



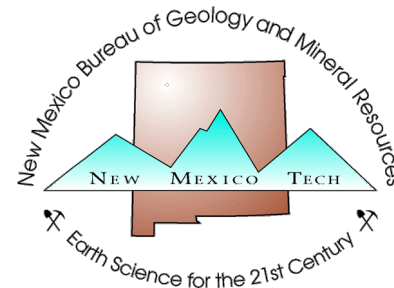
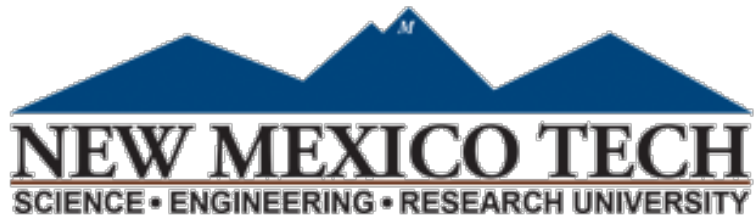
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CRITICAL MINERALS AND ACID MINE DRAINAGE IN BLACK HAWK MINE WASTE, GRANT COUNTY, NEW MEXICO

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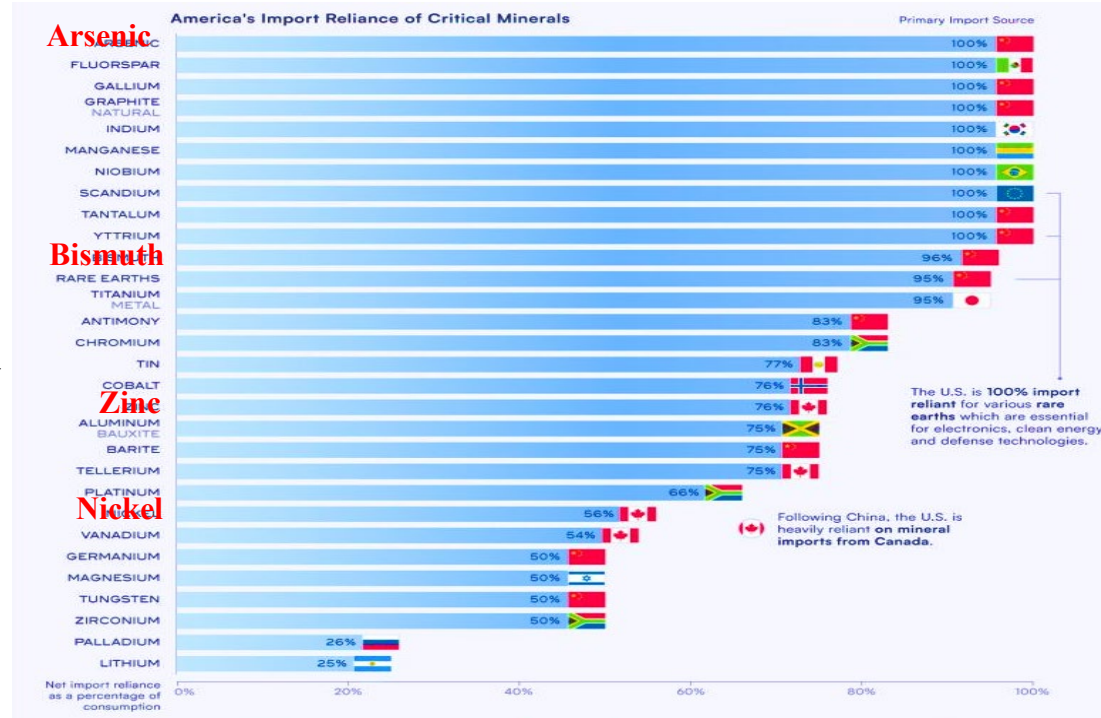
Acknowledgments

- This work is part of ongoing research of the economic geology of mineral resources in New Mexico at NMBGMR, Dr. Michael Timmons, Director and State Geologist.
- This study was partially funded by the USGS Earth MRI Cooperative Agreements No. G23AC00373 (mapping of Black Hawk area) and G22AC00510 (critical minerals in mine wastes).
- Thanks to Jacob Newcomer for his contribution to conducting the XRD analysis, and to Sebastian Griego and Abena Acheampong-Mensah for their assistance in performing the paste pH and collecting samples.

Introduction

Critical minerals

- Important to U.S. green/clean energy development
- Continued advancement of technology
- Identifying and producing critical minerals in New Mexico may directly benefit the economy

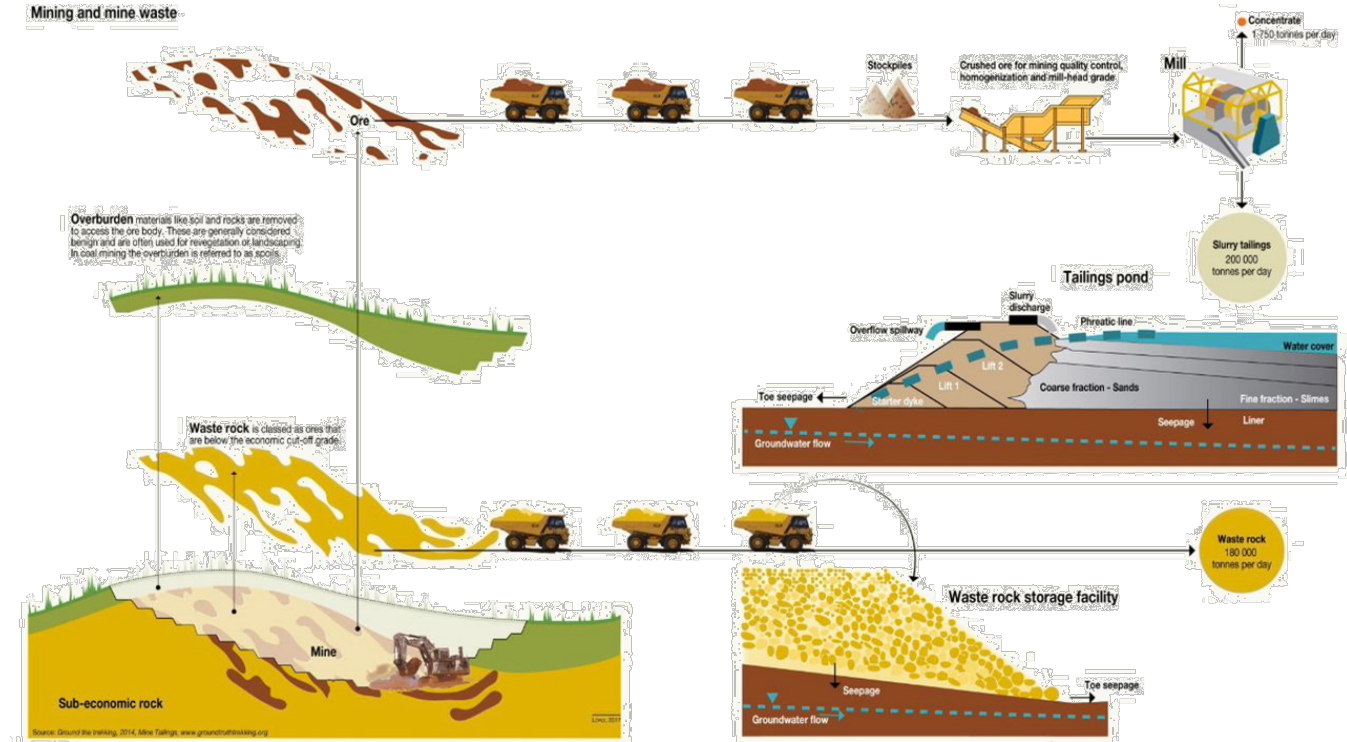


America's import reliance of critical minerals. Designed by Pernia Jamshed by using USGS data (2023).

Introduction

Mine Wastes

- In the original mine production, base and precious metals and not the critical minerals were produced.
- Mine wastes would contain any critical minerals in addition to those minerals that are present in the deposit.



A mining operation, showing a typical process in an open-pit mine, from excavation to waste disposal. Image by Kristina Thygesen/GRID-Arendal

Introduction

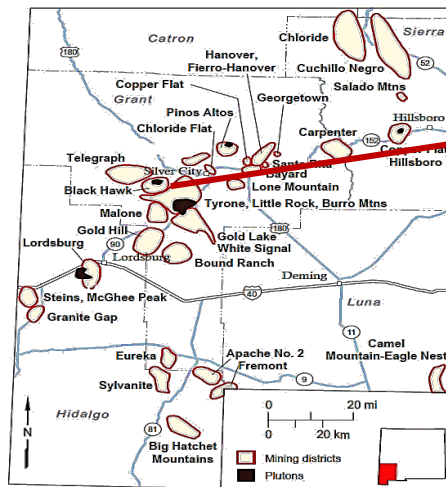
- Acid rock drainage occurs in mine waste rock, tailings, pits and underground workings.
- pH levels can influence the mobility and availability of critical minerals.
 - Rare earth elements (REEs) are more soluble in acidic environments.
- New Mexico has more than 15,000 abandoned mines.
 - Need to classify these waste dumps to understand their chemical composition, and mineralogy, and to evaluate their potential critical mineral value.

Location and Geology

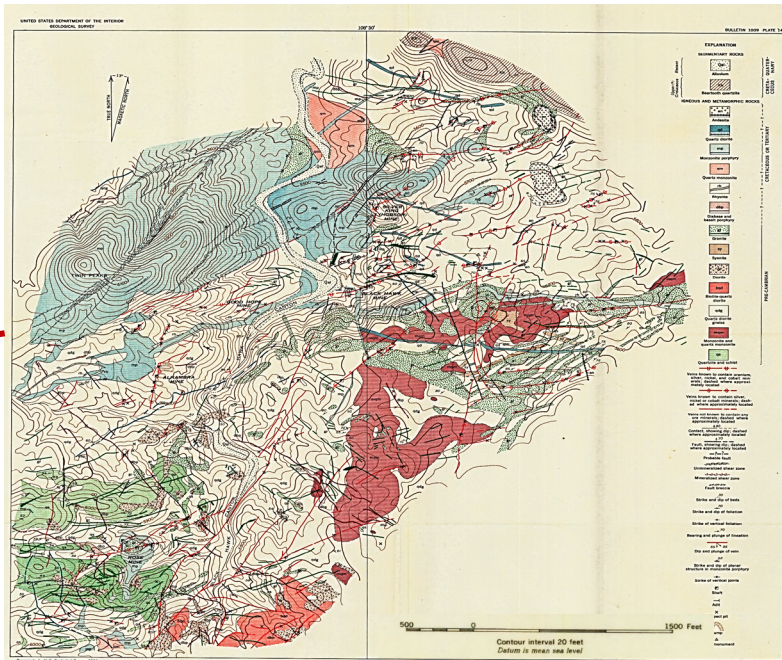
- The Black Hawk District is located in Grant County, NM.

- Deposit is classified as arsenide five-element vein deposits.

- From 1881 to 1960 the district produced Ag, Cu, Pb, Au, and some tungsten and fluorite.



Southwestern New Mexico districts with Laramide mineral deposits, polymetallic veins, and plutons (McLemore, 2008).



Geologic map of the Black Hawk mining district, Grant County, New Mexico. From (Gillerman & Whitebread, 1953).

What are arsenide five-element veins?

- Contain Ag-**Co-Ni-Bi-As** with local U, **Cu**, Pb, **Zn**, **Sb**, Hg, and others.
- Ag, **Bi**, and **As** generally occur as native elements; **Co** and **Ni** as arsenides and/or sulfides.
- Carbonates such as calcite and dolomite are the most common gangue minerals, although barite, quartz, and fluorite may be locally present.
- Unusual deposit type, as these elements have different chemical properties and aren't normally found together in the same environment.
- Generally mined as high-grade, low-tonnage Ag deposits.

Materials and methods

Sampling and sample preparation

- Samples were collected and separated as fines and coarse
- Clean equipment
- Suitable sampling tools
- Disposable gloves while sieving



Black Hawk mine wastes



0 15 30Meters

• waypoints
■ WasteRockPiles

Black Hawk mine waste sample locations

Materials and methods

Geochemical analyses

- ALS and the USGS laboratories
- Uncertainty of analyses is generally $<5\%$.

Mineralogy

- X-ray diffraction (XRD)



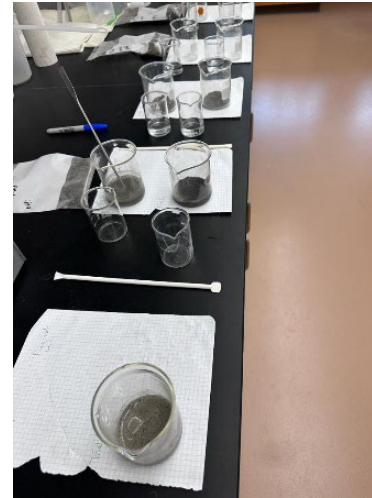
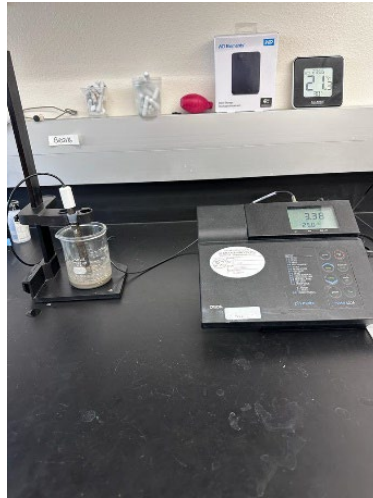
Preparing Black Hawk samples to perform XRD analyses

Materials and methods

Paste pH and fizz test

- To assess the geochemical behavior of mine waste materials subject to weathering in the field

Black Hawk mine waste samples pH Paste and fizz tests

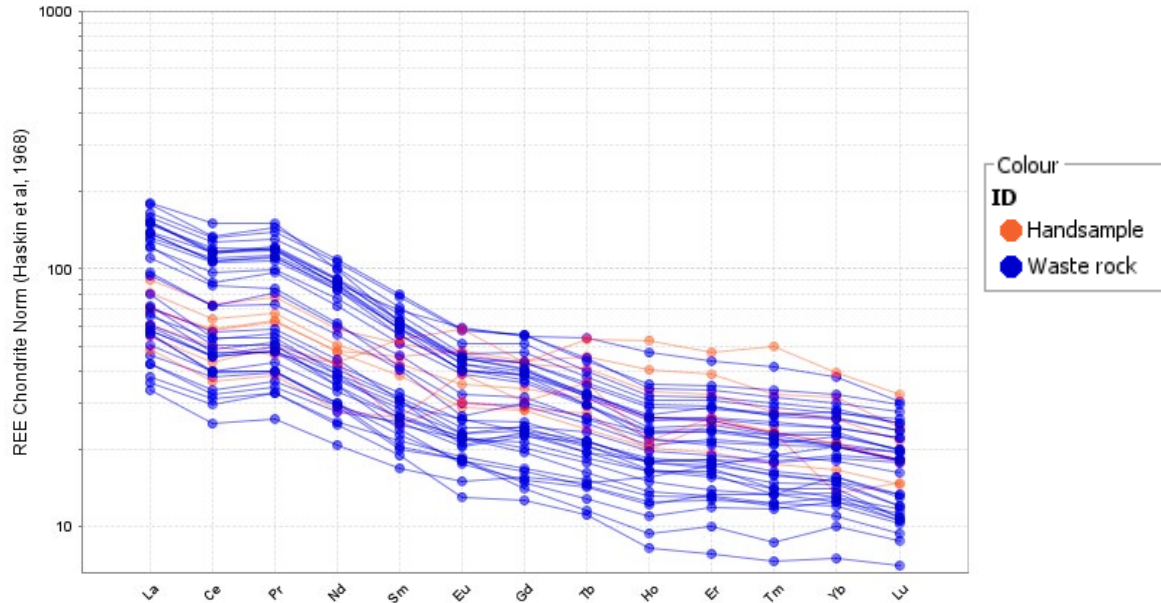


Results and discussion

Critical minerals in mine waste

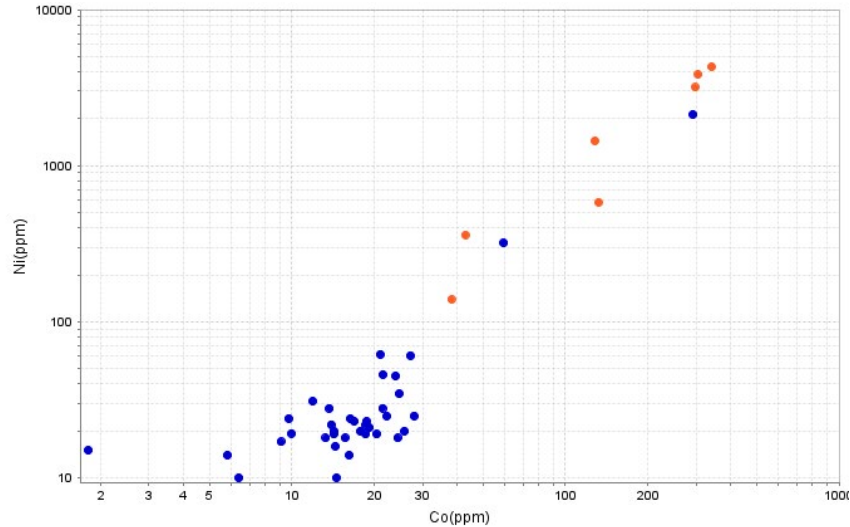
- Chemical plots were created using ioGAS-64

Chondrite normalized REE diagrams of Black Hawk mine waste samples showing LREE enriched profile

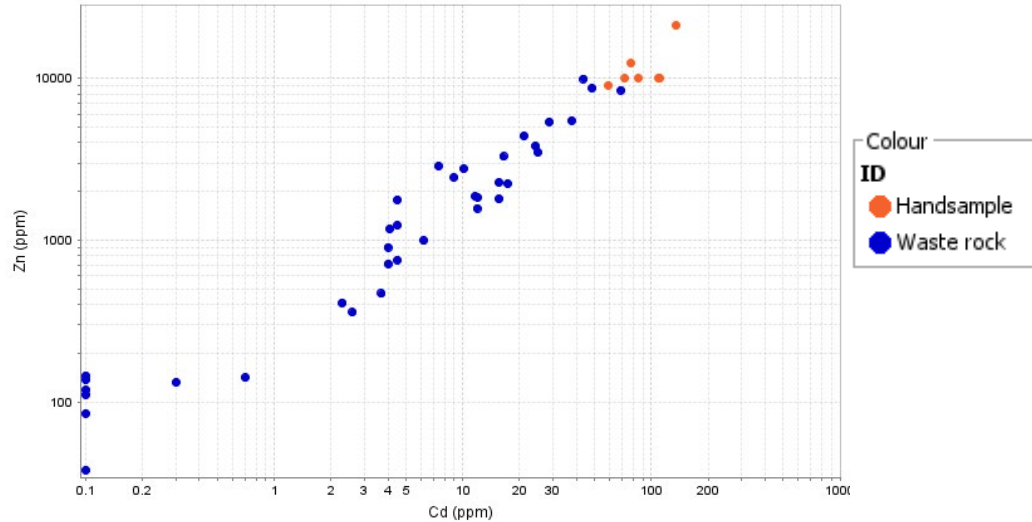


Results and discussion

Critical minerals in mine waste



Positive and strong correlation (0.94)
between nickel (Ni) and cobalt (Co)

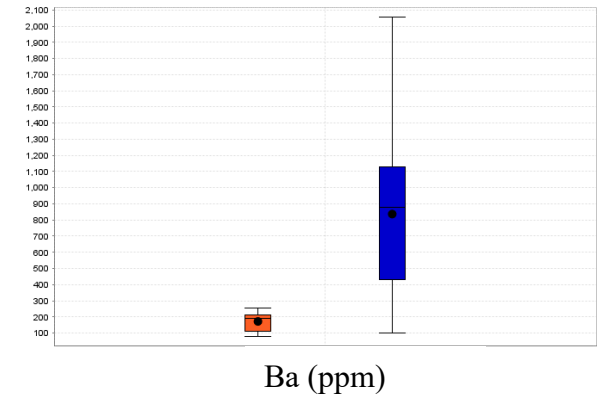
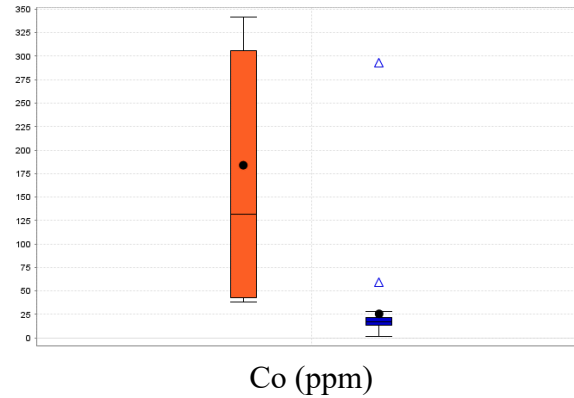
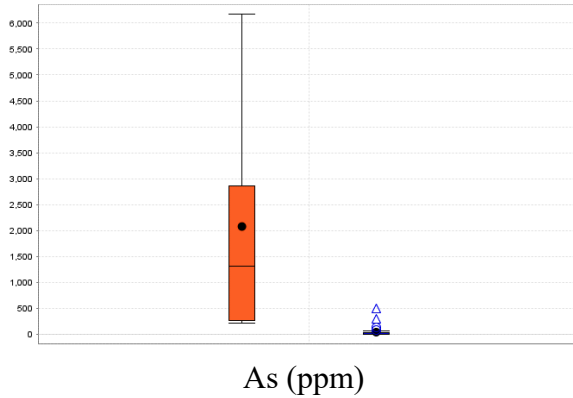


Positive and strong correlation (0.95)
between zinc (Zn) and cadmium (Cd)

Results and discussion



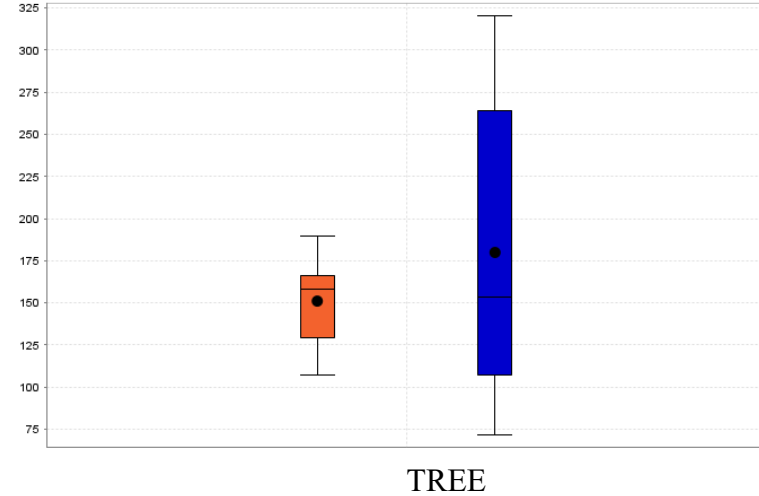
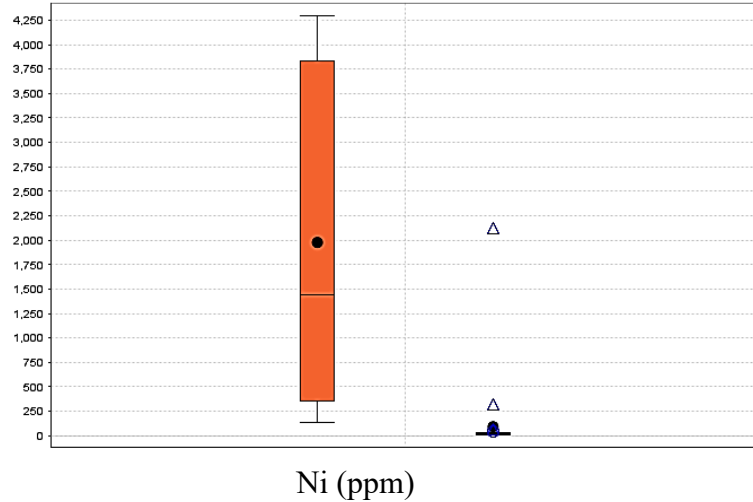
Based on Black Hawk mine waste chemistry results



Black Hawk District samples are elevated in arsenic (**As**), cobalt (**Co**), and barium (**Ba**).

Results and discussion

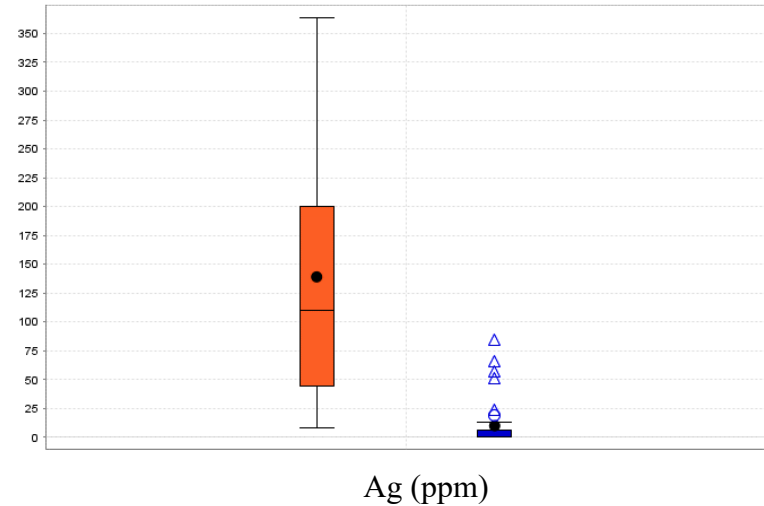
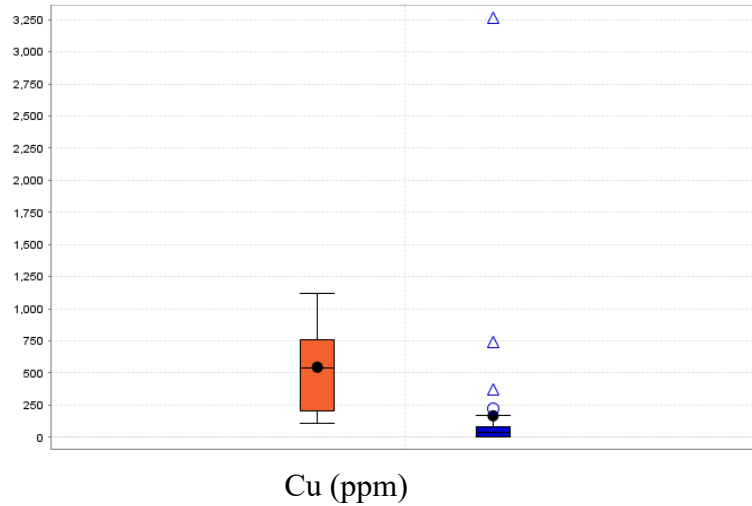
Based on Black Hawk mine waste chemistry results



Black Hawk District samples are elevated in nickel (**Ni**), and TREE.

Results and discussion

Based on Black Hawk mine waste chemistry results



Black Hawk District samples are elevated in copper (**Cu**) and silver (**Ag**).

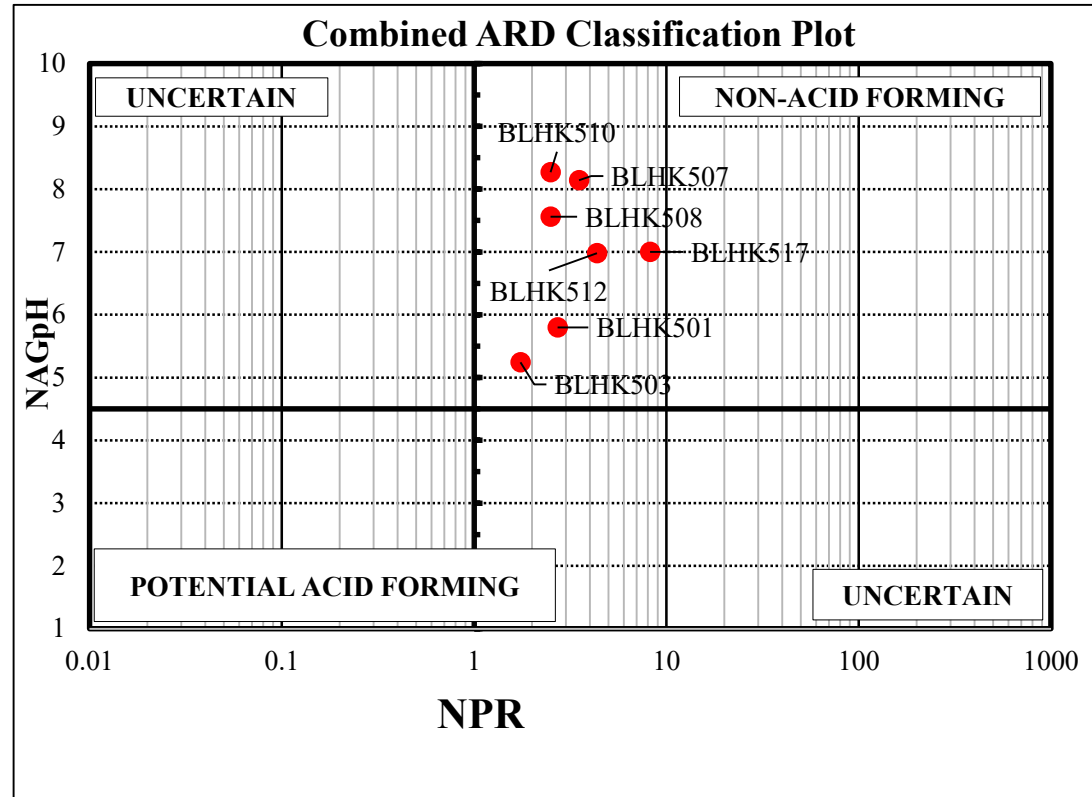
Results and discussion

Based on Black Hawk mine waste XRD results

- 10 samples were collected.
- Quartz (SiO_2) is the most predominant mineral.
- Sample BLHK505 shows sphalerite (ZnS) along with dolomite ($\text{CaMg}(\text{CO}_3)_2$) and quartz.
- Samples show the presence of clay such as illite, kaolinite ($\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$), and albite ($\text{NaAlSi}_3\text{O}_8$).

Results and discussion

Paste pH tests and Net Acid Generation graph



Preliminary conclusion

- Identifying critical minerals is seen as crucial for enhancing the overall economic well-being of the United States.
- The presence of critical minerals in waste material could be of economic interest.
- Based on Black Hawk mine waste chemistry results Black Hawk District mine waste samples are elevated in critical minerals such as **arsenic, cobalt, barium, copper, nickel, zinc, and TREE**.
- Determination of acid-generating potential in the area suggests that Black Hawk District mine wastes are in non-acid-forming quarters.

Future work

- Whole rock geochemistry and trace element analyses
- X-Ray diffraction to better understand the mineralogy
- Bulk density to determine the mass of mine waste
- Estimating critical minerals endowment

Questions?

Comments?

Thank you!