New Mexico
EARTH
MATTERS

Winter 2005

Mining In New Mexico: An Industry In Transition

The extraction of rocks, minerals, and earth materials likely began in New Mexico thousands of years ago, when humans first entered the state. Crude tools were fashioned of stone, and colorful rocks and minerals were worked into paints, jewelry, and other decorative artifacts. Quarries and excavations were developed to obtain larger quantities of important materials. Later the region was settled by European immigrants, often lured by tales of vast mineral wealth. Some found it, and during the nineteenth and early twentieth centuries thousands of pits, shafts, and adits were dug throughout New Mexico for a variety of metals and minerals including gold, silver, turquoise, lead, zinc, copper, coal, iron, limestone, and many others. Throughout the state's history, mining has been a significant part of the culture, especially in towns that were established or expanded to support nearby mines such as Mogollon, Chloride, Santa Rita, Pinos Altos, Elizabethtown, Magdalena, White Oaks, Lordsburg, and Hillsboro.

Smithsonite, a zinc mineral from the Magdalena district, Socorro County. © Jeff Scovil.

Mining in Our Generation

Mineral production in New Mexico and the world has increased dramatically in the last hundred years. During the last century the mining industry evolved from small mines operated by a few individuals to large operations that employ hundreds of people, in an effort to become more efficient and cost-effective while increasing production to meet the needs of a growing population. This has allowed lower grades of ore to be mined at a profit. Large-scale mining, predominantly copper, was established in the Silver City area. The once-thriving town of Santa Rita was swallowed up by the Chino copper mine, and its former location is now hundreds of feet above the floor of the Santa Rita pit. Uranium mining rapidly expanded near Grants and Gallup. Large surface coal mines opened in the San Juan Basin near Farmington, Gallup, and west of Raton to supply fuel to electric power plants. The largest reserves of potash in the nation, used primarily for fertilizer, were developed near Carlsbad. In addition, aggregate and stone are produced across the state, with the lion's share mined in the Rio Grande corridor near population centers.

In 2003 mineral production in New Mexico exceeded $1.2 billion, with coal, copper, and potash leading the way. The mining sector provides between 5,000 and 6,000 jobs with an average annual salary of $53,000, almost double the average for all job types in the state. Many mining companies also provide additional benefits to local communities such as infrastructure improvements, community services, and direct revenues.

There is a down side to a mining-based economy. Much of the mining industry is cyclic, resulting in a "boom-and-bust" economy. Commodity prices fluctuate, causing mines to open and close depending on whether the mine can make a profit. During the "bust" times, unemployment rises, mining revenues and taxes decrease, and the town falls on hard times. Eventually economic reserves may be mined out, causing the mine to shut its doors permanently. Elizabethtown, north of Eagle Nest Lake, boasted a population of 7,000 in 1870; today it is all but gone. The key to tempering these negative effects is for communities to develop a diversified economy. Silver City is an example of a town whose early years were dependent on mining but today is home to a university, has a significant arts community, and is a popular retirement destination, though mining continues to be a major player.

Living with Mining in Our Midst

MINERAL	PRODUCTION RANK (U.S.)	PRODUCTION VALUE ($)	NUMBER OF EMPLOYEES	PAYROLL ($)	REVENUE GENERATED ($) STATE AND FEDERAL (COMBINED)
Coal	12	628,291,436	1,651	110,979,081	34,027,172
Copper	3	158,138,070	879	26,815,001	548,521
Gold	–	–	–	–	3,900
Industrial minerals	–	153,198,856	663	18,708,370	941,640
Aggregates	–	77,848,579	1,063	17,190,991	703,926
Molybdenum	5	15,800,000	165	7,000,000	
Potash	1	202,166,863	824	47,249,963	3,833,394
Silver	–	–	–	–	1,763
Uranium		–	32	1,000,000	232
TOTAL		**1,235,443,804**	**5,277**	**228,943,406**	**40,060,548**

Summary of production rank, production value, employment, payroll, and revenue for selected mineral commodities in New Mexico in 2003.

Mining has a legacy of environmental concerns; one of them is acid drainage. Certain rocks contain minerals such as pyrite that react when exposed to oxygen, water, and bacteria to form sulfuric acid. These acidic waters then dissolve other minerals and metals that can impact surface and ground water. Other environmental problems associated with mining include impacts to wildlife and fisheries, habitat loss, dust, truck traffic, road damage, noise, blasting, and impacts to the landscape.

Few citizens want a mine in their back yard, but we don't have the option of locating mineral resources where it is convenient. Mineral deposits are relatively rare and form only under specific geologic conditions. Aggregate deposits, critical to building infrastructure across the U.S., are much more common, so sometimes we do have choices for their location. However, locating them far from where they're needed greatly increases transportation costs, which may double or triple the delivered cost.

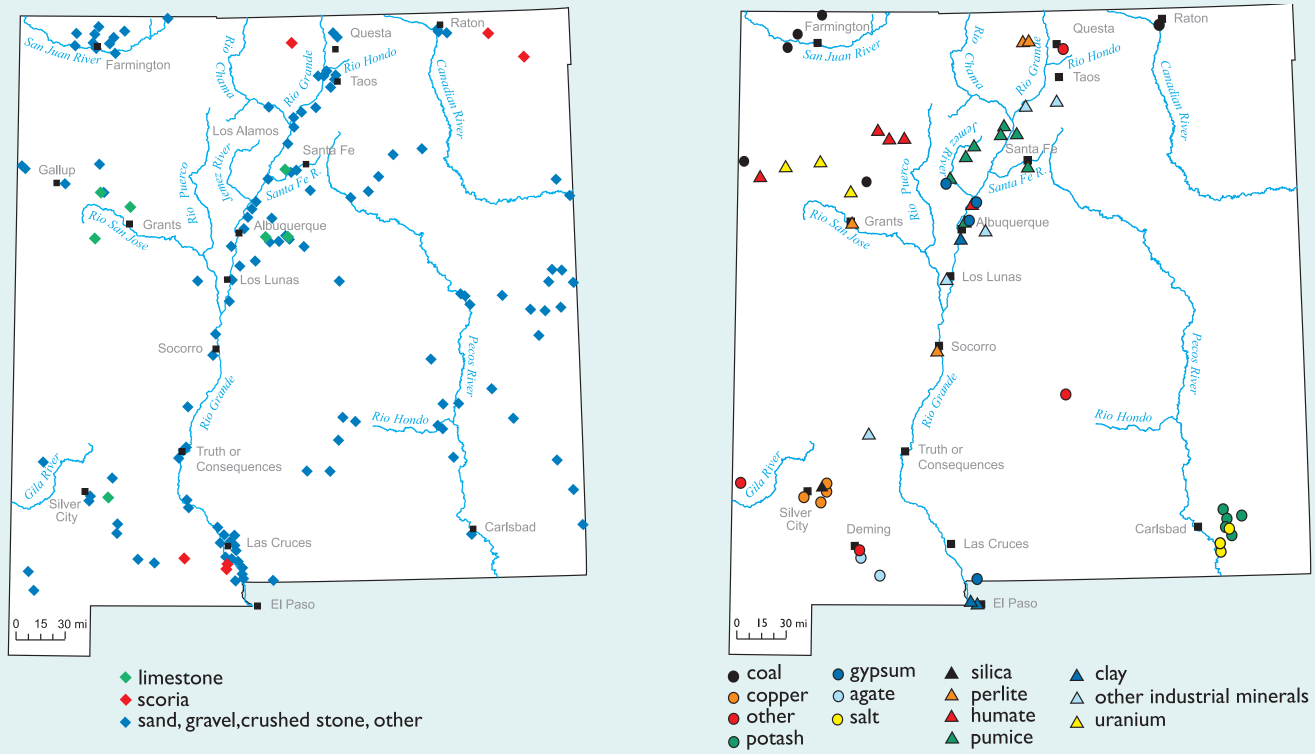
This dilemma has led to a complex web of federal, state, and local requirements designed to address environmental protections and citizen concerns. New Mexico's 1967 Water Quality Act and 1967 Air Quality Act are two of the more important laws that protect water and air resources. Reclamation of most non-aggregate mines is required under New Mexico's 1993 Mining Act and the 1977 New Mexico Surface Mining Act (for coal). Other laws address threatened and endangered species, worker safety, water rights, and other concerns. Federal and state land management agencies, including the U.S. Forest Service, Bureau of Land Management, and State Land Office, address mining on public and state-owned lands and have environmental and citizen protection requirements of their own.

The question of where mines should be located is not clearly addressed by current regulations. Some lands are simply off limits, including most national and state parks, monuments, wild and scenic rivers, wildlife refuges, and other protected areas. Other areas are zoned for different uses, such as residential or commercial. However, most lands do not have specific prohibitions on mining, and mining companies are sometimes at odds with organizations and local communities that are concerned with potential negative effects of proposed mines. The biggest unresolved question is: How much say should the public have regarding location and management of mines?

Permitting, environmental protection measures, and reclamation all add to the cost of operating and closing a mine. These costs are ultimately reflected in the price the consumer pays for the end products. How much is society willing to pay to ensure our natural resources are protected and our citizens are safe? The mining industry's image suffers from past practices, which often led to degraded land, contaminated water, or dangerous abandoned mine workings. Such practices were accept-

COMMODITY	GEOLOGIC SETTING	PERIOD OF PRODUCTION	MAJOR USES	ESTIMATED TOTAL PRODUCTION / VALUE IN NM
Coal	Sedimentary	1861 to present	Electric power generation	584,089,528 tons / $7,949,517,551
Copper	Igneous; sedimentary	1804 to present	Electrical and industrial	>10.2 million tons />$13.5 billion
Potash (incl. salt)	Sedimentary	1932 to present	Fertilizer; other uses	171 million tons / >$7 billion
Molybdenum	Igneous	1918 to present	Alloying agent in steel	>146 million pounds / >$214 million
Gold and silver	Igneous; placer deposits	1848 to 2001	Jewelry, monetary, electrical, photography	Gold: >3.2 million ounces / >$394 million; Silver: >117 million ounces / >$252 million
Uranium	Sandstones	1948 to 2003	Electric power generation	>347 million pounds / >$4.7 billion
Pumice	Volcanic	1940s to present	Construction	$31,000,000
Perlite	Volcanic	1947 to present	Construction, filter aid	$10,000,000
Humate	Sedimentary	1960 to present	Soil conditioner	> $1,000,000
Gypsum	Sedimentary	1960 to present	Construction (wallboard)	>$20,000,000
Limestone	Sedimentary	1959 to present	Construction	>$4,000,000,000
Zeolite	Volcanic ash	1990 to present	Commercial and industrial uses, incl. cat litter	>$20,000,000
Mica	Metamorphic	1990 to 2004	Construction, paint, and cosmetics	$9,000,000
Iron ore	Igneous	1883 to 1995	Cement and steel	8.2 million long tons/ $17.3 million
Clay	Sedimentary	before 1900 to present	Construction (bricks) and pharmaceutical	<$10,000,000
Aggregate/stone	Various	1600 to present	Construction, agriculture, and other	>$3 billion

Selected mineral commodities in New Mexico, their origin, uses, and production value.



Significant aggregate operations (left) and metal and industrial mineral mines and mills (right) in New Mexico.

able at the time, but no longer. Today there is a strong emphasis on mining in an environmentally sensitive manner, and returning the land to a beneficial use after mining ceases. Achieving these goals is particularly difficult for large mines that were established and operated decades ago when expectations and regulatory requirements were more lax or nonexistent. Today many operators must post a bond with the regulatory agency (financial assurance). These financial resources are used by the agency to reclaim the mine only if the operator is unable or unwilling to comply with reclamation obligations.

The decision to mine or not to mine has always been, ultimately, an economic one. Many mining companies are subsidiaries of multi-national conglomerates that operate all over the world. Efficient and rapid transportation has led to global competition and pricing for many commodities. Production costs vary widely due to differences in orebody characteristics, labor costs, environmental protection measures required, etc. These all affect whether a deposit can be mined economically. For example, New Mexico coal production faces stiff competition from lower-cost coal in Wyoming, perlite mining in New Mexico has been impacted by imports from Greece, and potash prices are depressed due to lower-cost imports from Canada.

The Future of Mining in New Mexico

Mining plays a vital role in the world's economy by filling a persistent demand for the raw materials that are the foundation of our civilization. Recycling and conservation can reduce but not eliminate the need for new mined materials, so mines will be required for the foreseeable future.

Minerals production in New Mexico has declined since its peak in 1989. This is the result of many complex and interrelated factors, including declining commodity prices and ore quality. The highest-grade metal ores are mostly mined out, and the discovery of new, large, high-grade deposits is uncertain. Other factors that have hindered new mines from opening in the state include water rights issues, public perceptions, and the complexity and length of time for regulatory permitting. Active copper operations report only a few decades of remaining reserves. However, other deposits may become economic if prices rise substantially or technological advances allow for lower-cost extraction. Vast uranium deposits remain in the Grants–Gallup area, but corporate policy prohibiting uranium production, lack of mills in the area, concerns over water quality, low prices, and other environmental issues have ended New Mexico uranium production for now. New technologies in leaching uranium in place without conventional mining (in situ leaching) could facilitate uranium production in the future. The potash district east of Carlsbad has seen extraction of its best reserves, and several mines have closed. Even so, consolidation of other operations has decreased mining costs, which will allow many decades of additional production if adequate prices prevail.

At current production rates, New Mexico has sufficient coal reserves to last hundreds of years, but current competition from lower-cost deposits, and concerns over greenhouse gas emissions from burning coal as fuel, have put the long-term future of coal in doubt. Society may turn to other cleaner energy sources if new technology is not developed that allows economical capture of greenhouse gases from the burning of coal. In any case, it is likely that coal will play a major part in the state's energy future for many years to come.

Industrial minerals and aggregates are becoming an increasing part of New Mexico's mining industry. Many of

Phelps Dodge's Santa Rita pit at the Chino mine near Silver City.

these minerals and materials have a low unit value, so long-distance transportation increases cost, favoring nearby sources. Most mining operations of this type do not impact water quality, and many deposits are outside of mountainous regions, which makes land reclamation easier and less costly.

Future production and consumption of minerals will rise as population grows worldwide, and as people demand a better quality of life. Companies will continue to explore for new deposits in known mineralized areas, including the major mining districts in New Mexico. However, there is a strong movement toward developing a sustainable economy, and mining will be a part of that. Technological improvements in mining practices and environmental protection continue to change how we mine. Stakeholders are increasingly included in decisions on how mines are located, managed, and closed, allowing mines to be temporary features of the land, eventually turned to other beneficial uses. If we as a society continue these current trends, mining will make a successful transition from past practices that are no longer acceptable, to an environmentally sensitive, economically viable industry, to the benefit of us all.

–Douglas Bland
New Mexico Bureau of Geology and Mineral Resources

Each issue of Earth Matters features an invited article on a subject of interest to New Mexicans. These articles represent the author's informed opinion on important geoscience issues in New Mexico. The New Mexico Bureau of Geology and Mineral Resources is a non-regulatory agency. – Ed.

For More Information

Minerals Industry in New Mexico in 1998-2000 by V. T. McLemore, G. K. Hoffman, and J. Pfeil, 2002. *New Mexico Geology*, v. 24, p. 19-28.

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Geology of New Mexico Minerals and Materials

New Mexico is one of the most geologically diverse states. The wondrous landforms that help make this the "Land of Enchantment" are also host to a wide variety of mineral deposits.

Copper is produced near Silver City from Tertiary igneous rocks that have undergone alteration and enrichment that has concentrated copper minerals. Gold, silver, and molybdenum are associated with some of these copper deposits, and have been produced as byproducts.

Coal is a sedimentary rock, formed in ancient swamps. All active mines are located in the San Juan Basin near Farmington, Shiprock, Gallup, and Grants. Coal beds from the Cretaceous Fruitland and Menefee Formations are interspersed with sandstone, shale, and mudstone. The Fruitland coal is also one of the most prolific producers of coalbed methane in the world.

Potash is mined near Carlsbad from the Permian Salado Formation, from mines about 2,000 feet below the surface. These deposits originated in shallow seas about 250 million years ago. These seas went through episodes of isolation and evaporation, causing minerals to precipitate out of the sea water, including gypsum, sodium chloride (table salt), and the potassium minerals sylvite and langbeinite. This formation is home to the WIPP (Waste Isolation Pilot Project) site.

Molybdenum is mined near Questa from Tertiary igneous rocks. Molybdenite is concentrated in veins and along fracture surfaces in a granitic host rock, formed when molten rock cooled beneath the earth's surface.

Industrial Minerals – White gypsum is mined from the Jurassic Todilto Formation sediments near San Isidro and processed into wallboard in Bernalillo and Albuquerque. Limestone and shale of Pennsylvanian age are quarried east of Albuquerque and processed into portland cement. Limestone is quarried in other areas of New Mexico and crushed into gravel. Perlite is a young volcanic deposit found near Tres Piedras and Socorro that contains water in its matrix. When ground and heated, it expands or pops to four to twenty times its original volume, forming a solid, lightweight, glass foam. Pumice in northern New Mexico is used as aggregate to make cinder blocks and other construction products.

Aggregates such as sand, gravel, crushed stone, and fill dirt are most commonly derived from alluvial deposits eroded from nearby hills and mountains. The eastern Great Plains produce caliche, an aggregate derived from unconsolidated materials that have been cemented by waters containing calcium carbonate. Aggregates can be found in every county of New Mexico.

Staff Profile

Virginia McLemore

Senior Economic Geologist • Minerals Outreach Liaison

Ginger McLemore, a native of Baltimore, Maryland, moved to Socorro, New Mexico, to attend New Mexico Tech. She completed B.S. degrees in geology and geophysics in 1977 and an M.S. in 1980. Upon completion of her M.S., Ginger joined the bureau staff. She completed a Ph.D. at the University of Texas at El Paso in 1993, on the geology and geochemistry of mineralization and alteration in the Steeple Rock district, New Mexico and Arizona. Over the years Ginger has worked on a variety of research and service projects and has become a well-known figure throughout the New Mexico mining industry.

Ginger's research interests cover a broad range of topics on the geology of New Mexico, including mineral resources of Taos County, Sierra County, Otero County, and the Pecos and Jones Hill areas of Santa Fe and San Miguel Counties. She has also worked on the geochemistry, geochronology, and evolution of igneous intrusions and mineralization in southwestern New Mexico; the geology and geochemistry of the Copper Flat porphyry copper deposit and associated deposits in the Hillsboro district; and Proterozoic rocks in the Burro Mountains and adjacent areas in New Mexico, Arizona and west Texas.

Ginger is currently the lead investigator for the bureau in a multi-million-dollar project at Molycorp's Questa mine, on the characterization of the Questa rock piles. This cooperative project includes bureau staff, New Mexico Tech faculty and students, the University of Utah, and several other universities. The goal is to better understand the weathering processes that affect mine rock piles to mitigate possible hazards.

In collaboration with Gretchen Hoffman and Maureen Wilks, Ginger developed the bureau's New Mexico Mine Database, which includes data on the districts, mines, quarries, deposits, and mills of New Mexico, with the goal of identifying and evaluating resource potential, resource development and management, production, and possible environmental concerns throughout the state. She is the manager of the bureau's Uranium Library and the National Uranium Resource Evaluation (NURE) database.

Ginger is actively involved in the bureau's outreach efforts. A regular participant in the bureau's annual workshop for K-12 teachers, *Rockin' Around New Mexico*, Ginger regularly works with teachers throughout the state. Ginger has authored over 150 articles, including the revised version of the very popular bureau map, *Silver and Gold in New Mexico*. Ginger is well known to *New Mexico Geology* readers for her numerous articles on the geology of New Mexico's state parks. She has worked closely with both staff and volunteers of the New Mexico State Parks Division in developing outreach programs and has been a familiar presence at their Discovery Weekends.

Ginger is an adjunct faculty member in the Earth and Environmental Science and Mineral Engineering Departments at New Mexico Tech, where she teaches the Geology of Industrial Minerals class and advises undergraduate and graduate students.

A longtime member of the New Mexico Geological Society, Ginger has worked on many annual field conferences and symposia. Ginger has been an editor for the American Institute of Professional Geologists (2001–2003) and is a certified professional geologist. She is a member of the Geological Society of America, the Society of Mining, Metallurgy and Exploration, the New Mexico Mining Association, and is a Fellow of the Society of Economic Geologists.

In 2004 Ginger received two awards acknowledging her tireless work for the mining industry in New Mexico. Ginger received an Appreciation Award from the New Mexico Mining Association for her participation at their sixty-fifth annual meeting, and the Team of Excellence Award from the Utah Engineering Experiment Station for her contributions to the Molycorp project.

Ginger and her husband James share an active interest in shooting. Both are members of the New Mexico Shooting Sports Association and firearm instructors. Ginger is a certified U.S. International Rifle coach and has won numerous awards. Ginger has two daughters; one works and lives in Albuquerque, and the youngest is currently serving in the Navy at Virginia Beach, Virginia.

New Mexico
EARTH MATTERS

Volume 5, Number 1
Published twice annually by the
New Mexico Bureau of Geology and Mineral Resources

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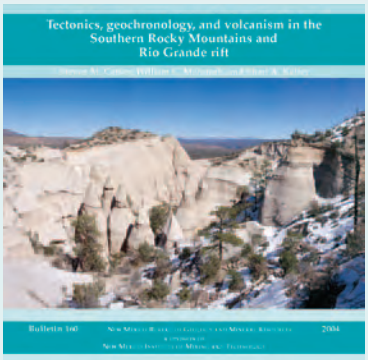
Cover photo of Ship Rock, New Mexico

New Publications



Bulletin 160—Tectonics, geochronology, and volcanism in the Southern Rocky Mountains and Rio Grande rift, edited by Steven M. Cather, William C. McIntosh, and Shari A. Kelley, 2004. ISBN 1-883905-21-4. Available on CD-ROM only. $10.00 plus $2.50 for shipping and handling.

The fifteen papers included in this volume represent decades of research on the tectonic and volcanic history of the Southern Rocky Mountains and the Rio Grande rift of New Mexico and Colorado. Detailed geologic mapping, geophysics, and expanded geochronology datasets provide important new insights into the tectonic history of major fault zones in New Mexico and document a complex history of Laramide-age faulting. Authors address the Laramide-age structural development of the Front Range of Colorado and identify previously unrecognized trends in the timing and distribution of latest Eocene to Pliocene volcanism in Colorado and New Mexico. A wealth of new geochronologic data is provided, including hundreds of previously unpublished dates. Among other things, these dates document the eruptive history of the Ocate volcanic field and provide ages for some of the youngest lava flows in the state of New Mexico. The data in the appendices are provided in a form that allows them to be imported into other programs (including GIS software) for manipulation. Many of these papers are destined to become classics in the scientific literature on the Rio Grande rift and the Southern Rocky Mountains.

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Bureau News

This year's **New Mexico Earth Science Achievement Awards** were presented on January 28, 2005 to State Senator Carlos R. Cisneros (District 6) for outstanding contributions advancing the role of earth science in areas of public service and public policy in New Mexico, and to Dr. John W. Hawley for outstanding contributions advancing the role of earth science in areas of applied science and education in New Mexico. This annual award is co-sponsored by the bureau and New Mexico's Energy, Minerals and Natural Resources Department in Santa Fe. It honors individuals who have made outstanding contributions to advancing or facilitating the role of geoscience in areas of education, research, public service, and public policy in New Mexico. Nominations for next year's awards are solicited from at large and can be made before to November 1, 2005. Names should be submitted directly to Director Peter Scholle at the New Mexico Bureau of Geology and Mineral Resources.

We've welcomed several new staff persons to the bureau in the past few months. **Valentina Avramidi**, our new business office manager, fills a position vacated by Judy Vaiza, who retired in December 2004. **Gina D'Ambrosio** has accepted the position of production editor that was vacated by Jeanne Deardorff in December. **Bonnie Frey** has accepted the position of manager of the water chemistry lab, following the departure of Terry Thomas in November 2004.

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