



New Mexico EARTH MATTERS

SUMMER 2008

New Mexico Potash—Past, Present, and Future

Potash is the general term for natural and manufactured water-soluble compounds of potassium in combination with magnesium, sodium, chloride, sulfate, and nitrate. Potash is used directly or indirectly by everyone every day because it is an essential element in plant and animal life. Most potash is used in fertilizer (potassium is the “K” in the “NPK” fertilizer rating, along with nitrogen, N, and phosphorus, P). Therefore, potash markets closely parallel agricultural supply and demand. The remainder is used in chemicals and pharmaceuticals, salt substitutes, soap, matches, glass, and storage batteries.

New Mexico potash production is in an area that covers about 425 square miles southeast of Carlsbad and southwest of Hobbs. This area of shallow, high-grade ore was designated the “Potash Area” in 1934 by the Secretary of the Interior. It lies within a larger 58,000 square mile area underlain by lower-grade potash minerals. The Potash Area includes both state and federal lands that are managed by the Bureau of Land Management. Mineral leases are available only through competitive bidding, and the area is protected from most oil and gas development. The Waste Isolation Pilot Plant (WIPP) for nuclear waste storage is on the southeast edge of the Potash Area. Commercial potash is produced primarily in Eddy and Lea Counties, which contain the three mines and four plants operated today by two companies, Mosaic Potash and Intrepid Potash.

Potash production in New Mexico is 70 percent sylvite and 30 percent langbeinite. New Mexico is in fact the only producer of langbeinite in the world. New Mexico ranked eighth in world potash production in 2006 at 825,000 metric tons of potassium oxide. In that same year the state accounted for 77 percent of U.S. potash

production and supplied 19 percent of the potash used in the U.S. Most potash used in the U.S. today, however, is imported from Saskatchewan, Canada.

Imports from Canada, Belarus, and Russia, declining reserves and grades, and increasing mining, transport, and environmental costs have caused a decline in the number of potash producers in



Sylvite (photo courtesy of Dennis Tasa)

New Mexico, from seven in 1985 to two in 2008. The average sylvinitic ore grade in New Mexico has decreased from 25–30 percent potassium oxide in the 1950s to about 14 percent today; langbeinitic ore now averages 8–10 percent potassium oxide. But even at current extraction rates the potash reserves in the state’s Potash Area should last for decades, and recent advances in processing may extend this significantly.

Taxes and other benefits such as employment in a rural area are substantial. From 2000 to 2004 annual severance taxes on New Mexico potash production averaged \$3,318,652 and nearly a thousand people were employed in the potash industry. Regional payroll attributable to potash was about \$300 million. Prices were \$290 per metric ton in 2006, significantly higher

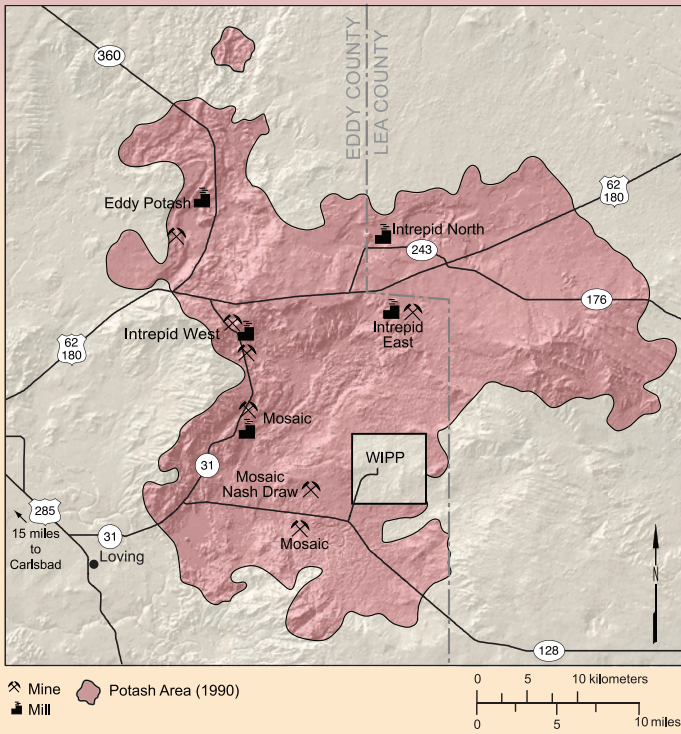
than the long-term average of \$120 per metric ton. In 2008 potash prices are already in excess of \$500 per metric ton.

History of Potash Production in New Mexico

Potash was originally leached from heated *pots* of wood *ash*, hence the name. Large-scale potash use started in Germany in 1859. The United States potash industry was initiated during World War I as the result of a German embargo that drove prices above \$450 per metric ton. Wartime potash (used in the manufacture of gunpowder) was produced at more than a hundred plants throughout the U.S., each with very small output. The bedded potash deposits in Eddy County, New Mexico, were not discovered until 1925.

The first commercial potash from New Mexico was shipped in March 1931. A 20-mile railroad spur from Carlsbad was run to the mine and later to other operations. By 1934 eleven companies were exploring for potash in southeast New Mexico. In 1936 Union Potash & Chemical, Texas Potash, Independent Potash & Chemical, New Mexico Potash, and Carlsbad Potash merged into what is now Mosaic and began producing mainly sylvinitic and langbeinitic in 1940.

Potash was discovered in Saskatchewan, Canada, by New Mexico potash companies in 1952. Many factors prevented major production until the late 1950s, with exports to the United States commencing in 1962. In 1964 U.S. consumption permanently exceeded domestic production. The maximum New Mexico production was 2.84 million metric tons of potassium oxide in 1966–67; production then decreased steadily as lower-cost Canadian potash imports eventually exceeded domestic production in 1971. Canada



The Secretary of the Interior's Potash Area (in pink), also referred to as the Known Potash Leasing Area, Potash Enclave, or Carlsbad Potash District. The Waste Isolation Pilot Plant was removed from the Potash Area, and no potash mining or petroleum drilling is allowed there.

Potash Production Today

Abundant lower-grade reserves exist in southeastern New Mexico, but high-grade potash is nearly depleted. Langbeinite (potassium-magnesium sulfate) and sylvinite (sylvite and halite) are the major potash minerals mined.

All mines in the Potash Area are underground. The room-and-pillar mines are relatively clean, dry, and orderly, because the beds are laterally extensive and nearly flat. Each mine has at least two or three shafts for safety and ventilation. Mines are connected underground, and working faces are now 6 miles

and further cleaned by leaching halite (sodium chloride) with water. Some associated minerals, such as kieserite (a hydrated magnesium sulfate) and polyhalite, are carried over as contaminants. As the high-grade ores are depleted, mixed sylvinite-langbeinite ores and langbeinite-kieserite ores have to be mined and processed. Technology for efficient separation of these minerals is unavailable, and some of the valuable minerals are lost to tailings.

Salt and clay tailings in the Potash Area are stockpiled and monitored for salt leakage. Waste brine is evaporated in impoundments or flows into local natural lakes where it is harvested. Methods for



Sylvinite ores from underground mines are crushed and ground in saturated brine. Clay minerals are removed in several stages, and solid-liquid mixture (pulp) is treated with chemicals that render sylvite surfaces hydrophobic (water-repellent). Air is then injected into the pulp and sylvite floats to the surface and is thus separated from halite, which sinks. The froth is then skimmed off with paddles to obtain sylvite concentrate. The red color is from occluded iron oxide minerals in sylvite. Tailings, mostly halite, are stockpiled in tailings dams.

nationalized potash in the mid-1970s, and American owners were bought out. Thus began the long decline of the domestic potash industry, as these American companies were left with higher-cost, lower-grade domestic production. The International Trade Commission forced an antidumping agreement with Canadian producers in 1988, to prevent them from selling below cost. This led to increased prices, which kept Horizon Potash in operation until 1996 and led to reactivation of Mississippi Chemical in 1988.

or more from the main shaft. Heavy machines known as "continuous miners" remove softer potash beds as thin as 4 feet. The harder langbeinite is broken with ammonium nitrate and fuel oil explosive. Mechanical loaders, underground crushers, subsurface conveyor belts, and hoists send potash to the surface. Room-and-pillar mining removes 60–75 percent of the potash. Subsequent pulling of support pillars increases yields to over 90 percent.

Potash plants use a combination of fines separation, flotation, heavy-media, leaching, and crystallization circuits designed for a specific sylvinite ore. Fine-grained potash ores are processed by froth flotation in saturated brine where sylvite is preferentially floated. Clay minerals in the potash ore adsorb flotation reagents, which increases cost and reduces recovery. Ores with clay content greater than 5 percent or very fine-grained potash are treated by an energy-intensive cyclic process of dissolution in hot brine, solution purification, and vacuum recrystallization.

Langbeinite ores are concentrated by gravity separation in coarse sizes

returning tailings to the mine are being studied, but they are costly.

Potash minerals are also recovered from the Dead Sea in Jordan and from Great Salt Lake in Utah by solar evaporation and separation of the salt mixtures by flotation. In Michigan and Canada sylvite is recovered from deep-seated orebodies and from mines with water infiltration problems by in situ solution mining. Depleted conventional mines have also been successfully converted to solution mining for residual potash recovery, as at the Intrepid potash operation near Moab, Utah. Planned conversion of the Eddy Potash mine in New Mexico to a solution mining operation is in the permitting phase.



A "continuous miner" at the Intrepid underground potash mine. The drum-like cutter head to the right rotates as it moves into the potash ore. The broken ore drops into the hopper below to be pulled onto a conveyor belt that brings ore to the rear of the miner for hauling to the hoist and plant. The reddish potash in the walls and ceiling show tool marks from the cutter head. Photo courtesy of Jim Lewis of Intrepid Potash.

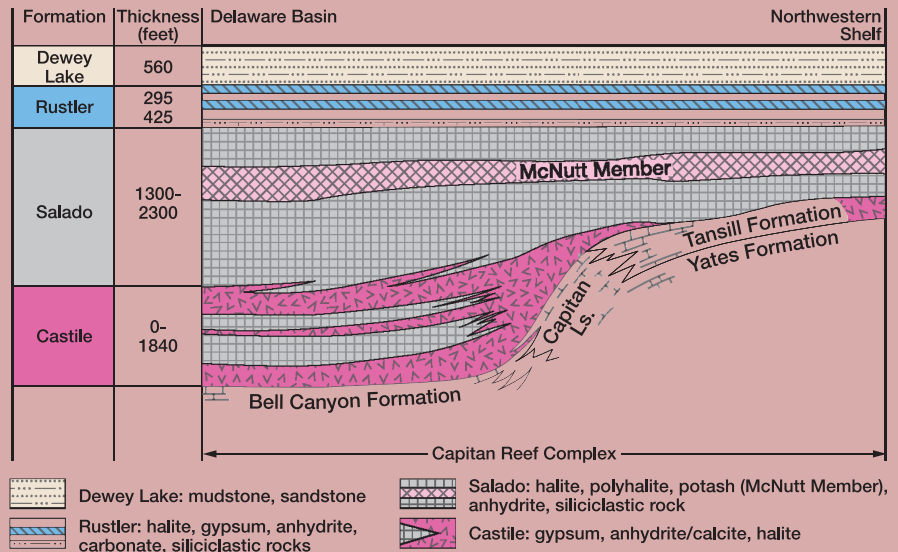
The Future of New Mexico Potash

The potash industry has been subject to oversupply worldwide. This glut has been buffered mainly by withheld Canadian production (they have until recently produced only 60 percent of their capacity) intended to keep prices high by limiting supply. This is changing as Brazil, Russia, China and India become major potash consumers. The emergence of India and China as major economies trading on world markets has led to significant balancing of potash supplies, with the caveat that increased prices will bring increased supply. Exploration and development of potash was very active worldwide in 2008 driven by low stockpiles of potash in consuming countries, and very high prices are expected to hold well after 2010. Increased transportation costs and demand for potash products unique to New Mexico (such as langbeinite) partly protected regional markets. The Potash Area in New Mexico is today a mature mining district with amortized capital costs and lower-grade potash resources available at greater depth, with the goal of extending current operations by embracing new technology.

Activity by other industries—notably agriculture, the petroleum industry, and deep geologic waste disposal—can affect the production of potash from southeast New Mexico. The fact that potash is used today primarily as a fertilizer ties it to cyclic trends in the agricultural industry, which in turn are related to complex interactions between weather and climate; advances in crop genetics, soil science, and farming practices; GNP of importing nations; farm income; population growth; distribution-system efficiency; freight rates and back-hauls; taxes; and tariffs. Current two-year contracts for potash are at a very high unit price of \$550–625 per metric ton.

Ongoing Research at the Bureau

In collaboration with Mosaic and Intrepid engineers, an international team at the New Mexico Bureau of Geology and Mineral Resources introduced new reagent and process modifications to increase the efficiency of potash recovery from existing ores. Both companies are reviewing and implementing these results. The implications of this research are significant in terms of increased recoveries, reduced energy and reagent costs, and more effective utilization of potash resources, given the large tonnages of potash processed. This extends the life of the New Mexico potash industry, to the benefit of both the



The Geology of Potash

Potassium is the seventh most abundant element in the earth's crust and the sixth in seawater. It is a major constituent of many surface and subsurface brines. Most potash deposits were precipitated from evaporated seawater or nonmarine water in restricted environments in an extremely arid region, such as estuaries, where outflow of evaporation-concentrated brine is restricted. The result is bedded potash in large, high-grade deposits amenable to low-cost mining and processing. There are few places on Earth today with conditions sufficiently arid to produce significant potash deposits.

Potash-bearing evaporites are in Upper Permian (Ochoan, 250 million years old) marine rocks in the Delaware Basin of west Texas and southeast New Mexico. The Ochoan Series contains four forma-

tions: the Castile Formation (oldest), the Salado, potash-bearing mainly in the McNutt Member, and the Rustler and Dewey Lake Formations. The Salado Formation hosts twelve potash zones, eleven of them in the McNutt Member. The area underlain by these twelve ore zones covers about 1,900 square miles.

The McNutt Member of the Salado consists of sylvite and langbeinite with halite, anhydrite, and other potash minerals. The potash minerals we see today are secondary, recrystallized from the primary marine minerals that originally precipitated from the mineral-rich brines, and their distribution is independent of original lithology. Typical mixed sylvinitic ore from the Salado contains about 60 percent halite and 30 percent sylvite, 5 percent langbeinite, 2 percent polyhalite, and 3 percent insolubles.

state of New Mexico and the nation.

Another promising avenue for research that benefits both the potash industry and the oil and gas industry is the possibility of using produced brine from nearby oil fields in solution mining or in processing plants. This would alleviate the problem of how to dispose of produced brines and provide a benefit to both the potash and petroleum industries. To make it work, hydrocarbons and toxic gases must be removed from the produced brine and potash producers must be assured of a dependable supply of produced brine.

Current efforts are also underway to eliminate the cyclic heating and cooling of brines used to dissolve and precipitate various constituents of potash ore. This high cost, energy intensive process could be

replaced by innovative flotation methods with improved recovery and significant cost savings.

The long and productive history of the potash industry in southeastern New Mexico has benefited the state and the nation. After declining since the 1980s, increasing demand coupled with new technology, developed through the New Mexico Bureau of Geology and Mineral Resources, is bringing increased revenue to the state's potash producers, which will add decades to mine production while increasing contributions to the severance tax fund that benefit us all.

—James Barker and Ibrahim Gundiler

James Barker is Associate Director and Senior Industrial Minerals Geologist at the New Mexico Bureau of Geology and Mineral Resources. He is manager of the Perlite Testing Laboratory.

Ibrahim Gundiler is Senior Metallurgist at the New Mexico Bureau of Geology and Mineral Resources, and manager of the Metallurgy Laboratory. He initiated the ongoing potash research program at the bureau, in collaboration with New Mexico producers.

Patrick Walsh is a subsurface fluids geologist with the New Mexico Bureau of Geology and Mineral Resources.

COMPOUND OR MINERAL	CHEMICAL FORMULA	POTASSIUM OXIDE (PERCENT)
Potassium oxide	K_2O	100.00
Sylvite	KCl	63.17
Sylvinitite	KCl + NaCl	10–35
Langbeinite	$K_2SO_4 \cdot 2MgSO_4$	22.70
Carnallite	$KCl \cdot MgCl_2 \cdot 6H_2O$	16.95
Kainite	$KCl \cdot MgSO_4 \cdot 3H_2O$	18.92
Leonite	$K_2SO_4 \cdot MgSO_4 \cdot 4H_2O$	25.69
Polyhalite	$K_2SO_4 \cdot MgSO_4 \cdot 2CaSO_4 \cdot 2H_2O$	15.62

Common potash minerals found in southeastern New Mexico. The potassium in potash minerals and fertilizer is reported as potassium oxide to compare fairly diverse mineralogy and composition. Sylvite and langbeinite are produced from sylvinitite and langbeinite ore, often associated with carnallite, kainite and leonite. Polyhalite is currently considered a waste mineral in the Potash Area and underlies about 27,000 square miles in New Mexico and Texas. However, it could be a potential source of potash if cost-effective processing technologies can be developed.

One metric ton = 2,205 lbs (1,000 kg)

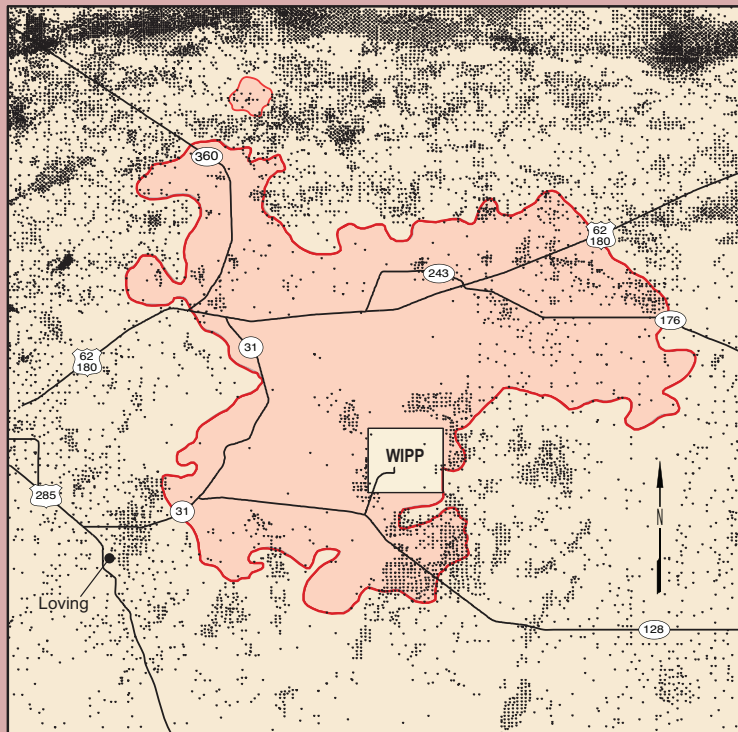
Potash and Petroleum in Southeast New Mexico

Southeast New Mexico is rich in two natural resources in particular, potash and petroleum, resulting in conflict between the two industries. The proximity of potash and petroleum resources, their relative rarity, safety issues, and regulations have led to both legal and political conflicts. This is exacerbated by fluctuating production costs and prices of both commodities. Sedimentary rocks below the potash-bearing zones contain oil and gas resources. As many as nineteen reservoir zones are producible at depths from a few hundred to more than 12,000 feet below the potash zones. Most of the oil and gas production within the area is from the Brushy Canyon and the Morrow Formations. The extraction of these resources provides a great economic benefit to the state and the nation, due to income from oil and gas leases and tax revenues. But the extraction of the petroleum resources represents a significant hazard to the potash mining industry. In 1973 gas leaking

from a well in southeast New Mexico caused a mine shaft explosion that injured ten workers. Oil wells must now be more than a quarter of a mile from existing mine workings (for gas wells it is a half mile), and potash mining companies allow the same berths around existing wells. In 1934, before these safety concerns had arisen, the U.S. government withdrew

much of the Potash Area from oil and gas production, or allowed only limited petroleum drilling, and the area was set aside as a strategic resource. Operators drilled over 2,600 wells in the 425-square-mile Potash Area. Well density is considerably higher outside the Potash Area, averaging five wells per square mile. Conventional, vertical drilling is not permitted throughout most of the area, so directional and horizontal wells that are more expensive to drill will be required to tap the valuable petroleum resources below the potash. High oil and gas prices have increased the pressure to allow more drilling, and increasing potash prices have increased the value of the potash resource as well. The federal government will attempt to balance the interests of these two industries through regulation, but creative solutions such as directional drilling and compromise will be necessary to maximize future exploitation of both resources.

—Patrick K. Walsh



Petroleum wells in and around the Potash Area. Many wells were drilled near the edge of the area, but the center has almost no wells due to restrictions on drilling.

BUREAU NEWS

Miocene Fossil Discovered

Bureau geologists Dave Love and Richard Chamberlin and New Mexico Tech graduate student Colin Cikoski discovered a nearly complete fossilized skeleton of an oreodont while mapping in the Bosque del Apache National Wildlife Refuge this spring. Oreodonts are a group of extinct herbivores that roamed the West between 35 and 10 million years ago. The Bosque del Apache animal belongs to a species of large oreodont that lived near the end of that period. Gary Morgan, paleontologist from the New Mexico Museum of Natural History and Science, describes it as having a large head, a small trunk, rather short legs on a longish body, and resembling a cross between a pig and a camel. Museum personnel completely recovered the fossil and transported it to Albuquerque where it is being prepared and will be added to their collection. Early results indicate that it is by far the most complete known specimen of *Merychyus major*.

Rockin' Around New Mexico

Twenty-one New Mexico teachers attended this year's three-day educational workshop on geology and natural hazards in July of this year. The participants divided their time between hands-on field instruction around Socorro with geologists from the bureau and New Mexico Tech, and indoor exercises at the Sevilleta National Wildlife Refuge Educational Laboratory. Acting refuge manager, Dennis Prichard, described Sevilleta's unique educational mission and new facilities. The focus of the teachers' field work included soil development, recognizing distinctive soil properties, using soil information to decipher the paleoseismic histories of faults, and examining the evidence for episodic fault movement. Earthquake safety drills and building-engineering exercises demonstrated the need for school safety plans and a review of school structural hazards. Discussions on emergency preparedness were led by David Freeborn, state hazard mitigation officer. New Mexico's Department of Homeland Security and Emergency Management was the major funder of the workshop. Financial support was also given by the New Mexico Mining Association and the Women's Auxillary to the American Institute of Mining, Metallurgy and Petroleum. For information on next year's workshop, contact Susie Welch (susie@nmt.edu).

Data Preservation

The bureau is beginning its second year of cooperation with the National Geological and Geophysical Data Preservation Program, a federal program funded by the Energy Policy Act of 2005 and administered by the U.S. Geological Survey. The program was designed to help state geological surveys and other energy organizations catalog, digitize, and otherwise develop their collections for listing in a national repository for geological and geophysical data, such as well records, cuttings, drillers' logs, core, rock analyses, and geologic and mine maps. The physical collections will continue to reside at the state geological surveys. Under the direction of Ron Broadhead, the bureau's principal senior petroleum geologist and head of the petroleum section, an inventory of the bureau's data collections was completed in 2007–2008: 122,000 rock and mineral samples and drill cuttings as well as 2.2 million other data items, including well logs; water, coal and mineral analyses; well and mine records; and maps. Ron's team, in collaboration with bureau librarian Maureen Wilks, now will start adding to the number of bureau data collections that will be available through the USGS-managed national digital catalog, as well as through the bureau. Persons interested in a particular area eventually will be able to query the national digital catalog, and it will direct the user to the state geological survey holding that information.

Sixth Decision-Makers Field Conference

Planning is underway for the 2009 Decision-Makers Field Conference. The 2009 conference will be the sixth such conference that the bureau has hosted since the program was initiated in 2001. It will focus on resource issues related to urban growth in the Albuquerque region, including a broad range of water issues, geologic hazards, and the development of resources in an urban setting. Dates for the conference have been set for May 19–21, 2009. For more information, contact Doug Bland at dmbland@comcast.net.



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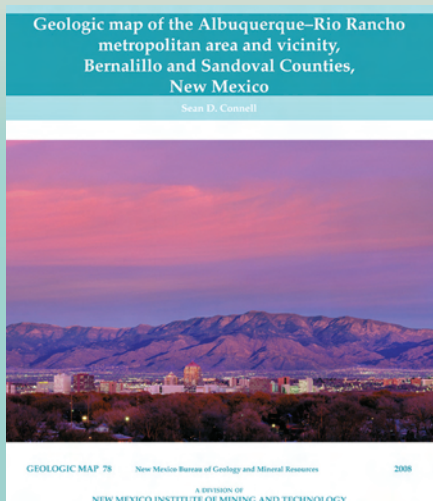
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Cover photo of Ship Rock, New Mexico

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NEW PUBLICATIONS

Geologic map of the Albuquerque–Rio Rancho metropolitan area and vicinity, Bernalillo and Sandoval Counties, New Mexico by Sean D. Connell, 2008, 2 oversized sheets, scale 1:50,000, ISBN 978-1-883905-26-2. Available September 2008. \$24.95 plus shipping and handling and taxes, where applicable. Available folded or rolled (\$5.00 additional shipping charge for rolled).



This new geologic map is a compilation of sixteen 7.5-min quadrangle maps and encompasses an area from Tijeras Arroyo on the south to Santa Ana Mesa north of Santa Ana and San Felipe Pueblos, and from the crest of the Sandia Mountains westward across the Rio Grande and onto the Llano de Albuquerque (West Mesa) west of the city limits of Albuquerque and Rio Rancho. A preliminary edition of this map was issued in 2007 as Open-file Report 496.

This geologic map graphically displays information on the distribution, character, orientation, and stratigraphic relationships of rock and surficial units and structural features. The map and accompanying cross sections were compiled from geologic field mapping and additionally from available aerial photography, satellite imagery, and drill-hole data (many published and unpublished reports, examination of lithologic cuttings, and from the interpretation of borehole geophysical log data).

The map and accompanying cross sections represent the most informed interpretations of the known faults in the Albuquerque–Rio Rancho area that are presently available. In addition to the positions of many faults, the cross sections show the approximate vertical extent

of poorly consolidated earth materials that may pose liquefaction hazards. This map also contains derivative maps selected to portray geologically important features in the metropolitan area, such as elevations of ground water levels, and the mostly buried boundary between generally poorly consolidated and saturated aquifer materials

and the more consolidated underlying materials. The gravity anomaly map is a geophysical dataset that shows major geological structures buried beneath the metropolitan area and vicinity.

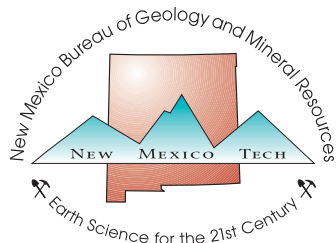


Geologic map of the Albuquerque metropolitan area from sheet 1.

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