Spring 1993

LITE geology

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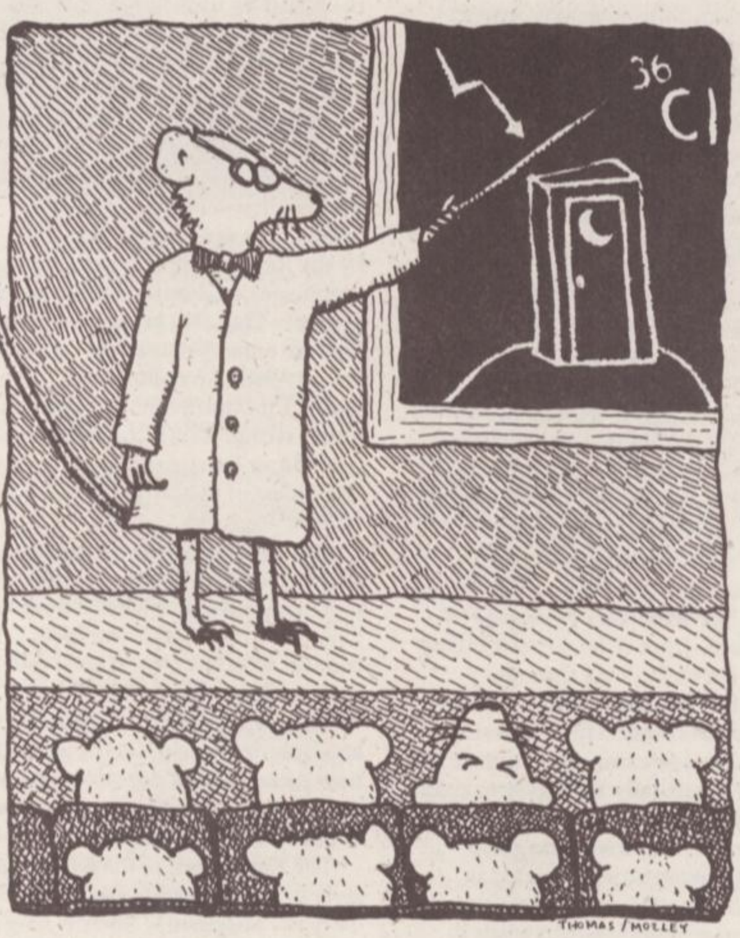
contemporary geological topics, issues and events

New Mexico Bureau of Mines and Mineral Resources (NMBM&MR)



pack rats reveal cosmic secrets

This Issue:

Earth Briefs

Pack Rats Reveal Cosmic Secrets

George Zamora
N. M. Tech Public Information Office

A New Mexico Tech geoscientist who developed a more accurate method of dating geological deposits by measuring the accumulation of a radioactive element is now using his new method to study ancient pack-rat "middens"—globs of precipitated pack-rat urine containing twigs, leaves, bones, and whatever else the rodents had dragged to their nests—for evidence of cosmic-ray bombardment of the Earth tens of thousands of years ago.

By measuring radioactive chlorine-36 isotopes in middens found in pack-rat nests, Dr. Fred M. Phillips and his research collaborators have tentative proof that the Earth was once subjected to a much stronger exposure of radiation from space. The radioisotope chlorine-36 normally forms when highly energetic cosmic-ray particles strike argon atoms in the atmosphere. The chlorine-36 then falls to the ground in rainwater and is taken up by the roots of plants. When animals such as pack rats eat the plants, they excrete the radioisotope onto the material collected in their nests. Eventually, the urine evaporates and precipitates around the debris, forming a hard, resinous clump, preserving indefinitely a natural "time capsule" record of the chlorine-36 levels present when the midden was formed.

Through his pack-rat research, Phillips and his colleagues have found evidence from urine salts found in middens radiocarbon-dated at 21,000 years old that cosmic-ray fluctuation then was 41% higher than it is now. Chlorine-36 analyzed from a newer sample, dated at 12,000 years ago, indicated a 28% higher flux in the cosmic radiation that once struck the Earth. These findings may support theories that the Earth's protective magnetic field was once weaker, thereby allowing more cosmic rays to penetrate the atmosphere.

Before his pack-rat studies, Phillips

focused much of his chlorine-36 research on describing glacial episodes. He dated past advances and retreats of mountain glaciers by measuring the buildup of chlorine-36 on boulders found on the crests of "moraines"—ridges of soil and rock that were deposited by movements of glaciers tens to hundreds of thousands of years ago.

Glacial chronologies are important indicators for global climate studies. Phillips has observed relatively rapid shifts between interglacial and glacial periods in mountain glaciers. Phillips notes that this might be relevant to today's worldwide concern about global warming.

Have you ever wondered. . .

How Old is the Rio Grande?

Charles E. Chapin
NMBM&MR Director and State Geologist

We often assume that our rivers were always present as we see them today. Actually, rivers are born, evolve, and disappear; their time span may extend over millions of years, but is nevertheless finite. Before about 5 million years ago, sedimentary basins of the Rio Grande rift, such as the Albuquerque and Española basins, were **closed hydrographically**. This means that streams entered the basin, but none left. Surface waters seeped into the sandy sediments and accumulated in shallow ponds, called playas, where they evaporated. The climate was drier than it is today. Five million years may seem like a long time, but the rift basins through which the Rio Grande flows started to form about 30 million years ago and the oldest rocks in New Mexico formed about 1,700 million years ago. Geologically speaking, the Rio Grande is a river come lately.

How do we know when the Rio Grande was born? First, we must distinguish the sediments deposited by the Rio Grande from older deposits. Sand and gravel deposited by a through-flowing, **axial river** like the Rio Grande differ in several respects from alluvial deposits of **local streams**. The sands of the Rio Grande are usually light gray in color because light-colored minerals like quartz are more resistant to weathering and abrasion and become concentrated in axial-river sands. The sands are also well sorted because long transport tends to sort particles by size. Larger particles drop out first; silt and clay remain in suspension to travel on downstream. Pebbles deposited during flood events are well rounded because of long-distance abrasion and consist of a wide variety of rock types present in a large drainage basin. Some pebbles can be recognized as having come a long distance, for example distinctive volcanic pebbles from the San Juan Mountains of Colorado.

Now that we know how to recognize the sands and gravels deposited by the Rio Grande, how can we determine their age? At several localities in New Mexico, lava flowed onto the floodplain of the Rio Grande and cooled to form a hard, dark-colored volcanic rock called **basalt**. A basalt flow, with an age of 4.6 million years before present, directly *underlies* sand and gravel deposits of the Rio Grande at the San Acacia dam north of Socorro. Geologists determined the age of the basalt by using a natural, radiometric time clock: a radioactive isotope of potassium in this rock decays to an isotope of argon; by measuring the ratio of parent to daughter and knowing the decay rate, the age of the rock can be calculated. A similar basalt flow at the perlite mine southwest of Socorro *overlies* some of the sands and gravels deposited by the Rio Grande and has a potassium/argon age of 4.1 million years before present. Thus, we know that in the Socorro area, the ancestral Rio Grande is *younger* than 4.6 million years and *older* than 4.1 million years. Vertebrate fossils found within Rio Grande river sediments provide an independent check on its age. The oldest of these fossils are about 4 million years old.

Other sections of the Rio Grande are much younger. The Rio Grande used to end in a large playa lake in the Las Cruces–El Paso area. The river did not connect with the *lower* Rio Grande and flow to the sea until 800,000 to 1,000,000 years ago. Similarly, the *headwaters* of the Rio Grande in Colorado flowed into a lake near Alamosa and did not connect with the Rio Grande Gorge near Questa until about 600,000 years ago.

The Rio Grande is the second longest river in the conterminous United States. Only the Mississippi River is longer. But unlike the Mississippi, the Rio Grande is an **exotic** river that flows through hundreds of miles of desert without the benefit of **perennial** (year-round) **tributaries**. The southernmost perennial tributary in New Mexico is Jemez Creek that joins the Rio Grande near Bernallilo. The Colorado River is also an exotic river. Radiometric ages of basalt flows and fossil ages of sedimentary deposits reveal that the Colorado, like the Rio Grande, did not exist as a through-flowing stream prior to about 5 million years ago. Increased surface runoff due to a cooler, wetter climate is thought to have caused the integration of local drainages to form these exotic rivers upon which our economy is so dependent.

Scenic trips to the geologic past

Scenic trips to the geologic past is a series full of interesting descriptions of scenic features and natural resources. Most of these handbooks take the reader on guided tours of selected areas via detailed road logs with maps, color photos, and commentary on landscape, recreation, wildlife, and vegetation.

Trail Guide to the Upper Pecos

by Patrick K. Sutherland and Arthur Montgomery

Venture into the splendor and incomparable beauty of the upper Pecos with two highly qualified geologists. Marvel at the rugged peaks and mighty canyons in this breathtaking wilderness. This illustrated guide shows how geologic processes have shaped the scenery–even affected the distribution of plants and animals. Some features are captured in full color. All the trips except the highway drive into the area are by foot or on horseback. The detailed large-scale map is especially useful.

116 pp., 82 photos, illustrations, and maps, 15 color photos, geologic and trail map in back pocket $6.50 Revised 1975

Mosaic of New Mexico's scenery, Rocks, and History

edited by Paige W. Christiansen and Frank E. Kottlowski

Our most popular book is composed of 15 articles describing New Mexico's history, peoples, deserts and mountains, geology, and recreational areas. This colorful guide includes stories and descriptions of many state and national forests, parks, and monuments; Indian pueblos; frontier forts; plants; and wildlife. Routes include major highways and secondary roads, both easy to follow on the full-color general map. The detailed index makes this a valuable reference volume.

170 pp., 64 photos, illustrations, and maps, 6 color photos $4.25 1972

The Enchanted Circle–Loop Drives from Taos

by Paul W. Bauer, Jane C. Love, John H. Schilling, and Joseph E. Taggart, Jr.

This guidebook's two main tours follow major highways north and south of Taos, incorporating descriptions of roadside geology with highlights on history, architecture, and vegetation and with notes on places to picnic, fish, and camp. One road log makes a 100-mile loop north through Questa, Red River, and Eagle Nest. A second 62-mile road log follows tranquil river valleys through the picturesque towns of Dixon, Peñasco, and Vadito while circling the Picuris Mountains. Four shorter side trips follow less-traveled roads into the Rio Grande Gorge and into the high country northwest of Red River. One side trip to Orilla Verde Recreation Area explains the basic principles of gold panning. The last side trip is a walking tour of the Harding pegmatite–an unusual opportunity to see an assemblage of very coarsely crystalline minerals, with a chance to collect some unique and attractive specimens.

137 pp., 98 photos, illustrations, and maps, 23 color photos $7.50 1991

Española–Chama–Taos–A Climb through Time

by William R. Muehlberger and Sally Muehlberger

This guidebook was written for either one long trip or two shorter trips, beginning in historic Santa Fe, the capital of New Mexico. North of Abiquiu our route parallels magnificent cliffs of yellow, white, and red sandstone and gypsum. The Carson National Forest-Ghost Ranch Visitor Center is a recommended stop. Watch for Echo Amphitheater, a natural formation in the cliffs to the left. El Vado Lake State Park and Heron Lake State Park are only a short drive west of the tour route at Tierra Amarilla. Chama is the northernmost town of our tour and a point of departure for the Cumbres and Toltec Scenic Railroad (see ST-11). At Tierra Amarilla the road log turns east and crosses the lush, forested Tusas Mountains. Our route reenters Carson National Forest and continues southeast to Taos, at the base of the Sangre de Cristo Mountains. The final leg of this loop follows the Rio Grande south and returns to Española.

97 pp., 69 photos, illustrations, and maps, 15 color photos $4.75 1982

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Ground-Water Overdraft and Land Subsidence

William C. Haneberg
Engineering Geologist, NMBM&MR

An aquifer is a saturated body of soil or rock that yields significant quantities of water. Contrary to the popular misconception, ground water does not generally exist in large underground lakes or rivers. Instead, it is found in small voids between grains of sand and gravel, or within small cracks in rock. In this regard, an aquifer is closer to a water-filled bowl full of marbles than an underground lake. An exception to this generality is ground water that flows through caves, which are found in only a few areas.

Aquifers are replenished or recharged by infiltrating rainwater and snowmelt. In arid and semi-arid areas such as New Mexico, however, the recharge rate is very low and the rate at which water is removed by pumping can easily exceed the rate of recharge. This imbalance is known as ground-water overdraft. The most obvious effect of continuous ground-water overdraft is a lowering of the water table. In the Albuquerque Basin, the water table is believed to have fallen as much as 40 meters (130 feet) between 1936 and 1988 (Summers, 1992). Likewise, water levels in parts of the Mimbres Basin south of Deming dropped more than 30 meters (105 feet) between 1908 and 1987 (Contaldo, 1989).

Falling water tables may cause shallow wells to go dry, in which case a deeper well must be drilled. Except for shallow ground water that may be heavily contaminated, ground-water quality generally decreases with depth. In addition to being more expensive, therefore, very deep wells may yield water that is hard, salty, or contaminated with naturally occurring metals.

Another undesirable consequence of ground-water overdraft is increased pumping cost. The amount of electricity required to pump 1 cubic meter (264 gallons) of water a vertical distance of 1 meter (3.2 feet) is about 0.003 kilowatt hours (Bouwer, 1978). Therefore, if a water table falls 20 meters, the amount of electricity required to lift 1.0 cubic meter of water to the ground surface increases

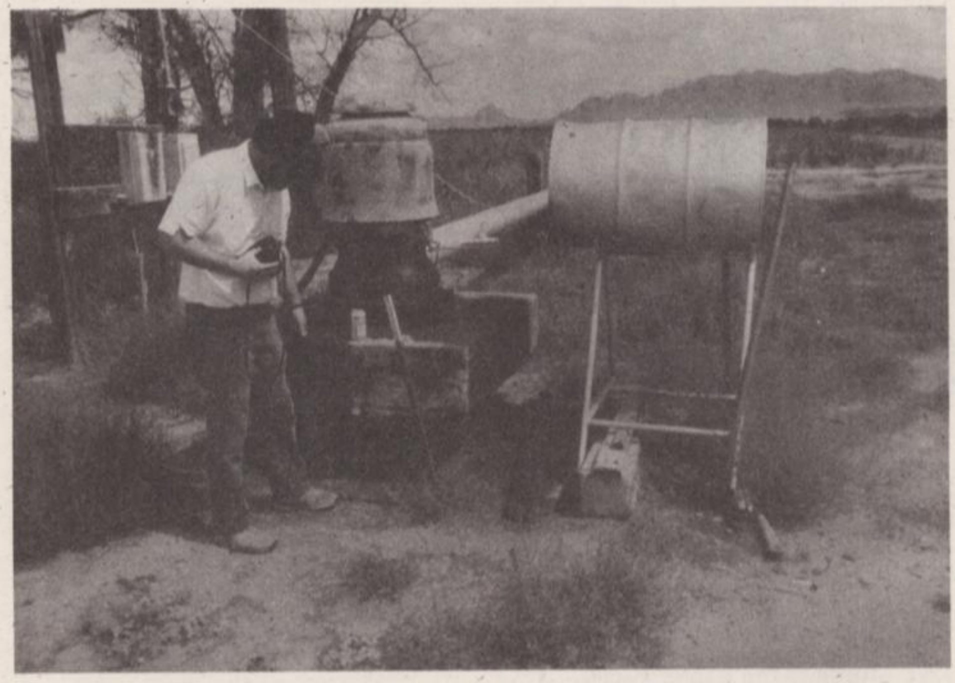

Figure 1—Several water wells drilled near the center of the Mimbres Basin south of Deming now protrude several tens of centimeters above the ground surface, and provide evidence of land subsidence. The well shown in this photo was drilled in the mid-1950s, suggesting that approximately 30 cm (1 foot) of subsidence has occurred over about 35 years. This yields an average subsidence rate of about 9 mm per year (0.35 inch per year) between 1955 and 1990.

Figure 2—An incipient earth fissure in the Mimbres Basin, which first appeared in 1984. View is toward the south. Total length of the crack in 1984 was 454 m (1480 feet). This portion of the crack had not yet been widened by erosion when the photo was taken. Earth fissures have been documented at 13 separate locations throughout the Mimbres Basin (Contaldo, 1989).

by 0.003 kilowatt hours/cubic meter/meter x 20 meters x 1 cubic meter = 0.06 kilowatt hours. The cost of electricity varies from place to place, but is generally on the order of 10 cents per kilowatt hour. Therefore, the cost of lifting 1 cubic meter of water per day an extra 20 meters is about $2.19 per year. If everyone living in the Albuquerque area, which is roughly 500,000 people, paid this amount, the total cost would be more than $1,000,000 per year! This is just a rough estimate, of course, but it does illustrate that ground-water overdraft has real costs.

Finally, ground-water overdraft can lead to aquifer compaction and land subsidence. Archimedes' principle states that the weight of the solid material composing the aquifer is supported in part by the buoyant force of the water. For example, a piece of gravel with a volume of 1 cubic centimeter and a specific gravity of 2.65 (which is the specific gravity of quartz) has a weight of 0.026 Newtons in air. When submerged, however, the same piece of gravel is supported by a buoyant force equal in magnitude to the weight of the water displaced by the gravel. This means that the submerged weight of the gravel is reduced to 0.016 Newtons, which is a decrease of about 38%. When the water table in an aquifer falls, the portion of the aquifer that has been drained loses the buoyant support of the ground water and begins to collapse. In most cases, sand and gravel undergo relatively little compaction. Clay and silt layers within the aquifer, however, can undergo a considerable amount of compaction. As the clay and silt layers become compacted, the ground surface is gradually lowered. Differential subsidence, which occurs when nearby areas undergo different amounts of compaction, can damage roads, utility lines, bridges, buildings, and other structures.

Cracks can also develop near the Earth's surface in areas of land subsidence. In rural areas, where storm runoff is not controlled, rainwater can flow into the cracks and enlarge them through the process of subsurface erosion. With little or no warning, the ground surface can collapse into buried cavities to form spectacular earth fissures that can be hundreds to thousands of meters in length. These large voids pose a hazard to both humans and livestock, and make irrigation of a fissured area difficult or impossible. In addition, fissures are frequently used for unsupervised disposal of chemicals that can eventually seep downward and contaminate the underlying ground water.

Ground water is a precious resource, and one that is essential for economic prosperity in arid and semi-arid areas such as New Mexico. Excessive ground-water consumption, however, can deplete an aquifer over the span of a few generations. The costs of ground-water overdraft, such as pumping lower quality water from deeper wells and repairing damage related to land subsidence, must be balanced against the short-term economic benefits of inexpensive and seemingly limitless ground-water supplies. The slow, almost non-existent recharge of aquifers in dry regions means that ground-water overdraft will probably never be entirely eliminated. The prudent use of ground water, including conservation measures, however, can slow the rate of overdraft and prolong the life of New Mexico's priceless aquifers.

Figure 3—A second view of the same fissure, but in this case looking north from the same vantage point as above. Surface runoff during heavy rainstorms flowed into a portion of the initial crack to produce the fully-developed fissure shown here.

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Exercises

1. Obtain a recent electrical bill for your home and find the cost of electricity, usually given in cents per kilowatt hour. Use this figure to calculate the annual cost of lifting 0.1 cubic meter per day an additional 30 meters due to a falling water table.
2. Illustrate Archimedes' principle by first weighing a small rock in air with a spring scale. To do this, tie or tape a piece of string to the rock and tie the other end to the scale. Record the weight of the rock in air. Next, submerge the rock (still attached to the scale by the string) in a pail or sink full of water and record the weight of the rock in water. The specific gravity of the rock is its weight in air divided by its weight in water, which is between 2.5 and 3.0 for most rocks.

Glossary of Terms for Understanding New Mexico's Water Supply

NMBM&MR Staff

"It is not really a mark of distinction for a geologist's writing to be so obscure that a glossary is required for its comprehension." Jules Braunstein

Aquifer—Soil or rock that is sufficiently permeable to transmit ground water and to yield economically significant quantities of water to wells and springs.

Capillarity—The action by which a fluid is drawn through voids or pore spaces in soil by surface tension.

Discharge (of Ground water)—Loss of water from, or movement of water out of, an aquifer; the process by which ground water is depleted.

Drainage—The ways water passes or flows off of an area, either by surface streams or subsurface conduits.

Erosion—The process or the group of processes whereby the materials of the Earth's crust are loosened, dissolved, and simultaneously moved by natural agencies, which includes weathering, solution, corrasion, and transportation.

Ground Water—Subsurface water, especially water in saturated soil or rock materials that exist below the water table.

Ground-water Basin—A structurally low, basin-shaped region in which aquifers form a coherent ground-water storage and flow system.

Ground-water Mining—The process—either deliberate or inadvertent—of extracting ground water from a source at a rate that exceeds replenishment, so that the ground-water level declines.

Hydraulic Conductivity—A measure of the ease with which water moves through an aquifer. It is a complex function of the shape, distribution, and connectivity of pore spaces in the aquifer. Hydraulic conductivity is expressed in units of length/time, such as feet/second; the greater the hydraulic conductivity, the more easily ground water flows through the aquifer.

Permeability—A measure of the relative ease with which a porous medium transmits a liquid. Permeability depends on the properties of the porous medium and the fluid, and on the forces causing the movement (also, see Hydraulic *Conductivity and Transmissivity*).

Precipitation—Water that falls to the surface of the Earth from the atmosphere as either rain, snow, hail, or sleet.

Recharge—The process whereby water is absorbed into the zone of saturation, thus becoming ground water. Recharge can occur by the process of infiltration either from precipitation, or from surface-water bodies.

water samples a hydrologist

Reservoir—A storage place for water, such as a lake or pond, from which water can be drawn, such as for irrigation, municipal uses, or flood control.

Runoff—Precipitation that does not infiltrate or evaporate, but runs off.

Salinity—A measurement of the total quantity of dissolved salts in water.

Subsurface Water—The water under the surface of the ground, including both ground water and vadose water.

Surface Water—All water on the surface of the Earth, including salt and fresh water, ice, and snow.

Transmissivity—A measure of the rate at which water moves through an aquifer. Expressed as gallons per day/ foot thickness of aquifer material.

Vadose water—Water in the zone of aeration, or that residual water that exists in pore spaces above the water table.

Water Contamination—The addition of any substance to water that reduces or prevents its use for drinking, preparing food, bathing, washing, cooling, recreation, or industrial processes. Some water contamination occurs by natural agents, especially in mineralized regions such as in New Mexico (eg. salt contamination of water could prevent its industrial use).

Water Quality—The measure of fitness of water for use, which is determined by chemical, biological and physical factors.

Watershed—The region drained by, or contributing water to a lake, stream, or other body of water.

Water Table—That surface in an unconfined aquifer at which water stands in wells; roughly corresponds to the top of the saturated zone. Specifically, the surface formed by points at which water pressure equals atmospheric pressure.

Zone of Aeration—A subsurface zone containing water that is held at less pressure than that of the atmosphere, including water held by capillarity, and containing gases or air, generally under atmospheric pressure.

Zone of Saturation—A subsurface zone where all of the pore spaces or voids are filled with water at a pressure greater than that of the atmosphere.

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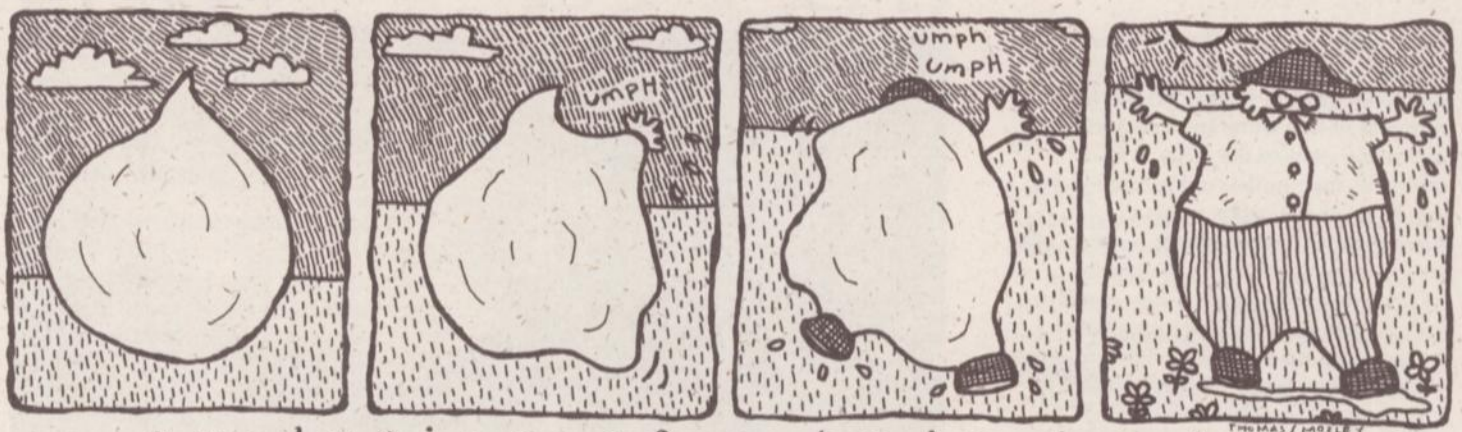
What Does a Ground-Water Scientist Do?



e v o l u t i o n   o f   a   h y d r o l o g i s t

Jeri Sullivan
Graduate Research Assistant,NMBM&MR

Scientists working in the fields of water resources and contamination hydrology must wear many different hats. There is no single discipline that applies in the business– it is truly a multidisciplinary job.

Ground-water science encompasses a broad range of topics, and thus, scientific areas. For example, a water resources manager needs to know about ground-water supplies, surface water availability and recharge, water quality, well installation and maintenance, and contract management. A geotechnical engineer might be a remediation specialist who designs excavations and back-fill projects, while a biologist might be interested in bacterial growth in wells or "bugs" that eat petroleum spills.

A person entering the field as a ground-water specialist might begin by studying geology or engineering in college. He or she will need to understand subsurface geologic processes as well as how water flows at the surface and through soil and rocks. A ground-water specialist must be able to write well, to communicate to others about where a water problem is found, how it occurs, who will deal with the problem, and what needs to be done to solve it. She or he will also benefit from a knowledge of chemistry, biology, math, and computer programming, because portions of each of these disciplines can be valuable tools to the ground-water scientist. Good library research skills are also helpful, because they allow the scientist to learn what others are doing elsewhere in the country, and apply that knowledge to the task at hand. Practicality and common sense, as well as good interpersonal skills always come in handy.

At work, a ground-water scientist is often a problem solver. This is the exciting part of the job. There can be a new and different problem every day. For instance, geology can be quite variable from one locality to another, and this may produce fundamental hydrologic and logistical differences between two "sites". An added complexity is the lack of ability to "see" directly underground. Although many techniques, such as geophysics and drilling, are available to assist the scientist, proper conceptualization of the problem is a key step toward an appropriate solution.

Some ground-water scientists are involved in helping to clean up the environment. Awareness of ground-water contamination, and knowledge of how to detect it and stop it has grown greatly within the last 20 years. Both government agencies, such as the EPA or state environmental agencies, and private companies, hire ground-water scientists to help evaluate contamination problems and determine the most efficient, cost-effective way to clean them up. Sometimes the scientist is involved in a risk assessment–the study of theoretical statistical risk that a spill or soil contamination may present to nearby homeowners. A hydrogeologist may install and sample wells to determine what chemical contaminants exist within an aquifer, and in which direction ground water is flowing. Remediation specialists may design a well network to pump contaminated water from beneath a site. He or she may determine what are the conductive properties of an aquifer, and whether nutrients and bacteria can be added to the water to support biodegradation of gasoline contamination that has been detected there.

Other ground-water scientists may work for local governments, to help produce public water supplies. A water resources engineer helps locate geologic formations or aquifers that can yield the needed quantities of good-quality water, and also designs the wells that are needed to extract this valuable resource. Some regions have abundant, renewable water supplies, such as many cities in the east and south, but others in the more arid west must carefully control the amount of water they remove, so that there will be enough for future supplies. The scientist here must have a good sense of the economic impact of what he or she does.

Private companies, such as mining and engineering companies, may hire a ground-water scientist to help them control the water that they encounter while constructing buildings or mining. Deep building foundations often reach below the water table, and the water must be removed during construction and special structural considerations made if the building is not to flood. Mine operators also encounter both shallow and deep ground water. While the removal of this water increases the operating costs of the mine, it also increases the number of locations that can be mined feasibly; again, the economics of ground-water removal play an important part in the operation.

Ground-water science is an exciting and growing field. New opportunities are opening up every day. For someone who is interested in solving problems, and in many aspects of science and communication, this field can be interesting and challenging, as well as a way to make life better for everyone.

New Mexico Water Facts

Did you know...

- New Mexico has about 7,400 miles of rivers and streams that flow year-round. Stretched end-to-end, they would form a stream of water approximately the same distance as from New York City to Los Angeles and back again!
- New Mexico's rivers feed three principal drainage systems: (1) the Canadian and Cimarron Rivers flow into the Mississippi; (2) the Rio Grande and Pecos River drain into the Gulf of Mexico; and (3) rivers west of the Continental Divide flow into the Colorado River.
- The Continental Divide is a sinuous line that appears on maps, and runs the length of the continent. It separates the drainages of rainfall in the East and rainfall in the West. Rain that falls east of the Continental Divide will eventually flow to the Atlantic, and rain that falls west of the line will flow into the Pacific. Several New Mexico towns that are located near, or at, the Divide include Animas, Silver City, Apache Creek, Pie Town, Trechado, Continental Divide, Hospah, Star Lake, and Chama.

(Sources of information: *New Mexico Environment Department; New Mexico Highway Department;* and *New Mexico Economic Development and Tourism Department)*

Photo by William A. Stone

Summer Shower

Skies grow dark while summer power tolls
The clouds and weights the waiting air
Poised to whip the mesa's brushy growth
Then tempest nips my leg and lifts my hair
As rain drops joining gather into flows
Of muddy soil ever quickly bearing
Sand and rock into the wash below
Where bank and boulder echo heaven's roll.

Go carefully child for every footprint moves
The soil and marks it lost to wind and rain
But look! Beyond this place the torrent slows
Spreads its precious load upon the plain
Of beast and man as one more time the old
Round of soil and water turns again.

Jacques Renault
Senior Geologist, NMBM&MR

high LITES

EARTH SCIENCE UPDATE

Teachers' Resources: Water Issues

Ground Water Education in America's Schools is a 41-page catalog of resource materials for elementary and secondary education professionals, and describes 80 different packages for classroom instruction about ground water and related environmental concepts. Single copies are free to educational organizations. Requests must include a 9" x 12" pre-addressed envelope and $2.00 postage. Send requests to American Ground Water Trust, 6375 Riverside Drive, Dublin, OH 43017, or call (614) 761-2215 for more information.

U.S. Geological Survey Water Resources Division Information Guide lists the district or state office address and phone number for your state. The guide also contains information on programs of the Water Resources Division. For a free copy, write to U.S. Geological Survey, Hydrologic Information Unit, Water Resources Division, 419 National Center, Reston, VA 22092.

The water resource poster series, distributed by the American Water Resources Association, consists of three posters (six more to be added later) that connect to form a mural depicting water resources and how they are used. The three titles available at present are:

Water: The Resource That Gets Used & Used & Used for Everything!
How Do We Treat Our Wastewater?
Wetlands: Water, Wildlife, Plants, and People

Each poster measures 2' x 3', and costs $5.00 including shipping. Printed on the back of the posters are activities tailored for either elementary or middle school students, so please specify grade level when ordering. For more information, call Stephanie Dodson, (301) 493-8600; or to order, write to American Water Resources Association, 5410 Grosvenor Lane, Suite 220, Bethesda, MD 20814-2192.

Geomedia CD-ROM, offered free to teachers by the U.S. Geological Survey (USGS), contains a mix of information on earthquakes, the hydrologic cycle, topographic maps, etc. Geomedia has an interactive, computerized format that allows teachers and students to experience how geology, hydrology and other earth sciences affect them, their communities, the nation, and the world. The USGS is distributing free copies, while supplies last, of Geomedia digital compact disks to teachers who are willing to experiment with this new technology in the classroom. System configuration requirements include:

1) Macintosh operating System 6 (version 6.0.7 or 6.0.8); or system 7 (version 7 or higher)
2) Hard disk and (optional) printer
3) 5 megabytes RAM (minimum); 8 megabytes preferred
4) 13" color monitor (or larger)
5) Compact disc (CD ROM) drive for Macintosh II series computers and Macintosh Hierarchical Filing System (HFS). Apple CD ROM driver version 3.0.1 or later.

Other learning products are also available. Please write to Project Chief, Geomedia, U.S. Geological Survey, 801 National Center, Reston VA, 22092.

Upcoming Geological and Earth Science Events

April 16-17, 1993
New Mexico Science and Engineering Fair, New Mexico Tech Campus, Socorro, New Mexico. Contact Vannetta Perry, (505) 835-5678, for more information.

April 22, 1993
Earth Day
Contact your local recycling office or City Hall to find out about Earth Day activities in your community. Lori Barzano, of the *New Mexico Earth Day Coalition* (NMEDC), can provide information about membership and activities of the NMEDC; call Lori at (505) 254-1111.

what is...

Magma?
Naturally occurring mobile rock material, generated within the Earth and capable of intrusion and extrusion. Igneous rocks have been derived from magma through solidification and other related processes.

Meander?
One of a series of regular freely developing sinuous curves, bends, loops, turns, or windings in the course of a stream. A meander is produced by a mature stream swinging from side to side as it flows across its flood plain.

Mineral?
A naturally occurring inorganic element or compound that has an orderly internal structure and characteristic chemical composition, crystal form, and physical properties.

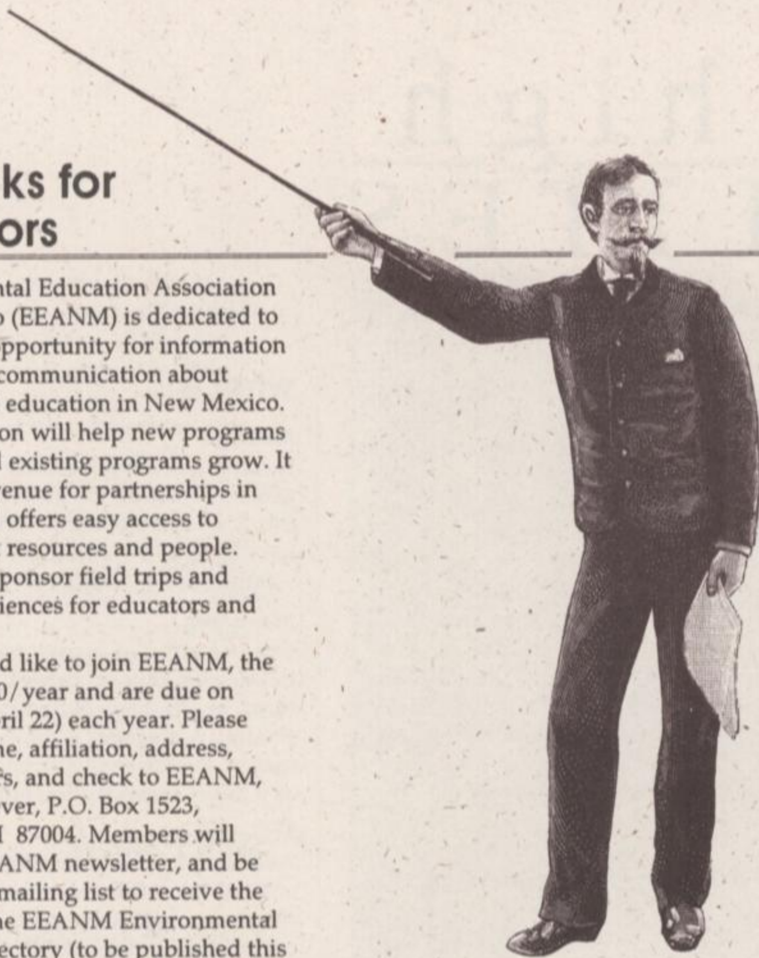
Reference-Bates, R. L., and Jackson, J. A. (editors), 1980, Glossary of geology: American Geological Institute, Alexandria, VA, 2nd edition, 749 pp.

someone said...

"In the end, environmental education boils down to a simple yet profoundly important imperative: preparing ourselves for life and all its surprises in the next century. When the 21st century rolls around, it will not be enough for a few specialists to know what is going on while the rest of us wander around in ignorance."

William K. Reilly
Administrator
U.S. Environmental Protection Agency

Earthlinks for Educators



Environmental Education Association of New Mexico (EEANM) is dedicated to providing an opportunity for information exchange and communication about environmental education in New Mexico. The organization will help new programs get started and existing programs grow. It provides an avenue for partnerships in programs, and offers easy access to environmental resources and people. EEANM will sponsor field trips and learning experiences for educators and students.

If you would like to join EEANM, the dues are $10.00/year and are due on Earth Day (April 22) each year. Please send your name, affiliation, address, phone numbers, and check to EEANM, c/o Mary Stuever, P.O. Box 1523, Bernalillo, NM 87004. Members will receive the EEANM newsletter, and be placed on the mailing list to receive the first issue of the EEANM Environmental Education Directory (to be published this year) listing environmental education programs in New Mexico.

An Environmental Education Forum is planned for June 24, 1993 at noon in Albuquerque. Contact Sue McGuire at the New Mexico Museum of Natural History, 841-8837 for more information.

Also, the Water Education Working Group (WEWG) of the EEANM is sponsoring two programs:

1) A statewide network of middle and high schools will be collecting water-quality data on New Mexico waterways. The students will learn about river issues and land uses, test waterways for at least 10 water-quality parameters, and network their data with other schools within the state and throughout the world. Contact Mary Stuever, (505)867-4661.

2) The first New Mexico Water Camp will be held this summer in Santa Fe, and has tentatively been scheduled for the last week in July. The program is for middle and high school students and will explore many aspects of water. Contact Jean Walter, 471-4711.

New Mexico Science and Engineering Fair

The 41st New Mexico Science and Engineering Fair will be held April 17, 1993 on the New Mexico Tech campus. 350 junior high and high school students representing six New Mexico regional science and engineering fairs will compete in one of fourteen categories, vying for top honors and prestigious awards. For the senior competitors, there will be an opportunity to compete in the 44th International Science and Engineering Fair (ISEF), to be held May 9-15, 1993, in Mississippi Beach, Mississippi.

If you would like information regarding any aspect of the Science Fair, or have comments and suggestions, please feel free to contact Vannetta R. Perry, Director, New Mexico Science and Engineering Fair, Martin Speare Building, New Mexico Tech, Socorro, New Mexico 87801, (505) 835-5678.

Sources for Earth Science Information

Teachers can receive free materials including curricula, student handouts, and reference materials for school resource media centers by contacting:

U.S. Bureau of Mines
Guy Johnson, Staff Engineer
Building 20
Denver Federal Center
Denver, CO 80225-0086
(303) 236-0747

For answers to questions on economic mineral deposits and the extractive mineral industry, contact:

Mine Registration & Geol. Serv. Bur.
Bill Hatchell
Mining and Minerals Division
2040 South Pacheco
Santa Fe, NM 87505
(505) 827-5970

A free teacher's packet including a poster, lesson plans, activities, and lists of mineral resources can be obtained by calling or writing:

Mineral Information Institute
Jackie Evanger: Vice President
1125 17th Street Suite 1800
Denver, CO 80202
(303) 297-3226

For information about state environmental programs in New Mexico, contact:

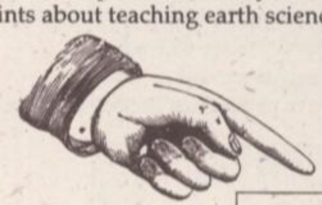
John Geddie, Administrative Asst.
Public Information
New Mexico Environment Dept.
P.O. Box 26110
Santa Fe, NM 87502
(505) 827-2850

The Environmental Protection Agency provides a free information hotline for radon. Call **1-(800) SOS-RADON.**

classroom hint...

Mary Stuever is an environmental educator from Placitas, New Mexico, who gives seminars about the New Mexico environment. Mary developed a method of helping students at her seminars understand the concept of geologic time. She made a set of "props" with her computer by printing the name of each time period on separate 8" x 11" sheets of various-colored paper, and then laminating these 17 sheets. Now, with the help of some masking tape, when she walks into a classroom, she can turn the room into a geologic timeline. When she talks about the various mountains and landforms in the state, she can roam about the room from time period to time period, physically illustrating geologic time. She also includes a table listing of geologic periods, years, and even some events or New Mexico landforms originating during that time.

(Teachers–please send us your classroom hints about teaching earth science)–editor



Ground Water Studies Curriculum Module

A teacher training workshop (1 credit-hour toward recertification) offered through the Denver Earth Science Project will be held in Durango April 23-24, 1993 from 8:00 a.m. - 5:00 p.m. Registration is $70, and includes a Teacher Resource Kit. For information about this and other modules, contact:

Marsha Barber, Director
Denver Earth Science Project
Colorado School of Mines
Golden, CO 80401-1887
(303) 273-3494

Wanted:

Experienced Geologists, or Mining or Petroleum Engineers willing to volunteer for at least one week this summer working with senior Boy or Girl Scouts at the 1993 Energy/Minerals Field Camps in New Mexico. Contact :

Stu Carlson
Minerals Outreach (901)
Bureau of Land Management
324 South State, Suite 301
Salt Lake City, UT 84111-2303
(801) 539-4244

Summer at Tech: 1993

Various summer programs at New Mexico Tech in Socorro offer middle school and high school students opportunities to enhance their science and math backgrounds, earn college credit, and become oriented to college life. Programs integrate classroom work, field trips, seminars, social activities, and in some cases, research apprenticeships. The following programs are available this summer:

*Summer Honors Program
*Summer Mini-Courses
*Bridge to Tech
*Summer Youth Program
*Young Scholars Program
*Native Americans Mineral Engineering and Science (NAMES)
*Minority Introduction to Mineral Engineering and Science (MIMES)
*Summer Science Program

Some programs focus on earth science topics such as geology, and environmental, mineral, and petroleum engineering. Qualifications for admission and application deadline vary with each program. For more information about any of the Summer at Tech programs, call 1 (800) 428-TECH.

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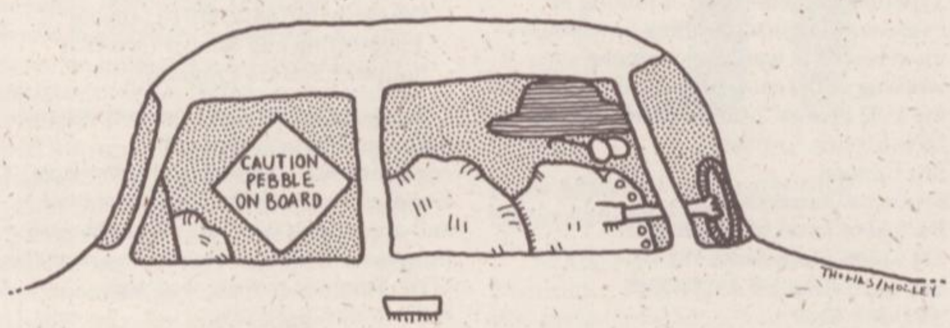
understanding New Mexico's water supply...

In this issue, we present water topics that may help the citizens of New Mexico to better understand their water supply. The successful management of our water resources requires that we all make informed and responsible decisions about New Mexico's water supply and its use. New Mexico Bureau of Mines and Mineral Resources (NMBM&MR) can supply water-resource information from a geological perspective. The NMBM&MR supports an active environmental and engineering geology group; one important area of emphasis for this group is applied research in ground-water resources. Information gathered by NMBM&MR scientists helps with the development and protection of ground-water supplies, and in evaluating water-quality and pollution problems. In a recent study conducted for the City of Albuquerque, NMBM&MR geologists constructed a three-dimensional model of the aquifers beneath the city to help determine how much water is available. The study utilized cuttings and electric logs obtained when the wells were drilled, as well as surface mapping and subsurface data obtained from petroleum exploration. Cooperative studies are continuing between the City, The Bureau of Reclamation, and the NMBM&MR.

Lite Geology Staff

Acknowledgments—Many thanks to the NMBM&MR staff members who have supported this project through their ideas, articles, resources, and time.



LITE geology

is published quarterly by **New Mexico Bureau of Mines and Mineral Resources** *(Dr. Charles E. Chapin, Director and State Geologist)*, a division of **New Mexico Tech** *(Dr. Laurence Lattman, President).*

Purpose: to help build earth science awareness by presenting educators and the public with contemporary geological topics, issues, and events. Use *Lite Geology* as a source for ideas in the classroom or for public education. Reproduction is encouraged with proper recognition of source.

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