ARD Treatment in a Case Study on a Millennium of Mining

Falu Gruva, Sweden

Presented by: Mike Bratty – Golder Vancouver
Contributors: Torsten Andersson - Falu Rödfärg, Stora Enso, Henning Holmstrom, Golder Stockholm; Neil Gallagher, Golder Denver
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 the 19th 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
Historically minewater was discharged without treatment
Old workings are characteristic of fire-setting/quenching; accessible by public tour
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 m³ “pyrite ash” which was treated with lime, and deposited underground
- HDS sludge was deposited on ash, part of rehabilitation (1995-2006)
- Paint plant wastes periodically deposited underground, including waste linseed oil
- 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
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
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.
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
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
Ferric sulfate reagent recovery through IX and MVR

Low feed flow rate, HDS is needed for water balance
Pigment Production from Waste Rock

30 yr cycle

WASTE ROCK SCREENING

PREPARATION

CALCINING

GRINDING

PREPARATION

RED PAINT
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