ML/ARD Mitigation at Red Chris Mine

25th ANNUAL BRITISH COLUMBIA-MEND ML/ARD WORKSHOP

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Acknowledgements

- Red Chris Development Company Ltd.
- Imperial Metals Corporation

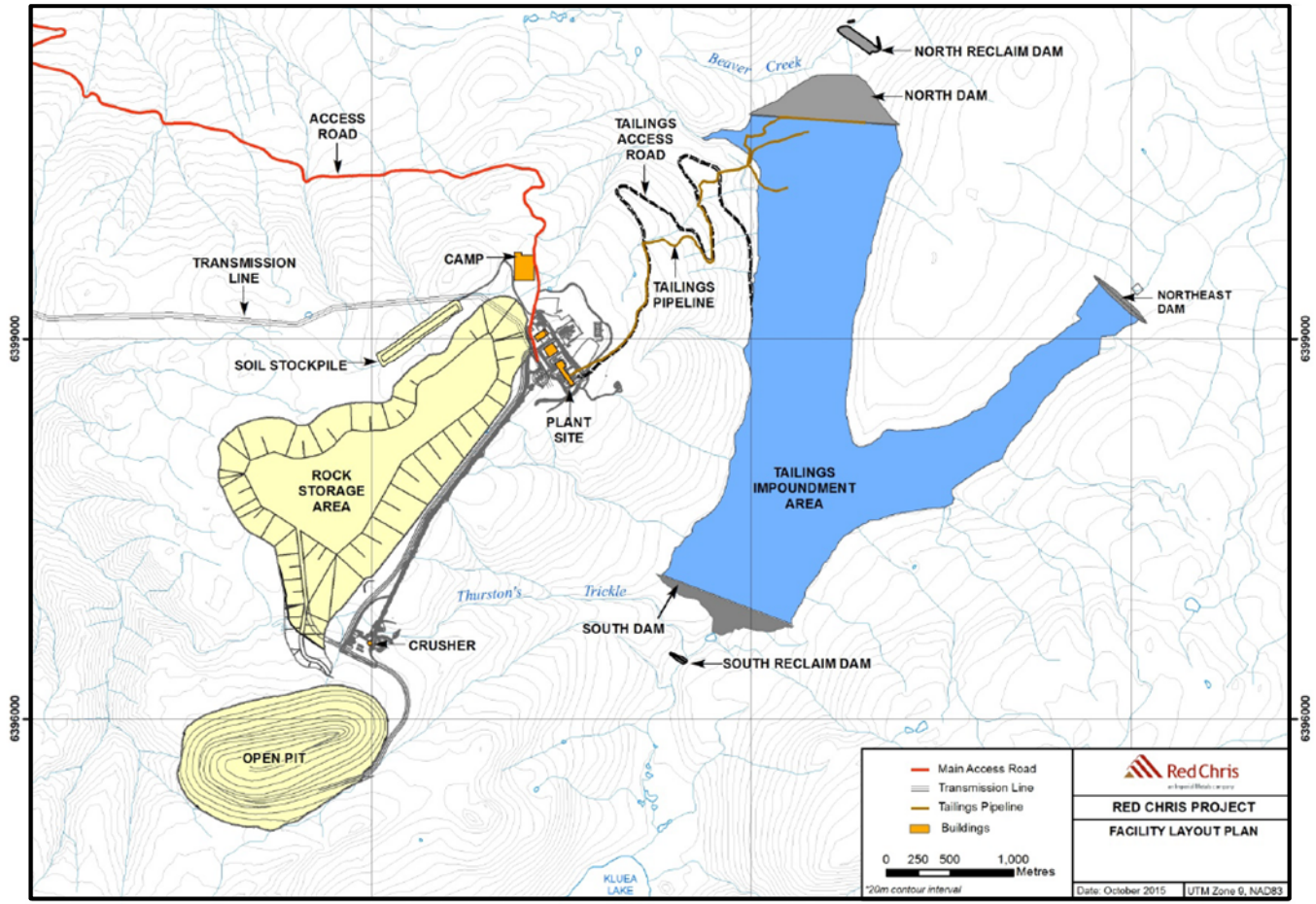
Topics

- Geological setting of the Red Chris Deposit.
- Geochemical characteristics.
- Waste rock management.
- Tailings management.

Red Chris Background

https://www.imperialmetals.com/

- Located in northern BC.
- Mineralization discovered in 1956.
- Construction of the open pit mine began in 2012.
- First copper concentrate in 2015.
- Mining until 2043 is anticipated.



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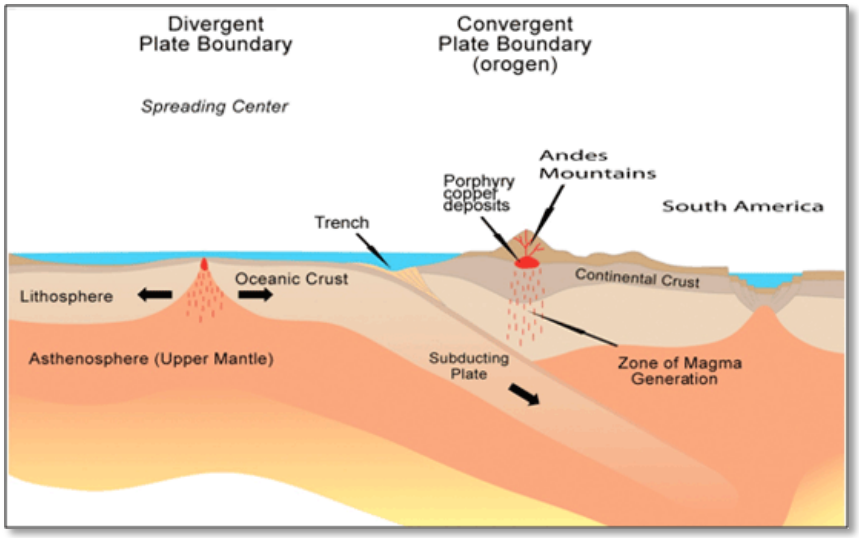
Red Chris - A Porphyry Copper-Gold Deposit



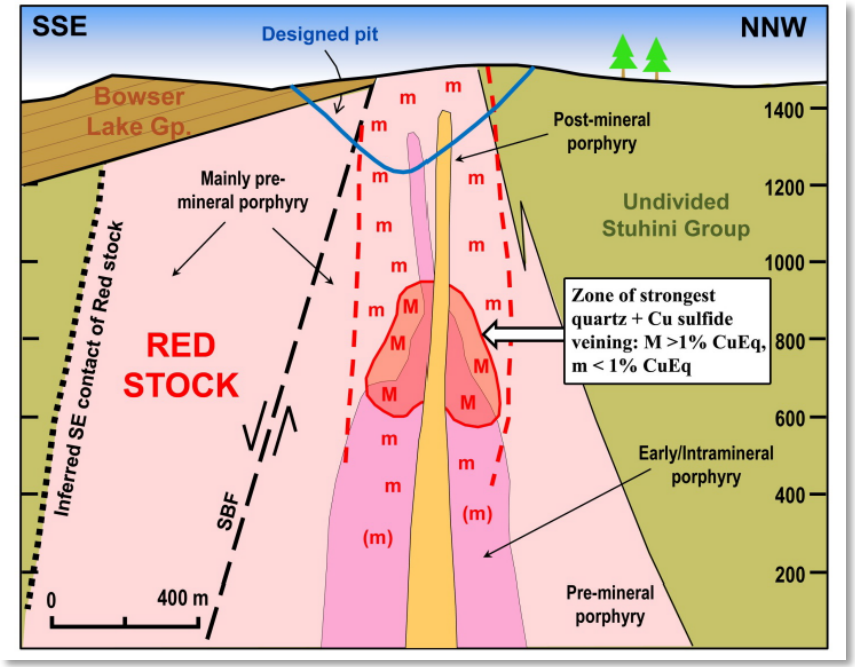
http://www.indicoresources.com/s/CopperPorphyryDeposits.asp

- Formed in sub-volcanic settings by circulation of hot fluids.
- Examples in BC include: Highland Valley Copper Mine, Island Copper Mine, Bell Mine, Gibraltar Mine, Huckleberry Mine, Mount Polley Mine, Copper Mountain.....

Geological History

- The mineralization was formed about 200 million years ago.
  - Potassic alteration with pyrite and carbonate (Ca, Mg, Fe).
  - Stockwork, vein and disseminated.
- It was likely exposed and deeply weathered about 50 million years ago when northern BC was warmer and low relief.
- Glaciation removed the soft oxidized rocks as the landscape became high relief.

Three Main Rock Types at Red Chris



https://www.imperialmetals.com/assets/docs/2010-Technical-Report-Red-Chris-43-101.pdf

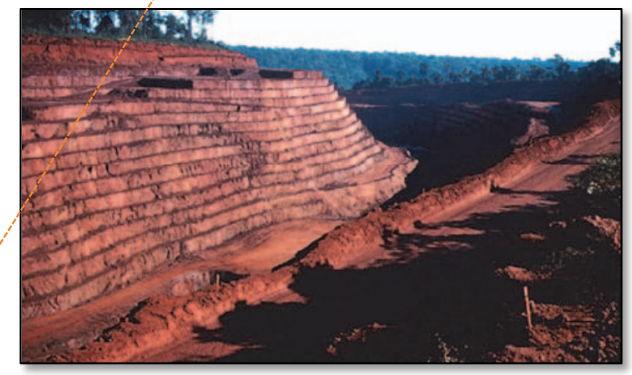
- Red Stock is the mineralizing intrusion.
- Intruded into the Stuhini Group (volcanic rocks).
- The Bowser Lake Group is mudstones and sandstones.
  - Faulted against the mineralized rock.
  - Contains pyrite.
- Post mineral porphyry, negligible sulphides.

Weathering Profile – a Remnant of Warmer Times

Glacial materials

Oxidized acidic bedrock (1 to 2 m)

Bedrock

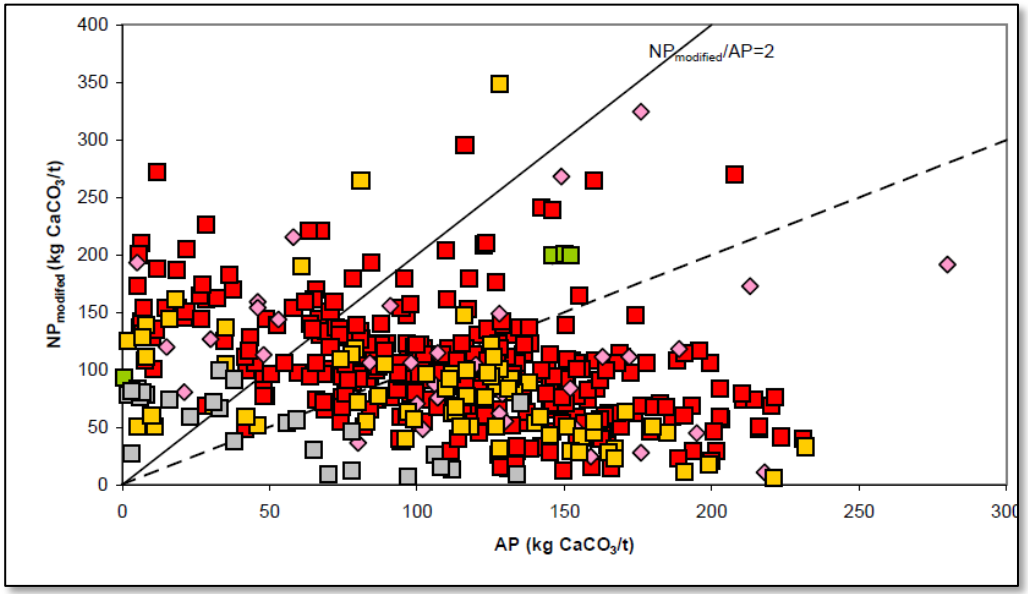


Vasconcelos PM, Reich M, Shuster DL. 2015. The paleoclimatic signatures of supergene metal deposits. Elements. 2015 Oct 1;11(5):317-22.

Waste Rock Management

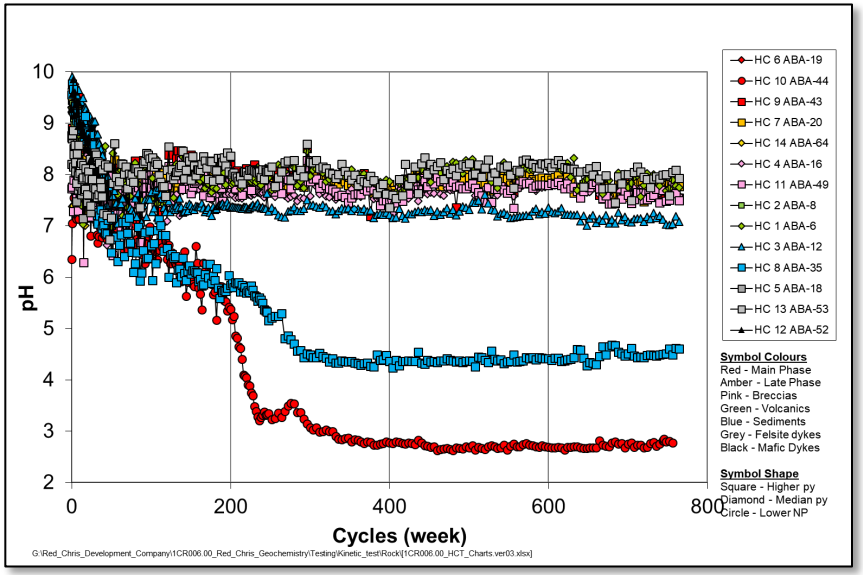
Rock Storage Area

Geochemical Characteristics – ARD Potential of Rock



- All three main rock types contain percent level pyrite.
- Red Chris Stock (waste rock and ore) are dominantly potentially acid generating (PAG).
- Stuhini Volcanics and Bowser Sediments are mixed PAG and non-PAG.
- Post mineralization dykes in stock often non-PAG.

Long Lag to ARD Onset Due to Carbonate Content



- Humidity cells running since 2003 confirm PAG rock does in fact generate acid.
- Typical PAG rock shows decades-long lag to acidification.
- Carbonates delay onset.
- Carbonate occurs with Ca, Mg and Fe
  - NP needs to consider their influence.

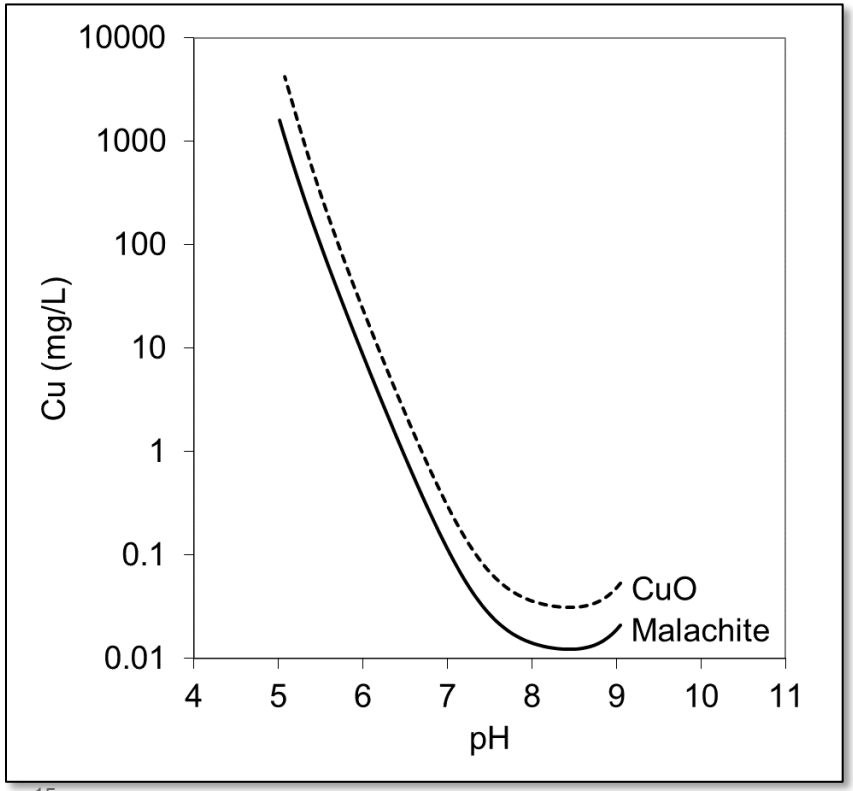
Metal Leaching

- Sulphide mineralogy at Red Chris is limited to iron and copper.
- Lack of lead, zinc, arsenic and antimony sulphides observed in some porphyries.
- Copper and selenium are the main enriched elements
- Selenium (average 8 mg/kg) occurs mainly as sulphides.
  - Bornite is most enriched (690 mg/kg in mineral) then chalcopyrite (400 mg/kg) and pyrite (140 mg/kg).

Metal Leaching

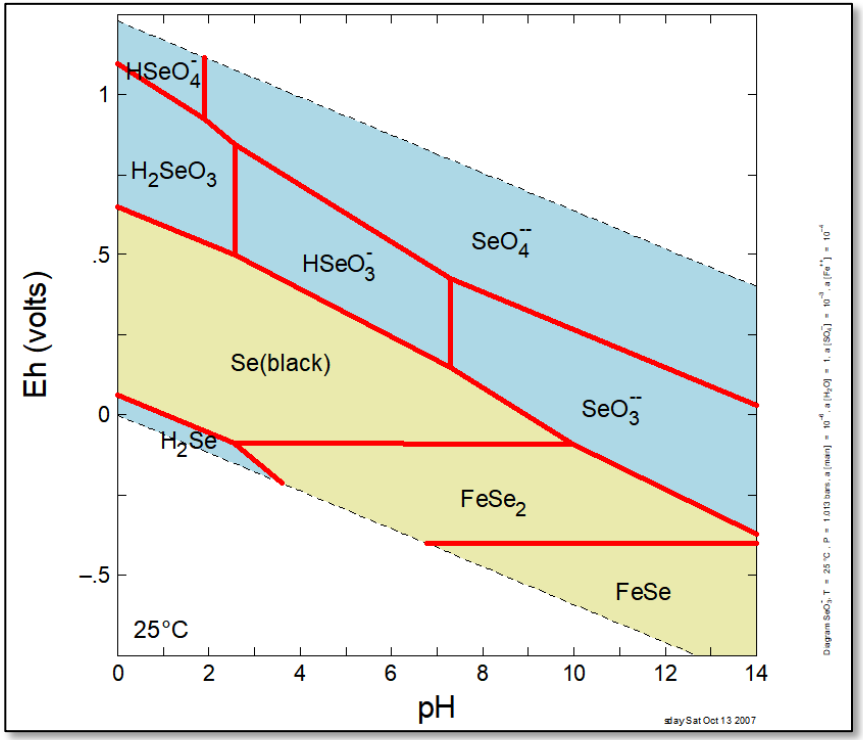
- Selenium also occurs as a water-leachable phase (about 0.2 mg/kg).
  - No discrete mineral form.
  - Believed to have resulted from deep oxidation.

Copper Leaching



- Copper leaching is strongly linked to pH (increased solubility at lower pH).
- Managing ARD potential is therefore an approach to managing copper leaching potential.
- Red Chris approach is to segregate PAG and non-PAG materials.

Selenium Leaching



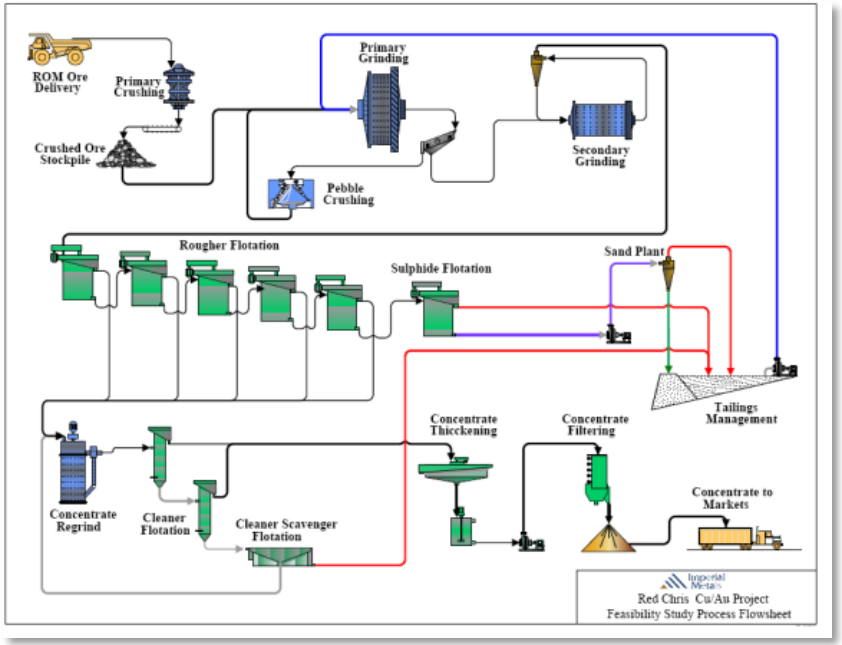
- Selenium leaching is linked to both pH and “oxygen availability”.
  - Higher pHs and more oxidizing conditions favour selenium leaching.
- Management of selenium makes use of oxygen deficient environments both to limit oxidation and immobilize selenium.

Waste Rock Management

- In-pit segregation of PAG and non-PAG waste rock and low grade by blast hole chips analysis at on-site lab (Total S and Total C)
  - Total C corrected to yield Ca+Mg carbonate (rock type specific) (NP*).
  - Both Total C and Total S corrected for blast fractionation.
  - NP*/AP<2 defines PAG.
- PAG rock is stockpiled in the Rock Storage Area.
- At Closure, waste rock will be reclaimed with a soil cover.
- Perpetual water quality management is anticipated.

Tailings

- Ore is processed by flotation to yield a single copper concentrate.
- Two tailings streams
  - Rougher tailings.
  - Cleaner tailings.
- Selenium leaching occurs during primary grinding which contributes to the tailings impoundment.



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Tailings Management

- Non-PAG tailings
  - Rougher tailings following de-pyritization.
  - Non-acid generating but potential for Se leaching.
  - Subaerial disposal.
  - Used for producing cycloned sand as dam construction material.
- PAG tailings
  - Cleaner tailings + pyrite from rougher de-pyritization.
  - Finer grained due to re-grind.
  - Permanently saturated to reduce O_2 availability.

Open Pit

- Exposed PAG walls.
- During operation the Pit water and the RSA water routed through the processing plant, and at closure managed with other site waters.
- Partially flooded at closure.
- Water treatment expected be required following closure.

Up next:

How Much Modelling is Too Much Modelling
Red Chris Mine: A Case Study