ROCKIN' AROUND NEW MEXICO: MINING 2020





New Mexico Bureau of Geology and Mineral Resources, New Mexico Tech, Socorro, NM



LONGER POWERPOINTS ARE IN BINDER AND ON MY WEB SITE

https://geoinfo.nmt.edu/staff/mclemore/home.html



MANY OF THE MINING DISTRICTS **IN NEW MEXICO ARE** ASSOCIATED WITH VOLCANIC ROCKS



OUTLINE

- Mining issues in New Mexico
 - Definitions
 - Importance of minerals
 - Phases of mining
 - Where mining is in New Mexico
 - Mining issues
 - Critical minerals
- St. Cloud zeolite mine
- Copper Flat mine
- Socorro perlite mine





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DEFINITIONS

Minerals

In the mining industry, minerals refer to any rock, mineral, or other naturally occurring material of economic value, including metals, industrial minerals, energy minerals, gemstones, aggregates, and synthetic materials sold as commodities.

Industrial minerals

- Any rock, mineral, or other naturally occurring material of economic value, excluding metals, energy minerals, and gemstones
- One of the nonmetallics
- Includes aggregates



Learn more at www.MineralsEducationCoalition.org

Minerals are essential to our way of life

https://mineralseducationcoalition.org/wp-content/uploads/2019-Mineral-Baby.pdf

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PHASES OF A MINE

Phases of <u>Mining (before 1994)</u>



Time

Abandon the site



WHAT, WHERE, AND HOW MUCH MINERALS ARE PRODUCED IN NEW MEXICO?

INTRODUCTION

- NM has some of the oldest mining areas in the United States
- Native Americans mined turquoise from Cerrillos Hills district more than 500 yrs before the Spanish settled in the 1600s
- One of the earliest gold rushes in the West was in the Ortiz Mountains (Old Placers district) in 1828, 21 yrs before the California Gold Rush in 1849



One of the turquoise mines in the Cerrillos Hills district



MINING DISTRICTS IN NEW MEXICO



New Mexico Bureau Geology and Mineral Resources A Division of New Mexico Institute of Mining and Technology

Resource Map 24

PRODUCTION SUMMARY—2020

- Value of mineral production in NM in 2018 was <\$1.7 billion (does not include oil and gas) ranked 28th in the US
- Employment in the mining industry is 5,000
- Exploration for garnet, gypsum, limestone, nepheline syenite, agate, specimen fluorite, gold, silver, iron, beryllium, uranium, copper, potash, rare earth elements, humate, clays
- MINERALS PRODUCTION IS DECREASING, ESPECIALLY COAL

MINERALS PRODUCTION IN NEW MEXICO 2000-2018



ACTIVE MINES 2020

- ~282 active registered mines (NMMMD)
- 4 coal
- 3 potash, 4 potash plants
- 2 copper open pits, 1 concentrator (mill), 2 solvent/electro-winning (SX-EW) plants
 - 2 additional mines in permitting stage
 - Several exploration
- 1 gold mine and 1 mill (on standby)
- 2 iron mines
- 32 industrial minerals mines, 18 mills
- ~236 aggregate/stone



ACTIVE MINES AND EXPLORATION SITES IN NEW MEXICO 2000-2020

METALS—3RD IN COPPER PRODUCTION IN 2019 (CHINO, TYRONE)



Copper Production 1882-2018



Years

1. Copper Flat (98.1 million short tons at 0.31% Cu, 0.009% Mo, 0.003 oz/short ton Au, and 0.07 oz/ short ton Ag)

- 2. Orogrande
- 3. Hanover Mountain (80 mill st reserves at 0.38% Cu)
- 4. Copper Hill, Picuris district (46.5 mill st of ore at 0.42% Cu)
- 5. Lone Mountain (7.5 mill st at 2-3% Cu, 1.2% Pb, 4-5% Zn, 203 opt Ag, .01-.02 opt Au)
- 6. McGhee Peak, Pelloncillo Mountains
- 7. Mimbres

POTENTIAL COPPER DEPOSITS



COPPER RESERVES—2019

- Chino (including Cobre)
 - milling reserves are 224 million metric tons of 0.51% copper, 0.05 g/t gold, 0.91 g/t silver and 0.01% molybdenum
 - leaching reserves are 100 million tons of 0.32% Cu
- Tyrone (incl. Little Rock)
 - leaching reserves are estimated as 49 million metric tons of ore grading 0.25% Cu
 - Expected to close 2020s
- Cobre
 - Included with Chino mine

Copper Flat, Themax Resources Planned production per year for ~15 yrs 50.76 mill lbs Cu **EXPLANATION** 1.01 mill lbs Mo Tertiary sediments with interbedded basalt Tertiary volcanics COPPER FLA Quartz diorite 12,750 oz Au Cretacec Copper Flat guartz monzonite Warm Springs guartz monzonite ate Andesite 455,390 oz Ag Paleozoic sediments Precambrian rocks Dikes and gold veins Start in 2020s? Fault 2 mi. <u>7</u> 8 Hillsboro





INDUSTRIAL MINERALS

Any rock, mineral, or other naturally occurring material of economic value, excluding metals, energy minerals, and gemstones, generally nonmetallics



POTASH PRODUCTION

1951-2018 115 million tons worth >\$16 billion

Reserves in Carlsbad District

Potash (>553 million tons)

Potash is used in fertilizers among other uses

Intrepid closed one mine

Competition from Canadian deposits





1ST IN POTASH IN 2018 (MOSAIC, INTREPID MINING)

ADDITIONAL INDUSTRIAL MINERALS IN NEW MEXICO



- 1st in zeolite (St. Cloud, Sierra County)
- 5th in pumice (6 operations)
- 1st in perlite (4 operations)
- 11th in salt (4 operations, Carlsbad)

WHAT ARE THE MINING ISSUES FACING NEW MEXICO?



Gold King adit



Animas River after Gold King spill

- Some current mines are reaching the end of their life and will close over the next decade
- There are not many new mines to replace them
- Results in unemployment and decrease in revenues
 - Affects rural economies
 - Affects state revenues

- Mining requires water and their environmental effects can not impact water supplies
- Legacy issues of past mining activities form negative public perceptions of mining
 - Abandoned or legacy mines, especially Grants uranium district and Questa mine (superfund sites)
 - Gold King spill

- Many inactive mines still have the potential to contaminate the environment or present a hazard to health and safety
 - Gold King spill
 - AML sites (Abandoned mine lands)
 - Grants uranium district
- Global competition is closing some of our mines
- Lower prices=closed mines, little exploration

- In some areas conflicts arise between mining and other activities
 - Grants uranium district
 - Otero Mesa
 - Water

 Shortage of young geologists and engineers to explore for, develop, mine, permit these commodities and evaluate their effect on the environment—math, science skills critical

CRITICAL MINERALS IN NEW MEXICO
CRITICAL MINERALS

- is a mineral (1) identified to be a nonfuel mineral or mineral material essential to the economic and national security of the United States, (2) from a supply chain that is vulnerable to disruption, and (3) that serves an essential function in the manufacturing of a product, the absence of which would have substantial consequences for the U.S. economy or national security
- President Trump signed an executive order (Presidential Executive Order (EO) No. 13817) that requires the Departments of Interior and Defense to develop a list of critical minerals

CRITICAL MINERALS

- 35 critical minerals were identified
- New Mexico has many of these critical minerals
 - Potash is currently being produced in Carlsbad
 - Copper deposits in Grant County contain rhenium, indium, and germanium
 - Uranium deposits in the Grants district
 - Exploration for other critical minerals include REE, tellurium, lithium, beryllium, cobalt
 - Other critical minerals were once produced from New Mexico (tin, vanadium, manganese, fluorspar, barite, graphite)

Critical Minerals in New Mexico



Note that any element or commodity can be considered critical in the future depending upon use and availability. Coal contains several of these critical elements.



OCCURRENCES OF RARE EARTH ELEMENTS (REE) IN NEW MEXICO

REE in Gallinas Mountains, Lincoln County





St. Cloud Winston Zeolite Mine, Winston, NM-2020



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ZEOLITES ARE

- A group of minerals known as aluminosilicates (composed of aluminum, silica, and other ions)
 - Approximately 48 natural zeolites and 120 synthetic zeolites exist
- Framework structure encloses cavities (or pores) occupied by cations and water molecules, both of which have considerable freedom of movement, permitting ion exchange and reversible dehydration
- Composed of a three-dimensional crystal lattice with loosely bound cations
- Able to hydrate and dehydrate without altering their crystal structure
- Have fixed pore sizes and active sites in the crystal lattice

New Mexico is the leading state in the US in zeolite production

Zeolite Physical Properties



- Soft to moderately hard, H=4-5
- Low density
- Transparent to translucent
- 48 natural Zeolites
- Over 120 synthetic Zeolites



• Industrially speaking, the term zeolite includes natural silicate zeolites, synthetic materials, and phosphate minerals that have a zeolite like structure



Zeolite structure

The primary building unit of zeolites are cations coordinated tetrahedrally by oxygen. These tetrahedra are connected via corners, thus forming the crystal structure of the

specific zeolite.



Source of diagram: www.mpi-muelheim.mpg.de/. ../zeolites_c2.html

Properties of Zeolites

All commercially useful zeolites owe their value to one or more of three properties: adsorption, ion exchange, and catalysis



Source of structures: www.mpi-muelheim.mpg.de/. ../zeolites_c2.html

ZEOLITES USES

- Animal feed (improves animal health, manages nitrogen and ammonia emissions, lowers mortality)
- Water treatment (treating drinking, municipal, agricultural, and industrial waster waters)
- Soil amendment (increases soil's nutrient holding capacity and water retention, prevents toxicity)
- Odor and moisture control (industrial, farm, and household uses)
- Environmental remediation (ion exchange for removal of radioactive and heavy metal cations)
- Specialty applications (food preservation, grease and oil absorption, and cement and pozzolan)
- Molecular sieves

GEOLOGY

- Occur in rocks of diverse lithology, age, and depositional environments
- Closed-basins, saline, alkaline-lake deposits
- Nonmarine and shallow marine basins in volcanic terrains
- In New Mexico, Clinoptilolite, the main commercial natural zeolite, is found in geologically young volcanic ash altered by alkaline groundwater
 - Tuff from a caldera erupted at 28 million years
 - Then tuff was altered last couple 100,000 yrs ago

Formation of Zeolites

- Formed by alteration reactions
- Temperatures range from 27°C 55°C
- pH is typically between 9 and 10
- Nature requires 50 50,000 years to complete the reaction
- Mostly altered volcanic glasses
- Fine-grained volcanic ashes or pumice particles are especially susceptible to alteration
- Starting materials can also be minerals, like nepheline, leucite, and feldspars
- Alteration in different environments: hydrothermal, saline or alkaline lakes, and groundwater
- The alteration conditions of these three environments are completely different with respect to chemistry, concentration, and pH of the reacting solution, solid/liquid ratio, temperature, reaction in closed or open system.



ZEOLITE DEPOSITS IN NEW MEXICO

ST. CLOUD WINSTON ZEOLITE MINE

- Started in 1991 (also known as Stone House Zeolite mine)
- Sells Winston zeolite
- 50,000 tons per year
- 2016 constructed a new processing facility
- 2018 conducted exploration program to delineate additional reserves

WINSTON ZEOLITE PROPERTIES

- High surface area, high surface charge density (readily available cation exchange sites), and physical durability
- High calcium and low sodium content make it preferable in agricultural applications
- Low clay content makes it desirable in water treatment applications

WINSTON ZEOLITE OPEN PIT (NOW RECLAIMED).THE WHITE UNIT IS THE ZEOLITE AND IT IS OVERLAIN BY UNALTERED TUFF.





Lighter color is the altered volcanic ash with clinoptilolite at the St. Cloud zeolite mine

Mining St. Cloud Zeolite



St. Cloud's zeolite operation includes facilities for custom sizing, bagging, blending and manufacturing of added value products. St. Cloud sells zeolite primarily through a network of brokers, distributors and manufacturers.

Source=http://www.stcloudmining.com/

ZEOLITE IS CRUSHED AND SIZED



VARIOUS PRODUCTS



ZEOLITE IS BAGGED FOR SHIPPING TO CUSTOMER



St. Cloud Zeolite Plant



WEB SITE: <u>HTTPS://WWW.STCLOUDMINING.COM/</u>

COPPER FLAT MINE, HILLSBORO, NM-2020





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COPPER FLAT MINE

- The Copper Flat mine is a proposed copper mine in the Hillsboro mining district in Sierra County and is being developed by the New Mexico Copper Corporation
- New Mexico Copper Corporation is a whollyowned subsidiary of THEMAC Resources Group (http://themacresourcesgroup.com/about)



LOOKING WEST AT COPPER FLAT, HILLSBORO DISTRICT, ANIMAS MOUNTAINS. **COPPER FLAT FORMS** THE GAP. THE PEAKS ARE ANDESITE. THE **BLACK RANGE FORMS** THE SKYLINE. THE **CLOSE UP PEAKS ARE** THE REMAINDER OF A **VOLCANO THAT ERUPTED 75 MILLION** YEARS AGO

IMPORTANCE OF COPPER

- Copper is number 29 on the periodic table and is a nonferrous metal
- Copper is one of the most important metals because of its high ductility, malleability, thermal and electrical conductivity and resistance to corrosion
- Copper is easily alloyed to form brass (copper, zinc), bronze (copper, tin), and even copper-nickel

COPPER FLAT IS A COPPER PORPHYRY DEPOSIT

- Large (many millions of tons of ore), low-grade (<0.8% Cu) copper deposits of disseminated and stockwork veinlets of copper minerals that are associated with porphyritic intrusions
- Generally hosted by granitic rocks with chalcopyrite and other copper minerals disseminated throughout the fractured host rock
- Porphyritic refers to a specific texture of an igneous rock consisting of large-grained crystals such as feldspar or quartz dispersed in a finegrained matrix or groundmass
- Generally mined by open pit
- Many copper porphyry deposits also include economic amounts of by-products such as molybdenum, silver, and gold
- Elements such as platinum, tellurium, indium, germanium, and gallium are recovered from the material remaining after smelting the ore concentrate



NEW MEXICO IS THE EASTERN PART OF A LARGE BELT OF COPPER PORPHYRY DEPOSITS IN SOUTHWESTERN UNITED STATES AND NORTHERN MEXICO

HISTORY

- In 1892, the first copper smelter in the town of Hillsboro was developed
- Exploration in the 1950-1960s by Newmont Mining Company (Newmont) and Bear Creek Mining Company (Kennecott's former exploration subsidiary)
- Quintana Minerals produced for 3 months in 1982, but closed due to the low price of copper (\$0.70/lb)
- Alta Gold acquired the property in 1994 and drafted a EIS for the project in 1999, but went bankrupted due to financial difficulties at other mines

Copper Flat mine, Themax Resources

Planned production per year for ~15 yrs 50.76 mill lbs Cu 1.01 mill lbs Mo 12,750 oz Au 455,390 oz Ag Start in 2020s?

PIT LAKE (REMAINING FROM QUINTANA MINERALS OPERATION), LOOKING EAST





MONITORING WELLS ARE THROUGHOUT THE MINE AREA TO **MEASURE DIFFERENCES IN** WATER LEVELS, CHEMISTRY, AND WATER FLOW. HYDROLOGISTS USE THESE DATA TO MODEL AND PREDICT THE WATER FLOW AND QUALITY BEFORE, **DURING, AND AFTER** MINING.

Sequence of events in the Hillsboro mining district		
GEOLOGIC EVENT	AGE	MINERALIZATION AND
		ALTERATION
Eruption of alkali basalt	4 Ma	None
Uplift of the Copper Flat	21-22 Ma	Minor supergene enrichment of porphyry
volcanic/intrusive complex followed by erosion	to present	copper deposit, Placer gold deposits
Eruption of Sugarlump and Kneeling Nun Tuffs (Emory caldera)	35-34 Ma	None in the Hillsboro district
Burial? or possibly minor erosion?	75 Ma to 35 Ma	Minor supergene enrichment of porphyry copper deposit?
Formation of jasperoids	75-35 Ma	Followed by deposition of carbonate- hosted replacement Ag-Mn and Pb-Zn deposits
Latite and quartz latite dikes	75-70 Ma	Vein (Au, Ag, Cu) deposits, type 4, 5, and 6 alteration (Table 3)
Intrusion of quartz monzonite porphyry	75 Ma	Porphyry copper deposits (Cu, Au, Ag,
and formation of breccia pipe deposit		Mo), type 1, 2 and 3 alteration (Table 3),
		formation of skarn and marble in
		limestone
Eruption of andesite volcano	75 Ma	None, possible early deuteric alteration
Deposition of the Copper Flat porphyry copper and yein deposits and formation of jasperoids most likely		

Deposition of the Copper Flat porphyry copper and vein deposits and formation of jasperoids most likely overlapped in time. From McLemore et al. (1999, 2000b).

ACID SEEP PROVIDES NM TECH STUDENTS OPPORTUNITY TO STUDY MICROBES ASSOCIATED WITH FORMING ACID


SAMPLES OF CHRYSOCOLLA, COPPER, COPPER ORE IN ROCK KITS

WEBSITE: <u>HTTP://THEMACRESOURCESGROUP.COM/COPPER_FLAT</u> <u>MINE</u>

Dicalite Perlite Mine, Socorro, NM-2020





New Mexico Bureau of Geology and Mineral Resources, New Mexico Tech, Socorro, NM



What is Perlite?

- Volcanic siliceous glass
- Rhyolite composition
- Commercial perlite must expand
- Vitreous, pearly luster
- Inert
- When perlite is heated rapidly in a furnace, the trapped water molecules turn to steam and expands up to 20 times its original size(like popcorn)
- 2-5% water allows it to expand similar to popcorn above 871 degrees C
- Gray, white, black, but when expanded-white
- New Mexico is the leading state in the US in perlite production

SAMPLES OF PERLITE (GRAY) AND OBSIDIAN (BLACK) IN ROCK KITS

SOCORRO PERLITE IS A RHYOLITE DOME ERUPTED ABOUT 3.9 MILLION YEARS AGO. PERLITE FORMED BY WEATHERING AFTER ERUPTION.

PROPERTIES OF PERLITE

- Lightweight
- Free of organic materials
- Insulating properties
- Fireproof
- Pest-proof



Perlite—uses

- Building construction products (ceiling tiles, insulation, sheetrock)
- Horticultural aggregate (breaks up soils and allows for better water retention)
- Cannabis growing (ensures oxygen is provided to the roots)
- Filter aid
- Fillers
- Other (high-temperature insulation, molten metal topping)



PERLITE LOCALITIES IN NEW MEXICO (EL GRANDE, NO AGUA, AND SOCORRO ARE ACTIVE MINES)

DICALITE MANAGEMENT GROUP PERLITE MINE, SOCORRO, NM

- Opened in 1949 but closed in 1961 due to a depressed market
- Reconstructed the plant and began operations again in 1975
- Has more than 30 yrs of proven reserves (more than 15 million tons) and more than 50 yrs of probable reserves
- Current demand is approximately 180,000 tons per year but the plant can operate at 250,000 tons per year
- Pit is 200 ft deep and the perlite is another 175 ft below the pit level



DICALITE MANAGEMENT GROUP PERLITE MINE, SOCORRO, NM, LOOKING WEST (HTTPS://WWW.DICALITE.COM/DICAPERL/)

OPEN PIT. COVERED CONVEYOR BELT TRANSPORTS THE WHITE PERLITE ORE TO THE PROCESSING PLANT.



PROCESSING PLANT



WEB PAGE: <u>HTTPS://WWW.DICALITE.COM/LOCATION/SOCORRO-</u> <u>NM/</u>

SUMMARY

- New Mexico has a wealth of mineral resources
 - Geologic processes control the location of mineral deposits and many of these same processes form the scenic views we treasure
- Minerals are critical in providing our way of life—everything we use has to be grown or mined
- Mining creates jobs and revenues in the community

SUMMARY

- Mining is no longer performed as in the past
 - Exploration and permitting takes many years before a deposit can be mined, >15 yrs
 - All mines require a reclamation plan and bond
 - Legacy issues are being addressed
 - However, negative perceptions are a major issue
- Global competition is a major threat
- NMBG/NMT research is addressing some of these issues, as well as training future geologists and engineers

MORE INFORMATION

• NM Mines and Minerals Division http://www.emnrd.state.nm.us/MMD/

Virginia McLemore web page http://geoinfo.nmt.edu/staff/mclemore/home.html

 New Mexico Bureau of Geology and Mineral Resources

http://geoinfo.nmt.edu/

QUESTIONS?