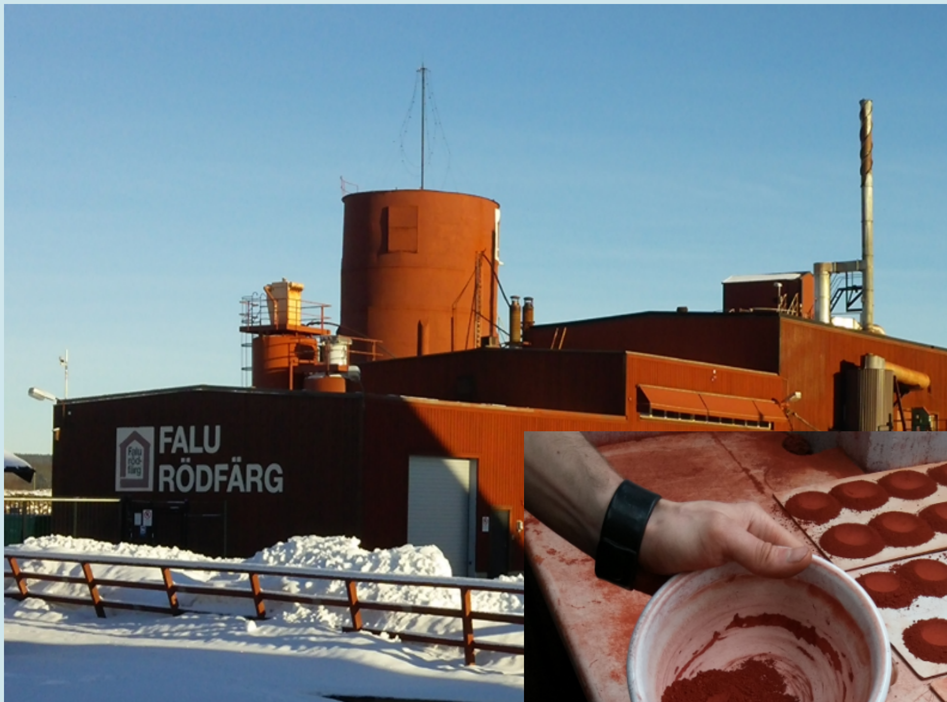
Iron Recovery

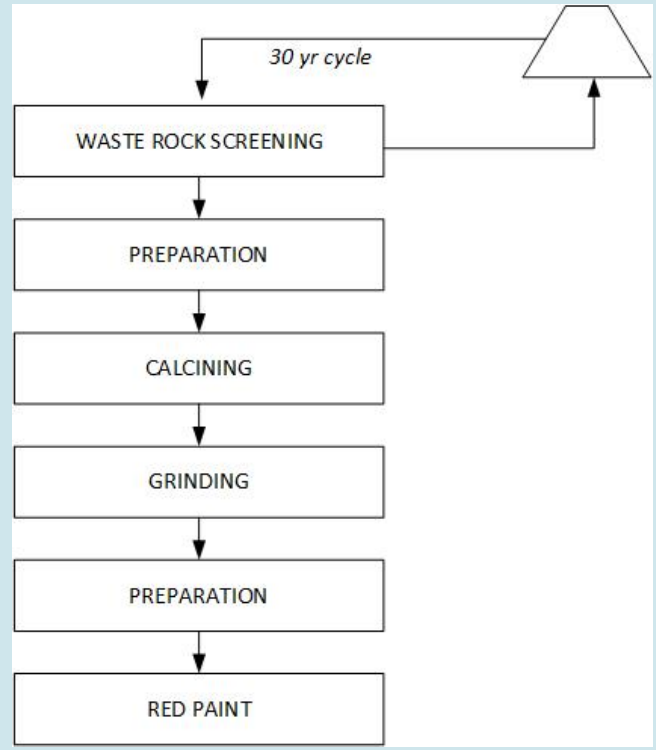
- Ferric sulfate reagent recovery through IX and MVR



- Low feed flow rate, HDS is needed for water balance

Pigment Production from Waste Rock





Conclusions

- Historic mine with a millennium of production
- Legacy issues of highly reactive wastes deposited underground
- Rising minewater levels created problems with ARD treatment, but conversion of GECO to HDS resulted in better operations, and success in control of minewater level
- High tenor ARD creates high lime consumption and sludge volume
- Loss of knowledge of old mine facilities through retirement
- Negotiation of impacts of closure measures on UNESCO values

Future Work

- Reduction of inflows, better characterization of hydrogeo
- Better characterization of wastes leading to further rehabilitation
- Considering limestone substitution process to reduce lime cost
- Improvements to metal recovery process

Questions