



New Mexico EARTH MATTERS

SUMMER 2013

ONGOING RESEARCH AT THE NEW MEXICO BUREAU OF GEOLOGY

Since 1927 the New Mexico Bureau of Geology and Mineral Resources has been pursuing fundamental research on the geologic framework of our state. This work has included geologic mapping and assessments of the state's natural resources, as well as research on diverse aspects of the state's geology. Throughout our history we have conducted statewide resource inventories and evaluations of oil & gas, coal, potash, and other minerals. We are also responsible for archiving and providing this information to other researchers, government agencies, industry, educators, and the general public.

In addition to these fundamental programs, which have flourished over the years, much of the research accomplished today at the bureau is through smaller, focused, regional studies. Many are done at the request of (and often with the financial support of) other state and federal agencies, including the U.S. Geological Survey, the National Park Service, the Bureau of Land Management, the National Science Foundation, the Department of Energy, the New Mexico State Land Office, and local city and county governments. These studies are generally more detailed, often with more specific goals in mind. But in all cases the ultimate goal is to provide solid, unbiased geologic information and expertise relevant to the state's societal needs (such as the increasing scarcity and vulnerability of the state's water resources) or to help boost regional economic development, be it related to agriculture, mining, oil & gas, geothermal resources, or tourism.



Kristoph Kinzli (left) and Paul Bauer measuring the flow of the river in the Rio Grande gorge north of Taos, as part of the Rio Grande Gorge Spring Study. BLM photo by Del DuBois.

As a division of New Mexico Tech, much of our research involves graduate students and is often conducted in collaboration with faculty from other departments or divisions of the university. What follows here is a description of some of our current, ongoing projects. Many of these are multi-year projects. All of the results of our research are shared with other state agencies and are made available to the public.

WATER RESOURCES

Southern Taos Valley Hydrology

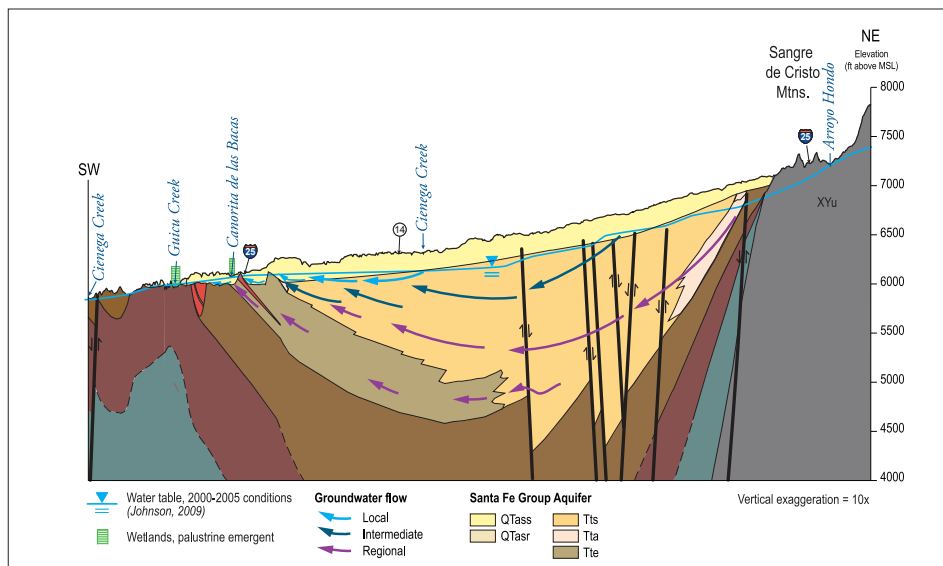
Since 1987 the bureau has been working in southern Taos County on detailed geologic mapping of the northern Rio Grande Valley. In 2011, in response to concerns regarding groundwater availability, the

bureau initiated a three-year hydrogeologic study of the southern Taos Valley, southwest of Taos. The goal is to produce a GIS-based, three-dimensional conceptual model of the groundwater system, which will include information on groundwater residence time, flow direction, and groundwater chemistry. This will help county officials make more informed decisions regarding the future of groundwater resources, and the impact of ongoing development on both surface water and groundwater resources.

In addition to geologic mapping, the work involves hydrologic inventories of wells and springs, measurement of water levels in existing wells, sampling of water for chemical analysis, and precipitation studies. The final report is due in 2014.

Springs and Wetlands at La Cienega

The bureau has been involved in a comprehensive study of the geohydrology of wetlands in the vicinity of La Cienega, south of Santa Fe, since 2011. These springs and wetlands occur where groundwater intersects the land surface. They provide an important source of water for domestic and agricultural use as well as wildlife. The goal of the study was to understand the sources of groundwater that sustain these wetlands. Future goals of collaborating agencies include developing strategies to restore springs and wetlands that have been impacted by local development, and assuring the future sustainability of these important resources. The study revealed a



Hydrogeologic setting for groundwater-fed wetlands at La Cienega, illustrated in a west-to-east cross section of the Santa Fe embayment. Groundwater flows west from the Sangre de Cristo Mountains across the basin and circulates to various depths within the Tesuque Formation (part of the Santa Fe Group aquifer).

complex, three-dimensional groundwater system. Groundwater discharge from the Santa Fe Group regional aquifer sustains these wetlands. These groundwater flows are susceptible to increased groundwater withdrawals and are affected by seasonal fluctuations. A majority of the wells in the study have shown a persistent decline in water levels in the last decade. This study has redefined the shallow aquifer in the Santa Fe region, and has broad implications for that part of the state.

Union County Groundwater Assessment

Ongoing drought, new groundwater appropriations, and water level declines in local wells—in a region whose economy is highly dependent upon groundwater—have led to concern over the sustainability of groundwater resources in Union County. In 2010 the bureau began a study of the regional hydrogeology, specifically an area of 650 square miles in east-central Union County where the majority of the irrigated agriculture exists. The broad goals were to understand the occurrence, age, and flow paths of groundwater. We were also interested in determining the degree to which the Ogallala–Dakota aquifer is being recharged. Findings indicated that the Ogallala aquifer has largely been dewatered since the 1950s and that current groundwater extraction rates greatly exceed the rate of recharge, which is consistent with the observed ongoing water declines. Groundwater resources currently being used in Union County are thousands of years old, and with no significant recharge

occurring, they are being used far faster than they can be replenished. The final report will be released this year.

Sacramento Mountains and the Tularosa Basin

The bureau has been involved in a major study of the hydrogeology of the Sacramento Mountains since 2006, in an effort to understand the complexity of this large hydrological system. This is the groundwater recharge area for the Roswell Artesian Basin, the Tularosa Basin, and the Salt Basin. The research included monitoring of groundwater levels and determination of groundwater ages, which are important in understanding the rate at which groundwater moves. Final products of the study have included a regional water table map and a very detailed regional geologic map. The research has also helped clarify the amount of recharge to adjacent regional aquifers, including the Roswell Artesian Basin. A final report on this project is now available to the public.

More recently our work in the area has focused on the effects of forest thinning on groundwater recharge in a high-elevation watershed in the southern Sacramento Mountains. Water balance calculations before and after tree thinning in Three L Canyon will help to assess the effectiveness of tree thinning as a method of increasing local and regional groundwater supplies in the area.

Since 2009 the bureau has been working on a comprehensive hydrogeologic investigation of the Tularosa Basin, with a goal of producing a conceptual model of the hydrologic system. Final products will include regional geologic map compilations, a regional water table map, and information on water quality and groundwater age. These data will ultimately help us provide estimates of mountain-front recharge to the northeastern Tularosa Basin, which supplies communities in and around Alamogordo, Three Rivers, and Carrizozo.

Hydrogeology of White Sands National Monument

The National Park Service has engaged the bureau (along with staff from NMT's Earth and Environmental Science Department) to study the shallow aquifers in the vicinity of White Sands National Monument. The goal has been to understand the degree to which increased regional



Talon Newton sampling a shallow observation well (for both water level and water quality) at White Sands National Monument. Photo by Trevor Kludt.

pumping of groundwater and climate change will affect the shallow groundwater systems, and how this may ultimately affect the stability of the gypsum dunes. White Sands National Monument includes a substantial portion of the largest gypsum dune field in the world, and attracts visitors from all over the world. The final report is due in 2015.

Paleohydrology of the Camino Real

As part of the ongoing plans for the development of Spaceport America, the bureau is studying the paleohydrology of the Camino Real. This research is being done in support of and in conjunction with archeological studies of the area, in order to mitigate adverse effects to the

historic Camino Real de Tierra Adentro, which has been designated a national historic trail by Congress. Involving an area of 611 square miles of the Jornada del Muerto surrounding Spaceport America and El Camino Real, the work is focused on the hydrogeologic framework of the region and the groundwater flow conditions. With an emphasis on the past one thousand years, the study includes a look at both extinct and historic water sources, including paleosprings and paleo-wetlands.

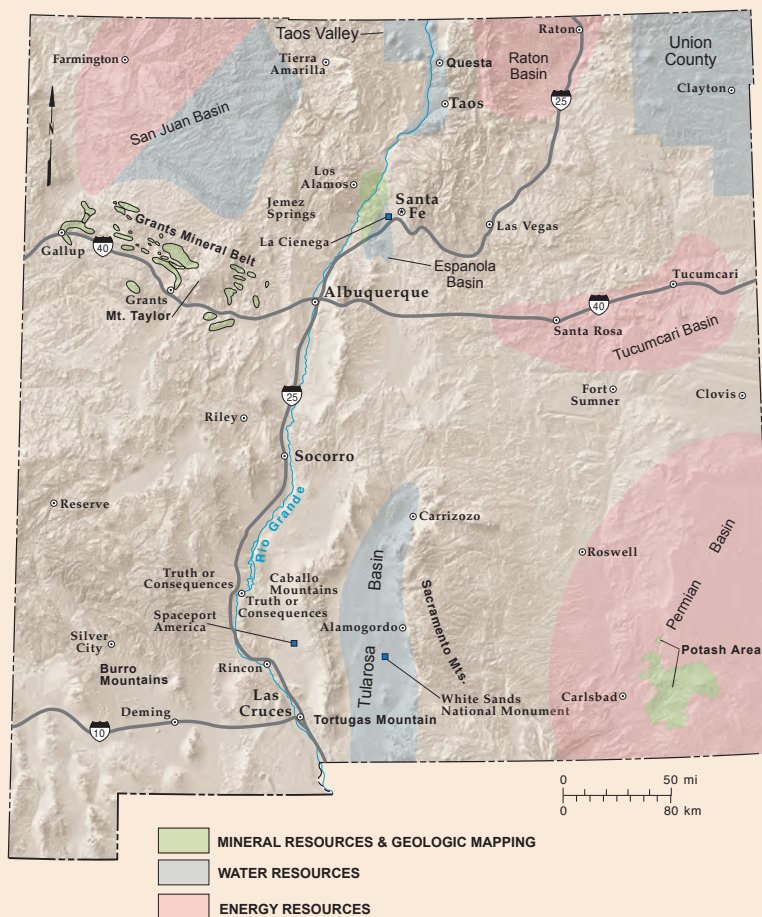
San Juan Basin

At the end of 2012 New Mexico Tech embarked on a project in the San Juan Basin of northwestern New Mexico. This project is a joint effort of the Petroleum Recovery Research Center (PRRC), the Department of Petroleum Engineering, and the Bureau of Geology. Project goals include a more detailed characterization of existing Mancos Shale oil and gas reserves, as well as an evaluation of water resources available for the future development of these reserves. The bureau's work will involve making preliminary estimates (using GIS data) of the total volume of material (rock, water, oil, and gas) in each of eleven major aquifers in the San Juan Basin. We will use petroleum reserve information to determine how much of the fluid might be petroleum. We will then use water chemistry data to estimate how much of the water is potable and how much is saline. The project will continue through October 2014.

ENERGY RESOURCES

Oil & Gas Resource Assessments

The bureau has been involved for many years in studying the geologic framework and petroleum geology of the Mancos Shale, in the San Juan Basin of northwest New Mexico. Development of resources within the Mancos Shale are likely to constitute a large portion of future oil and natural gas production in the state. We have also been developing a summary of



Areas of current research are highlighted on this map of New Mexico. Since 1927 we have worked in virtually every corner of the state. Detailed geologic maps (1:24,000) are available for about one third of the state.

the state's unconventional shale oil and shale gas resources, primarily from formations within the Permian Basin, the San Juan Basin, and the Raton Basin. We have conducted detailed studies of the Woodford and Barnett Shales in the Permian Basin, and the Pierre and Niobrara Shales in the Raton Basin. These unconventional resources are likely to fill the gap created down the line by the decline of the state's conventional oil and gas resources.

Petroleum geology studies at the bureau of the Tucumcari Basin over a twenty-year period have resulted in extensive leasing and exploratory drilling in the basin, which in turn has resulted in substantial gas discoveries. Exploratory drilling in the Tucumcari Basin is ongoing.

We have also been involved in evaluation of the state's helium resources, as demand for increasingly scarce domestic sources of this indispensable gas has increased. Finally, in conjunction with the Earth and Environmental Sciences Department, we recently submitted a proposal to the U.S. Geological Survey to investigate induced seismicity associated with the disposal of

produced water in the vicinity of the Dagger Draw oil field in Eddy County.

Geothermal Resources

New Mexico currently utilizes low and intermediate temperature geothermal resources for aquaculture, greenhouses, recreation, district heating, and space heating. In recent years there has been renewed interest in exploring and developing these geothermal resources, and in determining the sustainability of existing resources statewide.

With support from the Department of Energy, and in cooperation with bureau staff, the Jemez Pueblo is drilling an exploratory geothermal well in the vicinity of Jemez Springs. Drilling is expected to begin in September of this year. Bureau geologists will be responsible for logging and interpreting data from the well, and for helping to evaluate the pueblo's geothermal resources.

In 2012 New Mexico Tech was approached by the city of Truth or Consequences to help them understand the

complexity of their geothermal resources. Increased drilling in the vicinity of T or C has been seen as a potential threat to existing warm springs and established wells, upon which the city relies heavily for its economic health. No in-depth study of these resources had been undertaken since the 1970s. The goal of the study has been to develop an understanding of the hydrology of both the shallow and deep regional aquifers, with an eye toward the sustainability of these resources. The work has involved measuring temperatures and water levels in local wells, evaluating water chemistry and water residence time, and developing hydrogeologic models.

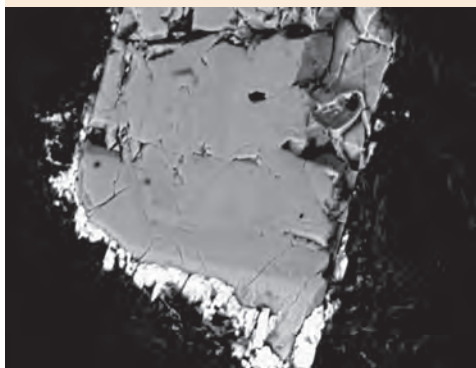
We continue to work toward the development of a National Geothermal Data System, working with other states and federal agencies to create a publically available, comprehensive online resource. Well data from the vast archives of the bureau are being digitized and incorporated into this database. The applications of these data—which include geologic formation tops, reservoir pressures, and reservoir

porosity and permeability—extend far beyond an understanding of geothermal resources, and are already being used in other projects where a detailed understanding of the subsurface is required.

Bureau staff have also been involved in a study of the age and duration of geothermal systems in the southern Rio Grande Rift. The investigation involves a study of manganese and fluorite ore deposits present along the rift. The presence of these deposits, which appear to be related to geothermal activity in the Rio Grande Rift, could be a guide to previously unknown geothermal systems. It may also help us to understand the longevity of existing geothermal systems.

Coal Resources

For 35 years the bureau has worked cooperatively with the U.S. Geological Survey to contribute to the National Coal Resource Data System (NCRDS). The goal has been to acquire stratigraphic and coal quality data for all of the coal-bearing regions of New Mexico into a national database. Much of this information has been released through bureau publications, including our coal resource maps. Between 1988 and 2005, detailed coal availability studies were conducted in the San Juan Basin, the Raton Basin, and in the Standing Rock area northwest of Grants. Recently our work has expanded to include geodatabases for coal outcrops in New Mexico, which will allow us to produce digital coal outcrop maps for the state, including attributes regarding thickness and coal quality. Our current project for



Backscattered electron image of an REE-rich overgrowth (clearly visible here as a bright white band) on a zoned magmatic zircon. Field of view is 150 micrometers (0.15 mm).

the NCRDS runs through 2015 and is focused on verifying and entering existing data from our Coal Data Library into this database.

MINERAL RESOURCES AND GEOLOGIC MAPPING

Rare Earth Element Resource Potential

There has been increased interest in the U.S. recently on the evaluation of critical mineral resources, in particular of the so-



Deep red REE-bearing altered granite (episyenite) in the Burro Mountains. The deep red color is due to iron.

called “rare earth elements” (REE). These elements are vital for a number of strategic and electronic uses, as well as renewable energy applications. This past year we have been engaged in a study of the REE potential in the Caballo and Burro Mountains of southern New Mexico. The study has focused on occurrences associated with 400–600 million-year-old (Cambrian-Ordovician) igneous activity, specifically areas that have undergone hydrothermal alteration and the subsequent concentration of REE. This study, which includes field mapping and a range of geochemical and geochronological analyses, has involved both graduate and undergraduate students at New Mexico Tech. The final report is due in June 2014.

Enhanced Potash Recovery Techniques

In cooperation with several partners in industry, a team at the bureau has developed and introduced new reagent suites and process modifications, which have dramatically increased the efficiency of potash recovery from existing reserves. These new techniques have been adopted by plants within the state and will result in increased recoveries, reduced energy and reagent costs, and more effective

utilization of the state’s potash resources. These resources, which are concentrated in the southeast corner of the state, are used primarily in the manufacture of agricultural fertilizer and as raw material in the chemical industry.

Geologic Mapping

For more than 20 years the bureau has participated in the National Cooperative Geologic Mapping Program (or STATEMAP). During that time, we have mapped nearly 12 percent of the state at a standard scale of 1:24,000, surpassing the previous 60 years of mapping in the state. In addition to traditional geologic mapping, in which geologists make first order, ground-based observations, these maps are now produced in digital format, which makes the information more widely accessible and useful. Our mapping has emphasized the main population corridors along the Rio Grande, addressing pressing societal needs in natural resources, most notably groundwater.

The northern Rio Grande and the Grants mineral belt have been a focus of intense study for many years. Detailed



Mt. Taylor and the surrounding volcanic vents were active from roughly 4 million years ago to 1.5 million years ago. Not far to the south, however, are some of the youngest lava flows in the state, less than 4,000 years old. Photo by Colin Cikowski.

mapping of the Española Basin near Santa Fe and the southern San Luis Basin near Taos has better characterized the distribution and compartmentalization of the principal aquifers by mapping discrete aquifer bearing units. Within the Grants area, our mapping has advanced our understanding of the complex volcanic history of Mount Taylor. Furthermore, an understanding of the complex bedrock geology in this region may help identify possible groundwater pathways for both naturally occurring and anthropogenic contaminants.

ONGOING RESEARCH (CONTINUED)

Volcanic Hazard Assessment

Volcanic hazards are a very real issue in New Mexico, where the youngest volcanic eruptions are only a few thousand years old. This year bureau researchers will begin an assessment of volcanic hazards in the southwestern U.S., based on detailed determinations of recent (late Quaternary) eruptive activity in the state. Much of the work will be accomplished through the bureau's newly upgraded geochronology lab, using ultra-high-precision Argon/Argon dating techniques on minerals and rock samples from young volcanic centers. This work is now made possible as a result of recent upgrades to the analytical equipment in that lab that include two new low-volume, high-sensitivity, multicollector ARGUS VI mass spectrometers, making it one of the state-of-the-art facilities in the U.S. In addition to hazard assessment, this study is expected to provide insights into ongoing geothermal exploration in New Mexico, the integration of modern river systems, and volcanic landscape evolution.

Although our mission has remained essentially the same since 1927, our focus continues to shift a bit, as we endeavor to meet the growing and changing needs of the state. And our staff continues to respond to critical needs as best we can, as they arise. This summer we helped address the water crisis that developed in the village of Magdalena, when the town well went dry. Fortunately, this was an area where previous geologic mapping, archival data, and our in-house expertise served us well. In conjunction with the New Mexico Environment Department, domestic well owners, and the village of Magdalena, we were able to provide technical support as the immediate crisis was resolved. The kind of basic research that we've outlined in this brief summary is what allows us to address these kinds of issues statewide, as they come up, to the future benefit of all of us who live in New Mexico.

—L. Greer Price

L. Greer Price is the director of the New Mexico Bureau of Geology and Mineral Resources and the state geologist. He has worked at the bureau since 2001.

Thanks to the following members of our staff for their contributions, edits, and input on this article:

Paul Bauer	Shari Kelley
Doug Bland	Virgil Lueth
Ron Broadhead	Virginia McLemore
Nelia Dunbar	Talon Newton
Abe Gundiler	Geoff Rawling
Matt Heizler	Mike Timmons
Gretchen Hoffman	Stacy Timmons
Peggy Johnson	Maureen Wilks

For More Information

Most of the research outlined here is ongoing, so only preliminary reports (if that) are generally available, with a couple of exceptions. Some of the available reports are listed below and on the back of this issue. Most of them are available free, online, at our website, geoinfo.nmt.edu. As we complete these research projects, all of the final reports will be made available to the public on our website.

Water Resources

Springs of the Rio Grande Gorge, Taos County, New Mexico: Inventory, data report, and preliminary geochemistry, Bauer, Paul W., Johnson, Peggy S., Timmons, Stacy, 2007, 49 pp., New Mexico Bureau Geology Mineral Resources, Open-file Report 506.
<http://geoinfo.nmt.edu/publications/openfile/details.cfm?Volume=506>

Hydrogeologic investigation of the northern Taos Plateau, Taos County, New Mexico, Johnson, P., Bauer, P., 2012, 96 pp., New Mexico Bureau Geology Mineral Resources, Open-file Report 544
<http://geoinfo.nmt.edu/publications/openfile/details.cfm?Volume=544>

A hydrogeologic investigation of springs and wetlands at La Cienega, Santa Fe County, New Mexico, Johnson, P. S., Koning, D. J., Timmons, S. Due out fall 2013.

Sacramento Mountains Hydrogeologic Study: Final technical report. Prepared for Otero Soil and Water Conservation District, Newton, B. T., Rawling, G. C., Timmons, S. S., Land, L., Johnson, P. S., Kludt, T., Timmons, J. M., 2012, 77 pages, Open-file Report 543
<http://geoinfo.nmt.edu/publications/openfile/details.cfm?Volume=543>



New Mexico EARTH MATTERS

Volume 13, Number 2
Published twice annually by the
NEW MEXICO BUREAU OF GEOLOGY
AND MINERAL RESOURCES

L. Greer Price
Director and State Geologist
a division of
NEW MEXICO INSTITUTE OF
MINING AND TECHNOLOGY

Daniel H. López
President
801 Leroy Place
Socorro, New Mexico 87801-4750
(575) 835-5420

Albuquerque Office
2808 Central SE
Albuquerque, New Mexico 87106
(505) 366-2530
Visit our main website
geoinfo.nmt.edu

Board of Regents
Ex Officio
Susana Martinez
Governor of New Mexico

José Z. Garcia
Secretary of Higher Education
Appointed

Richard N. Carpenter
President
2009–2014, Santa Fe

Jerry A. Armijo
Secretary/Treasurer
2009–2014, Socorro

Deborah Peacock
2011–2016, Albuquerque

Debra P. Hicks
2013–2018, Hobbs

Israel Rodriguez-Rios
Regent Designate
2013–2014, Socorro

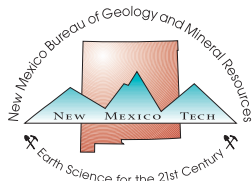
Editors
L. Greer Price
Gina D'Ambrosio

Layout and Graphics
**Gina D'Ambrosio, Leo Gabaldon, and
Brigitte Felix**

Earth Matters is a free publication.
For subscription information please call
(575) 835-5490, or e-mail us at
publications@nmbg.nmt.edu

Cover photo of Ship Rock, New Mexico
© Gary Rasmussen

New Mexico Institute of Mining & Technology
New Mexico Bureau of Geology and Mineral Resources
801 Leroy Place
Socorro, New Mexico 87801-4750
Return service requested



NONPROFIT ORGANIZATION

U.S. Postage

PAID

PERMIT NO. 1888
ALBUQUERQUE, NM

For More Information (continued)

Oil and Gas Resources

Helium in New Mexico, Broadhead, R. F., Gillard, L., 2004, New Mexico Bureau Geology Mineral Resources, Open-file Report 483, <http://geoinfo.nmt.edu/publications/openfile/details.cfm?Volume=483>

Petroleum geology of the Tucumcari Basin—overview and recent exploratory activity, Broadhead, R. F., New Mexico Geology, v. 26, no. 3, pp. 90–94.
http://geoinfo.nmt.edu/publications/periodicals/nmg/downloads/26/n3/nmg_v26_n3_p90.pdf J.

Geothermal Resources

For geothermal data in the state of New Mexico, visit the National Geothermal Data System Catalog at <http://search.geothermaldata.org/> and select New Mexico to see data, including borehole temperatures, well log observation data, and temperature-depth logs.

Coal Resources

Coal Resources of New Mexico, Hoffman, G. K., 1996, Scale 1:1,000,000, 1996, New Mexico Bureau Geology Mineral Resources, Resource Map 20.
<http://geoinfo.nmt.edu/publications/maps/resource/20/>

Recently digitized coal outcrop maps are available as follows:

Coal geology of Torreon Wash area, southeast San Juan Basin, New Mexico, Hoffman, G. K.; Pokorny, C., 2013 New Mexico Bureau Geology Mineral Resources, Open-file Report 552.
<http://geoinfo.nmt.edu/publications/openfile/details.cfm?Volume=552>

Geology and coal resources of the Gallup–Zuni Basin, New Mexico, Hoffman, G. K.; Pokorny, C., 2013, New Mexico Bureau Geology Mineral Resources, Open-file Reports 553, 554.
<http://geoinfo.nmt.edu/publications/openfile/details.cfm?Volume=553>

<http://geoinfo.nmt.edu/publications/openfile/details.cfm?Volume=554>

Rare Earth Elements

Geology and mineral deposits of the Gallinas Mountains, Lincoln and Torrance counties, New Mexico: Preliminary report, McLemore, V. T., 2010, New Mexico Bureau Geology Mineral Resources, Open-file Report 532.
<http://geoinfo.nmt.edu/publications/openfile/details.cfm?Volume=532>

Geologic Mapping

For an overview of our mapping program, go to: <http://geoinfo.nmt.edu/statemap/home.html>

To search for a specific geologic map: <http://geoinfo.nmt.edu/publications/maps/geologic/home.html>

For More Information About the Bureau and its Publications:

Visit our website at <http://geoinfo.nmt.edu>

Write or visit our Publications Office on the campus of New Mexico Tech, 801 Leroy Place, Socorro, New Mexico 87801

Call (575) 835-5490 or e-mail us at publications@nmbg.nmt.edu