Heap leaching is a metal recovery process where a lixiviant dissolution and "decrepitation" can cause alteration of the and increase in solution holding capacity (Milczarek, et al., 2013). Moisture sensors every 15 cm in
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Sample Preparation:

- 1600 kg of 16-inch crushed copper ore for copper leaching tests. Cured with sulfuric acid (4 kg acid/ton of ore) and agglomerated with raffinate (7% moisture).

Hydraulic Properties: 6-inch diameter flexible-wall flow cells were used to test ore saturated hydraulic conductivity (Ksat) and unsaturated hydraulic conductivity (Kunsat) properties at various confining pressures (Dane & Topp, 2002, Milczarek, et. al., 2013.)

Large Column Preparation:

- 1.5 m high, 50 cm in diameter columns for irrigation tests
- 24,000 kg of ore in column
- Electrical resistivity probes every 7 cm at 13 locations on the edge of the column, and 1 at the top and 1 at bottom
- Prepare dye (1g FD&C Blue1) and 100mg Bt tracer solutions with raffinate.

Controlled inflow and outflow monitoring
- Moisture content and ER sensor monitoring every 5 minutes
- Neutron probe measurements from four different directions
- Conduct tracer test after steady state conditions achieved

Solution Content over Time

Baseline Test

- 1/8th of baseline rate
- 1/16th of baseline rate
- 1/4th of baseline rate
- 1/2th (1h on/1h off)
- 1/4th (4h on/4h off)

Ramp-up Test

- 1/8th of baseline rate
- 1/16th of baseline rate
- 1/4th of baseline rate
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RESULTS

BASELINE TEST

Ore Collapse/Slump

Baseline: Full rate
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TEST 2: RAMP-UP

Solution Content over Time

Baseline Test

- Fastest collapse occurs in the first 4 h, from
- then it all collapses at the same rate until 29 h
- Then inside the wetting area, initial solution content 7%, Steady state water content 16%
- Bulk solution content 0.098 cm³/cm³ (mass balance)
- Lateral spreading captured by neutron probe at height 95 and below

Ramp-up Test

- Outer ring suggests lower permeability near the center ring after steady state (more agglomeration failure and lost permeability at the center)
- Most flow occurs at edge when it arrives at the bottom of the column

Neutron probe measurements

- Fastest collapse occurs in the first 4 h, from
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Hydraulic Properties:

- Significant increase in fines (decrepitation) for acid addition and agglomeration of ores
- Kunsat tests show incompetent ore hydraulic behavior under high irrigation rates and marginal behavior under low irrigation rates.

Large Column Studies:

- Fast solution advance in baseline test (less than 6h) due to possible preferential flow.
- Observed ore collapse/slump and dye test in baseline test suggest broken down agglomeration, ore compaction, and possibly decrepitation and subsequent downward fine particle migration, causing loss of permeability.
- Less ore collapse in ramp-up test suggest that ore structure and permeability are less affected with slow irrigation ramp up.
- Neutron probe measurements show lateral spreading occurs from height 95 cm after 165 hrs in baseline test, but only detected when 1/8th of final rate is set in ramp-up test.

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