New Mexico EARTH MATTERS

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MISSION

The New Mexico Bureau of Mines & Mineral Resources, established by legislation in 1927, is a service and research division of the New Mexico Institute of Mining & Technology (NM Tech). It acts as the geological survey of New Mexico with these main goals:

CONDUCT research and interact with State and Federal agencies and industry to facilitate prudent exploitation of the state's geological resources.

DISTRIBUTE accurate information to scientists, decision makers, and the New Mexico public regarding the state's geologic infrastructure, mineral and energy resources, and geohydrology (including water quantity and quality).

CREATE accurate, up-to-date (digital and GIS-based) maps of the state's geology and resource potential.

PROVIDE timely information on potential geologic hazards, including earthquakes, volcanic events, soils- and subsidence-related problems, and flooding.

ACT as a repository for cores, well cuttings and a wide variety of geological data. Provide convenient physical and internet access for New Mexicans to such resources.

PROVIDE public education and outreach through college teaching and advising, a Mineral Museum, and teacher- and student-training programs.

NM Bureau of Mines & Mineral Resources
New Mexico Tech
Earth Science for the 21st Century

NOTES FROM THE STATE GEOLOGIST

THIS is the first issue of a semi-annual newsletter that is distributed free-of-charge to New Mexicans interested in the state's water, landscapes, and earth resources. Each issue will contain an informative article about an earth science topic of importance to our state, along with NM Bureau of Mines & Mineral Resources (Bureau) news and highlighted current or upcoming publications. We want this newsletter, along with our informative web site, to stimulate your interest in what the Bureau does, and increase our interactions with people and agencies throughout the state. Our 60 employees, including 38 scientists, are eager to participate in earth science studies, collaborate in outreach activities, and respond to service requests from the New Mexico public. We look forward to putting our 73 years of experience to work serving your needs. Some easy ways to reach us are:

Via internet: http://geoinfo.nmt.edu

Via phone: Peter Scholle (Director) 505 835-5302
Socorro main office switchboard: 505 835-5420
Albuquerque office switchboard: 505 366-2530

Via mail: NM Bureau of Mines & Mineral Resources
New Mexico Tech
801 Leroy Place
Socorro, NM 87801-4796

THE Bureau is changing in many significant ways, and this newsletter is just one indication of that transformation. We have a new logo. We are in the process of trying to change our name from the Bureau of Mines & Mineral Resources to the Bureau of Geology & Mineral Resources to emphasize that we work on much more than mining-related activities. Indeed, much of our research is now directed toward solving problems related to water resources, geologic hazards, and environmental geology. We have diversified our outreach activities to include an earth science publication for K–12 teachers (Lite Geology), summer geoscience camps for teachers and minority students, a very popular Mineral Museum, and an upcoming series of field conferences for decision makers. Our publications program is also taking some new turns. We have a long tradition of producing first-rate scientific papers and maps detailing the geology and hydrology of the state. Now we are expanding that program by adding non-technical publications that will bring the value and interest of New Mexico's spectacular geology and landscapes to all its citizens and visitors. We hope that you will enjoy and support these changes.

WATER IN THE DESERT

OVER the last 100 years, severe droughts have occurred on average every 10 years in New Mexico. During 2000, most of the state experienced a moderate to severe drought for at least part of the year, and many climatologists predict we are entering a long-term cycle of warmer and dryer weather. However, when compared with annual records kept over the last century, this year's weather appears normal amid typical cycles of wet and dry years. Much of New Mexico is defined as a desert, "a region with a mean annual precipitation of 10 inches or less, which is so devoid of vegetation as to be incapable of supporting any considerable population" (Wilson and Moore, 1998). By the year 2030, a 48% increase in population is projected for New Mexico, and the impacts of drought are increasing as water resources are stretched to meet the demands of a growing population in a desert environment. This article presents a summary of New Mexico's water, its availability, variability, and limitations.

A Desert Climate

THE words hot and dry describe the weather on most days in New Mexico, yet our climate is more complex and variable than that. The "climate" of our region reflects its characteristic weather, particularly temperature and precipitation, averaged over several years. New Mexico's climate varies both regionally and seasonally. The effects of mountains, elevation, and different north-south weather patterns create a mosaic of arid to subhumid climates. Annual precipitation averages 13.2 inches statewide, but it ranges from 6.7 inches at Shiprock to just over 26 inches in Cloudcroft. Winter precipitation, which occurs from November to March, originates in large storms tracking over California from the northern Pacific. These low to moderate intensity storms are widespread and may persist for several

Riparian vegetation along the Rio Grande near Escondida, Socorro County.

days, producing soaking rains at low elevations and snow in the mountains. These winter storms provide about 30% of our annual precipitation, and they are important because spring snowmelt from high elevations fills reservoirs and replenishes local underground aquifers. The summer monsoon, which is associated with rains during July, August, and September,

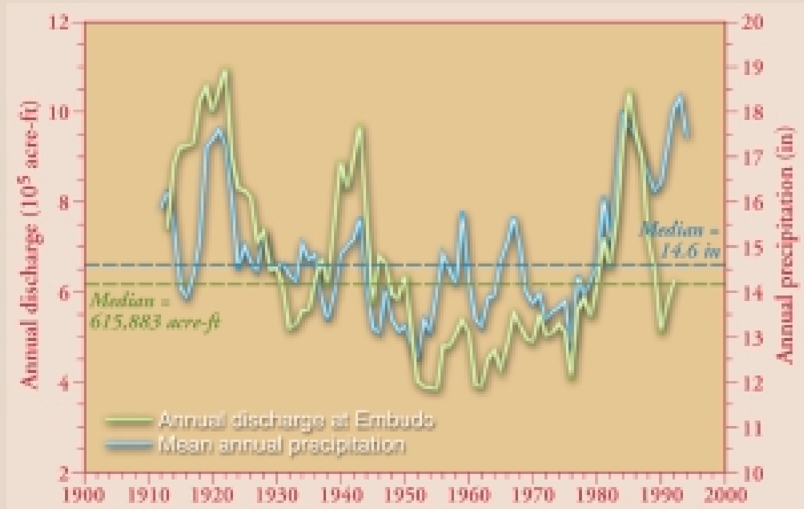

Figure 1. Five-year moving average of annual discharge for the Rio Grande at Embudo, and annual precipitation for Cerro, Red River, and Taos. Reference lines reflect the median of the moving average (Johnson, 1999).

provides up to half of the annual rainfall. During summer monsoon season, moisture-laden air circulates northward from the Gulf of California and the Gulf of Mexico, producing brief yet severe thunderstorms.

How does our climate vary and why?

BOTH droughts and floods are normal in New Mexico. Year-to-year and decade-to-decade fluctuations in precipitation cause significant impacts on agriculture, tourism, recreation, urban infrastructure, and water management. The fundamental reason for this climatic variability is New Mexico's location between the mid-latitude and subtropical atmospheric circulation patterns, and the state's position relative to shifts in these patterns (Sheppard et al., 1999). Shifts in atmospheric circulation that affect both our weather and the long-term climate are driven by natural changes in sea surface temperature and atmospheric pressure over the Pacific Ocean. One such event is the well-known El Niño-La Niña cycle, which operates on an average interval of three to four years. During El Niño, winters in the Southwest are typically cool and wet. Conversely, La Niña years are typically warmer and drier. Regional shifts in summer atmospheric circulation likewise result in extremely varied and unpredictable monsoon rains that range from daily cycles of heavy thunderstorms to many weeks with practically no rain, as happened this summer.

How are rivers linked to climate?

THE volume of water in our lakes, streams, and reservoirs is inextricably linked to the amount of precipitation. Prolonged droughts and wet periods are documented in meteorological records, which extend back 100 to 120 years. The most extreme drought occurred during the 1950s. Reconstruction of climate conditions based on tree-ring data from northwestern New Mexico indicates that the 15-year period from 1950 to 1964 received 90% of long-term average precipitation, yet was one of the five most severe droughts since 1500 A.D. (Grissino-Mayer, 1995). An 80-year record of precipitation and stream flow measured in northern New Mexico *(Figure 1)* shows the impact of the 1950s drought on flow in the Rio Grande. Near Taos, New Mexico, rainfall between 1950 and 1964 was 91% of normal. The impact of the drought on stream flow in the Rio Grande, however, extended well into the 1970s, and stream discharge at Embudo gaging station for the 30-year period from 1950 to 1978 was only 64% of normal. Clearly, the consequences of drought extend beyond diminished rainfall. The effects are longer and more severe for streams, reservoirs, and the people, plants, and animals dependent on surface water.

How are aquifers linked to climate?

New Mexico's drinking water is derived entirely from large underground aquifers associated with thick deposits of sand and gravel under the Rio Grande valley, the Pecos River valley, and other large river basins. Extended droughts result in less replenishment or "recharge" to aquifers, but the effects of this decrease are not readily apparent because underground aquifers are large compared to the amount of recharge. The relationship between ground-water recharge and precipitation is illustrated in *Figure 2,* which shows a 100-year record of precipitation from the Jornada Research Facility in Doña Ana County (green line) and resulting ground-water recharge events (blue bars). This study from New Mexico Tech found only five time periods during the last 100 years, centered at 1904, 1936, 1942, 1979, and 1987, during which precipitation might have infiltrated to the aquifer. This recharge responded to conditions ranging from a single, very large rainstorm followed by average rainfall, to several years in a row of above average rainfall without any large storms. Total recharge at a depth of 20 feet for the 100-year period was an estimated 1.48 inches or 0.17% of precipitation. If this 100 years of recharge was applied to the entire middle Rio Grande basin, the resulting volume of ground water would approximately equal the volume of water lost in 1 year by evaporation from Elephant Butte Reservoir or the volume of ground water withdrawn from City of Albuquerque wells in 2 years.

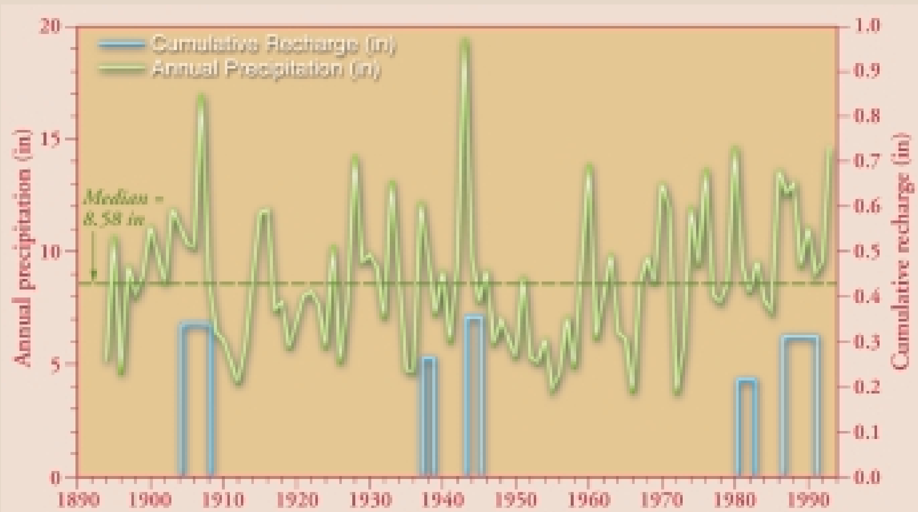

Figure 2. Annual precipitation and simulated ground-water recharge, Jornada Research Facility, Doña Ana County, New Mexico 1892–1991 (Kearns and Hendrickx, 1998). Reference line reflects median precipitation.

What is ground-water mining?

Most hydrologists agree that ground-water recharge is negligible in desert climates, except in areas along mountain fronts, rivers, streams, and arroyos. What then is the source of ground water in our aquifers? Large volumes of ground water and small annual recharge rates mean that our ground water is very old. In the Albuquerque Basin, ground water at depths greater than 500 feet below the water table and all ground water in the western half of the basin has been in the aquifer since a colder and wetter glacial climate 18,000 to 20,000 years ago (Plummer et al., 1999). Most ground water in the upper 500 feet of the aquifer is a mix of older and younger water having an average age of about 7,000 years. Modern ground water replenished during the past 30 to 50 years is detected only in some locations near the basin margins and in the upper 200 feet of the inner valley. The "age" of ground water has important implications for resource management. When we use ground water that is not being replenished, we are mining water. This practice may be necessary in certain circumstances (like withdrawing money from savings in an emergency), but it is certainly not sustainable. The practice causes lowering of the water table, which in turn causes the aquifer to collapse, the land surface to subside, and can dry springs, wetlands, and perennial streams. On the other hand, ground waters that are actively recharged are part of the modern hydrologic cycle and are constantly renewed. Development of actively recharged aquifers can be sustainable.

Living Within our Means

Sustainable development is a familiar but elusive concept in New Mexico's rapidly expanding communities. This root principle embraces the idea that development should be undertaken so that resources will be available in sufficient quantity and quality for future generations. Current water management, however, does not practice this standard. Surface water in the Rio Grande basin is over-appropriated amongst multiple "uses" *(Figure 3),*

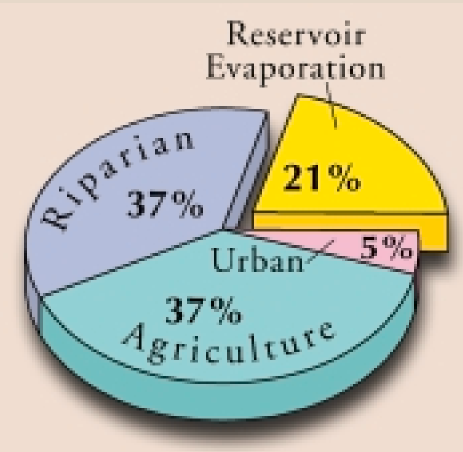

Figure 3. Depletions from the middle Rio Grande, year 2000 (S. S. Papadopulos & Assoc., 2000).

and a water budget for the middle Rio Grande indicates that the present water supply "is barely adequate" (S.S. Papadopulos & Assoc., 2000). Old ground water is being mined for municipal and domestic use at alarming rates in Bernalillo, Santa Fe, Torrance, and Doña Ana Counties, and projections in these four counties indicate a 52% increase in population by 2030. Given the physical limitations of our supplies, where will water come from to support the projected growth? The answer is from "somewhere else," or rather from "someone else." In order to maintain the overall water-supply balance that Mother Nature and interstate compacts ultimately demand, any increase in water use must be offset by a reduction in use elsewhere in the basin. Thus regional water planning and litigation-forced negotiations are bringing the various water "users" to the same table for the first time to discuss and decide how best to use the limited water that is available to us. The process is painful, polarizing, and promising. We are simultaneously becoming aware of both the limitations and the alternatives. We have many options for reducing undesirable depletions (reservoir evaporation and riparian evapotranspiration by non-native species) and stretching our supplies (conservation, realistic growth, irrigation efficiency). Two requirements are primary: 1) learn to share, 2) live within our means.

—Peggy S. Johnson, Hydrogeologist

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S.S. Papadopulos & Assoc., Inc., 2000, Middle Rio Grande water supply study (DRAFT), available *http://www.sspa.com/ashu/rio/start.htm* (accessed September 15, 2000).

Sheppard, P.R., Comrie, A.C., Packin, G.D., Angersback, K., and Hughes, M.K., 1999, The Climate of the Southwest, online, University of Arizona Laboratory of Tree-Ring Research, available *http://www.ltrr.arizona.edu/~sheppard/swclimate/swclim.htm* (accessed September 7, 2000).

Wilson, W.E., and Moore, J.E. (eds.), 1998, Glossary of hydrology: American Geological Institute, Alexandria, VA, 248 p.

Selected Water-Related Reports

Ground water in the Sandia and northern Manzano Mountains, New Mexico, by F. B. Titus, Jr., 1980, Hydrologic Report 5, 66 pages, 1 oversize sheet, *$12.00*.

Hydrogeology and water resources of San Juan Basin, New Mexico, by W. J. Stone, F. P. Lyford, P. F. Frenzel, N. H. Mizell, and E. T. Padgett, 1983, Hydrologic Report 6, 70 pages, 7 oversize sheets, *$23.00*. A study of new water supplies for growing municipalities and energy development.

Selected papers on water quality and pollution in New Mexico, compiled by W. J. Stone, 1984, Hydrologic Report 7, 300 pages, *$12.00*. Contains 25 papers on surface and ground-water chemistry and microbiology, water-treatment technology, resource-development impacts, and legal aspects of ground-water pollution.

Hydrogeologic framework of the northern Albuquerque Basin, compiled by J. W. Hawley and C. S. Haase, 1992, Open-file Report 387, 165 pages, *$31.50*.

Albuquerque Basin—studies in hydrogeology, 1995, New Mexico Geology, v. 17, no. 4, 36 pages. Contains four papers describing hydrogeologic studies undertaken by New Mexico Bureau of Mines & Mineral Resources (NMBMMR) scientists and associates. *This special issue is available from NMBMMR for $2.50.*

Characterization of hydrogeologic units in the northern Albuquerque Basin, New Mexico, edited by W. C. Haneberg and J. W. Hawley, 1996, Open-file Report 402c, 227 pages, *$48.40*.

Hydrogeology of potential recharge areas for the basin- and valley-fill aquifer systems, and hydrogeochemical modeling of proposed artificial recharge of the upper Santa Fe aquifer, northern Albuquerque Basin, compiled by J. W. Hawley and T. M. Whitworth, 1996, Open-file Report 402d, 575 pages, *$131.26*.

Surface-water assessment, Taos County, New Mexico, by P. S. Johnson, 1998, Open-file Report 440, 333 pages, *$68.60*.

Albuquerque Basin—studies in hydrogeology II, 1998, New Mexico Geology, v. 20, no. 1, 32 pages. Contains four more papers describing Albuquerque Basin hydrogeologic studies. *This second special issue is available from NMBMMR for $2.50.*

Hydrogeologic and water-resource assessment for the Placitas development area, Sandoval County, New Mexico, phase II report, by P. S. Johnson, 2000. *Available as a CD-ROM from NMBMMR for $20.00.*

Arsenic in ground water in the Socorro Basin, New Mexico, by L. Brandvold, 2001, New Mexico Geology, v. 23, no. 1. *Single issue available from NMBMMR for $2.50.*

These and other NMBMMR reports can be ordered by calling (505) 835-5410 or 835-5490, or email us at pubsofc@gis.nmt.edu

Bureau News

Mapping Money Multiplies!

THE NM Bureau of Mines & Mineral Resources geologic mapping program (STATEMAP) is partly funded by the National Cooperative Geologic Mapping Program, a joint federal-state effort administered through the U.S. Geological Survey. We are in the 8th year of a project designed to produce and distribute expeditiously state-of-the-art, detailed geologic maps of select areas of the state. New Mexico is the most successful state survey in the country in competing for STATEMAP funds. By June 2001, we will have mapped 48 topographic quadrangles (approximately 2800 sq. miles), mostly along the Rio Grande watershed from Taos to Socorro. You can view some of the results at our web site: *http://geoinfo.nmt.edu/statemap/home.html*.

FROM 1993–2001, the Bureau received a total of $1,153,040 from the USGS, the highest amount in the nation. In addition, Congress recently increased the money available to STATEMAP from $4,033,821 in FY 2000, to $6,660,550 for FY 2001, an increase of 60%. However, the program is based on matching funds—the Bureau matches all federal monies dollar-for-dollar. Thus, we are limited in our ability to expand the program based on availability of state dollars. Growth in the STATEMAP program is especially important to New Mexico, because, of the approximately 2000 7.5-minute quads in the state, less than 15% have been mapped at the standard scale of 1:24,000.

MUCH of the success of STATEMAP is due to the requirement that maps must be designed to address critical societal and/or scientific problems as determined by a committee of citizens and agency representatives (end-product users). In New Mexico, recent concerns about water quality, water availability, geologic hazards (earthquakes, floods, unstable soils), mineral resources, transportation, and environmental problems throughout the Rio Grande corridor have illustrated the importance of modern, detailed geologic data. Our program has received widespread support and praise from political leaders, government agency scientists, university professors, professional hydrologists and engineers, water planners, and others. One of the most visible uses of our maps has been by the USGS to produce a hydrogeologic model of the Albuquerque region. If you have an opportunity to help support STATEMAP through the New Mexico budget process, please do so. This program has been very good for New Mexico and much remains to be done throughout the state!

Bureau Receives NASA Group Achievement Award

A field study of the Taos area was conducted by geoscientists from the Bureau and New Mexico Tech in conjunction with NASA's Astronaut Training Program. This work resulted in the research group being named a recipient of the space agency's Lyndon B. Johnson Space Center Group Achievement Award.

IN the summer of 1999, Bureau and Tech researchers worked alongside NASA astronaut candidates making gravity measurements to map geologic structures that are far below the Taos city streets and that extend for miles beneath the Taos Plateau. Subsurface data gathered in the joint research and training program has allowed researchers to better understand how the specific locations of buried faults in Earth's crust correlate with the extent and placement of the area's limited ground-water resources.

DURING the study, 31 prospective astronauts were provided with valuable "hands-on" training on properly conducting geophysical field surveys, garnering knowledge and skills that may eventually have practical applications in other-worldly locales, such as finding water below the surface of Mars.

"THE program provided us with geophysical data that should be useful in evaluating ground-water availability in the Taos area," says Paul W. Bauer, associate director and senior geologist at the Bureau. "And, at the same time, we got the highest-quality field assistants that anyone could possibly hope for."

NASA's astronaut training program runs on a two-year cycle, so it won't be until the summer of 2001 when an entirely new batch of astronaut candidates could step onto the Taos Plateau. "Whether or not this program continues is largely dependent on the response of the participating astronauts," Bauer points out. "And since they all raved about it, the program is likely to continue....Although, we'll probably expand it by adding additional exploration techniques into the curriculum." Since the Bureau was chosen to receive the Group Achievement Award for providing the training, another such collaborative program is highly probable.

State Trust Lands Evaluations Funded

THE state legislature has earmarked $50,000 for mineral and energy resources evaluations by the NM Bureau of Mines & Mineral Resources for the NM Commissioner of Public Lands, State Land Office. Three studies on state trust lands are planned for FY 2000–2001: a $20,000 evaluation of oil and natural gas potential in the Tucumcari Basin in Guadalupe, Curry, San Miguel, and Harding Counties; a $15,000 evaluation of mineral resources in Luna County; and a $15,000 statewide evaluation of construction aggregate (sand and gravel, crushed stone). The construction aggregate evaluation includes a proof-of-principle version to be demonstrated during the upcoming legislative session. All three studies are part of a proposed long-term plan combining mineral and energy resources evaluations of state trust lands, including surrounding private land, in a comprehensive geographical information system (GIS). With continued funding, future projects will contribute additional data to the statewide GIS and increase the economic value of state trust lands.

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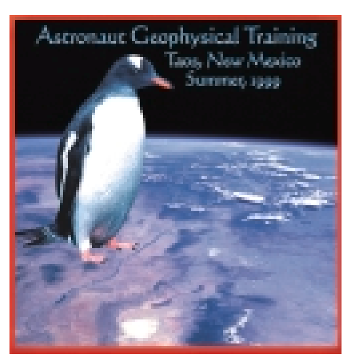
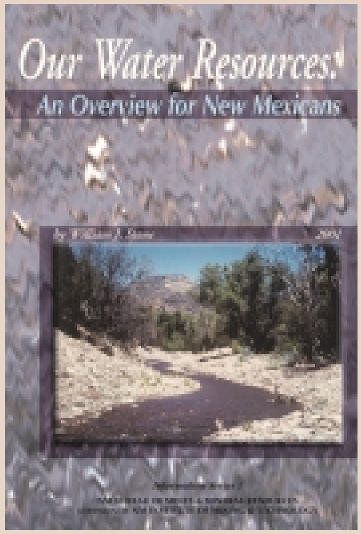
Photograph of Shiprock by Paul G. Logsdon; reproduced by permission of Marcia L. Logsdon©



NEW PUBLICATIONS

MEMOIR 48—Stratigraphic framework of upper Paleozoic rocks, southeastern Sangre de Cristo Mountains, New Mexico, with a section on speculations and implications for regional interpretation of ancestral Rocky Mountains paleotectonics, by E. H. Baltz and D. A. Myers, 1999, 272 pages, 89 figures, 2 appendices, 25 measured sections, 14 plates, 5 oversize sheets, scale 1:125,000. $35.00 ISBN 1-883905-03-6

Pennsylvanian and Lower Permian rocks of the Sangre de Cristo Mountains and adjacent areas in north-central New Mexico are heterogeneous marine and nonmarine deposits that accumulated in and on the flanks of structurally deep late Paleozoic basins that subsided between large uplifts of the Ancestral Rocky Mountains. From detailed and reconnaissance mapping of an area extending from Bernal to Mora and from biostratigraphic studies undertaken for this report, the authors present a more complete Paleozoic stratigraphic framework for the southeast Sangre de Cristo Mountains. New hypotheses about regional stratigraphy and paleotectonics are also discussed.

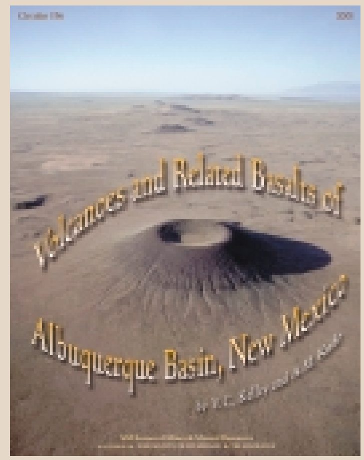


INFORMATION SERIES 1—Our Water Resources: An Overview for New Mexicans, by W. J. Stone, 2001, 38 pages, 10 tables, 9 figures, 20 photographs. $5.00 ISBN 1-883905-07-9

The first booklet in this new non-technical series answers such common questions as: Where does our water come from? Why do water availability and quality vary across the state? What contaminants can get into our water? How can I find out if my water is safe to drink? Are there laws governing water use and pollution in New Mexico? What can I do to protect New Mexico's water resources? What information is available on the water resources of my area and where can I get it?

RESOURCE MAP 23—Satellite Image of New Mexico, 2000, 47 inches x 54 inches, scale 1:500,000. $20.00 ISBN 1-883905-09-5

This spectacular new view of New Mexico from Landsat satellites orbiting the Earth is printed in shades of green, blue, and red for a natural-looking image. Residents of New Mexico will recognize many of the state's unique landforms: the fertile valleys of the Rio Grande and Pecos River, Mount Taylor, Valle Grande, Elephant Butte Reservoir, and the young lava flows near Grants and Carrizozo. For visitors, these and many more less-distinctive features are labeled.



CIRCULAR 156—Volcanoes and related basalts of Albuquerque Basin, New Mexico, by V. C. Kelley and A. M. Kudo, 1978, reprinted 2001, 30 pages, 16 tables, 32 figures, 2 oversize sheets. $10.00 ISBN 1-883905-06-0

This reissue honors the collaboration 25 years ago of two great New Mexico geologists. In 1975, Vincent C. Kelley and Albert M. Kudo submitted a manuscript describing the late Cenozoic volcanic rocks of the central Rio Grande rift. Circular 156 laid the groundwork for a quarter of a century of research on the volcanic rocks of the Albuquerque Basin.

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