Geochemistry of critical minerals in mine wastes at Hillsboro and Steeple Rock, New Mexico

Abena S. Acheampong-Mensah[1], Virginia T. McLemore[2]
[1]Department of Mineral Engineering, New Mexico Institute of Mining and Technology, Socorro, NM 87801
[2]New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, NM 87801

ABSTRACT

Most of our electronic equipment, such as smartphones, laptops, computer chips, wind turbines, hybrid and electric cars, etc., depend on rare earth elements (REE) and other critical minerals. This coupled with the anticipated rise in demand for critical minerals and the potential shortage of production capacity from China and other nations has made it necessary to examine the New Mexico (NM) mine wastes for its critical mineral and future mining potential. In the 274 mining districts in NM, including those for coal, uranium, metals, and industrial minerals, there are tens of thousands of inactive or abandoned mine features. These features range in depth from shallow prospect pits to 500-feet-deep mi ne shafts. To comprehend its composition, accurately estimate its volume, and determine its potential economic value, it is imperative to categorize these features. Future mining of mine wastes that potentially contain critical minerals can help pay for reclamation and clean up these sites. Critical mineral endowment of mine wastes in two mining districts in New Mexico (Copper Flat at Hillsboro and Carlisle-Center mines in the Steeple Rock district) were characterized and estimated. “Potential critical minerals at these deposits include As, Bi, Te, Zn, Co, Ni, Mg, Mn, and fluorite. pH and particle size of samples were analyzed to determine weathering and migration potential of heavy metals. Soil pH was also measured to determine the potential for acid rock drainage for several mine waste. The S present in samples from Carlisle-Center mines are mostly acid forming and can potentially cause acid mine drainage which can dissolve other minerals. Samples from Copper Flat that are nonacid forming may be used as back fill material. Most of the waste rock pile at Copper Flat is characterized by mostly relatively coarse sand fractions.

PURPOSE

- Determine the acid generating potential of mine waste in NM
- Characterize and estimate the critical minerals endowment of mine wastes in two mining districts in NM (i.e., Copper Flat at Hillsboro and Carlisle-Center mines in Steeple Rock district).
- “beta-test” USGS procedures for sampling mine wastes. Future mining of mine wastes that potentially contain critical minerals can help pay for reclamation and clean up these sites.

THE STUDY AREA

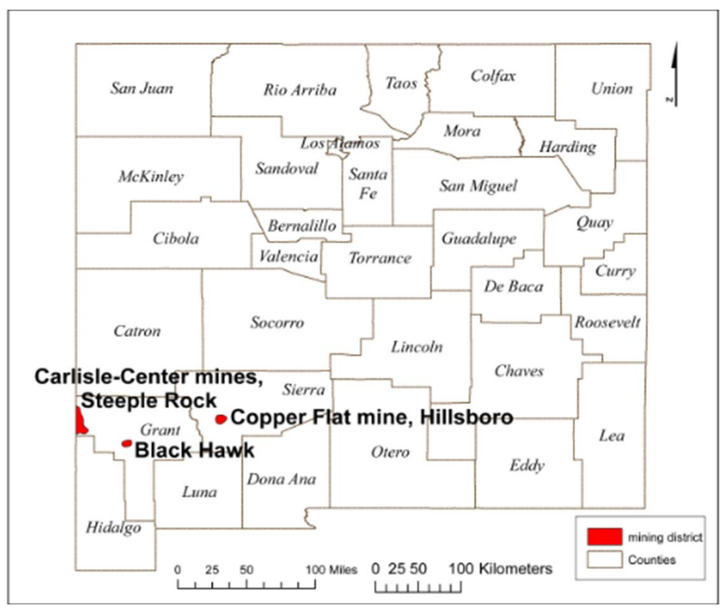


FIGURE 2: Location of the Copper Flat at Hillsboro, Black Hawk in Burro Mountains, and Carlisle-Center mine in Steeple Rock areas, southwestern NM.

FIGURE 3: Sample of the slope face of waste rockpile in Hillsboro.

GEOLOGY & MINE HISTORY

Carlisle-Center	Copper Flat
• Volcanic-epithermal system with little sulfidation and has Au-Ag veins. • 2 groups of alteration assemblages: acid-pH and neutral-pH. • Six different types of mineral deposits; base-metal (Ag, Au), Au-Ag (base metals), Cu-Ag, fluorite, Mn, and high-sulfidation disseminated Au deposits. • As, Bi, Te, fluorite and Zn. Exploration in the district began about 1860. • Between 1880 and 1994, the district produced metals worth an estimated $10 million.	• The district's core is dominated by a quartz monzonite stock (74.4±2.6 Ma) with a breccia pipe, and latite dikes extend outward from it. • Quartz veins with Cu, Au, Mo, and Ag. disseminations make up the Copper Flat porphyry copper deposit. • Te, As, Bi, Mg, Mn, and Zn. • First copper smelter was built in 1892. • Exploration in the 1950s and 1960sThe mine ran for three months in 1981.

METHODS

- The use of sampling techniques developed by USGS staff, the BLM (Bureau of Land Management, 2014), USGS, and EPA.
- Health and Safety Plan (HASP).
- Laboratory studies; Geochemistry, Petrography, Electron Microprobe analyses, XRD and Particle size analysis.

FIGURE 4: Sampling of waste rock pile at Hillsboro

FIGURE 5: Sampling of tailings, red line is the boundary between tailings and cover material at Hillsboro District

Formulas for the ARD diagram

AP – Acid Potential: S(%) *31.25

NP - Neutralization Potential : C(%)*83.3

NPR – Net Potential Ratio (**NPR = NP/AP)**

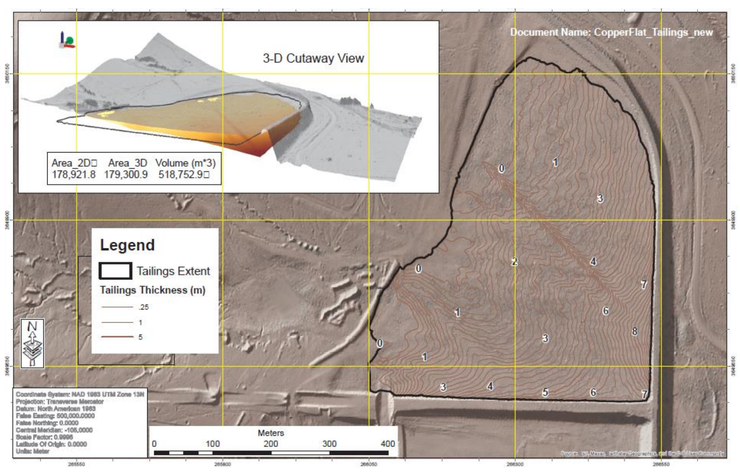


FIGURE 6: Map of tailings at Copper Flat showing area and volume computation

PRELIMINARY RESULTS

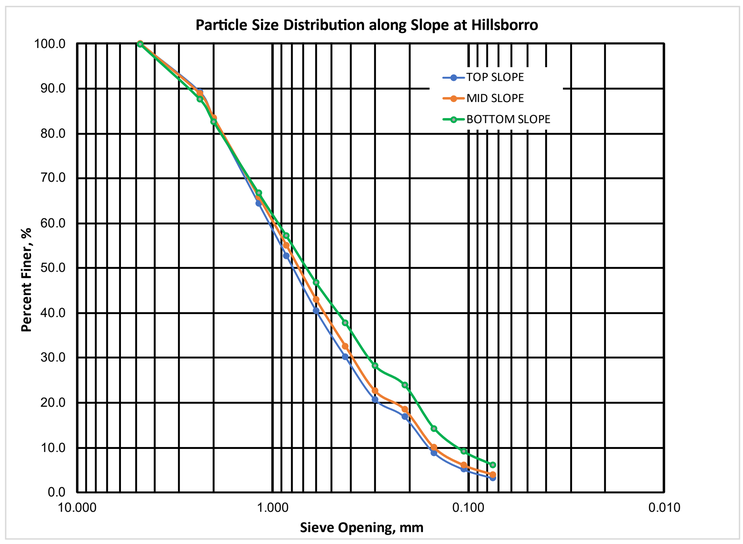


FIGURE 7: A plot of particle size distribution along rock pile slope at Copper Flat mine.

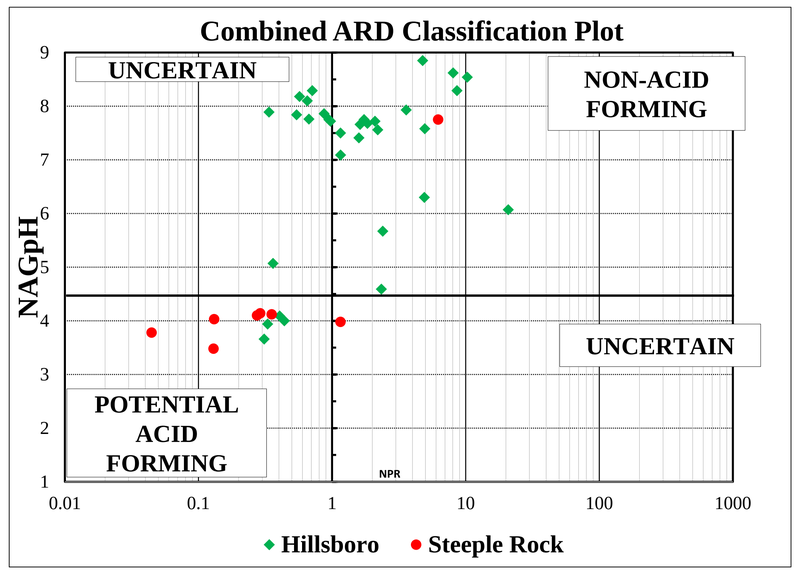
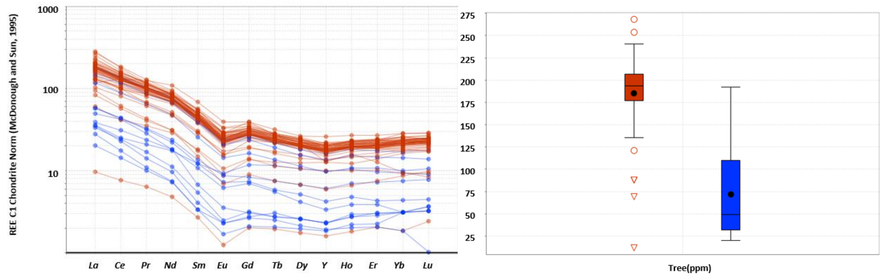
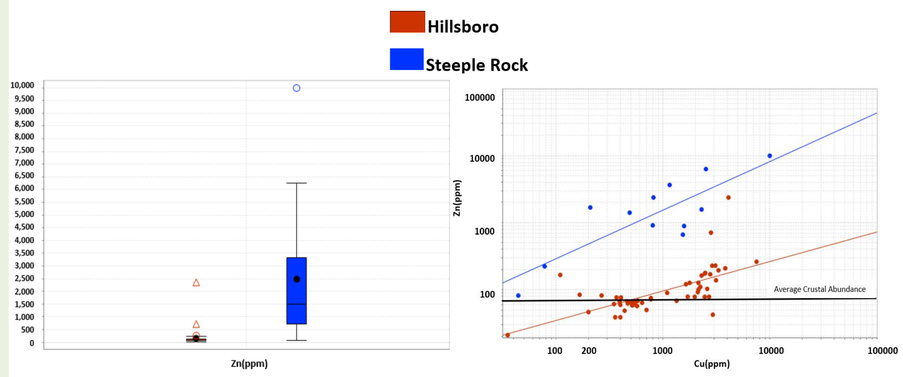


FIGURE 10: Acid Rock Diagram of samples at mines at Copper Flat mine and Carlisle-Center..



FIGURES 11& 12: TREE concentrations at Hillsboro and Steeple rock.



FIGURES 13 & 12: Shows higher Zinc concentrations at Hillsboro than at Steeple Rock.

XRD RESULTS

Copper Flat

- Samples from the waste rock pile include clay minerals especially for OH clays, the rest are mostly rock forming minerals.
- Notable for Alunite, an indicative of acidic precipitation of SO_4.
- Samples from the tailings are notable for the presence of calcite.

Steeple Rock

- Most samples have abundant quartz and minor micas.
- SR 6 also indicates presence of Mn oxide.
- Another interesting mineral found in some of the samples was Beaverite which, is a Pb-Fe-Cu Sulfate.

PRELIMINARY CONCLUSIONS

Samples from Carlisle-Center are mostly acid forming and can possibly cause acid mine drainage.

Samples from Copper Flat that are nonacid forming may be used as back fill material.

Geochemistry results from Copper Flat shows higher light REE enrichment than Carlisle-Center.

FUTURE WORK

- More samples to be collected, analyzed and archived from mine waste rock piles in the two mining districts.
- Geochemistry on different particle fractions would be analyzed.
- Compute the tonnages of mine waste and thus estimate the critical mineral endowment of the study areas.

ACKNOWLEDGEMENTS

- This work is part of an ongoing research of the economic geology of mineral resources in New Mexico at NMBGMR, Dr. J. Michael Timmons, Director and State Geologist.
- This study is partially funded by the U.S. Geological Survey Earth MRI (Mapping Resources Initiative) Cooperative Agreement No. G22AC00510, all geochemistry test on this project are being done by the USGS.
- Kate M. Campbell-Day and Robert R. Seal assisted in explaining the USGS sampling protocols.
- Thanks to Richard Kelly for assisting with lidar data, Mark Russel for assisting with database support and Jakob Newcomer for assisting with XRD analysis.
- Evan Owen and all members of the economic geology team in the NMBGMR that assisted are greatly appreciated.