



Extracting metals from mine waste

Three cases of Ni and Cu Tailings and Waste Rock in Norway

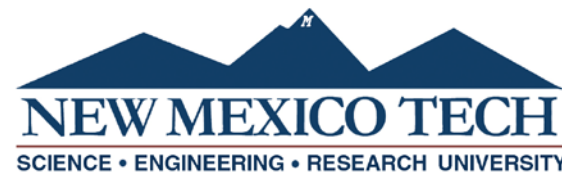
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New Mexico Tech,

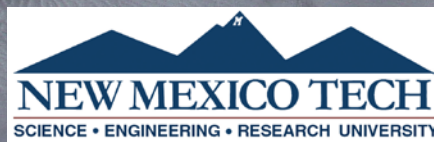


NM Tech – 27th-28th of March 2018

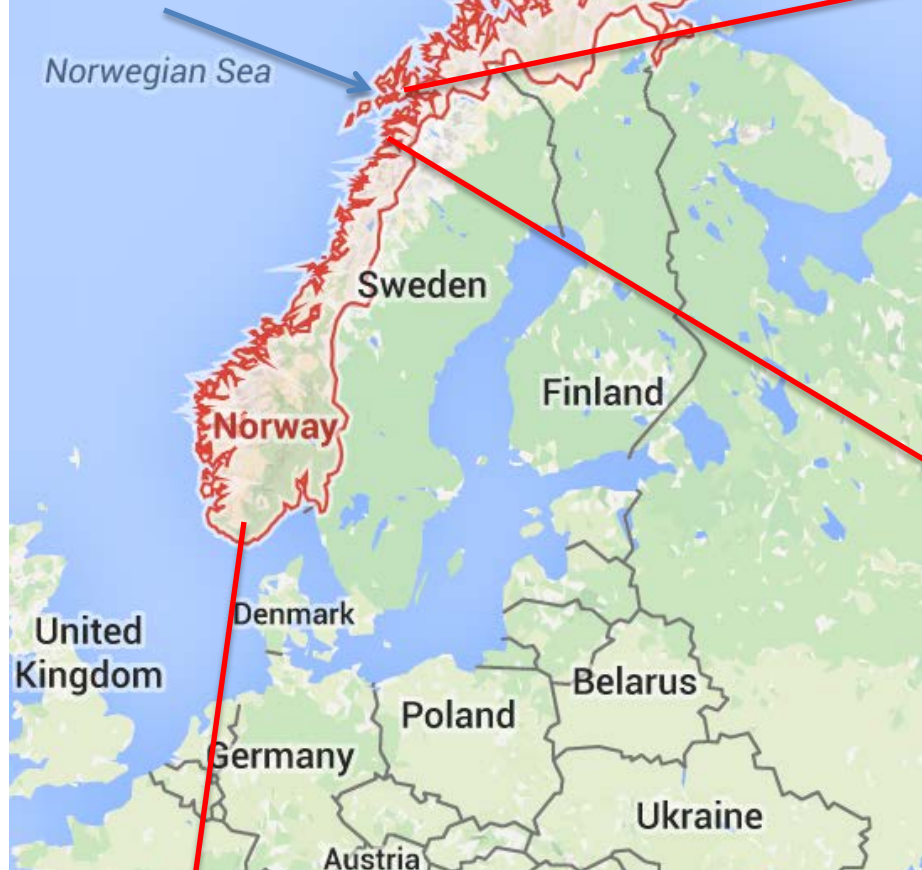


OUTLINE

- LOCATION - BACKGROUND - SETTING
- PURPOSE OF THE STUDY
- METHODS
- TESTS RESULTS
- EXTRACTION POTENTIAL



Kjeøy Research & Education Center



Råna Layered Mafic Intrusive

- Dunite – pyroxenite –norite
- Massive to simi-massive ore bodies
- Associated with the dunite layers
- Pyrrhotite-pentlandite- chalcopyrite-pyrite
- Tailings 7-8 Mton; 200-300 ppm Ni
- Waste rocks approx 0.5 Mton

Sulitjelma VMS Deposits

- 20 dep.+ within an offiolite complex
- Associated with greenstone layer
- Cpy – Sph - Gal. in pyrite matix
- Tailings 10-15 Mton
- Waste rocks approx. unkn. amount

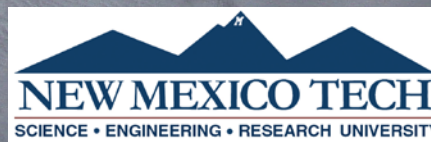
Tellnes deposit – Titania Mine

- Ilmenite-norite in an anorthosite complex
- Ilmenite extraction; Sulfide extraction biprod.
- Pentlandite, millerite, pyrrhotite, chalcopyrite
- 2 Mt/year tailings deposition (so far 30 years)
- 200-250 ppm Ni conc. in tailings



PURPOSE

- Drainage water issues and geochemical processes within the waste material
- Leaching potential through column studies for metal extraction
- Practical research projects for Bachelor (2), Master (2) and PhD (1) students



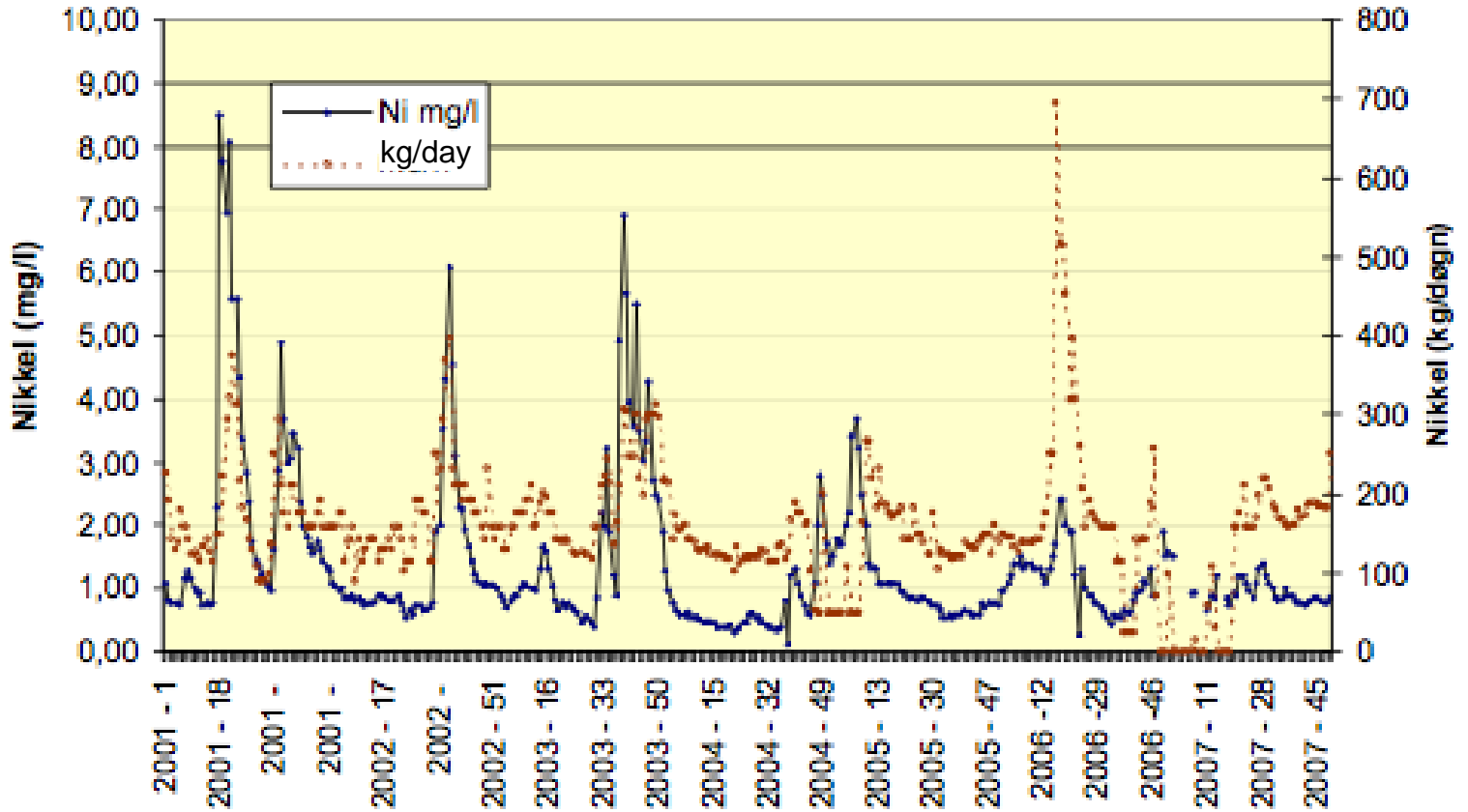
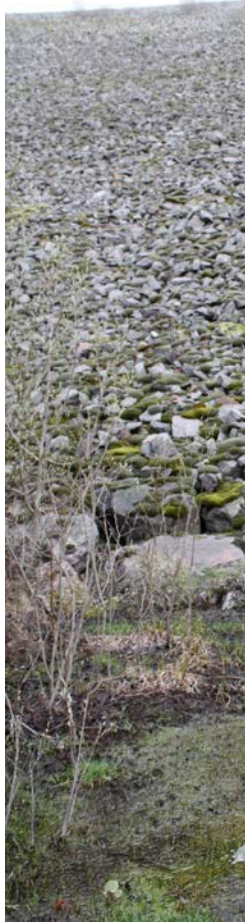
SEEPAGE WATER

Tailings dam



SEEPAGE WATER

Tailings dam



ANALYSIS

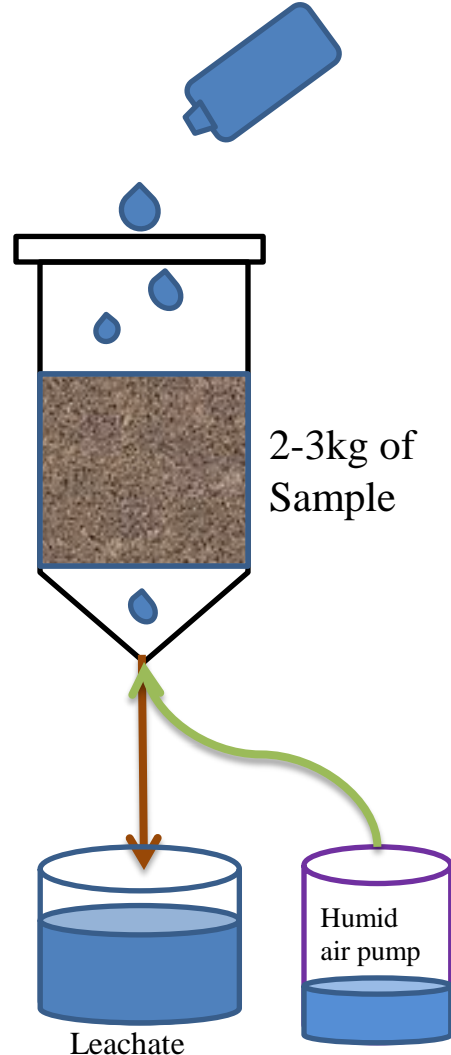
- Mineralogy (XRD-SEM)
- ABA (acid–base accounting)
- SCE (sequential chemical extraction)
- Water analysis
- Leach tests
 - Humidity cell tests 3-7 months
 - Column Leach tests 2 months and going



Column leach tests



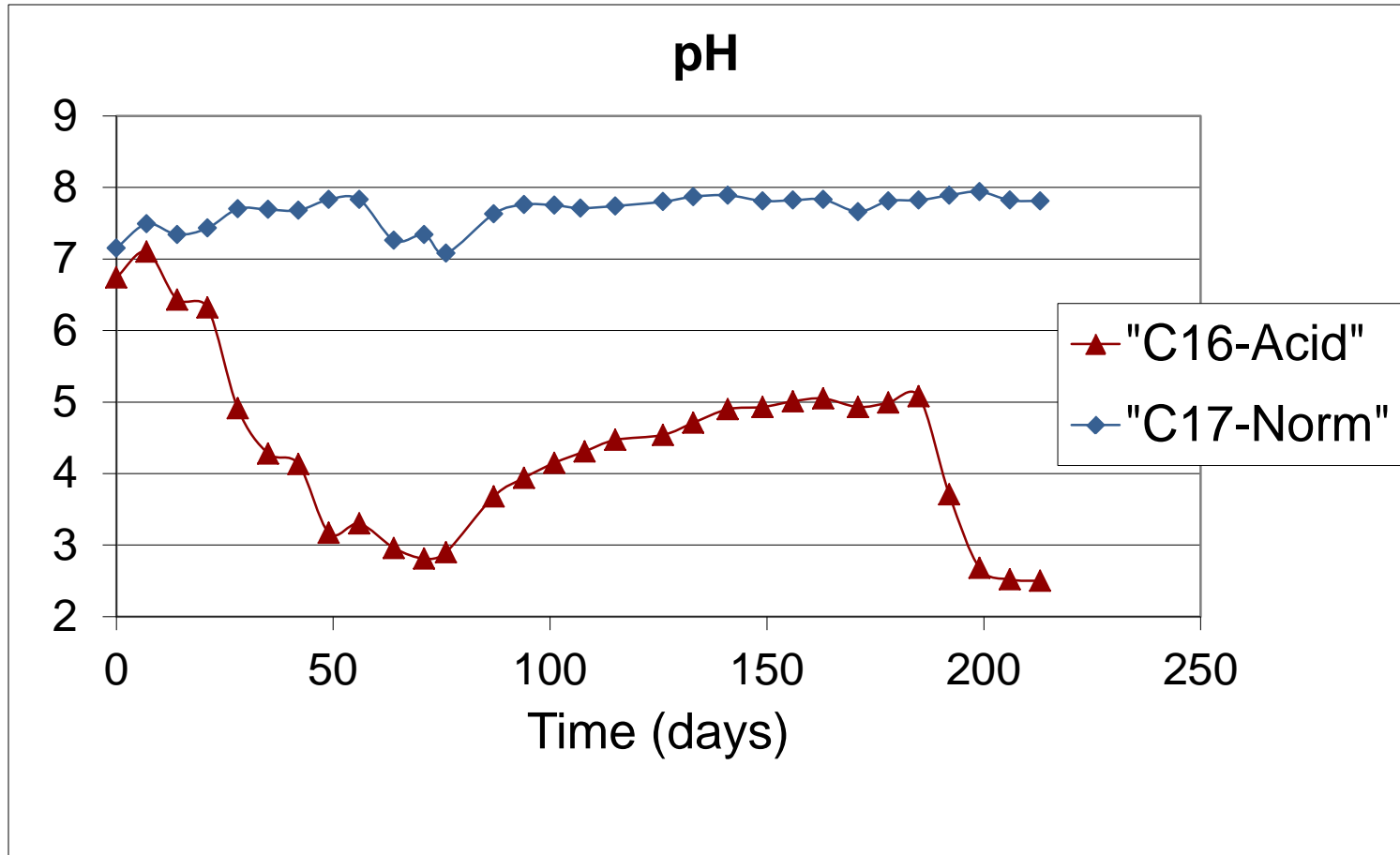
- 6 kg sample
- 1L leach solution/week
- 7 months duration
- Weekly analysis
- Acidic process water
- Deionized water



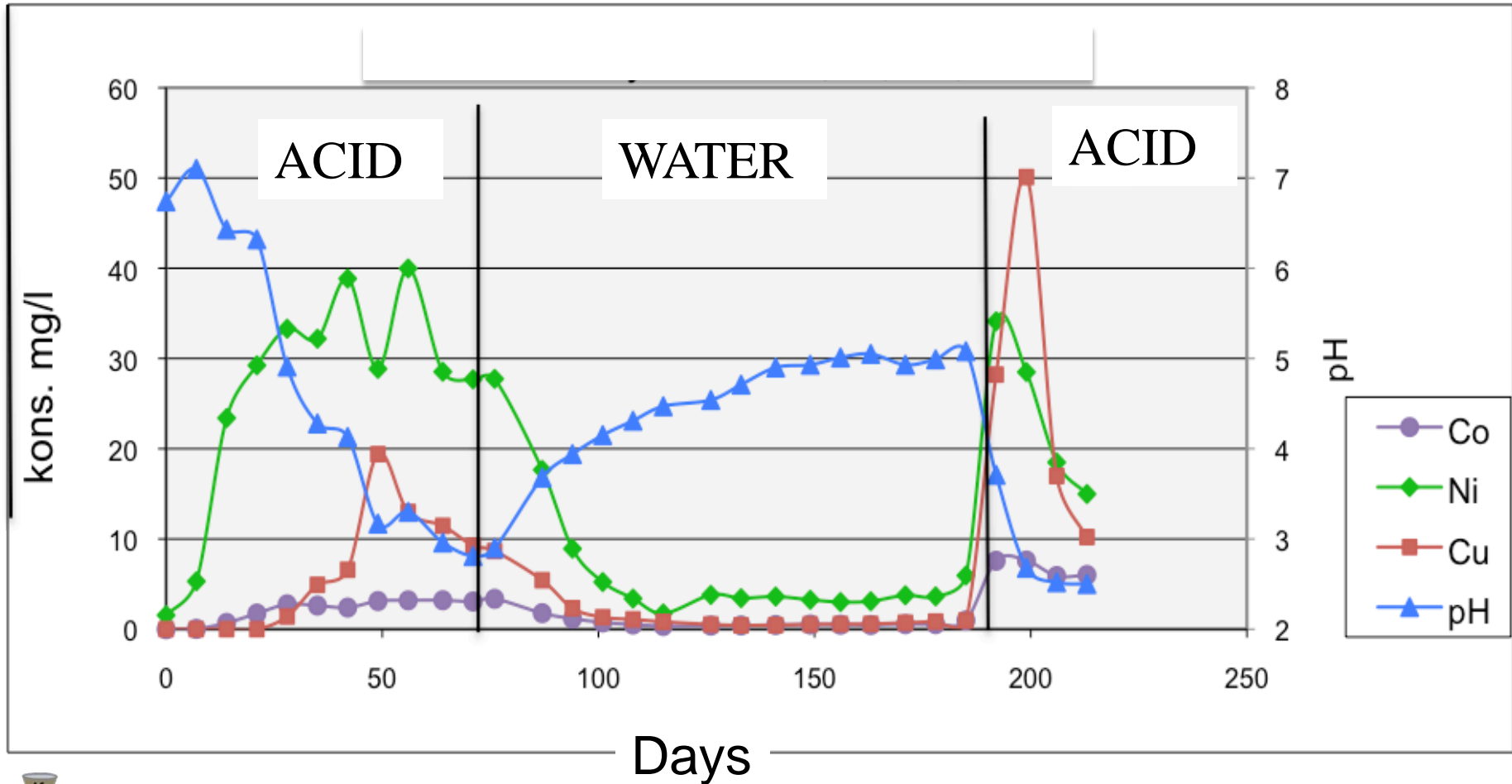
- 6 kg sample
- 0.5 L/day leachate
- +2 months duration
- Analysis 1-3 days
- Acidic process water
- Sulphuric acid



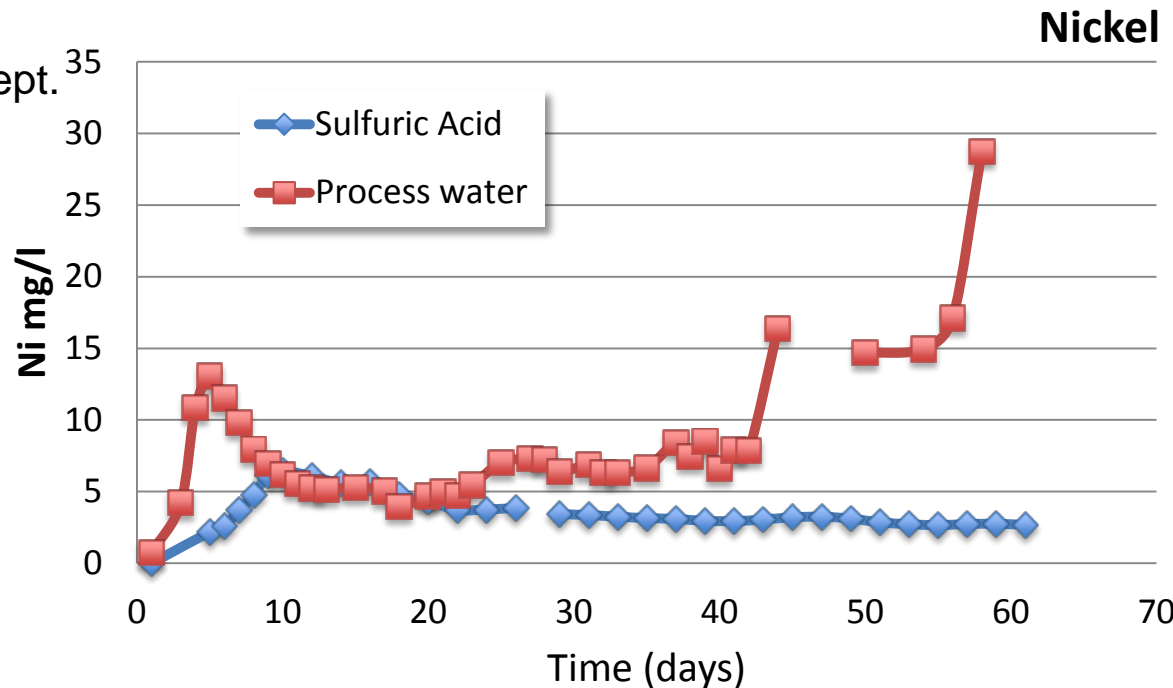
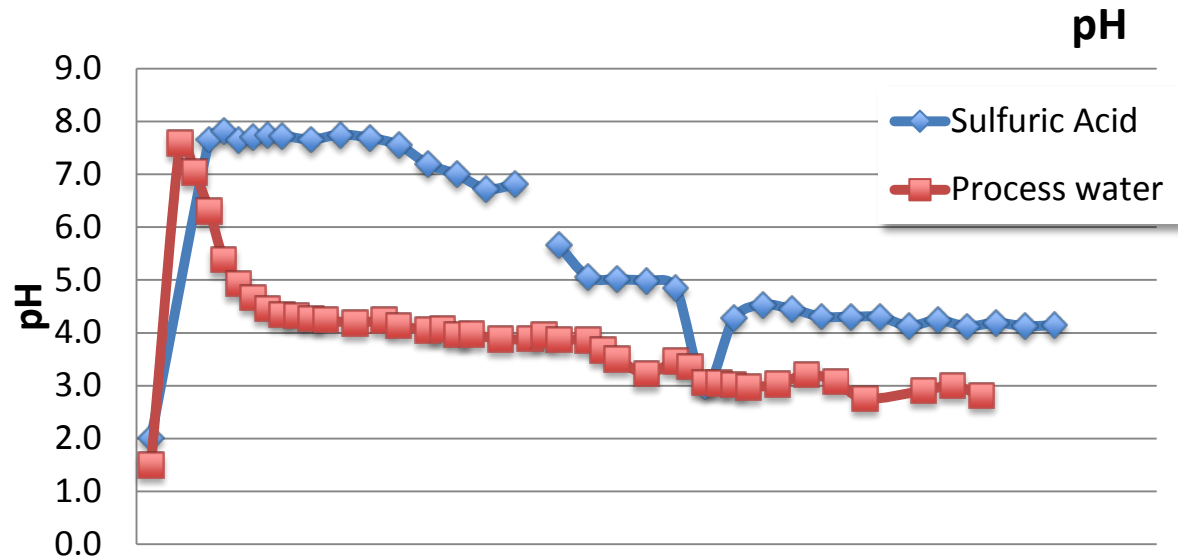
Column leach tests weekly rinse



HCT- acid column



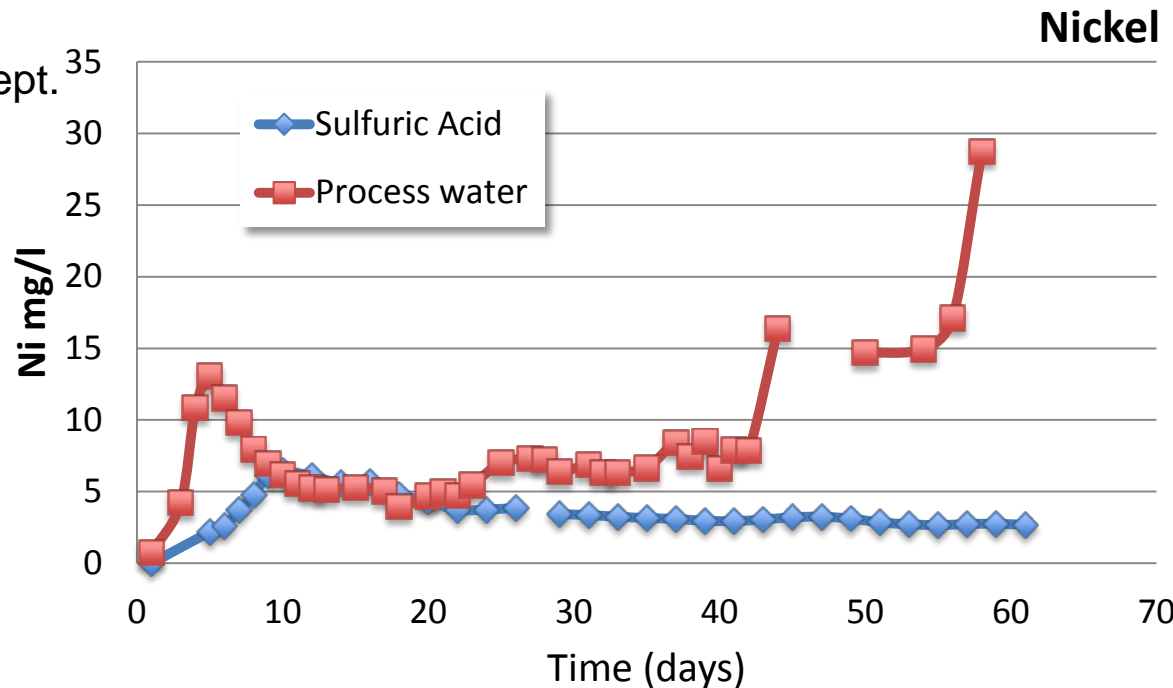
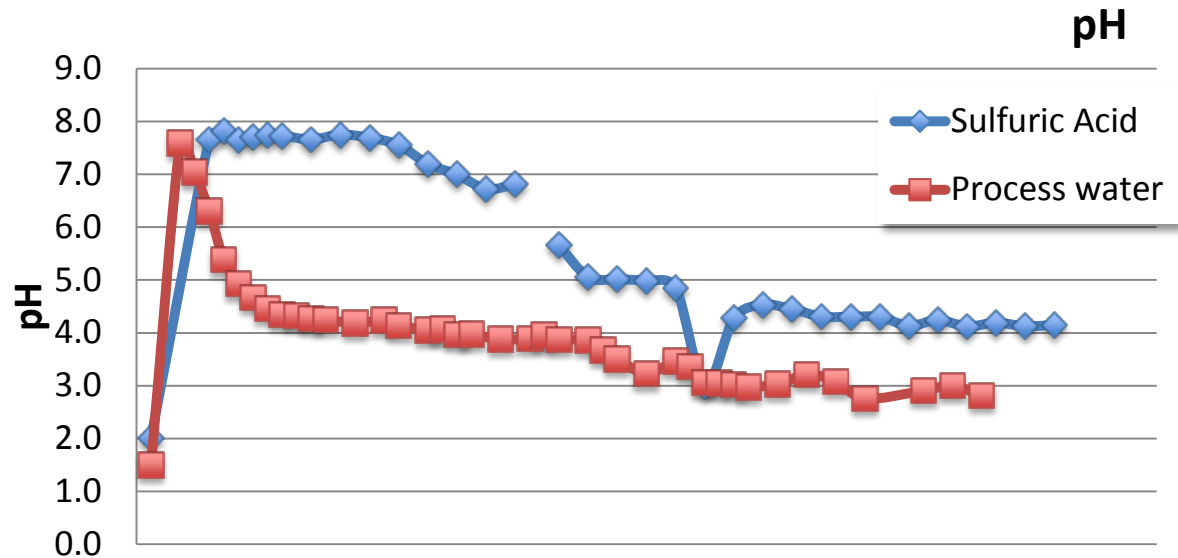
Leach columns



Ashlynn Winton, BS
Earth and Environmental Dept.



Leach columns

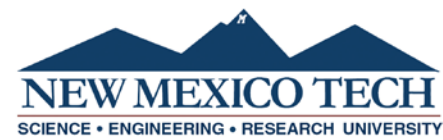
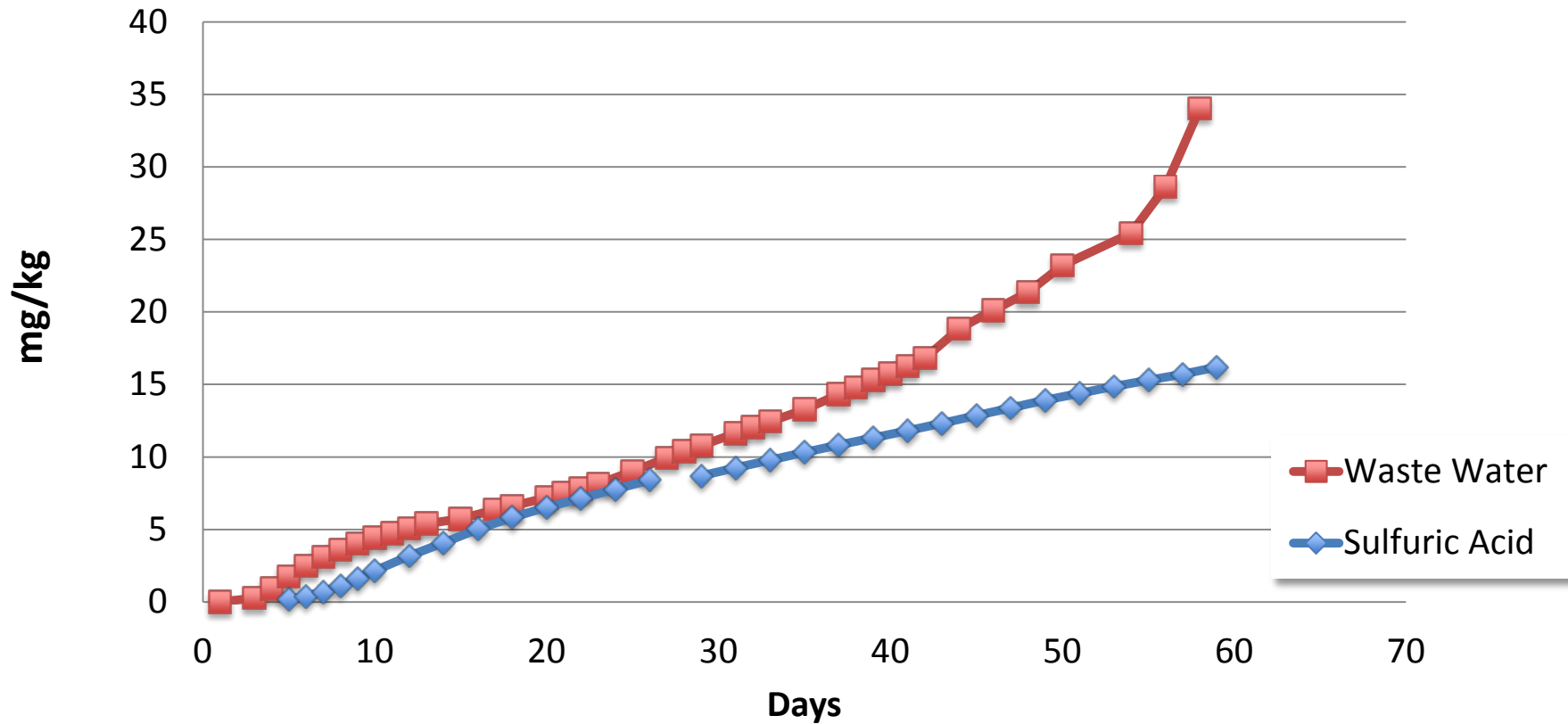


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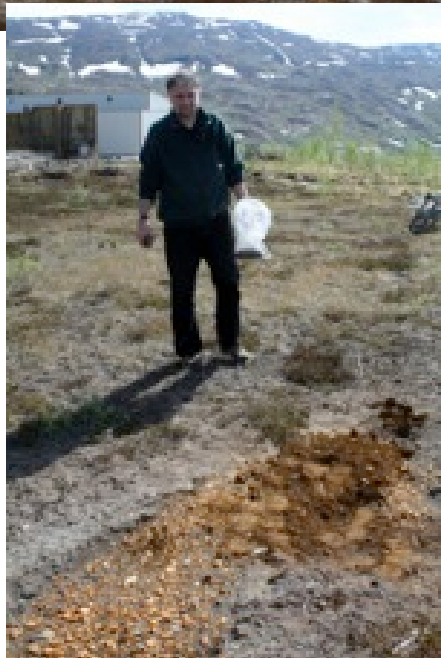


Leach Columns

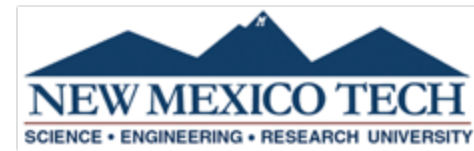
Nickel Extraction



SULITJELMA TAILINGS and WASTE ROCKS

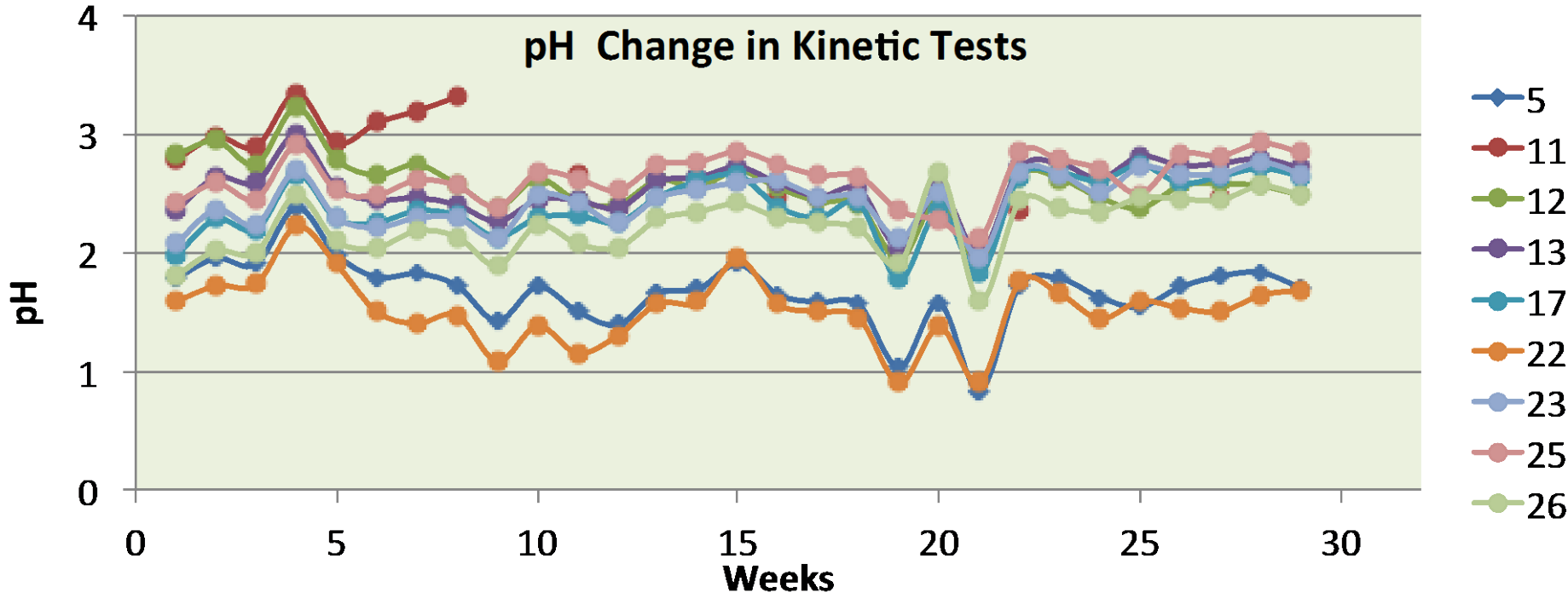


Alice Clark, BS
Earth and Environmental Dept.



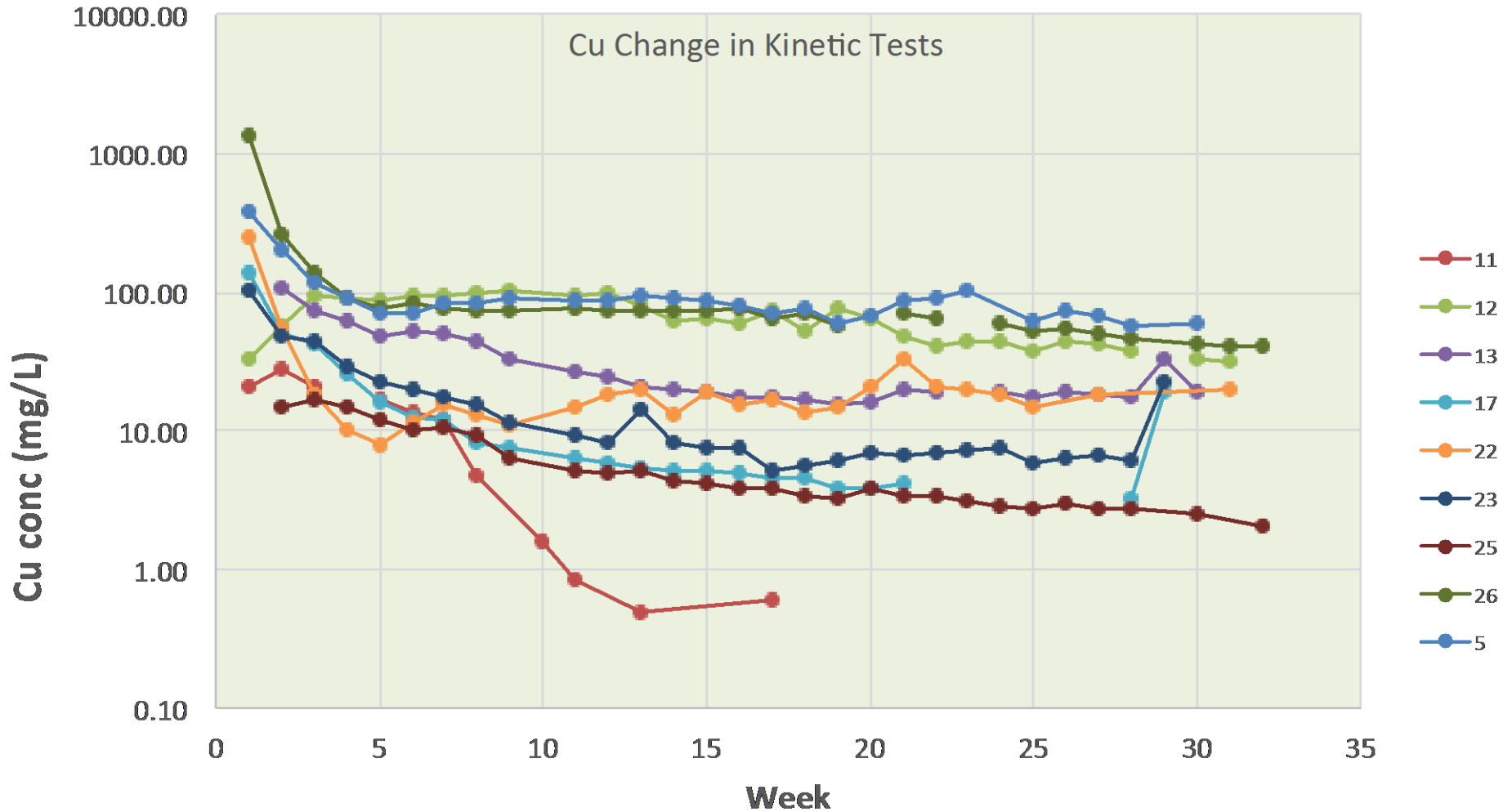
pH – kinetic tests

Waste rocks, Sulitjelma



Copper – kinetic tests

Waste rocks, Sulitjelma



Franciszka Stopa MS
Mineral Engineering Dept.

Potential for Nickel Leaching from the Bruvann Nickel-Olivine Deposit, Northern Norway



Acid and Alkaline Leach Columns

Weakly Column leach tests

- 1 L/week
- 3-5 kg sample old waste rocks
- 35 weeks

Continuous flow columns

- Leachate collected continuously, sampled in batches
- about 5 kg sample
- Leachate
 - Leached with water (weekly),
 - pH 2.0 H_2SO_4 ,
 - pH 1.5 H_2SO_4 ,
 - either water or pH 12 NaOH.

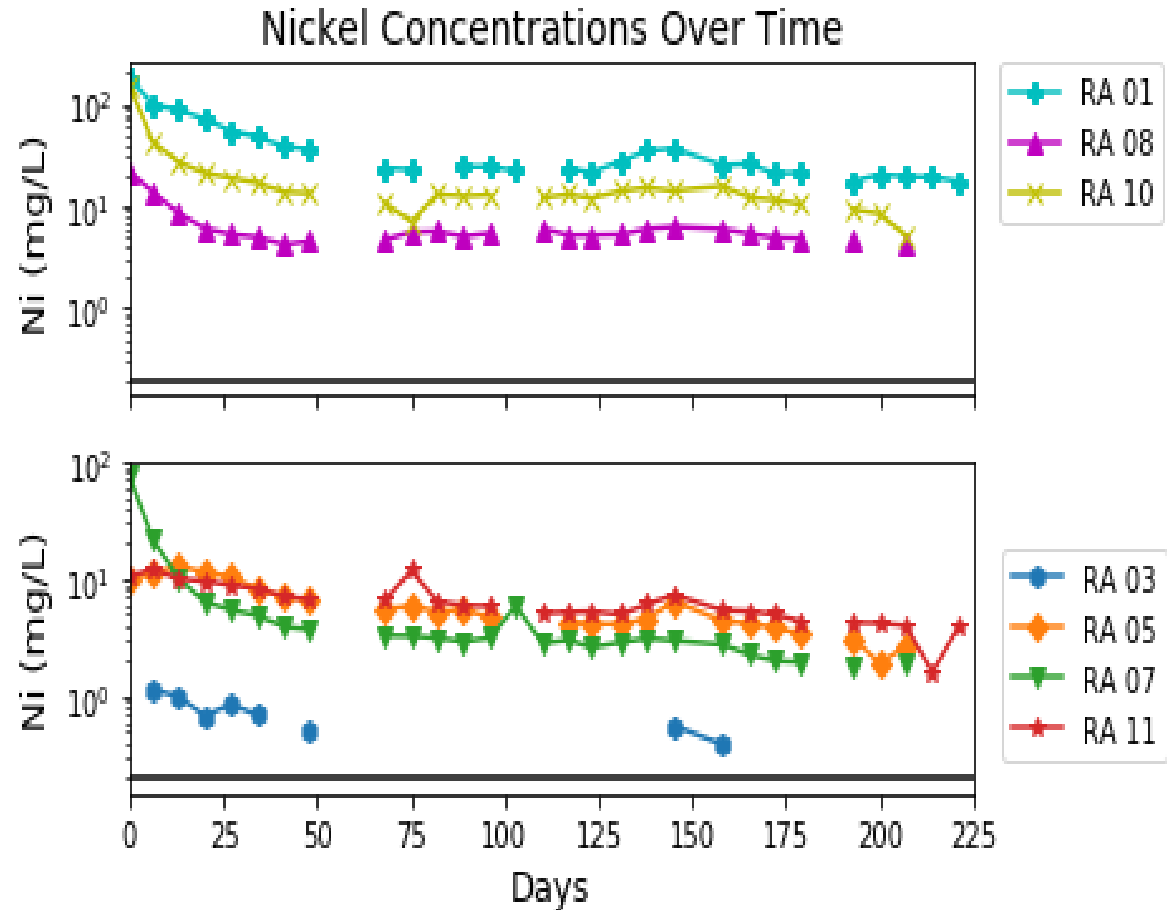


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Weakly DI water Columns

- Nickel has a smooth decline, remains at mg/L levels for months
- Moderately acidic

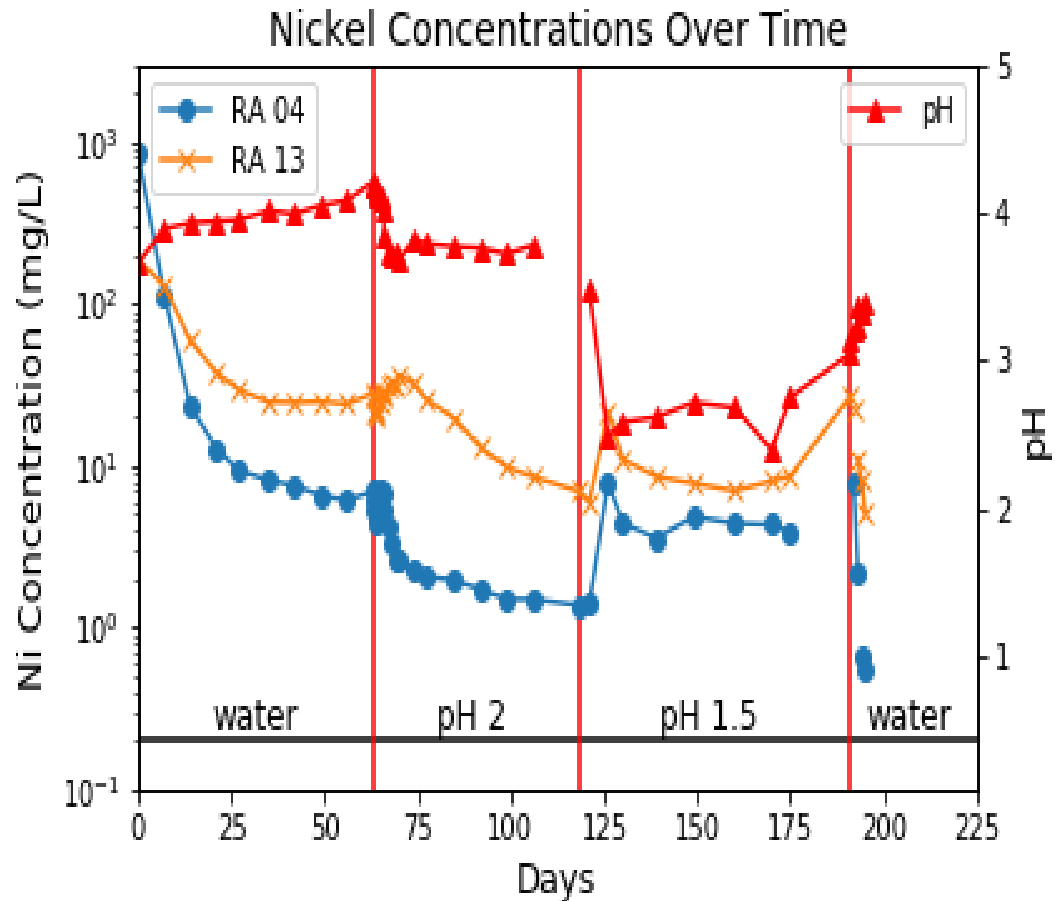


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Water → Acid → Water Leach Results

- Long lasting neutralizing capability
- Lower pH temporarily increases leaching
- Returning to water leach yields a spike in nickel concentration, then a sharp drop.



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Earth and Environmental Dept.



CONCLUSIONS

- Standard leaching methods feasible for Ni extraction
 - Tellnes tailings as well as Råna waste rocks
- Olivine content reduces the acid leachability by effectively consuming hydrogen ions
- Approx. 0.2 wt. Cu leached from waste rocks and tailings at Sulitjelma. over two years,
- Nickel extraction is feasible using the acidic process water
- Low pH increase the release of Nickel, but is not effecting the mobility.
- To get cobalt, and copper from the same ore require a low pH solution.



Further Student Research

Active leaching copper of Mine Waste from Sulitjelma

- Mineralogy work
- Vat leaching, high oxygen flow

Olivine leaching to improve Ni recovery

- HVEP (patent pending)
- Alkaline leach

Vanadium extraction EU funded

- Magnetite reaction rates
- Preheating before leaching

Extraction of metals from solution

- Solvent extraction electro winning
- Ion exchange

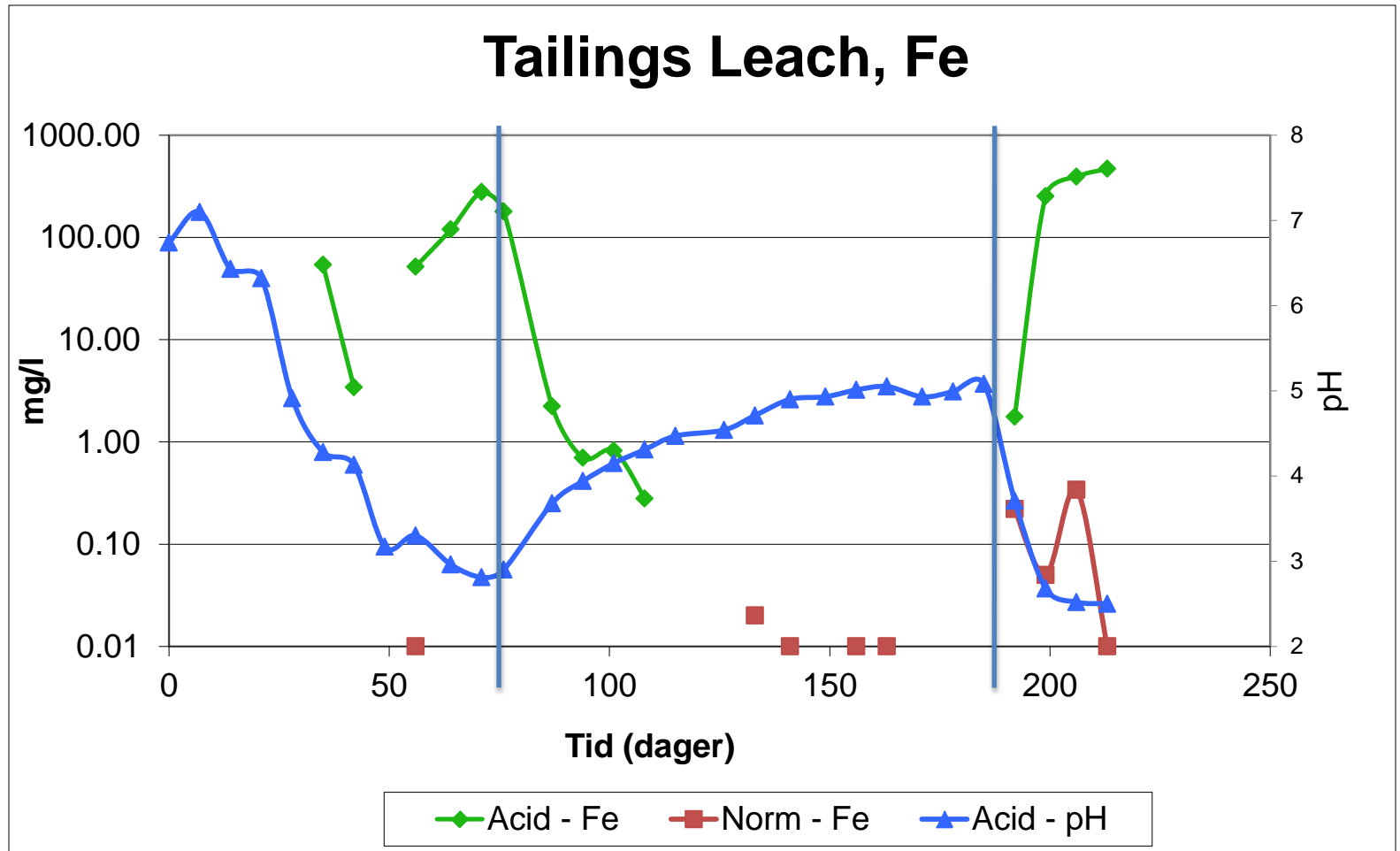


Thank you
Any Questions



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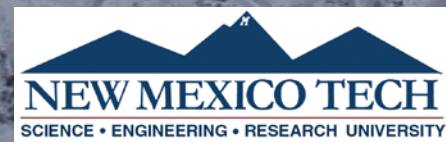
Weekly rinse - columns



THANK YOU

QUESTIONS

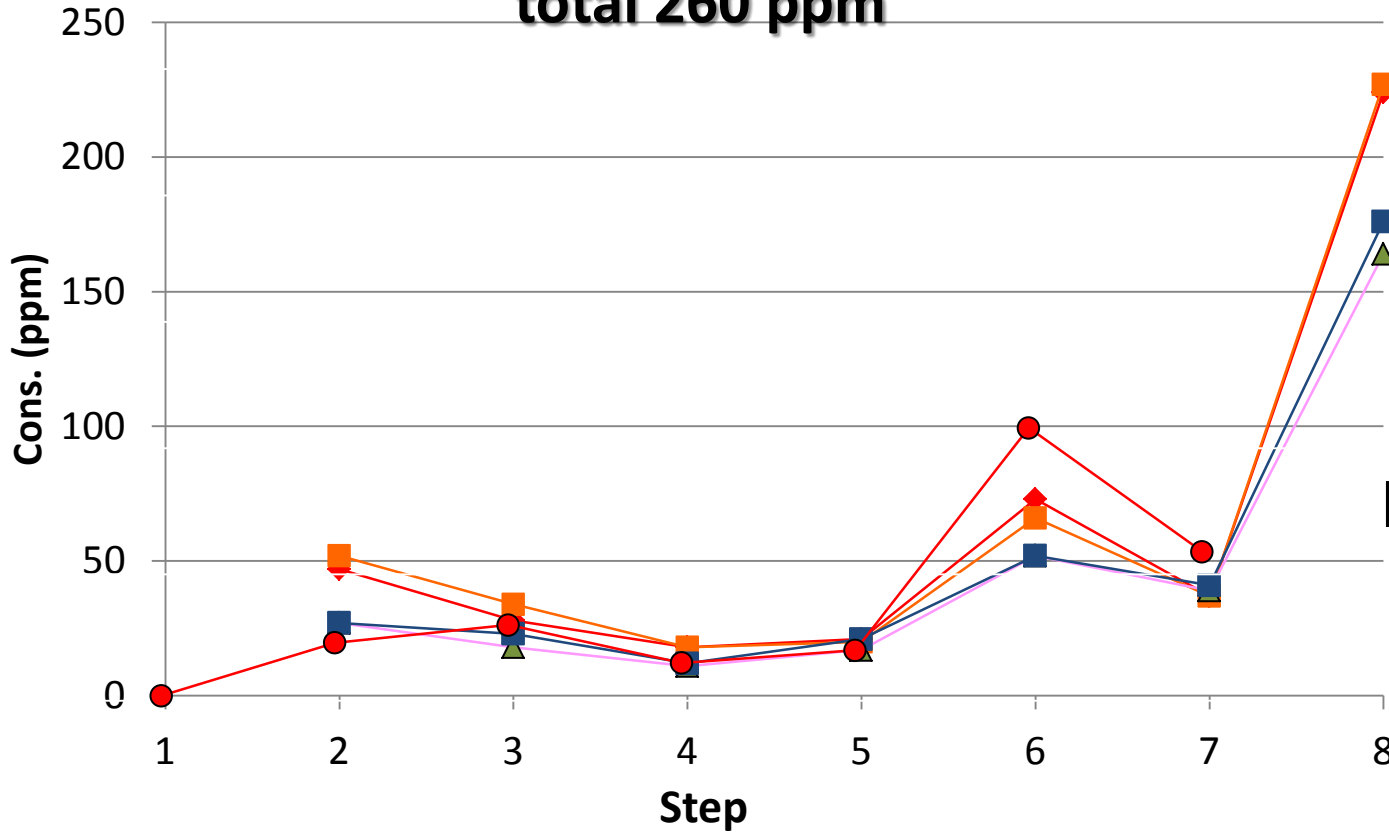
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HCT – SCE (Dold, 2003)

NICKEL

total 260 ppm



Water
 NH₄- Acetate
 NH₄-oxalate
 NH₄-Oxalate
 H₂O₂
 KCl+HCl+HNO₃
 Four acid dig.

◆ "Norm Top" ■ "Norm Bot." ▲ Acid Top ■ Acid Bot.

