MINING ISSUES FACING NEW MEXICO-2014

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ACKNOWLEDGEMENTS

- New Mexico Energy, Minerals and Natural Resource Department
- Company annual reports
- Personal visits to mines
- New Mexico Mining Association
OUTLINE

- What are minerals?
- Why are they important?
- How are minerals formed?
- What, where, and how much minerals are produced in New Mexico?
- What are the Mining Issues Facing New Mexico?
- More Information
WHAT ARE MINERALS?
Minerals refer to any rock, mineral, or other naturally occurring material of economic value, including metals, industrial minerals, energy minerals, gemstones, and aggregates.
WHY ARE MINERALS IMPORTANT?
YOUR WORLD IS MADE FROM MINERALS

Every American Born Will Need...

- 27,471 lbs. Salt
- 11,994 lbs. Clays
- 1.20 million lbs. Stone, Sand, & Gravel
- 978 lbs. Copper
- 521 lbs. Zinc
- 72,556 gallons Petroleum
- 1.77 Troy oz. Gold
- 840 lbs. Lead
- 16,306 lbs. Phosphate Rock
- 445,903 lbs. Coal
- 6,107 lbs. Bauxite (Aluminum)
- 27,416 lbs. Iron Ore
- 43,721 lbs. Cement
- Plus 52,288 lbs. Other Minerals & Metals
- 6.63 million cu. ft. Natural Gas

3 million pounds of minerals, metals, and fuels in their lifetime

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The Society for Mining, Metallurgy and Exploration Foundation

Learn more at www.MineralsEducationCoalition.org

http://www.mii.org/
Every Year—38,212 pounds of new minerals must be provided for every person in the United States to make the things we use every day

- 9,002 lbs. Stone used to make roads, buildings, bridges, landscaping, and for numerous chemical and construction uses
- 6,251 lbs. Sand & Gravel used to make concrete, asphalt, roads, blocks and bricks
- 556 lbs. Cement used to make roads, sidewalks, bridges, buildings, schools and houses
- 348 lbs. Iron Ore used to make steel—buildings; cars, trucks, planes, trains; other construction; containers
- 349 lbs. Salt used in various chemicals; highway deicing; food & agriculture
- 207 lbs. Phosphate Rock used to make fertilizers to grow food; and as animal feed supplements
- 152 lbs. Clays used to make floor & wall tile; dinnerware; kitty litter; bricks and cement; paper
- 78 lbs. Aluminum (Bauxite) used to make buildings, beverage containers, autos, and airplanes
- 12 lbs. Copper used in buildings; electrical and electronic parts; plumbing; transportation
- 11 lbs. Lead 87% used for batteries for transportation; also used in electrical, communications and TV screens
- 7 lbs. Zinc used to make metals rust resistant, various metals and alloys, paint, rubber, skin creams, health care and nutrition
- 35 lbs. Soda Ash used to make all kinds of glass; in powdered detergents; medicines; as a food additive; photography; water treatment
- 6 lbs. Manganese used to make almost all steels for construction, machinery and transportation
- 488 lbs. Other Nonmetals have numerous uses: glass, chemicals, soaps, paper, computers, cell phones
- 24 lbs. Other Metals have the same uses as nonmetals but also electronics, TV and video equipment, recreation equipment, and more

Including These Energy Fuels

- 906 gallons of Petroleum
- 5,666 lbs. of Coal
- 84,348 cu. ft. of Natural Gas
- 1/4 lb. of Uranium

To generate the energy each person uses in one year—
How are mineral deposits formed?

- By natural geologic processes in specific places in the world.
- Mineral deposits are not always found in the most convenient places in the world.
Figure 1. Formation of a Porphyry Copper Deposit

Initial formation of a porphyry copper deposit associated with a magma chamber beneath a stratovolcano. Hot water circulating near the magma forms low-grade copper mineralization next to the solidifying magma. High-grade mineralization forms over the top of the magma and in chemically reactive wall rocks, like limestone.

Zone Above Water Table Leached of Copper

Erosion removes the stratovolcano and top of the original copper deposit. Rainwater and weathering cause copper to be leached from the top of the deposit and redeposited as the downward-moving groundwater reaches the water table. The resulting enriched zone is commonly high grade and fairly flat.
After erosion and enrichment, the deposit is covered by younger rocks, in this case volcanic rocks. The high-grade enriched zone is protected from further erosion, but now is buried and hidden. The volcanic landscape at the surface may contain few clues to the geological riches that lie at depth. Finding the deposit may require special methods (e.g., geochemical or electrical surveys), a number of risky drill holes, persistence, or luck.
WHAT, WHERE, AND HOW MUCH MINERALS ARE PRODUCED IN NEW MEXICO?
Value of mineral production in 2012 was $2.8 billion (does not include oil and gas)—ranked 12th in the US

Employment in the mining industry is 7511

1980-2012 >$29.9 billion dollars worth of mineral production (excluding coal, oil and gas)

Exploration for garnet, gypsum, limestone, nepheline syenite, agate, specimen fluorite, gold, silver, iron, beryllium, uranium, copper, potash, rare earth elements, humate, clays
<table>
<thead>
<tr>
<th>Mineral</th>
<th>Production</th>
<th>Production Rank</th>
<th>Production Value $</th>
<th>Employment</th>
<th>Reclamation Employment</th>
<th>Payroll $</th>
<th>Revenue Generated $</th>
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<tbody>
<tr>
<td>Coal</td>
<td>22,919,717</td>
<td>12</td>
<td>$797,394,984</td>
<td>1,770</td>
<td>377</td>
<td>$121,925,446</td>
<td>$24,924,777</td>
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<td>Copper</td>
<td>226,646,592</td>
<td>3</td>
<td>$819,214,107</td>
<td>1,841</td>
<td>84</td>
<td>$100,240,382</td>
<td>$6,338,256</td>
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<tr>
<td>Gold</td>
<td>9,758</td>
<td>-</td>
<td>$16,034,878</td>
<td>64</td>
<td>-</td>
<td>$3,301,917</td>
<td>$170,538</td>
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<td>Industrial Minerals</td>
<td>1,491,760</td>
<td>-</td>
<td>$100,975,769</td>
<td>470</td>
<td>21</td>
<td>$16,660,487</td>
<td>$911,955</td>
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<td>Aggregates</td>
<td>8,543,379</td>
<td>-</td>
<td>$76,945,909</td>
<td>913</td>
<td>102</td>
<td>$14,552,762</td>
<td>$6,380,696</td>
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<tr>
<td>Other Metals</td>
<td>117,199</td>
<td>-</td>
<td>$1,569,648</td>
<td>19</td>
<td>20</td>
<td>$1,229,746</td>
<td>-</td>
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<tr>
<td>Molybdenum</td>
<td>1,726,484</td>
<td>-</td>
<td>$21,687,231</td>
<td>282</td>
<td>-</td>
<td>$14,952,000</td>
<td>-</td>
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<tr>
<td>Potash</td>
<td>1,548,047</td>
<td>1</td>
<td>$953,477,008</td>
<td>1,473</td>
<td>30</td>
<td>$98,182,919</td>
<td>$4,443,294</td>
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<tr>
<td>Silver</td>
<td>203,221</td>
<td>-</td>
<td>$6,334,625</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>$93,779</td>
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<tr>
<td>Uranium</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>24</td>
<td>21</td>
<td>$1,189,898</td>
<td>-</td>
</tr>
</tbody>
</table>

| TOTAL           | $2,801,634,159 | 6,856      | 655                 | $372,235,557 | 43,263,295 | $19,180,372 |

Source: Mining and Minerals Division, unless otherwise noted.
ACTIVE MINES AND EXPLORATION IN NEW MEXICO 2000-2014 (EXCLUDING AGGREGATES)
~240 active registered mines (NMMMD)
5 coal
3 potash, 5 potash plants
1 moly (mine and mill)
1 gold mine and mill (on standby)
2 copper open pits, 1 concentrator (mill), 2 solvent/electro-winning (SX-EW) plants
2 additional mines in permitting stage
Several exploration
20 industrial minerals mines, 18 mills
~200 aggregate/stone
COAL
COAL

- Fuels electrical generating plants
- 4 surface mines and 1 underground mine in San Juan Basin
- Resources at Raton, Carrizozo
- 13th in production in U.S. in 2012
- 11th in estimated recoverable coal reserves—7 billion tons of recoverable reserves (2005 figures)
- Coal production is expected to decrease in the near future
3\textsuperscript{rd} IN COPPER IN 2012 (CHINO, TYRONE)
COPPER RESERVES—2009

- **Chino**
  - milling reserves are 54 million tons of 0.66% copper, 0.03 g/t gold and 0.013% molybdenum
  - leaching reserves are 69 million tons of 0.41% Cu

- **Tyrone**
  - leaching reserves are estimated as 139 million tons of ore grading 0.32% Cu

- **Cobre**
  - leaching reserves are 71 million tons of 0.40% Cu

- **Niagara deposit**
  - contains 500 million tons of ore grading 0.29% Cu (leaching)
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 million st reserves at 0.38% Cu)
4. Copper Hill, Picuris district (46.5 million st of ore at 0.42% Cu)
5. Lone Mountain (7.5 million st at 2-3% Cu, 102% Pb, 4-5% Zn, 203 opt Ag, .01-.02 opt Au)
6. McGhee Peak, Pelloncillo Mountains
7. Mimbres
Copper Flat, Themax Resources
Planned production per year for 11 yrs
50.76 mill lbs Cu
1.01 mill lbs Mo
12,750 oz Au
455,390 oz Ag
Start in 2018?
6TH MOLYBDENUM IN 2012 (QUESTA)—CLOSED IN JUNE 2014
1919-2012 >173 MILLION POUNDS MO WORTH
>$827 MILLION
MOLY RESERVES AT QUESTA CHEVRON MINING INC.

- **Proven reserves**
  + 16,344,898 tons of 0.343% MoS₂ at a cutoff grade 0.25% MoS₂

- **Probable**
  + 47,198,409 tons of 0.315% MoS₂

- **Possible**
  + 3,223,000 tons of 0.369% MoS₂

*FIGURE 1. Location map of the Red River mining district. 1 = Red River district; 2 = Elizabethtown-Baldy district; 3 = Twining district; 4 = Molycorp Questa mine.*
VICTORIO MOUNTAINS, LUNA COUNTY

- 21.5 million tons indicated ore at a grade of 0.15% Mo, 0.13% W
- Drilling this year increased the resource estimate
- Be also found in district
GOLD AND SILVER PRODUCTION IN 2004-2013 AS A BYPRODUCT OF COPPER PRODUCTION FROM THE IVANHOE CONCENTRATOR (FREEPORT-MCMORAN)

2009 SUMMIT MINE OPENED (CURRENTLY ON STANDBY)

9TH IN GOLD PRODUCTION
10TH IN SILVER PRODUCTION
1804-2012 >3.2 MILLION TROY OUNCES AU
WORTH >$448 MILLION
1804-2012 >118 MILLION TROY OUNCES AG
WORTH >$277 MILLION
1. Vera Cruz, Lincoln Co
2. Carache Canyon, Santa Fe Co
3. Lukas Canyon, Santa Fe Co
4. San Lazarus, Santa Fe Co
5. Jicarilla Au placers
6. Steeple Rock district
7. Mogollon
In 2009, Santa Fe Gold opened the Summit mine in the Steeple Rock district. The ore is milled at Lordsburg.
RESERVES IN CARLSBAD DISTRICT

Potash (>553 million tons)
Potash is used in fertilizers among other uses
1ST IN POTASH IN 2013 (MOSAIC, INTREPID MINING)
UNDERGROUND OPERATIONS AT MOSAIC POTASH MINE, CARLSBAD.
NEW DEVELOPMENTS IN POTASH

- Intercontinental Potash Corp. (IPC) plans to mine polyhalite at the Ochoa deposit SE of the district.
- Intrepid Mining NM LLC plans to solution mine at the HB Solar Solution mine (old potash workings).
INDUSTRIAL MINERALS ARE INCREASING IN IMPORTANCE IN NEW MEXICO

- 1st in zeolite (St. Cloud, Sierra County)
- 5th in pumice (6 operations)
- 1st in perlite (4 operations)
- 13th in gypsum (4 operations)
- 11th in salt (4 operations, Carlsbad)
STONE HOUSE ZEOLITE MINE, SIERRA COUNTY (18.3 MILLION TONS OF RESERVES).
PERLITE IN NEW MEXICO
GYPSUM IS MINED AT WHITE MESA, SANDOVAL COUNTY (EAGLE MATERIALS, FORMERLY CENTEX AMERICAN GYPSUM) AND USED TO MANUFACTURE WALLBOARD.
OTHER INDUSTRIAL MINERALS DEPOSITS

- Brick and clay in El Paso, Albuquerque areas
- Cement in Tijeras Canyon
- Humate in the San Juan Basin
- Travertine (dimension stone), Meso del Oro, west of Belen
  - 477.6 million tons of travertine
NEW MEXICO CLAY PRODUCTION 1949-2009

CLAY PRODUCTION
>3 MILLION TONS WORTH $8 MILLION 1949-2009
AGGREGATES

- ~200 active and standby aggregate mines in 2013
- highways, railroad, and home construction
- More aggregate operations are in rural areas
- A shortage of aggregate in urban areas is expected
AGGREGATE MINES IN NEW MEXICO
Annual volume of CO$_2$ gas produced from natural geological accumulations in New Mexico in billion ft$^3$ (BCF). Production data not available prior to 1965. Compiled by Ron Broadhead from data obtained from New Mexico Oil Conservation Division.
CARBON DIOXIDE FROM BRAVO DOME FIELD OF UNION AND HARDING COUNTIES, AND THE NOW ABANDONED DES MOINES FIELD OF UNION COUNTY AND THE TWO ESTANCIA FIELDS OF TORRANCE COUNTY

BRAVO DOME AND SIERRA GRAND UPLIFT INDICATING LOCATIONS OF THE BRAVO DOME AND DES MOINES CO₂ GAS FIELDS, WELLS THAT ENCOUNTERED CO₂ GAS SHOWS

WEST-CENTRAL NEW MEXICO SHOWING MAJOR TECTONIC ELEMENTS, THE ST. JOHNS CO₂ FIELD
Helium-rich gases have been produced from small Devonian, Mississippian and Pennsylvanian reservoirs in western San Juan County since World War II.
New Mexico has produced sulfur, mostly as a by-product of natural gas plants, although there are geological occurrences of sulfur in New Mexico.

Sulfuric acid from copper mills.
2nd in uranium resources 15 million tons ore at 0.277% U3O8 (84 million lbs U3O8) at $30/lb (DOE estimates in 2002)
Numerous companies have acquired properties (Strathmore, Energy Minerals, Laramide Resources, among others)
Energy Fuels acquired Strathmore in 2013 and is now permitting the Roca Honda mine
HRI, Inc. awaiting permits for in situ leach in Church Rock, Ambrosia Lake areas
Several exploration permits approved or in progress
URANIUM IN GRANTS DISTRICT

- World-class deposits
- 340 million lbs of $U_3O_8$ from 1948-2002 produced
- 4th largest district in total uranium production in the world
- More than 30% of the total uranium production in the United States
- ~380 million pounds of resources identified by the companies in 1980s (McLemore, 2007, 2013)
- Probably another 300 million lbs of $U_3O_8$ remaining to be discovered
- District total of 600-900 million lbs of $U_3O_8$
Uranium Production 1948-2002

Mine Water Recovery only
MOUNT TAYLOR HEAD FRAME, 2006
Importance of sandstone uranium deposits in the Grants district

► Major mining companies abandoned the districts after the last cycle leaving advanced uranium projects.
► Inexpensive property acquisition costs includes $$ millions of exploration and development expenditures.
► Availability of data and technical expertise.
► Recent advances in in situ leaching makes sandstone uranium deposits attractive economically.
OTHER POTENTIAL COMMODITIES
IRON ORE FROM THE CAPITAN MTS

- Produced 250,000 mill tons Fe ore 1963-1988
- El Capitan Precious Metals Corp. claims a resource of 141,000 tons ore of 0.041 opt Au
- Drilling permit approved by MMD 11/26/07, but rejected by the USFS requesting additional work
KLINE MOUNTAIN KAOLIN DEPOSIT
MINERALS NEEDED FOR EMERGING GREEN TECHNOLOGIES

beryllium tuff (USGS OF 98-524)
SOME OF THE MINERALS REQUIRED FOR THESE GREEN TECHNOLOGIES ARE FOUND IN NEW MEXICO
Elements in Computer Chips
(National Research Council, 2007)

- **Green** elements needed in 1980s
- **Yellow** additional elements needed today

The diagram shows the periodic table with elements highlighted for their significance in computer chips.
OCCURRENCES OF RARE EARTH ELEMENTS (REE) IN NEW MEXICO

- Tertiary REE veins and alkaline rocks
- District with numerous Cretaceous beach placer sandstone deposits
- Cretaceous beach placer sandstone deposits
- Cambrian REE veins and alkaline rocks
- Proterozoic alkaline rocks and pegmatites
REE in Gallinas Mountains, Lincoln County
REE IN CORNUDAS MOUNTAINS, OTERO MESA
Be in NM

Be in Proterozoic pegmatites
Porphyry Mo deposits
Be in alkaline rocks (syenites)
Be in carbonate-hosted replacement/skarn deposits
Volcanogenic Be (Spor Mountain Be-F-U, volcanic-hosted, or volcanic-epithermal) deposits

Mineral Veins and Deposits
- volcanic-epithermal veins
- Au-Ag-Te alkaline-related veins
- skarn/carbonate-hosted polymetallic veins
- veins/replacement in Proterozoic rocks
- porphyry copper

Map of New Mexico showing locations of beryllium deposits.
Porphyry copper deposits

- **Current**
  - Gold
  - Silver
  - Molybdenum
- **Possible**
  - Tellurium
  - Gallium
  - Germanium
  - Indium
  - Others
OTHER POTENTIAL COMMODITIES

- Nepheline syenite from Wind Mt, Cornudas Mts (200,000,000 tons)
- Garnet from Grant County, San Pedro, Orogrande
- Iron ore from Orogrande
- Titanium (Fe, REE, Th, Y, Zr) from Cretaceous black sandstone deposits in San Juan Basin
- Kaolin, tin in Taylor Creek
- Au, Ag Steeple Rock, Malone, Burro Mountains
SUMMARY
Commodities are needed to maintain our standard of living, even for green technologies, like solar, wind.

Mineral deposits are controlled by geology.

Mining disturbs the ground—there can be risks.

Boom or bust—cyclic industry.
exploration and permitting takes many years before a deposit can be mined

mining is important to rural New Mexico (create wealth)

New Mexico has a wealth of mineral resources
WHAT ARE THE MINING ISSUES FACING NEW MEXICO?

- Legacy issues of past mining activities form negative public perceptions of mining.
- Mining today is not performed in the same manner as 20 years ago.
- More land is being withdrawn from future exploration (i.e. land status).
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—math, science skills critical.
MORE INFORMATION

- Mines and Minerals Division
  http://www.emnrd.state.nm.us/MMD/index.htm
- Virginia McLemore web page
  http://geoinfo.nmt.edu/staff/mclemore/home.html
- New Mexico Bureau of Geology and Mineral Resources
  http://geoinfo.nmt.edu/