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

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ABSTRACT

The majority 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 mine shafts. In order to comprehend its composition, accurately estimate its volume, and determine its potential economic value, it is imperative to categorize these wastes. Hence this project seeks to: 1) characterize and estimate the critical mineral endowment of mine wastes in two mining districts in NM (i.e., Copper Flat at Hillsboro and Carlisle-Center mines in Steeple Rock district) , 2) "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.

INTRODUCTION

"Mineral commodities that have important uses and no viable substitutes, yet face potential disruption in supply, are defined as critical to the Nation's economic and national security" (Schulz, 2017). The majority of our electronic equipment, such as smartphones, laptops, computer chips, wind turbines, hybrid and electric cars, etc., depend on these 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 and evaluate the NM mine wastes for its critical mineral and future mining potential. The NM Mines Database lists more than 9,000 mines, of which more than 7,000 are inactive or abandoned. While the actual mineral production was typically for precious and base metals rather than critical minerals, the majority of these mines have existed mine wastes that were generated during mineral production and may have potential for critical minerals. As a result, any essential minerals discovered in a mineral deposit would also be present in the mine wastes (mine waste dumps, tailings, etc.) Although the main focus of this project is the critical mineral endowment of mine wastes, we also intend to assess the stability of the mine features and typical environmental characteristics of the mine wastes (acid base accounting, pH, leaching tests, etc.), considering that these assessments are necessary to secure a safe working environment during mining, reclamation, and/or waste processing.

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.

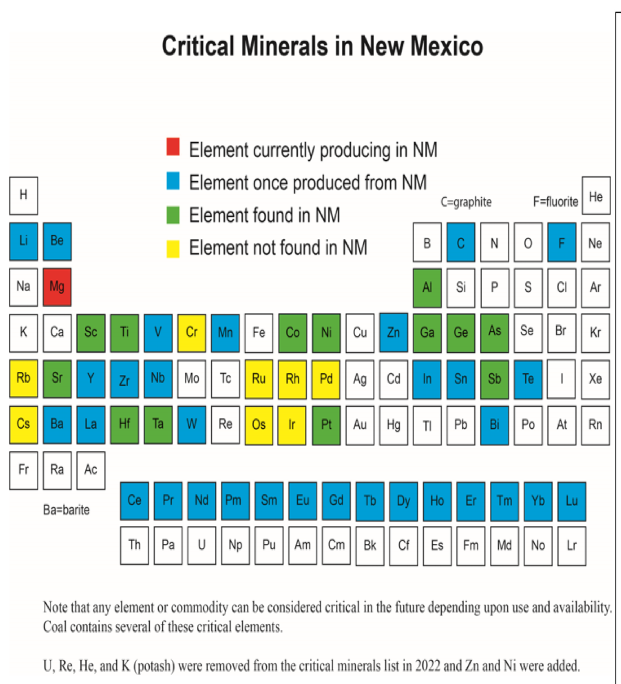


FIGURE 1: Critical minerals found in New Mexico

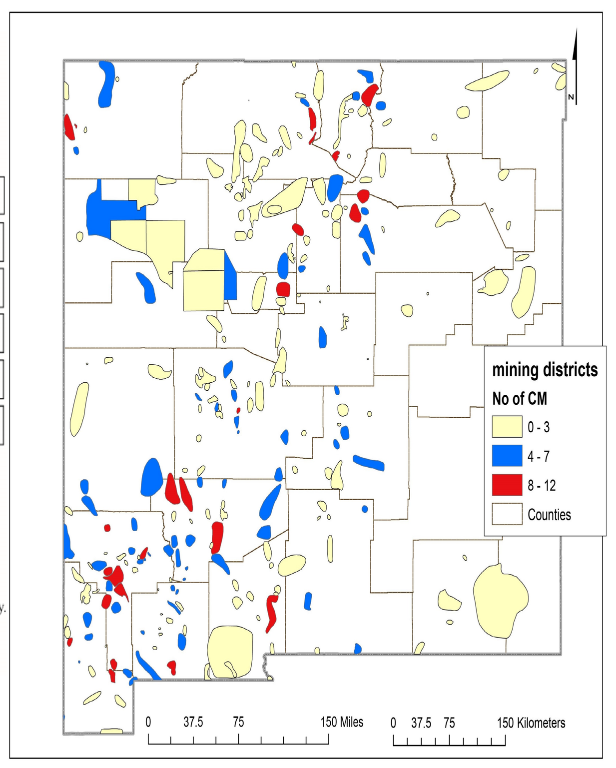


FIGURE 2: Mining districts in NM with critical minerals

FIGURE 3: Mine rock pile (left) and pit lake (right) at Copperflat mine in the Hillsboro district

THE STUDY AREA

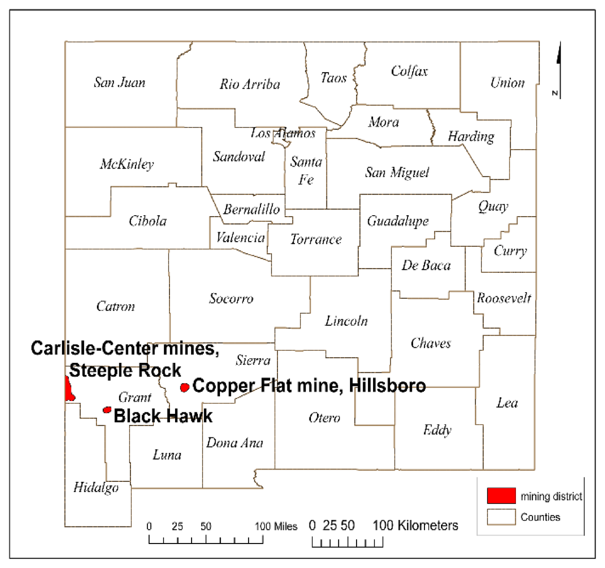


FIGURE 4: Location of the Copper Flat at Hillsboro, Black Hawk in Burro Mountains, and Carlisle-Center mine in Steeple Rock areas, southwestern NM.

TABLE 1. Shows location of mine sites (in decimal degrees, NAD27), prominent geologic features and known critical minerals

Mine Name	Carlisle-Center	Copper Flat
DISTRICT	Steeple Rock	Hillsboro
Latitude	32.852103, 32.8491178	32.968933
Longitude	-108.963512, -108.9600555	-107.533257
Prominent Geologic Features	This site has a volcanic-epithermal system with little sulfidation and has Au-Ag veins. There are also two groups of alteration assemblages: acid-pH (alunite, kaolinite, quartz, or acid-sulfate) and neutral-pH (propylitic to sericitic). Six different types of mineral deposits can be found in the district; base-metal (Ag, Au), Au-Ag (base metals), Cu-Ag, fluorite, Mn, and high-sulfidation disseminated Au deposits (McLemore, 1993, 1996, 2000).	The district's core is dominated by a quartz monzonite stock (74.930.66 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. Many of the latite dikes are host to Laramide veins that radiate outward from the Copper Flat porphyry.
Known Critical Mineral	As, Bi, Te, fluorite and Zn	Te, As, Bi, Mg, Mn, and Zn
Mining History	Exploration in the district began about 1860, but it wasn't until 1880 that production occurred. Between 1880 and 1994, the district produced metals worth an estimated $10 million, primarily from the Carlisle and Center mines (McLemore, 1993).	In the town of Hillsboro, the first copper smelter was built in 1892. In the 1950s and 1960s, Bear Creek Mining Company and Newmont Mining Company conducted exploration. Additionally, the mine ran for three months in 1981. New Mexico Copper Corp. is applying for permits to begin mining.

METHODS

- The use of sampling techniques developed by USGS staff, the BLM (Bureau of Land Management, 2014), USGS, and EPA.
- Preparation of a Site Health and Safety Plan (HASP).
- General geologic mapping (GIS), sampling of waste and rock piles.
- Laboratory studies; Geochemistry, Petrography, Electron Microprobe analyses, XRD
- The use of geologic and geochemical data to determine potential of acid production within the wastes, estimation of the volumes and tonnages of waste and rock piles.
- Particle size analysis.

FIGURE 5: Sampling of waste rock pile (left) and tailings(right) at Hillsboro District

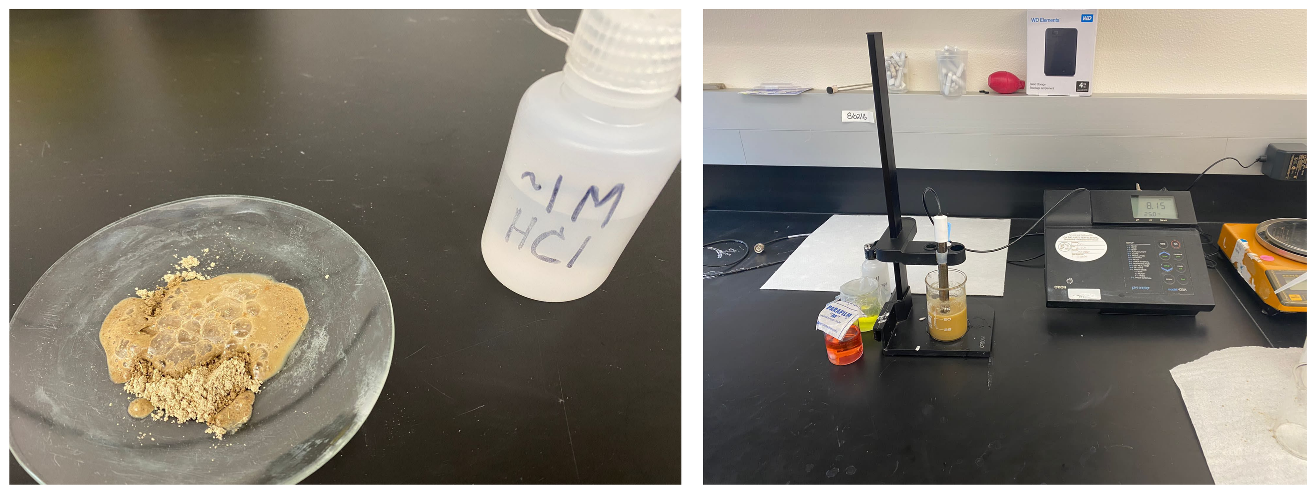
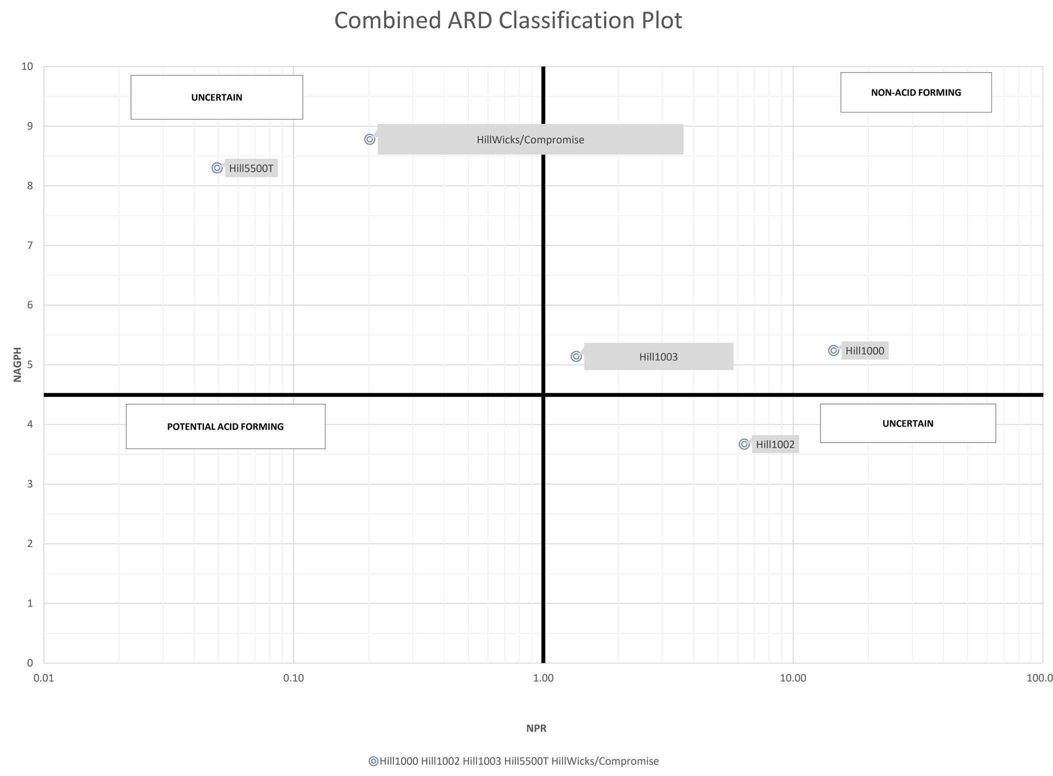


FIGURE 6: Laboratory test on sieved samples, Fizz test(left) and Paste pH test (right)

PRELIMINARY RESULTS

SAMPLE ID	Paste pH	S%	C%	AP (Kg CaCO3)	NP (total C)	NNP	NPR
Hill1000	5.24	17.85	0.46	557.81	38.32	519.49	14.56
Hill1002	3.67	0.51	0.03	15.94	2.50	13.44	6.38
Hill1003	5.14	0.47	0.13	14.69	10.83	3.86	1.36
Hill5500T	8.3	0.12	0.91	3.75	75.80	-72.05	0.05
HillWicks/Compromise	8.78	0.14	0.26	4.375	21.66	-17.28	0.20
Hill2001	3.94	WFC	WFC				
Hill2003	3.66	WFC	WFC				
Hill2005	5.07	WFC	WFC				
Hill2006	7.09	WFC	WFC				
Hill2007	7.93	WFC	WFC				
Hill2008	8.85	WFC	WFC				
Hill2009	7.56	WFC	WFC				
Hill2010	7.41	WFC	WFC				
Hill2011	4	WFC	WFC				
Hill2012	4.09	WFC	WFC				
Hill2013	5.67	WFC	WFC				
Hill2014	4.59	WFC	WFC				
Hill2018	7.76	WFC	WFC				
Hill2019	7.75	WFC	WFC				
Hill2020	8.54	WFC	WFC				
Hill2021	7.89	WFC	WFC				
Hill2022	8.18	WFC	WFC				
Hill2023	7.84	WFC	WFC				
Hill2024	8.1	WFC	WFC				
Hill2025	6.3	WFC	WFC				
Hill2026	8.29	WFC	WFC				
Hill2027	7.75	WFC	WFC				
Hill2029	7.68	WFC	WFC				
Hill2031	7.66	WFC	WFC				
Hill2032	8.29	WFC	WFC				
Hill2033	7.58	WFC	WFC				
Hill2034	7.86	WFC	WFC				
Hill2035	7.5	WFC	WFC				
Hill2037	8.62	WFC	WFC				
Hill2038	6.07	WFC	WFC				
Hill2039	7.72	WFC	WFC				
Hill2040	7.72	WFC	WFC				

AP – Acid Potential
NP - Neutralization Potential
NNP – Net Neutralization Potential
NPR – Net Potential Ratio
WFC – Waiting for Chemistry



None of the samples have a potential to generate acid drainage though some samples were slightly acidic when a paste pH test was done.

FIGURE 3: Acid Rock Drainage(ARD) plot of waste rock pile at mines at the Hillsboro District.

PRELIMINARY CONCLUSIONS

Since none of the samples are potential forming, the waste rock pile can be suitable for backfilling. More studies and samples are being collected from the district to confirm earlier results and provide insights on the geochemistry of the mine waste in the area.

FUTURE WORK

- More samples to be collected, analyzed and archived from mine waste rock piles in the two mining districts.
- Tailings from both districts would be sampled and tested as well.
- Particle size analysis would be done and compared to mineralogy if possible

ACKNOWLEDGEMENTS

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