

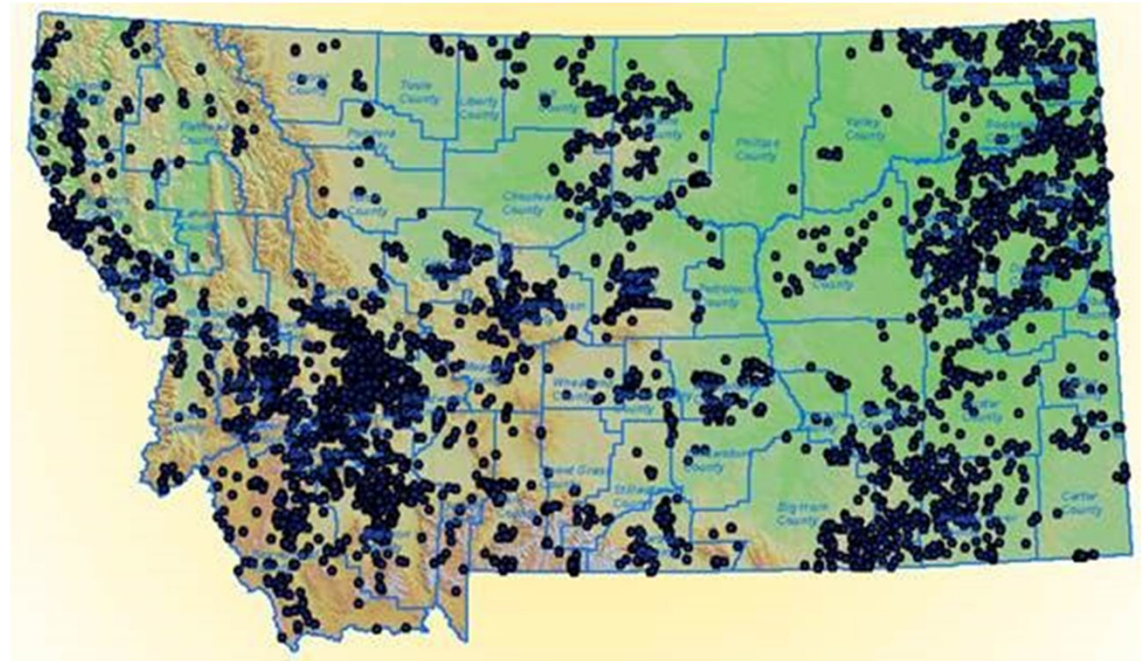
Identification of Rare Earth Element Occurrences in Mine Waste Throughout Montana

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REE search

- REE demand continuing to increase
- MT targeted for search
- First year of project
- 400 samples taken



Sampling

- Streams/Seeps



- Wells



Sampling

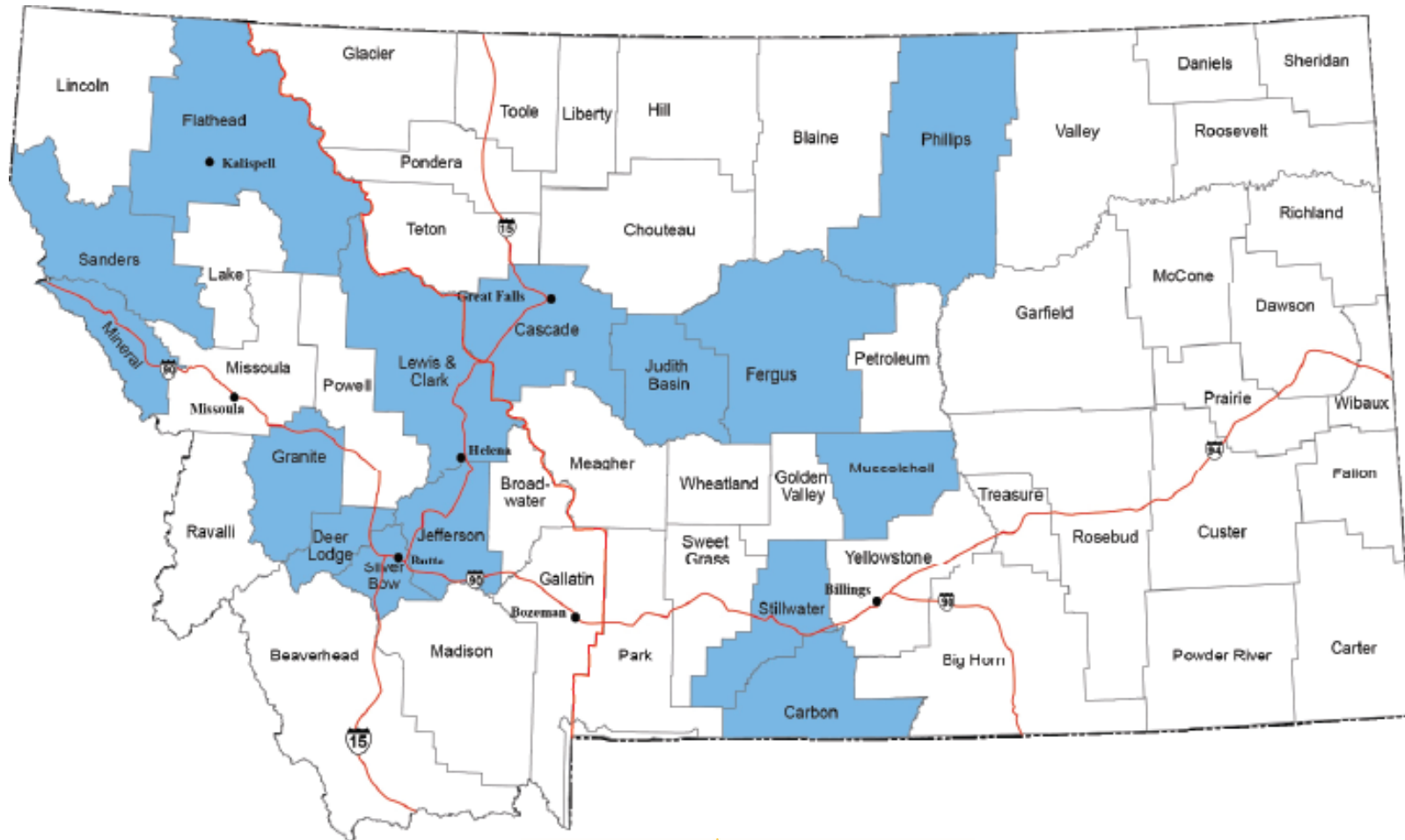
- Waste Piles



- Water Treatment Facilities

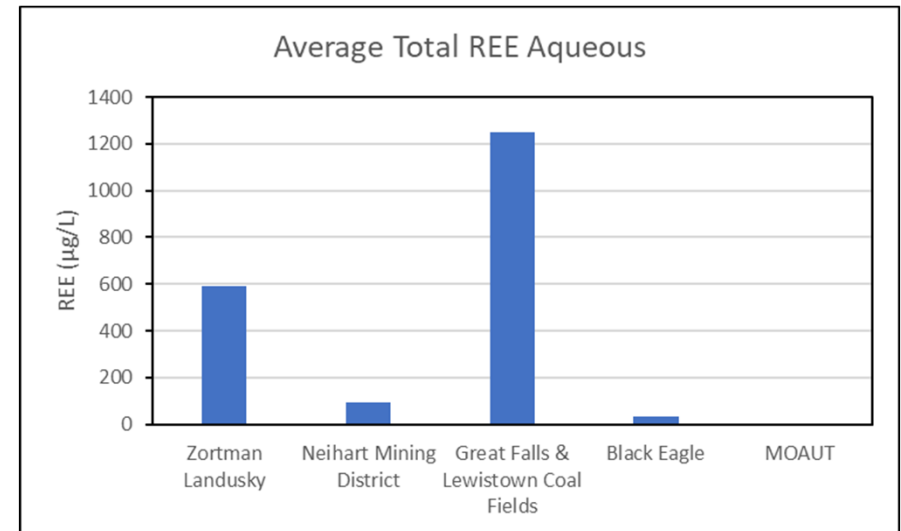
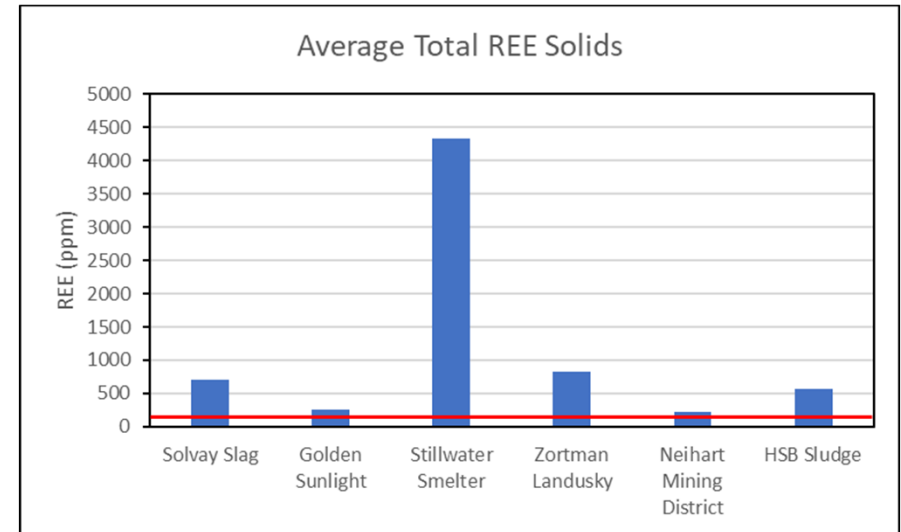


Southwest & Central Montana



Central Montana

- Zortman Landusky Mine
- Stillwater Mine
- Neihart Mining District



Zortman Landusky Mine

- Mining occurred from 1890, closing in 1998 due to company going bankrupt
- Three water treatment plants built during remediation
- Highest total REE value observed ~2000 ppm. For aqueous samples the highest value observed was ~4000 µg/L

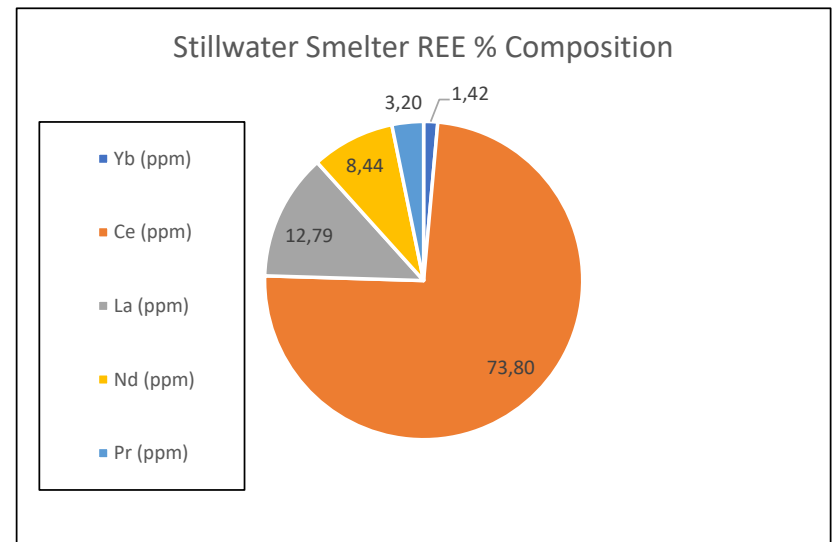


Zortman Landusky Solids (ALS) Statistics					
Sample ID	Coutl	Total REE (ppm)	Average REE	Minimum REE	Maximum REE
BioPlant Carbon	0.93	153.54	9.97	0.20	54.70
L-83	1.68	499.66	29.69	0.97	127.00
L-91-Vent	0.78	69.13	4.28	0.14	25.70
Landusky WTP Sludge	2.22	1,876.09	110.61	1.30	513.00
Swift Sludge	1.92	955.27	26.43	0.33	281.00
Zortman WTP Sludge	1.15	1,998.65	118.26	0.70	643.00
ZL-Slag (12' deep Alabama pit)	1.21	140.00	8.98	0.18	45.30
ZL-Sludge-1	1.03	1,043.43	62.95	1.30	373.00
ZL-Sludge-2	0.88	788.31	53.97	0.60	317.00
ZL-Sludge-3	0.79	755.60	46.27	0.50	324.00

Stillwater Mine

- Active mine, mining and processing Platinum group elements
- Main ore body is the JM-REEF, very high in REE
- Highest total REE value observed ~8000ppm

Stillwater Smelter Statistics					
Sample ID	Coutl	Total REE (ppm)	Average REE	Minimum REE	Maximum REE
Slag-Stillwater Mine	0.13	7,948.27	468.04	0.06	5880.00
Stillwater Mill Conc.	0.14	698.86	41.93	0.04	518.00



breakdown of REE concentrations for every solid sample taken from the Stillwater Smelter. Elements with less than 1% concentration were removed.

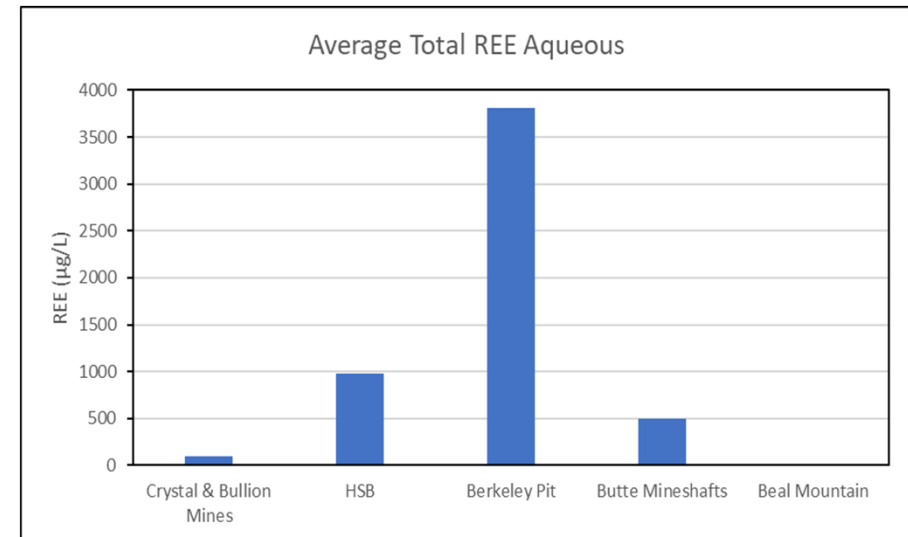
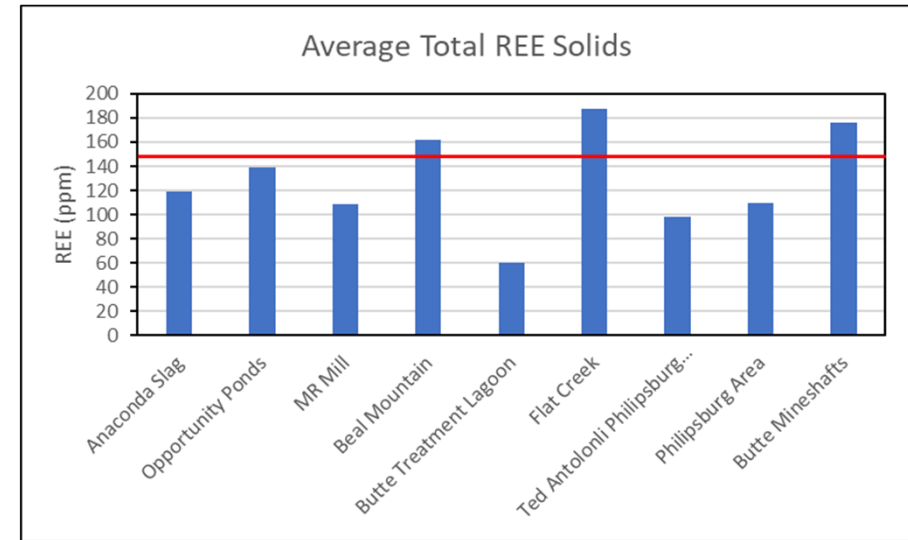
Neihart Mining District

- Historic mining district, beginning in 1890 & ending in 1945
- 31 samples collected, half of the district is still unsampled
- On average the total REE concentration was about 200ppm for solid samples. Aqueous samples ranged from 0.38 to 705 $\mu\text{g}/\text{L}$



Southwest Montana

- Berkeley Pit & Horseshoe bend
- The Solvay Plant
- Philipsburg Mining District



The Berkeley Pit and Horseshoe Bend WTP

- 1984 the Berkeley pit began to fill with water
- Berkeley Pit water is pumped to the HSB WTP for treatment
- Highest Total REE for sludge is ~900ppm. Berkeley Pit water ranged from 2400 to 5100 $\mu\text{g/L}$



HSB Sludge Statistics					
Sample ID	Coutl	Total REE (ppm)	Average REE	Minimum REE	Maximum REE
HsB-Stage 1	0.97	32.00	2.04	0.05	11.20
HsB Stage 2	1.68	707.85	41.93	0.60	213.00
HSB-WTP-Stage1, BP, Jan 23	1.61	700.56	44.07	2.74	208.00
HSB-WTP-Stage1 Feb 23	1.64	653.35	41.09	2.50	197.00
HsB 1st stage clarifier, HsB	1.86	397.82	24.86	1.81	112.70
HsB 1st stage clarifier, HsB 5/23/2023	2.11	902.47	56.40	3.30	284.47

The Solvay Plant

- Constructed in 1950 for the production of elemental Phosphorous
- Closed in 1997, leaving phosphorus sludge, slag and waste piles
- Total REE values range from 680 to 720ppm

Solvay Slag Statistics					
Sample ID	Coutl	Total REE (ppm)	Average REE	Minimum REE	Maximum REE
Solvay Slag #1	5.57	684.49	40.79	0.50	269.00
Solvay Slag #2	5.70	714.32	45.14	1.86	283.00
Solvay Slag #3	5.66	710.43	44.93	1.95	280.00
Solvay Slag #4	5.68	721.60	45.64	1.92	285.00
Solvay Slag #5	5.71	693.19	41.30	0.70	274.00
Solvay Slag #6	5.67	701.98	44.39	1.82	278.00



Coutl Outlook Coefficient

- Ratio of high demand REE to more abundant REE
- Tied directly to economic values of REE and will change as the values of REE changes
- The higher the Coefficient, the greater potential industrial value

Southwest MT Solids Average Coutl	
Sample Site	Average Coutl
Montana Resources	0.77
Montana Resources Mill	0.79
Anaconda	0.89
Solvay	5.66
Golden Sunlight	0.69
Opportunity Ponds	0.81
Stillwater	0.14
Phillipsburg	1.33
Mammoth Mine	0.78
Mean Southwest MT	1.32

Southwest MT Aqueous Average Coutl	
Sample Site	Average Coutl
Berkeley Pit	1.19
HSB	1.96
Butte Flooded Mines	4.65
Beal Mountain	3.14
Upper Bullion	1.60
Lower Bullion	0.96
Crystal	1.56
Mean Southwest MT	2.15

Central MT Solids Average Coutl	
Sample Site	Average Coutl
Zortman	1.12
Flat Creek	0.97
Neihart Mining District	0.66
Mean Central MT	0.92

Central MT Water Average Coutl	
Sample Site	Average Coutl
Black Eagle	5.56
Belt	1.71
Zortman	2.04
Neihart Mining District	1.83
Mean Central MT	2.78

Conclusion

- Preliminary results promising
- Central MT trended higher
- Important for the future



Acknowledgments

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