MICROBES:
URANIUM MINERS, MONEY MAKERS, PROBLEM SOLVERS

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Uranium 2010, Saskatoon, Saskatchewan

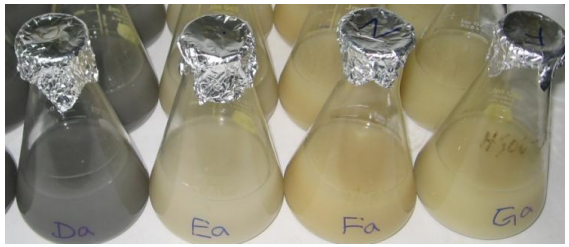
Overview

- The Quirke Syncline
  - Elliot Lake Uranium Mining History
  - Rare Earth Element

Elliot Lake

- Bioleaching

- Bench-top Bioleaching Study
  - Results
  - Applications and Future Work



Elliot Lake & the Quirke Syncline

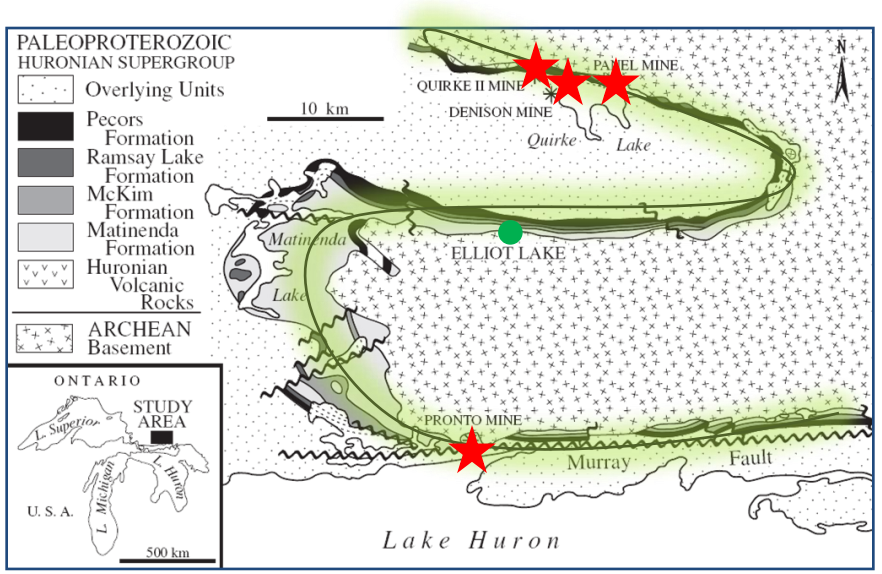
- Uranium-bearing conglomerate associated with thicker sections of the Matinenda Formation
  - *The Big Z*

Lower Grade

Uranium mineralization

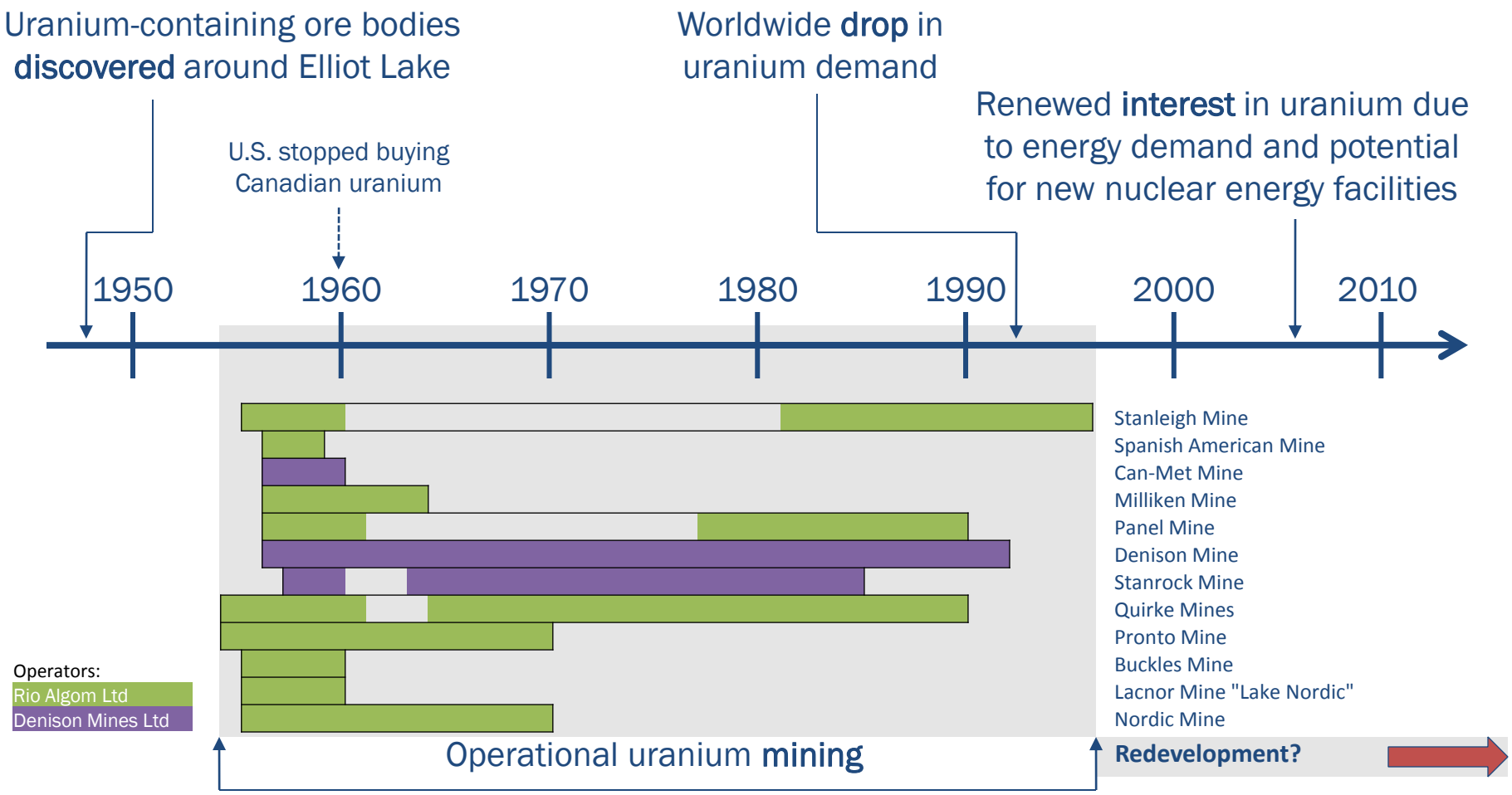
Higher Grade

- Quartzite beds
- Quartz-pebble conglomerate with pyrite matrix



Geology of the Elliot Lake area, northern Ontario
J.P. Burton & P. Fralick, Economic Geology. *Vol. 98, 2003, pp. 985-1001.*

Elliot Lake Mining Camp



Redevelopment and Rare Earth Elements

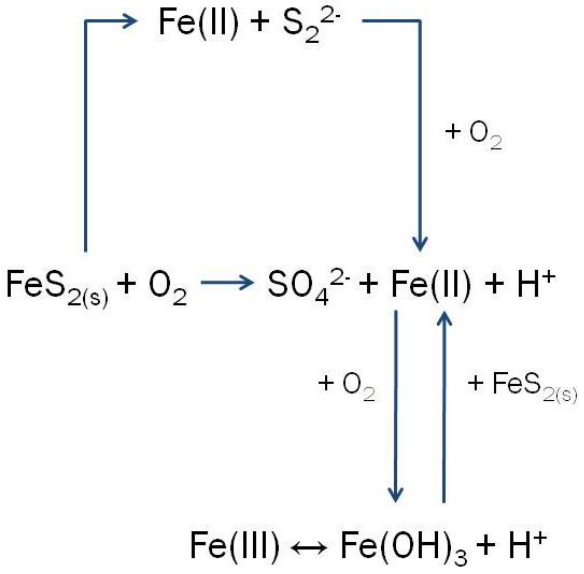
- REE-containing minerals associated with the conglomerate beds of the Quirke Syncline

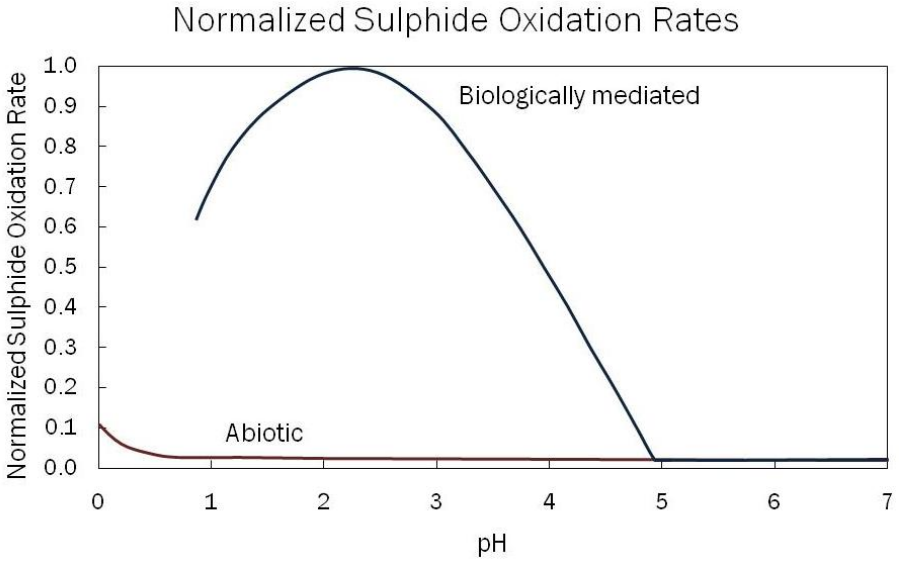
	Group 3	f-block												
Row 4	Sc 21													
Row 5	Y 39													
Lanthanoids	La 57	Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71
Actinides	Ac 89	Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Nd 101	No 102	Lr 103

Minerals	Applications
Allanite, Brannerite, Coffinite, Florencite, Monazite, Mz-Silicate, Pitchblend, Thorite, Th-uraninite, Xenotime, UO_2-Rutile, UO_2-Pyrite, UO_2-Pyr-AlSi-mix	Magnets, NiMH batteries, Auto Catalysis, Fluid Cracking, Catalysis, Phosphors, Optic Polishing, Glass Additives

Fundamental of Bioleaching

- **Water + Oxygen+ Metal Sulfides** (ex. FeS_2)
  →react to form **acid** containing dissolved **metals**
  - *AKA acid mine drainage*
- Oxidation **rate** of sulfides can be **increased** by 5 to 6 orders of magnitude in the presence of sulfur oxidizing **bacteria** at low pH





Microbes – Acid Generation – Dissolution

Increased $Fe^{2+} \rightarrow Fe^{3+}$ oxidation rate

↓

Increased rate of acid generation

↓

Increased mobility of elements contained in ore

↓

Elements released into solution

U-containing Material + Bioleachining →

- Bench-top bioleaching study:

1. Assess the biologically-mediated **recovery** of uranium and rare earth elements from uranium-baring rock samples originating from the Quirke Syncline.

2. Preliminary assessment of the overall **acid generating potential** of residue or waste material from uranium-bearing rock samples subjected to bioleaching.

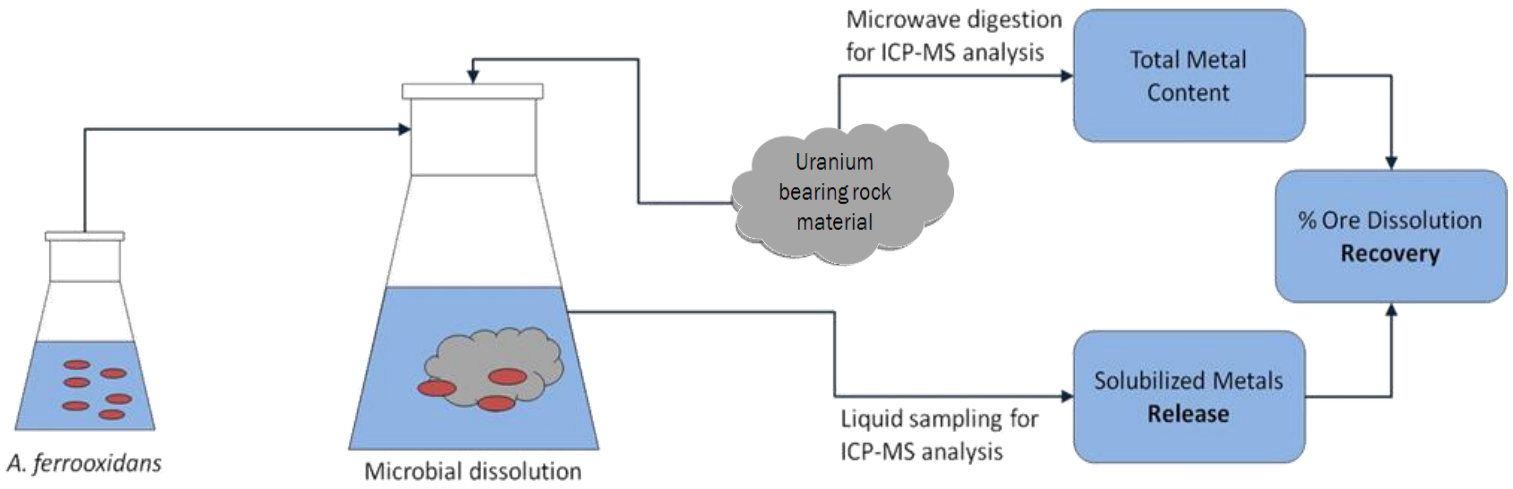
Experimental Design

- Standard conditions
  - Particle size of rock: <200 mesh
  - Solid-liquid ratio: 1:20
  - Nutrient solution: Modified TK media (KH_2PO_4, $MgSO_4$, $(NH_4)_2SO_4$)
  - Bacterial culture: *Acidithiobacillus ferrooxidans*

Treatment I.D.	Inoculated*	Nutrient media pH	Iron addition**
1	**no**	2.5	no
2	yes	2.5	no
3	yes	**4.8**	no
4	yes	2.5	**yes**

*Inoculum= 5 mL laboratory cultured *A. ferrooxidans* , 2.4×10^7 cells mL^{-1}

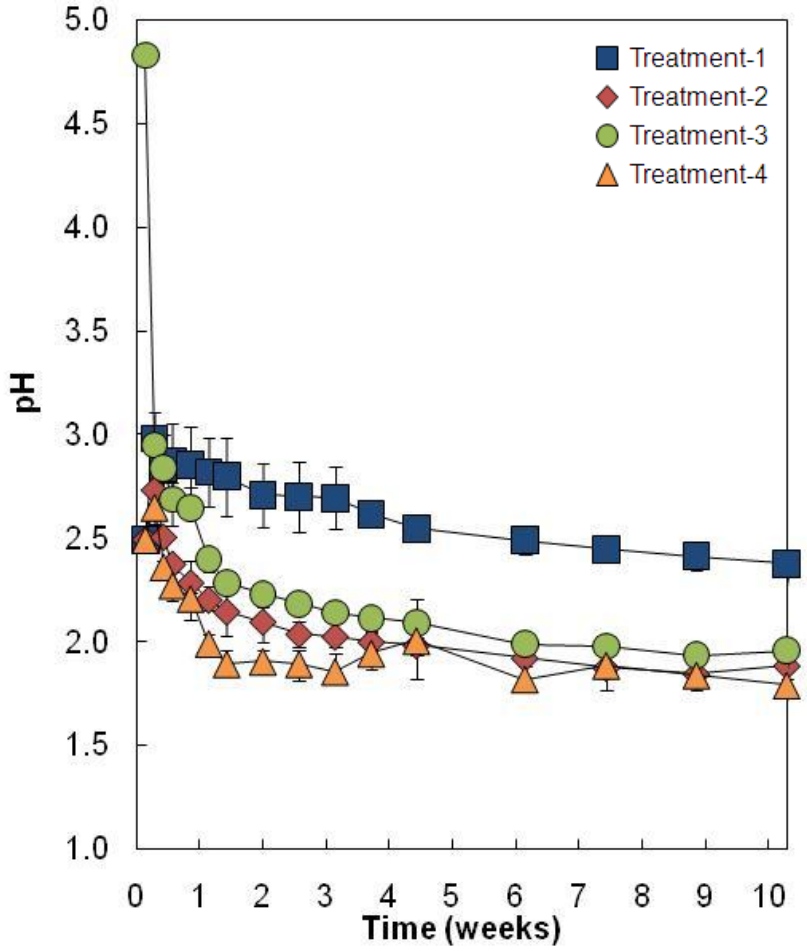
**Equivalent to 10% total iron content of ore added every fifth day

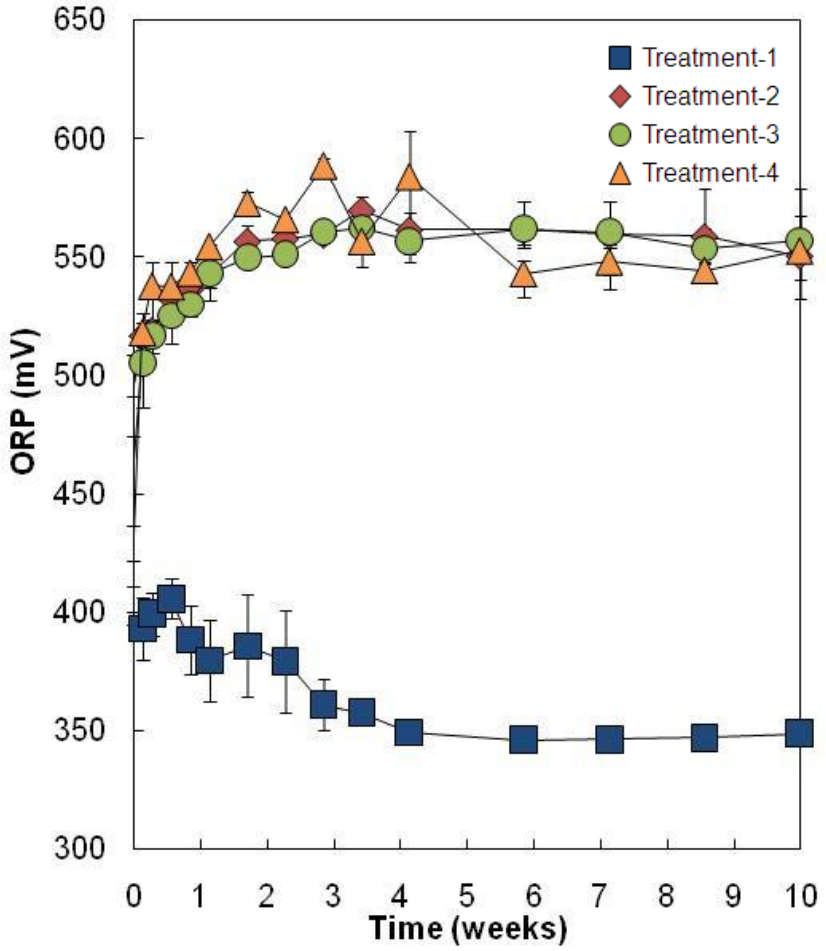


Results

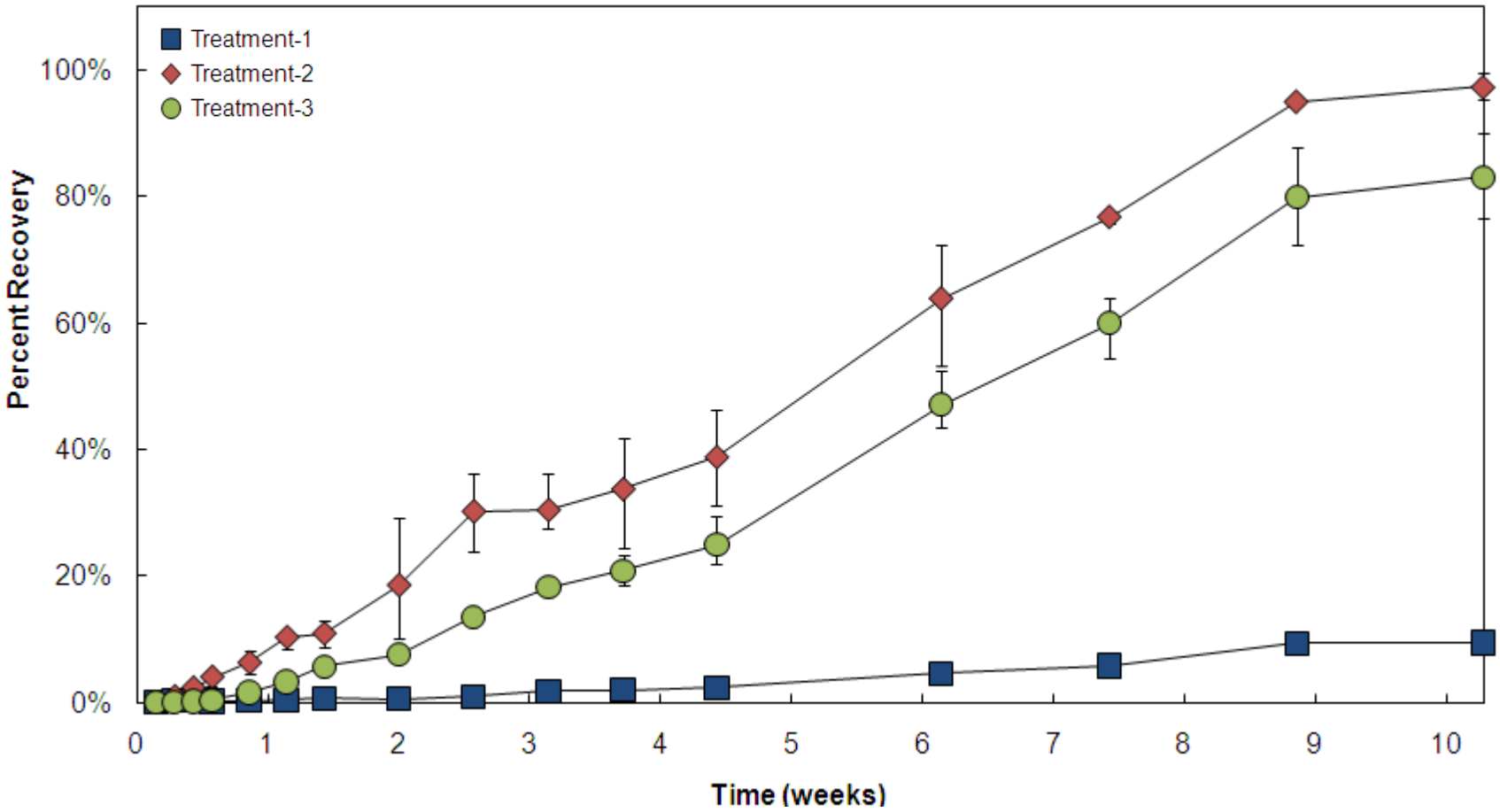
- Change in pH and Oxidation Reduction Potential
- Iron Recovery
- Uranium Recovery
- Rare Earth Element Recovery

pH & Oxidation-Reduction Potential



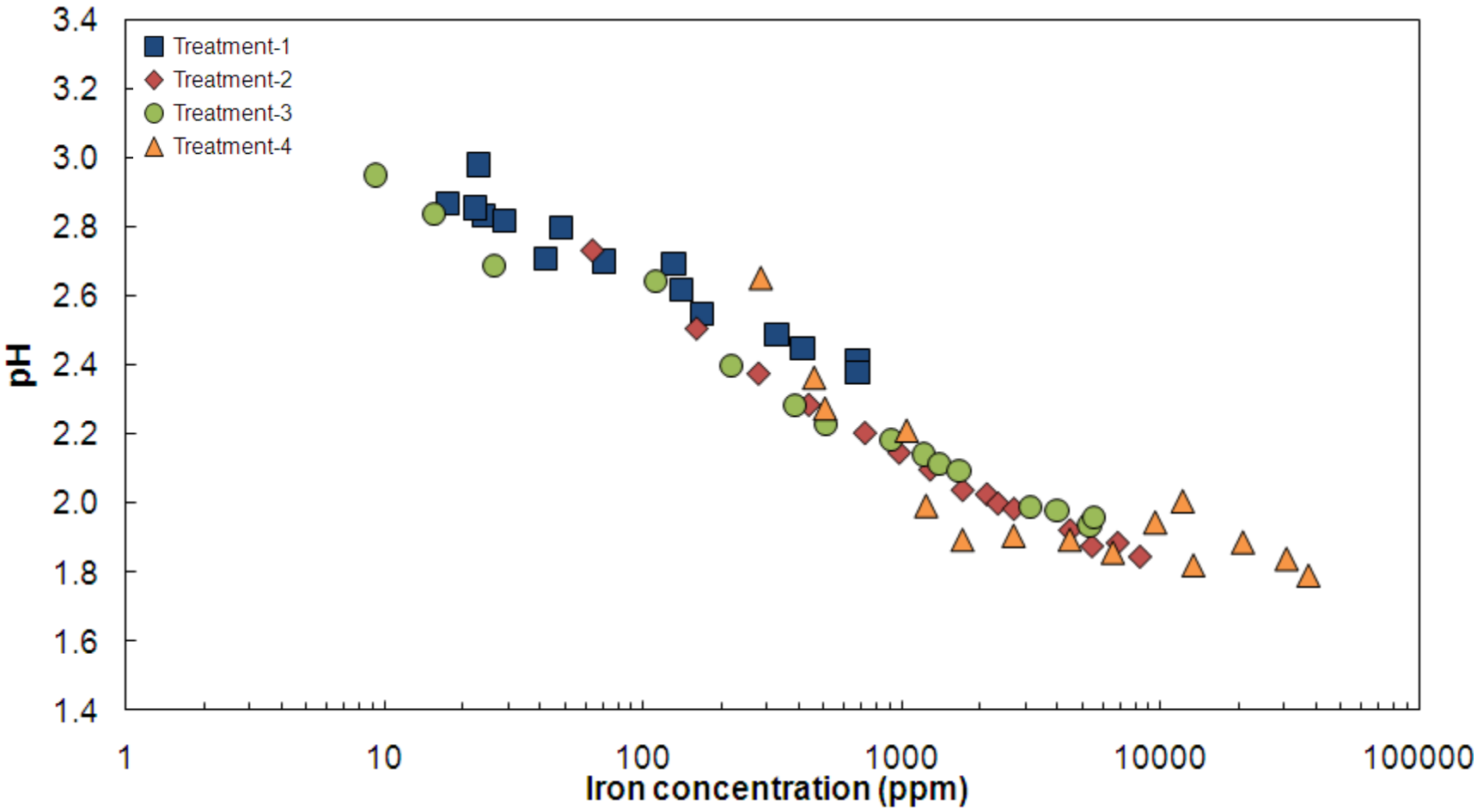


Iron Recovery

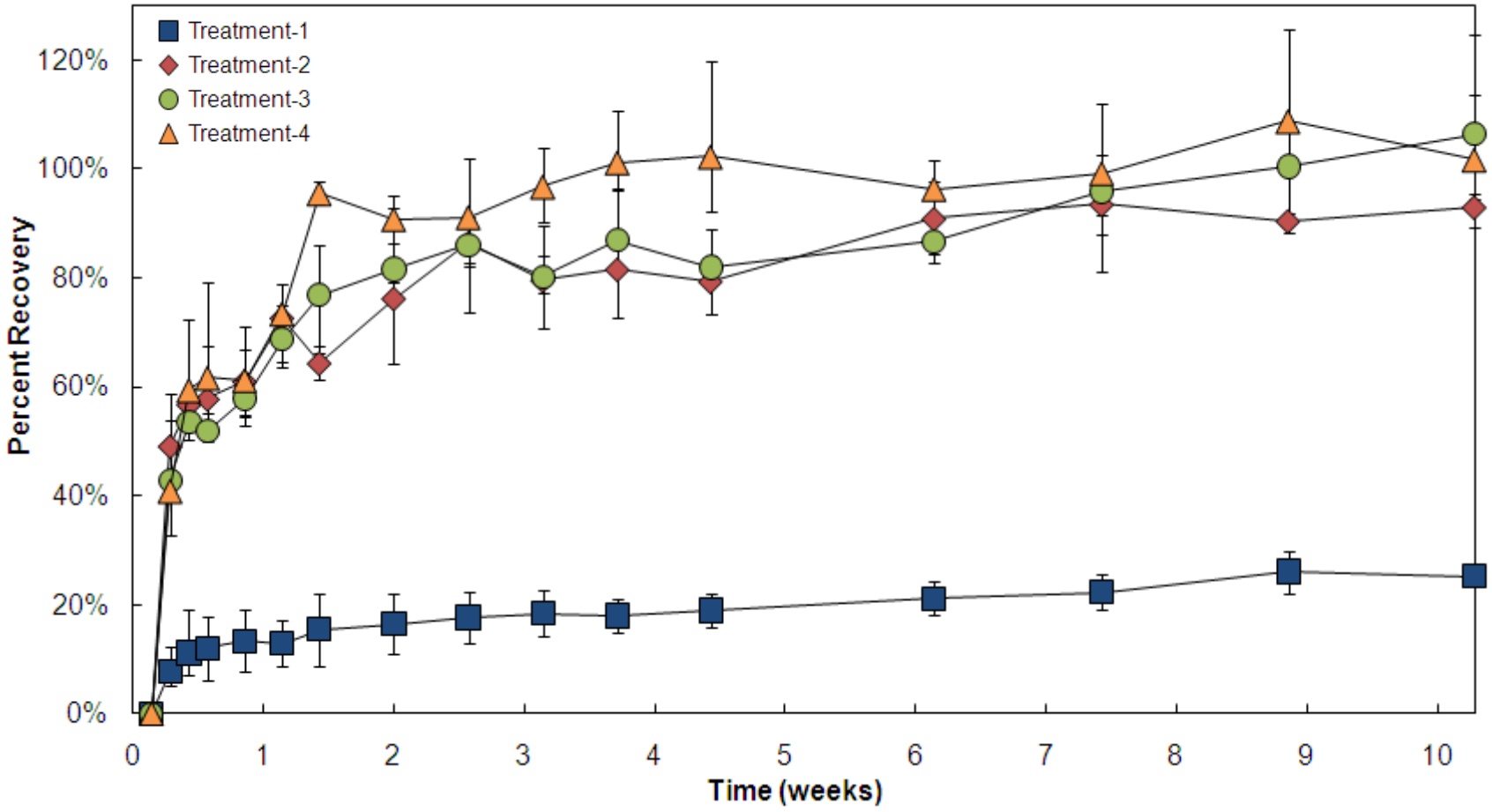


Iron Concentration & pH

t=10 weeks

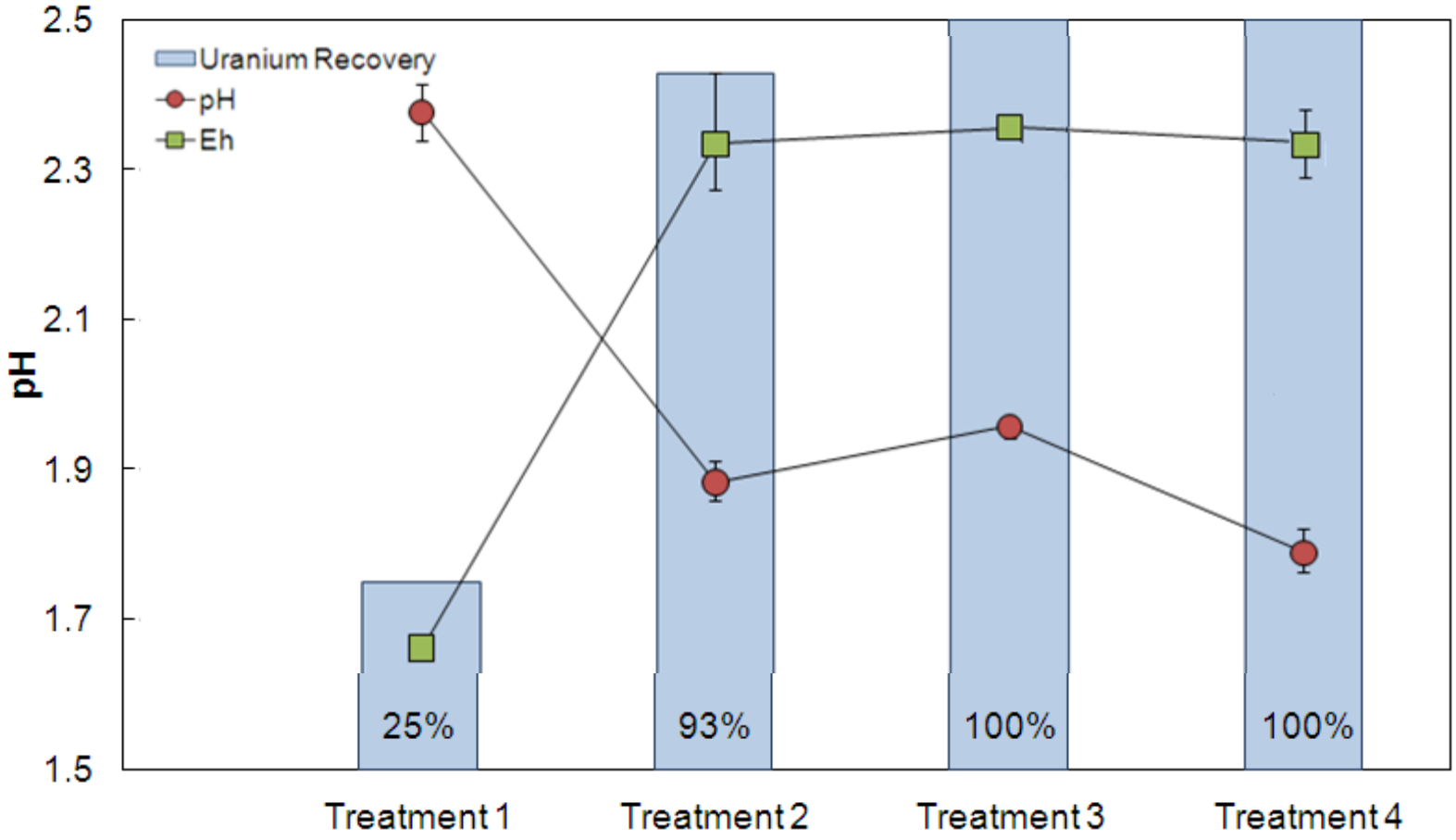


Uranium Recovery



Uranium Recovery

t=10 weeks



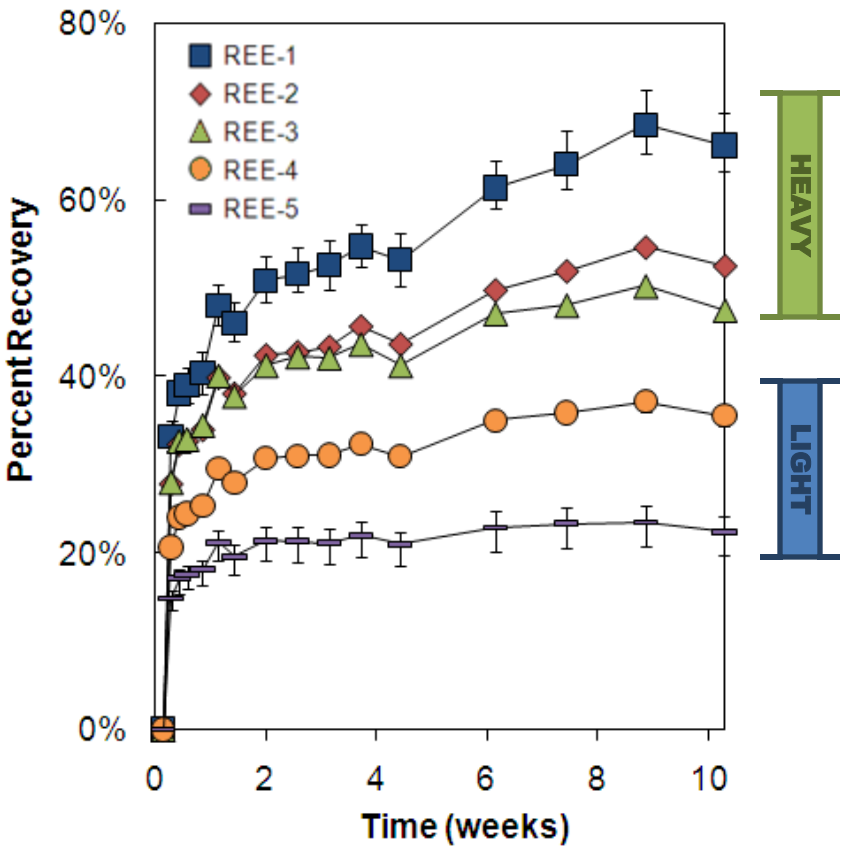
Rare Earth Element Recovery

- Five groups for REE recovery
  - Separation of heavys and lights

Rare Earth Element	Symbol & Atomic Weight	Recovery Group
Luterium	Lu-175	REE-1
Ytterbium	Yb-172	
Thulium	Tm-169	
Erbium	Er-167	
Holminm	Ho-165	
Dysposium	Dy-163	
Terbium	Tb-159	REE-2
Gadolinium	Gd-155	REE-3
Europium	Eu-153	REE-4
Samarium	Sm-149	
Neodymium	Nd-146	REE-5
Praeseodymium	Pr-141	
Lanthanum	La-139	

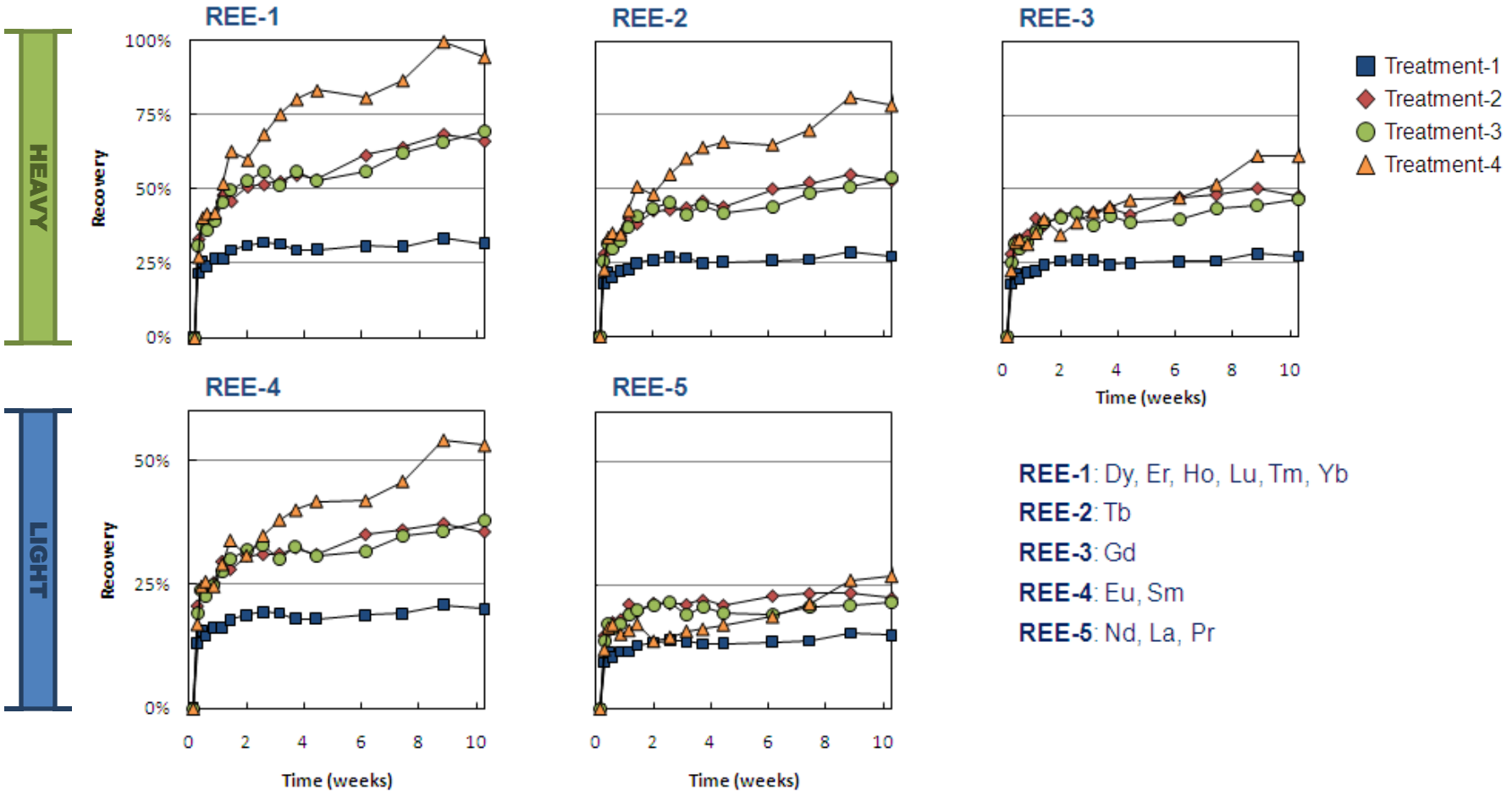
HEAVY

LIGHT



Treatment-2

Rare Earth Element Recovery



Conclusions

Uranium:

1. **Excellent recovery of uranium** from rock samples originating from Pele Mountain Resources' Eco Ridge uranium project site can be achieved using *A. ferrooxidans*.

Rare Earth Elements:

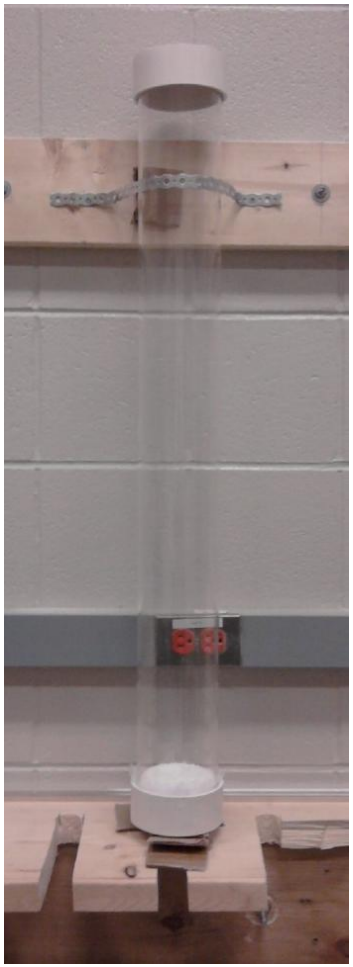
2. **Successfully extracted** into solution with the bioleaching of the uranium-bearing rock samples, presenting possible economic benefits.

Acid Generating Potential:

3. Microbially mediated iron-oxidation increased the ORP and decreased the pH of the system, with almost **complete oxidization** of iron from the rock material.
4. The resulting residue is expected to be completely devoid of iron-sulphides, **minimizing the acid generating potential** of the residual waste material.

Current Work

- **Experimental work is continuing:**
  - Larger size material and leach column testing to confirm the uranium, REE and iron recoveries obtained with shake flask testing.
  - Geo-chemical analysis to be conducted on residual samples to further investigate the dissolution of iron sulphides.



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