New Mexico's mineral wealth is among the richest of any state in the U.S. In 2015, New Mexico ranked 10th in coal production, 28th in copper production, and 20th in total nonfuel mineral production (McLemore, 2017). Most of the state’s production comes from oil, gas, coal, copper, potash, industrial minerals (phosphatic, perlite, cement, zeolites, etc.) and aggregates. Other important commodities include molybdenum, gold, uranium, and silver. However, legacy issues of past mining activities often negatively impact perceptions of mining, and inhibits future mineral production in the state. Some legacy mines have the potential to contaminate the environment, the Gold King uncontrolled release into the San Juan River is a recent example. At the time the General Mining Law of 1872 was written, there was no recognition of the environmental consequences of discharge of mine and mill wastes into drinking water, and riparian and aquatic habitats. Mining operations on federal lands had little or no requirement for environmental protection until the 1960s-1970s, although the dumping of mine wastes and tailings directly into rivers was banned by an Executive Order in 1915. It is important to recognize that these early miners were not breaking any laws, because there were no laws to break, but legacy issues still exist.

The New Mexico Bureau of Geology and Mineral Resources (NMBGMR) has been examining the environmental effects of legacy mines for decades, with a focus on mine rock piles and tailings throughout New Mexico since the early 1990s (http://geolres.unm.edu/staff/mclemore/projects/environmental.html). There are tens of thousands of inactive or abandoned mine features in 274 mining districts in New Mexico (McLemore, 2017; including coal, uranium, metals, and industrial minerals districts), however, many of them have not been inventoried or prioritized for reclamation. The New Mexico Abandoned Mine Lands (AML) Bureau of the New Mexico Mining and Minerals Division (NMMMD) estimates that there are more than 15,000 abandoned mine features in the state (http://www.emnrd.state.nm.us/MMD/AML/amlmain.html). The U.S. Bureau of Land Management (BLM) recently estimated that more than 10,000 mine features are on BLM lands in New Mexico and only 301 sites have been reclaimed (http://www.blm.gov/wy/minerals/programs/BLM-Abandoned-Mine-Lands-abandoned-mine-sites.html). The New Mexico AML Program has catalogued over 2,000 mine features since inception in 1981 as part of hundreds of site construction projects (some of which were focused on coal gob reclamation and not safeguarding). The BLM, U.S. Forest Service, and many private mining companies have also reclaimed some of these mine features.

The NMBGMR has collected published and unpublished data on the districts, mines, deposits, occurrences, and mills since it was created in 1927 and is still converting historical data into a relational database, the New Mexico Mines Database (McLemore et al., 2005a, b). More than 6,000 records are stored in the New Mexico Mines Database and more than 7,000 are inactive or abandoned. These mines generally include two or more active mine features.

New micro features do not pose any physical or environmental hazard and many, more pose only a physical hazard, which is easily both costly to remediate. But a complete inventory of these features is needed. Some of these inactive or abandoned mine features can pose serious health, safety and/or environmental hazards, such as open shafts and adits (some concealed by deterioration or vegetation growth), tunnels and drifts that contain deadly gases, highwalls, encountering with wild animals, radon and metal-laden waters. Other sites have the potential to contaminate surface water, groundwater and air quality. Heavy metals in mine waste piles, tailings and acid mine drainage can potentially impact water quality and human health.

Many state and federal agencies and mining companies have mitigated many of the physical safety hazards by closing and/or abandoning some of these mine features, but very few of these remediation efforts have examined the long-term environmental effects. There is still potential for environmental effects long after remediation of the physical hazards, as found in several areas in New Mexico (for example Texas Honda, Backpack and Quebra mines). Some of these observations only come from detailed geochemical and electron microprobe studies that are not part of a remediation effort.

The NMBGMR in cooperation with the Mining Engineering Department at New Mexico Tech and the NMACE project is conducting research on legacy mine features in New Mexico with the electron microprobe analyses. The objective of our research is to develop a relatively quick and inexpensive procedure to inventory and characterize legacy, inactive or abandoned mine features in New Mexico. This project will inventory, characterize, and prioritize for reclamation the mine features in three mining districts in New Mexico: the Jicarilla Mountains district in Lincoln County and the North Magdalena and Rosedale districts in Socorro County for the NM MMAP. Additional mining districts in Socorro County are being examined as well. The project involves field examination of the mine features and collecting data on the mine features (Bureau of Land Management, 2014). Samples are collected to develop a total world rock geochemistry, mineralogical, physical, and engineering properties, acid-base accounting. Hydrologic conditions, particle size analyses, soil classification, shear strength testing for stability analysis, and prioritization for remediation, including hazard ranking. Not only will samples be collected for geochemical and geotechnical characterization, but the mine features will be mapped, evaluated for future mining-resource potential, and evaluated for slope stability.

WHAT ARE ABANDONED MINE LANDS (AML)?

Lands that were mined and left unattended where no individual or company has reclamation responsibility. These may consist of excavations, either caved in or sealed, that have been deserted and where further mining is not intended. Also called inactive, legacy and orphaned mines.

To develop a relatively quick and inexpensive procedure to inventory and characterize AML (legacy) mines

1. Determine if there is potential for leaching metals or acid drainage from waste materials
2. Understand geologic processes
3. Compare trace-element concentrations in mined versus undisturbed areas
4. Determine background concentrations
5. Undermine geologic processes
6. Provide data on mining districts, mines, and mills in New Mexico
7. Sample characterization

ELECTRON MICROPROBE ANALYSES

Backscattered electron images of pyrite and Fe-oxide grains distributed in sample Jic412. Note how pristine the pyrite grain is.