Geochemistry of critical minerals in Black Hawk District, Grant County, New Mexico

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Abstract

The state of New Mexico has tens of thousands of inactive mines in 274 districts, including coal, uranium, metals, and industrial minerals districts. However, many of these mines remain unexamined and lack prioritization for reclamation. Many legacy mine waste deposits have commodities and critical minerals, due to low recovery processes during past production. The project aims to characterize and estimate critical minerals endowments of mine wastes, particularly in the Black Hawk District mine wastes in Grant County, New Mexico, emphasizing mineralogical and geochemical analysis. This initiative is crucial for New Mexico, as it addresses the need to identify critical mineral resources before land decisions are made. Potential critical minerals include As, Ni, Co, and Sb. The pH levels in the Black Hawk District mine wastes ranging from 6.30 to 8.62, likely attributed to the existence of carbonates. The disparities in particle size fractions and their distribution along the slope are typically influenced by natural factors like gravity and pre-mining hydrothermal alteration, as well as operational activities such as the piling or dumping of materials. The project not only benefits the economy through potential future mining but also considers reclamation efforts and includes training for young geologists and students in economic and reclamation geology. Future work will delve into mineralogy, particle size correlation, and further estimation of critical mineral endowment in New Mexico's mine wastes.

Introduction

- Critical minerals are nonfuel minerals that are essential to the economic and national security of a country whose sources are vulnerable to disruption.
- Critical mineral resources in New Mexico must be recognized before government authorities withdraw land from mineral entry, or make other decisions regarding land use (Fig. 1).
- New Mexico has more than 15,000 abandoned mine that needs re-evaluation of the critical mineral potential and one of them is Black Hawk District, Grant Co., NM.
- This area is classified as an arsenide five-element vein deposit.
- Arsenide five-element veins (Ag, **Ni**, **Co**, **As**, and **Bi**) are hydrothermal veins.
- Other minerals include elements such as U, **Cu**, Pb, **Zn**, **Sb**, and Hg.

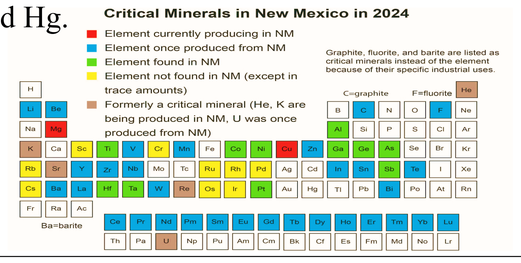

Figure 1. Periodic table showing critical minerals in New Mexico. From McLemore and Gysi (2023) as revised in McLemore, 2024.

Geologic Setting

- The Black Hawk District is located in Grant County, NM within Precambrian rocks of Burro Mountains
- The oldest rocks in the Black Hawk District belong to the Proterozoic Bullard Peak Group.
- The predominant rock in the area is Proterozoic quartz diorite gneiss.
- The area may have been affected by Laramide compression and magmatic intrusions followed by magmatism intrusions.
- In the Black Hawk District, the mineral deposits mostly occurring in quartz diorite gneiss near bodies of monzonite porphyry (Fig. 2).

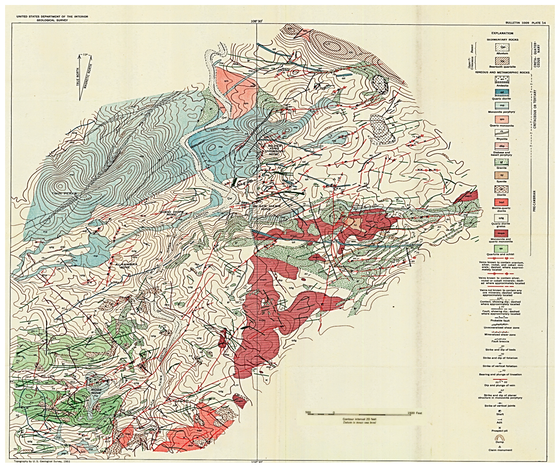

Figure 2. Geologic map of the Black Hawk mining district, Grant County, New Mexico. From (Gillerman & Whitebread, 1953).

Purpose

- Develop a sampling plan based on the understanding of geology (rock mass, etc.).
- Characterize and estimate the critical minerals in Black Hawk mine wastes
- Determine the acid-generating potential

Methodology

- Geologic mapping and developing a sampling plan
- Collect samples to represent ranges of compositional variation within a unit
- Whole rock geochemistry for major and trace elements
- XRD analysis for minerals not easily identified with optical methods
- Paste pH and fizz tests

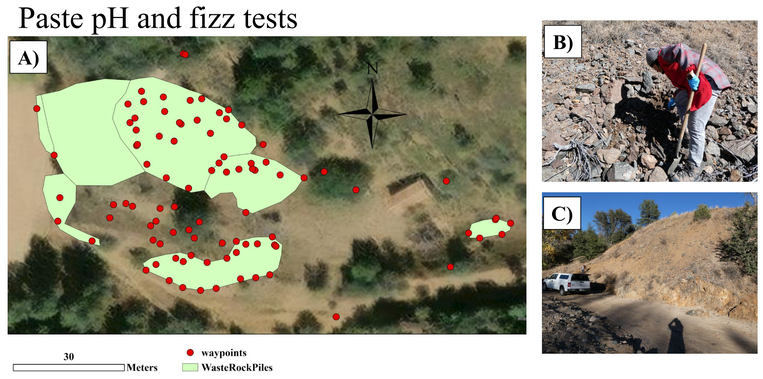

Figure 3. **A)** Black Hawk mine waste samples location, **B)** Digging hole to remove the weathered surface, **C)** Black Hawk mine wastes

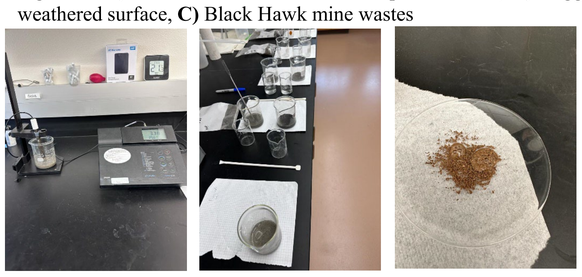

Figure 4. Black Hawk mine waste samples paste pH and fizz tests

Results and discussion

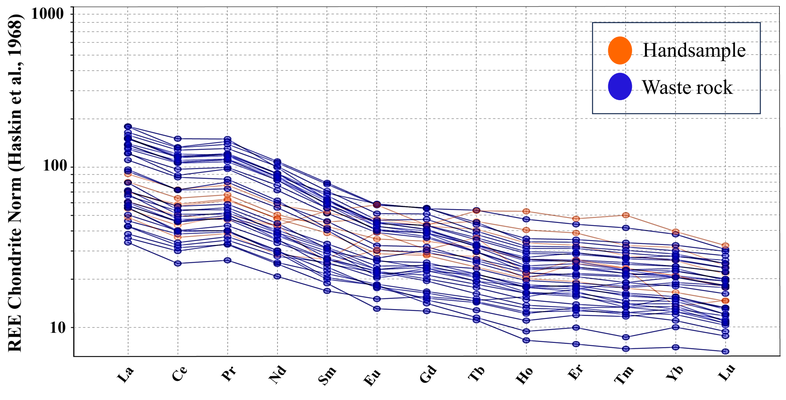

Figure 5. Chondrite normalized REE diagrams of Black Hawk mine waste samples showing LREE enriched profile.

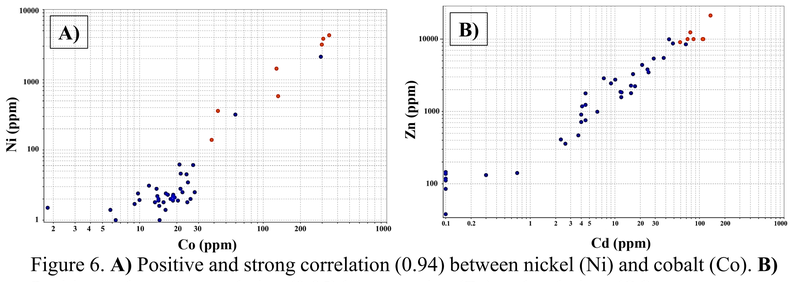

Figure 6. **A)** Positive and strong correlation (0.94) between nickel (Ni) and cobalt (Co). **B)** Positive and strong correlation (0.95) between zinc (Zn) and cadmium (Cd)

Results and discussion

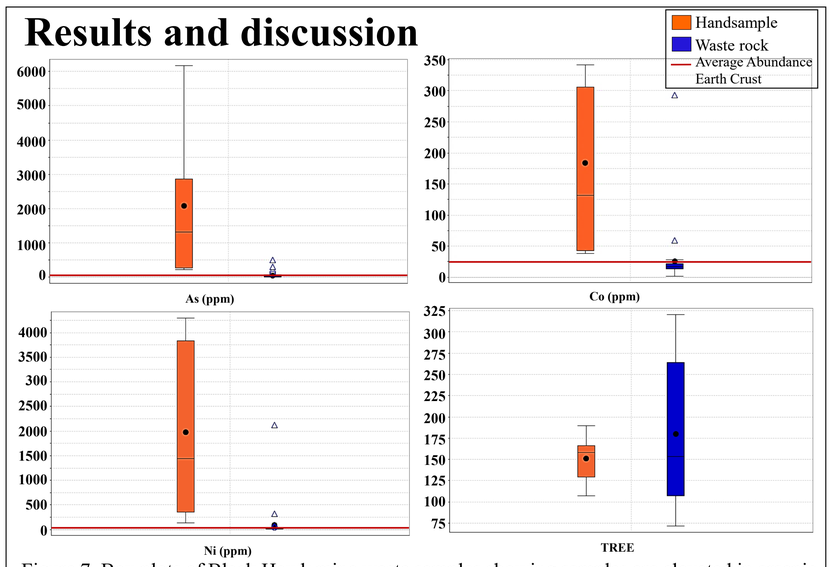

Figure 7. Box plots of Black Hawk mine waste samples showing samples are elevated in arsenic (As), cobalt (Co), nickel (Ni), and TREE.

Combined ARD Classification Plot

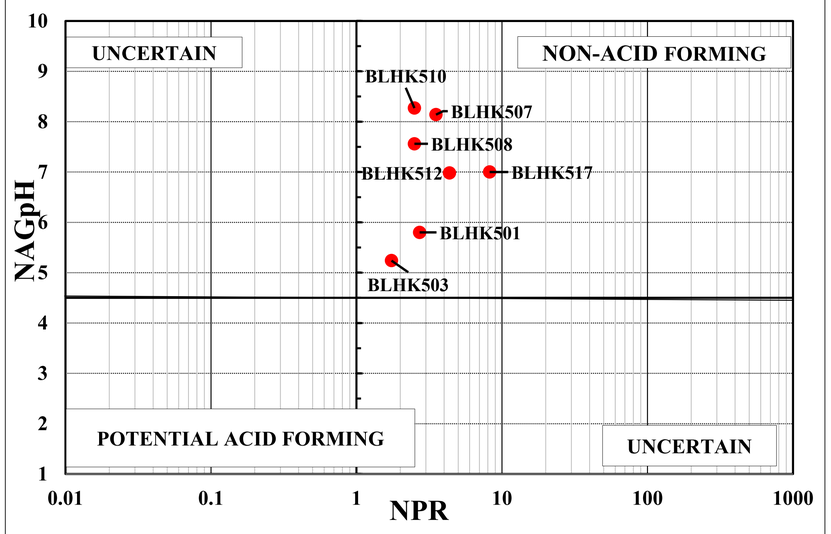

Figure 8. Acid Rock drainage (ARD) diagram of Black Hawk mine waste samples

Preliminary Conclusions

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

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

Acknowledgments

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References

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