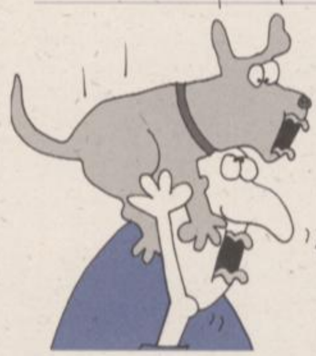
LITE geology

A quarterly publication for educators and the public–
contemporary geological topics, issues and events

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

unusual weather patterns

Earth Briefs



El Niño is brewing in 1997

What does the warming of waters off the coast of South America have to do with the price of oil and natural gas in America? Why does a plentiful harvest of shrimp cause dismay to Peruvian fishermen? These effects are symptoms of an apparent global climate condition called El Niño that seems to be building this year.

An El Niño is the accumulation of unusually warm water near the coast of South America. In the El Niño cycle, trade winds that normally blow westward across the south Pacific weaken; warm water that is usually pushed westward instead sloshes back near the western coast of South America (Chapin; Lite Geology, 1995). The displaced warm water mass affects precipitation patterns and alters the typical jet stream. Changes in wind strength and direction affect weather patterns around the globe. Good records are available for the 20th Century that show the El Niño cycle tends to occur about every three to seven years, and lasts one to two years. However, the latest cycle lasted from January 1992 to either mid-1994 or mid-1995, a double cycle!

In order to better understand and predict El Niño cycles, the variability of temperature, winds, and currents along the equatorial Pacific are continuously monitored by satellites and a network of high-tech buoys anchored to the ocean floor. NASA's TOPEX/POSEIDON satellite employs a radar

This Issue:

altimeter that measures the exact distance between the satellite and the sea surface. These sea-surface height data can be used to detect warm water masses that appear as humps about 6–8 inches high in the ocean. Two such warm-water masses, or Kelvin waves, were detected recently, one in late December and one in late February (NASA, 1997). The changes in currents and upper-ocean structure associated with these Kelvin waves was monitored by NOAA's TOGA-TAO buoy array along the equator (NOAA, 1997).

Wind data are derived both from satellite-borne radar, the NASA scatterometer, which is on the Japanese Advanced Earth Observing Satellite (ADEOS), and from the TOGA-TAO buoys. The continuous collection and sharing of data on sea-surface heights, upper-ocean currents and water temperatures, and trade winds provide the best picture of an evolving El Niño ever avaiable to scientists around the world.

The data observations are fed into computer models that use equations of motion (exactly analogous to a numerical weather forecasting model) to describe and predict the coupled evolution of the trade wind system, the ocean surface temperature, and upper-ocean currents in anticipation of the onset of El Niño. One such model is used by the National Oceanic and Atmospheric Administration (NOAA) to make predictions and issue advisories when there are early indications of El Niño conditions (NASA, 1997). NOAA has issued an advisory for the likelihood of a moderate or strong El Niño in late 1997.

El Niño is evidenced by dramatic shifting of fish populations seeking either warmer or cooler waters, and by unusually high or low air temperatures and precipitation levels across the globe. Fishermen from Peru have reported the appearance of shrimp and lobster that normally reside in the warmer waters near Ecuador; meanwhile the usual catch of hake and grouper has fled south seeking cooler waters (Friedland, 1997). Mackerel has invaded the warming waters of British Columbia.

Nations are bracing for the consequences of widespread climate disturbances, such as flooding in South America and California; a wet, snowy winter across the southwestern United States; and droughts in India, Australia, and Africa. Besides the physical damage that extreme weather causes, economic effects are felt as well. Milder winters in the northeastern United States create a soft market for heating oil and natural gas, which can affect New Mexico producers and impact the state's revenue stream. Textile producers in Peru feel the impact of unseasonably warm temperatures as the winter clothing market plummets. Fish-processing factories either close down or cut back production drastically as their normal catch is disrupted (Friedland, 1997).

El Niño climate shifts and their associated effects on the world are part of a continuing cycle that is recognized by many scientists. Anticipation of the cycle may become an increasingly important factor in strategic planning by governments and businesses. A Denver-based consulting geologist, Michael Wilson, studies the El Niño cycle in relation to oil economics. He states that although gas companies are skeptical of weather forecasts, "El Niño is not weather. It's climate, and it's big and it happens again and again" (Freeman, 1996).

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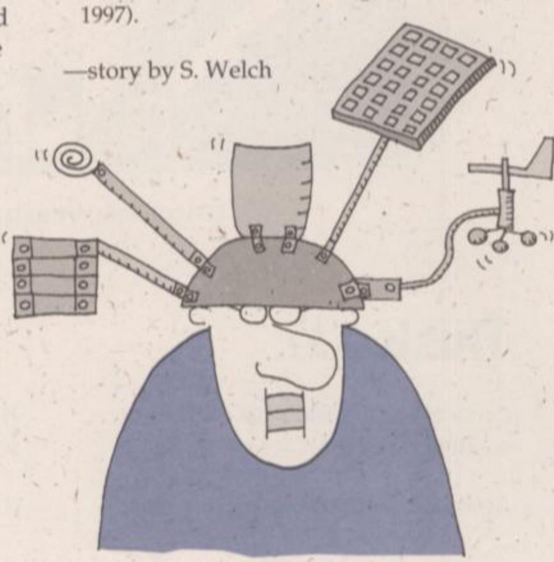
—story by S. Welch



personal weather station

Aggregate in the Modern Stone Age

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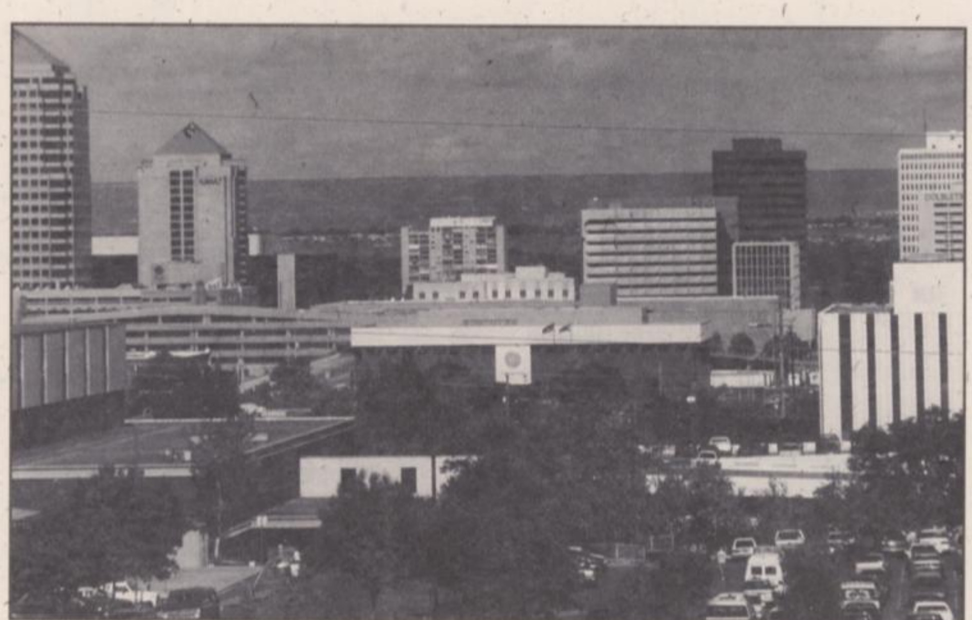


Figure 1—View looking west from I-25 toward downtown Albuquerque. All of the structures visible are constructed of aggregate, cement, stone, and brick.

The Earth supplies all of the materials used by modern society in the construction of homes, apartment buildings, small office buildings to large skyscrapers, roads, and bridges (Fig. 1). These commodities, once called non-renewables, often can be recycled. Still, we consume large amounts of newly mined earth materials, especially for new construction.

Although many different commodities are used in construction, no item is more common than concrete, which consists of particles of rock (called **aggregate**) held together by cement. Aggregate is composed mostly of sand to small fist-size stone fragments (either natural or crushed) and makes up as much as 80% of the concrete. Steel-reinforced concrete forms the footings, floors, pillars, walls, and other structural elements of many buildings, to which other materials such as stucco, bricks, and stone are attached. Aggregate also is used on unpaved roads, as well as paved ones where it is bound together with asphalt or cement.

Aggregate commonly is divided into two principal categories, (1) crushed stone and (2) sand and gravel. According to the U.S. Department of the Interior's Mineral Industry Surveys and Mineral Commodity Summaries, the annual U.S. production of crushed stone in 1994 was 1.4 billion tons (Tepordei, 1995). The value of this crushed stone, produced by 1,600 companies operating 4,000 active quarries in 48 states, was $7 billion. In the same year, nearly 1.0 billion tons of sand and gravel valued at $4.3 billion was produced by 4,250 companies from 6,000 active operations in 50 states across the country (Tepordei, 1995a). The combined value of about $11 billion for aggregate represents about one-third of the total estimated value of U.S. nonfuel mineral production (Smith and others, 1995). The total weight of all metal and nonmetal minerals used in America during 1994, divided by the total U.S. population, shows that about 10 tons (20,820 lbs) of nonfuel earth materials were used by every U.S. citizen in that year. Of that tonnage, 50% was crushed stone, 37% was sand and gravel, and 11% was the other nonmetal minerals; metals were only about 2% of the total. Aggregate companies employ about 75,000 workers with an annual payroll of almost $3 billion.

New Mexicans, like people everywhere, are consumers. We eat food, wear out shoes, use highways, and burn gasoline. Each of us consumes large amounts of earth materials. New Mexico, like all other states, has a tremendous appetite for construction materials. Wherever there are people, construction materials are needed to build modern structures. One is constantly aware of new construction in our urban areas. Even where the population is sparse, as in some of the counties in the northeastern and western parts of the state, extensive roads and highways (constructed with aggregate) are necessary to connect population centers.

From 1985 through 1992 when the national average was 10 to 11 tons of aggregate production per person, New Mexico produced less, between 8.2 and 9.7 tons (Fig. 2). From 1993 to 1995 production was equal to or exceeded the national average (between 9.9 and 11.5 tons per person). During this 10-year period, the population of New Mexico grew at a faster rate (17%) than the national average (11%).

From 1985 to 1995, New Mexico

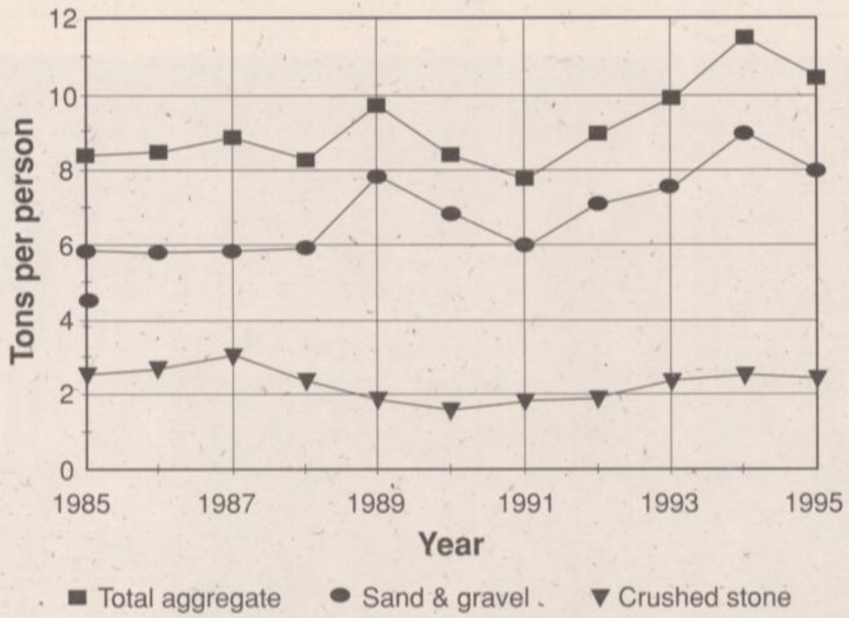


Figure 2—Production of aggregate in tons per person for New Mexico (1985–1995). Source: U.S. Department of the Interior, The mineral industry of New Mexico (1985–1995), and U.S. Department of Census, 1996, Populations: (via the Internet).

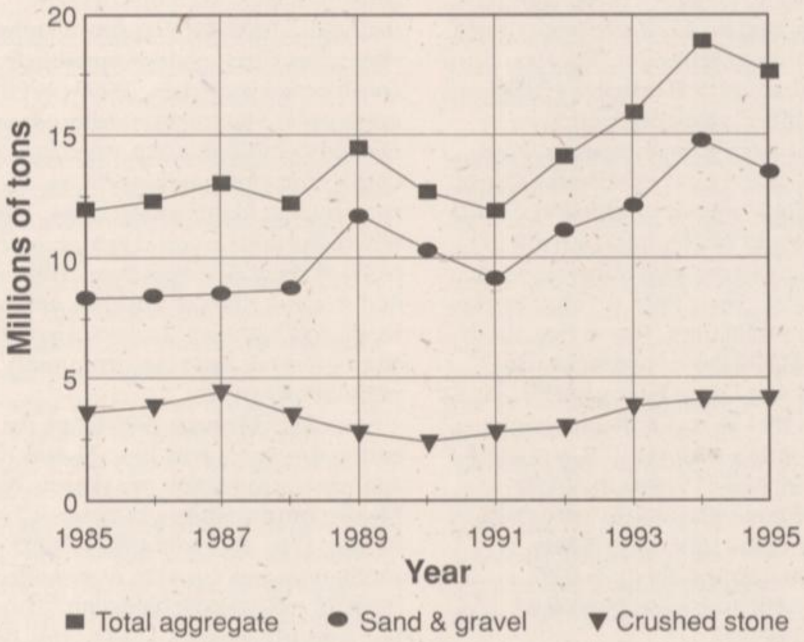


Figure 3—Aggregate production tonnage in New Mexico (1985–1995). Source: U.S. Department of the Interior, The mineral industry of New Mexico (1985–1995).

production and consumption of aggregate increased at a greater rate than did the population (Fig. 2). In addition, there was a subtle shift in the relative demands for various construction materials. The percentage of sand and gravel used increased during the same time from 70% of construction materials in 1985 to 76% in 1995 (Fig. 3). In part, this is a result of lower production cost because the material does not need to be quarried and crushed, but only needs to be separated by size. However, the price increased as demand for sand and gravel rose while supplies became more restricted (Fig. 4). Consequently, the value of sand and gravel rose from 60% of all aggregate in 1985 to 73% in 1995, with the high of 81% reached in 1990 (Table 1). An examination of the value of nonfuel mineral production in New Mexico from 1985 to 1995 reveals that aggregate rose from 6 to 9% of total production. Copper continues to dominate the value of nonfuels, followed by potash, with aggregate a distant third. The annual value of these categories (copper, potash, and aggregate) commonly will account for about 90–92% of the total nonfuel mineral production in the state. However, each year the value of aggregate alone, at 8–10% of production, will exceed the combined value of New Mexico's clay, gemstones, gold, gypsum, lead, perlite, pumice, mica, molybdenum, salt, and silver production.

In 1995, aggregate pits and quarries were active in all New Mexico counties except Harding County (Fig. 5). Many more inactive pits and quarries are present in all counties. Both types are clustered in the Rio Grande Valley or along interstate and other major highways. Much of the sand and gravel is in river beds (modern and ancient). From near Velarde north of Española to El Paso in the south, this valley is the most

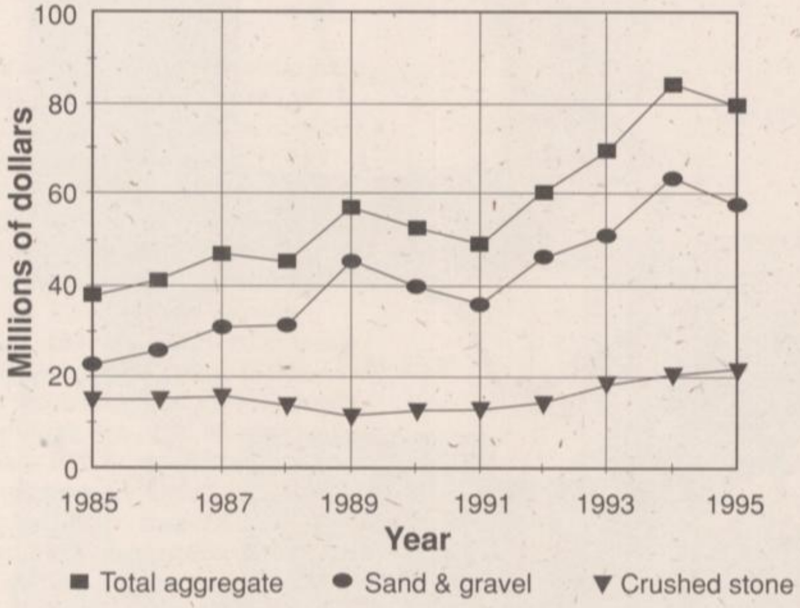


Figure 4—Value of aggregate production in New Mexico (1985–1995). Source; U.S. Department of the Interior, The mineral industry of New Mexico (1985–1995).

densely populated corridor in New Mexico. Increases in population cause land prices to rise along the Rio Grande. Higher prices for land means aggregate producers must pay higher prices to purchase or lease sites for pits and quarries. These increased costs translate into higher aggregate prices for the consumer.

Populous counties like Bernalillo County commonly have a large number of pits and quarries, but much construction material is imported from other counties as well. This is because cities tend to be built over deposits of construction materials that otherwise would have been used. Note the nine active quarries in Bernalillo County and the 25 in Doña Ana County (Fig. 5). In 1990, Albuquerque's population was 385,000 compared to Las Cruces's

Table 1—New Mexico production of sand, gravel, and crushed stone (million tons), value (million $), calculated value per ton, and value percentage of sand and gravel of all aggregate. Source: U.S. Department of the Interior, The mineral industry of New Mexico (1985–1995).

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Sand and gravel											
Tonnage	*8.40	8.47	*8.60	8.79	*11.80	10.36	*9.20	11.21	*12.20	14.88	*13.60
Value	*22.80	25.86	*31.00	31.37	*45.40	39.71	*35.90	46.18	*51.10	63.40	*57.80
$/ton	*2.71	3.05	*3.60	3.57	*3.85	3.83	*3.90	4.12	*4.19	4.26	*4.38
Crushed stone											
Tonnage	3.64	*3.90	4.50	*3.50	2.78	*2.40	2.80	*3.00	3.86	*4.20	*4.20
Value	15.23	*15.30	15.92	*13.90	11.67	*12.80	13.09	*14.40	18.41	*20.70	*21.80
$/ton	4.18	*3.92	3.54	*3.97	4.19	*5.33	4.67	*4.80	4.77	*4.93	*5.25
Total aggregate (sand, gravel, and crushed stone)											
Tonnage	12.04	12.37	13.10	12.29	14.58	12.76	12.00	14.21	16.06	19.08	17.80
Value	38.03	41.16	46.92	45.27	57.07	52.51	48.99	60.58	69.51	84.10	79.60
Percentage of total aggregate represented by sand and gravel											
	60	63	66	69	80	81	73	76	74	75	73

*Estimated (sand and gravel is surveyed one year, crushed stone the next; estimates for either commodity are used for the off year).

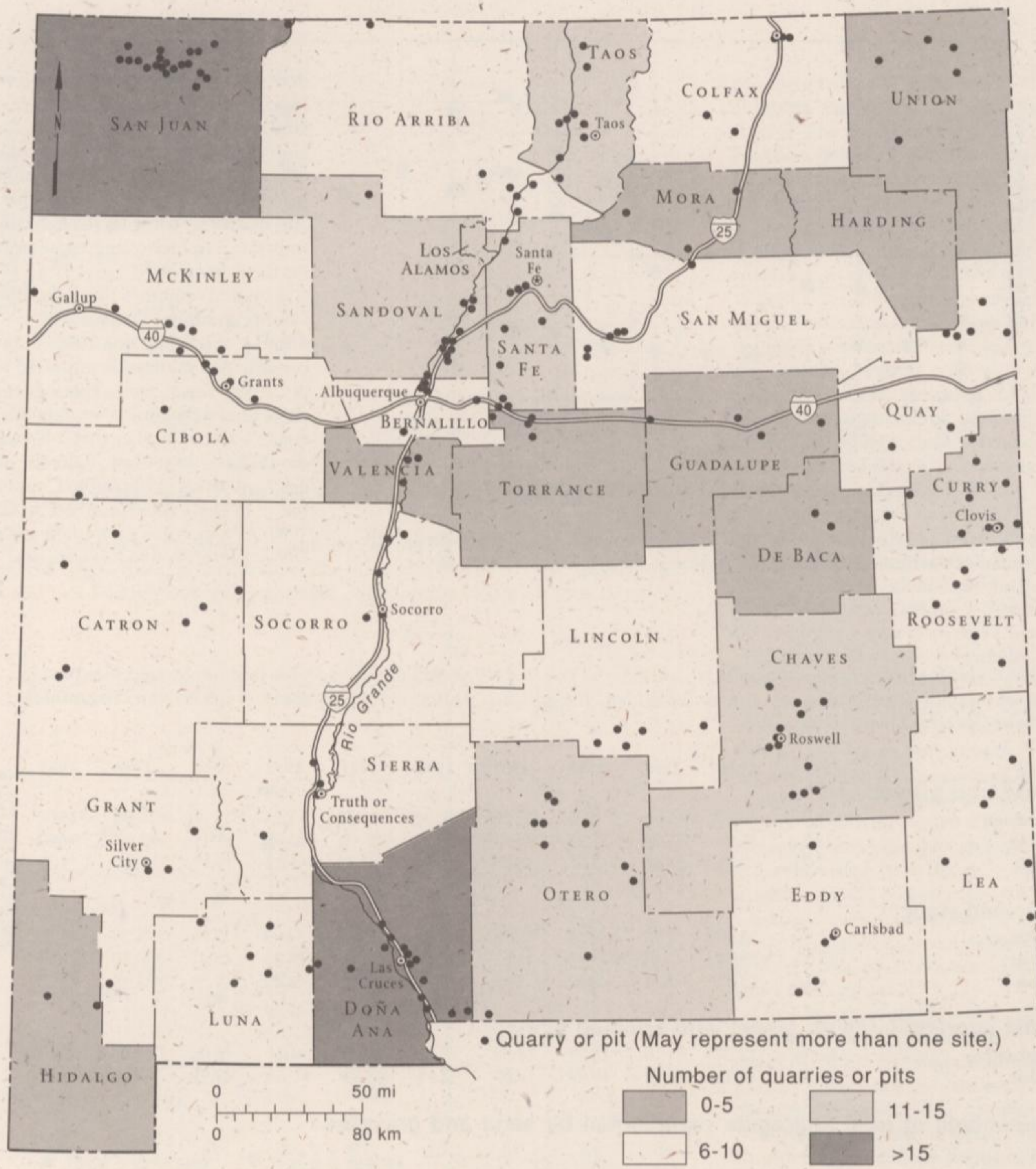
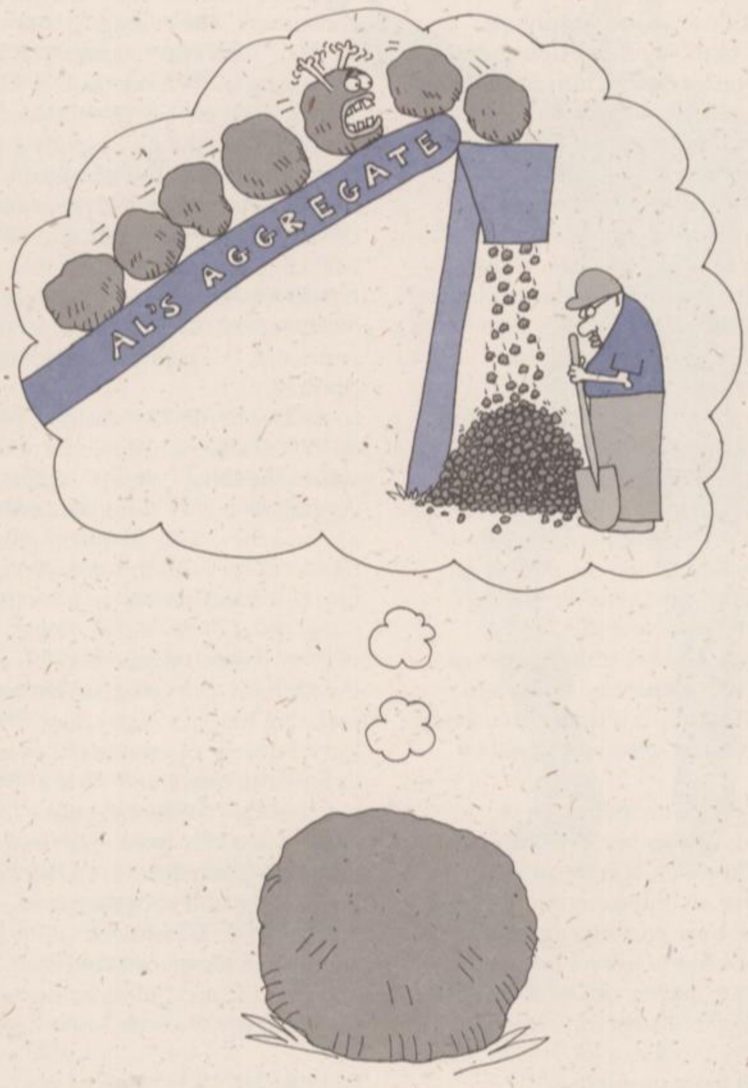


Figure 5—Numbers of active pits and quarries in New Mexico by counties.

population of 135,500 in the same year. Does this mean that citizens of Las Cruces use more construction materials than do those of Albuquerque? Not necessarily. It may mean instead, that aggregate is not readily available near Albuquerque and must be transported to Bernalillo County from Santa Fe, Sandoval, Torrance, and Valencia Counties. However, Las Cruces is one of the fastest growing cities in the United States and grew more than 40% between 1980 and 1990. New people mean new buildings, and new buildings mean increased demand for more construction material.

Quarry operators must contend with urban sprawl and they must also worry about who controls the land. Various Pueblo Indian tribes control land to the north and south of Albuquerque. In the past, their land has supplied significant sand and gravel to Albuquerque. The pueblo tribes may become less interested in leasing their land for production of aggregate. To the southeast, Kirtland Air Force Base blocks future development of sources of aggregate. East of Albuquerque, the Sandia and Manzanita Mountains have both federal and state restrictions on mineral production. To the west, Petroglyph National Monument limits development.

Green areas like the bosque along the Rio Grande also have an impact on land available for pit and quarry development because river gravels are a prime source. Throughout New Mexico, federal and state lands have supplied construction materials in the past, but with increased restrictions on access, operators have been forced to transport construction materials longer distances. Many modern aggregate operations are hidden behind berms to ease sometimes tense community relations. Extensive efforts are made to keep quarries landscaped and relatively quiet and free of dust.



rock nightmares

At present, quarries north of Albuquerque in the Rio Grande Valley in Sandoval and Santa Fe Counties, and on the east side of the Sandia-Manzanita Mountains in Santa Fe and Torrance Counties are supplying aggregate to most of the Albuquerque market. Some construction materials for cinder blocks, notably light- and dark-colored volcanic rock known as pumice and scoria or cinder, respectively, have been brought to Albuquerque for many years. The quarries for these materials on the flanks of the Jemez Mountains (pumice) and in the Rio Grande valley near Santa Fe (scoria) involve trucking this material as far as 60 miles.

Nearly all of the aggregate used in New Mexico is moved by truck from the pit or quarry to distribution yards or to the final site where it is used. The only exceptions are some aggregates moved mainly out of state by rail. Some scoria is shipped primarily to non-New Mexico customers in 100-ton train hopper cars. Railroad ballast quarried in eastern Torrance County, and used extensively in the Southwest, also is shipped by rail.

While truck transportation is flexible, it is also expensive. In terms of ton-miles, it is the most expensive of all of the commonly used methods of transporting aggregate. The cost of a ton of gravel from an Albuquerque quarry can be $2.65 at the pit but is $6.55 (nearly triple!) when delivered by truck to a job site 50 miles away (data from unpublished NMBMMR files). As the distance increases from the quarry or pit to where the aggregate is used, the principal cost of aggregate is not the aggregate itself, but the transportation. This is one reason that quarries are scattered all over New Mexico, mostly near large urban areas. Except for a few specialty materials, all of the markets are local. High transportation costs highlight why the elimination of quarries near urban centers drastically increases the cost of construction materials and therefore the final cost to consumers. The average house of about 1,700 ft^2 uses approximately 100 tons of aggregate (A. F. Barsotti, U.S. Bureau of Mines, oral comm., 1993) valued at about $300 at the pit or quarry. With transportation to the job site and markup by the builder, the value of this aggregate can easily add $1,000-3,000 to the cost of a home. As transport distances for aggregate increase because local sources are restricted, the price will continue to rise dramatically.

To live in modern society, planners and consumers must be aware of where the things we use originate. Aggregate comes from the Earth at pits and quarries. City planners must take this need for nearby pits and quarries into consideration along with the need for parks and other green areas. Too often, we consumers complain about the high price of construction without realizing that our expanding cities have forced quarry operators either to close down or to move to distant and more costly sites. The modest noise, dust, and truck traffic from modern quarries may have been there long before the new homes and shopping centers were built nearby. Careful planning and zoning can lessen or avoid conflicts and provide an equitable arrangement for life in the Modern Stone Age.

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Aggregate in the Modern Stone Age—a summary

•Rock particles used in road building and construction are called aggregate and consist of crushed stone, sand, and gravel. Concrete is composed of as much as 80% rock particles held together with cement.

• In 1995, crushed stone valued at $7 billion was produced in the United States by 1,600 companies operating 3,900 active quarries in 48 states. Construction sand and gravel valued at $3.8 billion was produced by 4,250 companies from 6,000 operations in 50 states.

•The combined value of about $11 billion for aggregate represents about one-third of the total estimated value of U.S. nonfuel mineral production.

•The total weight of all metals and nonmetal minerals used in America during 1995 divided by the total U.S. population shows that about 10 tons (20,820 lbs) of nonfuel earth materials were used by every U.S. citizen.

•Of the 20,820 lbs used per person in 1995, 87% was aggregate (50% was crushed stone and 37% was sand and gravel), 11% was the other nonmetal minerals, and 2% was all of the metals.

•In New Mexico from 1985 to 1995, production and consumption of aggregate increased at a rate greater than did the population. The value of nonfuel mineral production was dominated by copper, followed by potash, with aggregate a distant third at 6 to 10%.

•In New Mexico, after many years (1985–1992) below the national average for the production of aggregate with (8.2 to 9.7 tons per person), production from 1993–1995 has been equal to or higher than the national average (10 to 11 tons per person). In 1994, New Mexico's aggregate production reached a high of 11.5 tons per person. This occurred while New Mexico's population was growing at a faster rate (17%) than the national average (11%).

• In 1995, aggregate pits and quarries were active in all New Mexico counties except Harding County.

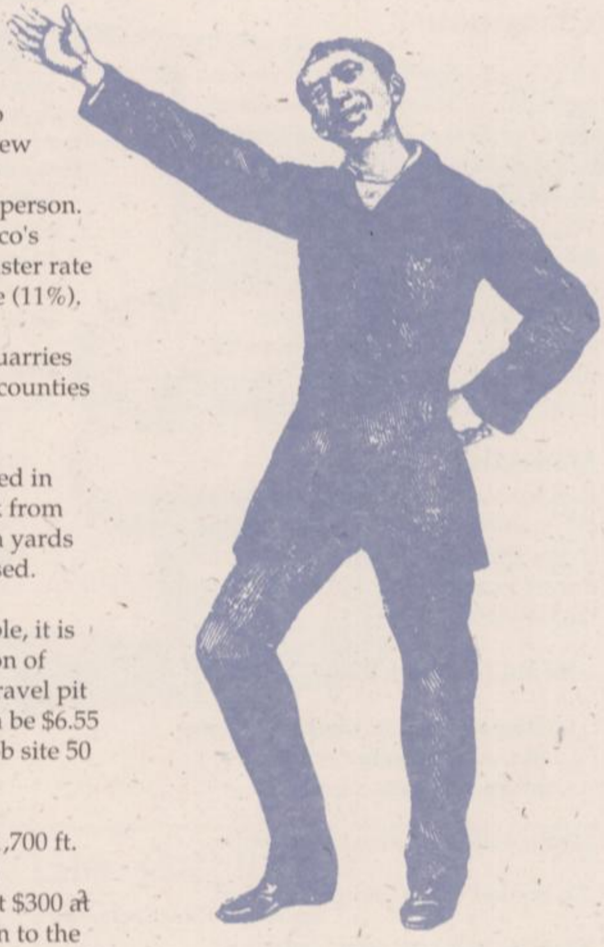
•Nearly all of the aggregate used in New Mexico is moved by truck from the pit or quarry to distribution yards or to the final site where it is used.

•While truck transport is flexible, it is also expensive. The cost of a ton of gravel from an Albuquerque gravel pit can be $2.65 at the pit but it can be $6.55 when delivered by truck to a job site 50 miles away.

•If an average house of about 1,700 ft. uses approximately 100 tons of aggregate with a value of about $300 at the pit or quarry, transportation to the job site and markup by the builder will cause an increase of $1,000–$3,000 to the cost of the home.

•As cities surround and cover suitable sources of aggregate and the construction industry is forced to go farther to get aggregate, its price will continue to rise faster than inflation.

•The major cost of aggregate is not the material in the pit or quarry ready to use, but the transportation to the construction site.



Earthquake Education Follow-up:

How to Prepare an Emergency Kit for your Classroom

Does your school or classroom have an emergency kit containing essential items for first aid and comfort in the event of an earthquake or other disaster? Using the exercise below, your students can assemble a simple, inexpensive emergency kit. This activity will provide opportunity for discussion on what to do in an emergency. To expand the activity, have the students design a similar kit for their homes or family vehicles.

Materials :
Purchase an inexpensive backpack or other ample container with shoulder straps (this is to be worn by the teacher during evacuation). Fill the pack with the following items:

Items for the kit:

1. Class roster with students' names, addresses, phone #, medical information, etc.
2. First-aid checklist and supplies
3. Bottled water and plastic cups
4. Flashlight and spare batteries
5. Pocket radio with spare batteries
6. Paper and pens; permanent marker for leaving messages
7. Colored flag to summon aid
8. Compact, durable food (granola bars, crackers, etc.); comfort foods (hard candy, chewing gum)
9. Trash bags for raincoats, ground cloths, etc.
10. Playing cards and pocket games

Procedure

1. Discuss the need for the classroom kit; identify which items in the classroom should be left behind and which are necessary for survival and comfort.

   Have students brainstorm about items that should go into the kit and make a list on the board. Identify items that are already in the classroom and those that need to be purchased.

2. Divide the class into teams, which should include:
   A. List-making Team: Copy the kit contents list from the board. Attach one copy (in plastic sheet) of the list to the kit pack to serve as a check list. Provide another list to the supply team.

   B. Supply Team: Review list; determine which items on the list are available in the classroom, which can be brought from home, which must be purchased. Gather supplies with the help of teacher.

   C. Promotional Team: Design a logo with important information and attach it to the emergency pack. Make posters about the kit, safety, evacuation, and first aid procedures.

Follow-up:
Invite the school nurse, the Red Cross or Fire Department to demonstrate first-aid procedures and evaluate the kit. Have the class make improvements to the kit as necessary. Decide on where the kit should be kept; the teacher must be able to reach the kit easily during an evacuation drill or actual emergency. Finally, practice the Drop-Cover-Hold drill with your students, and then practice evacuating the building (don't forget to bring the kit!).

Sources for Earth Science Information

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

Mineral Information Institute
Jackie Evanger
475 17th Street; Suite 510
Denver, CO 80202
(303) 297–3226

Information on Earth Science programs, projects, reports, products and their sources is available from:

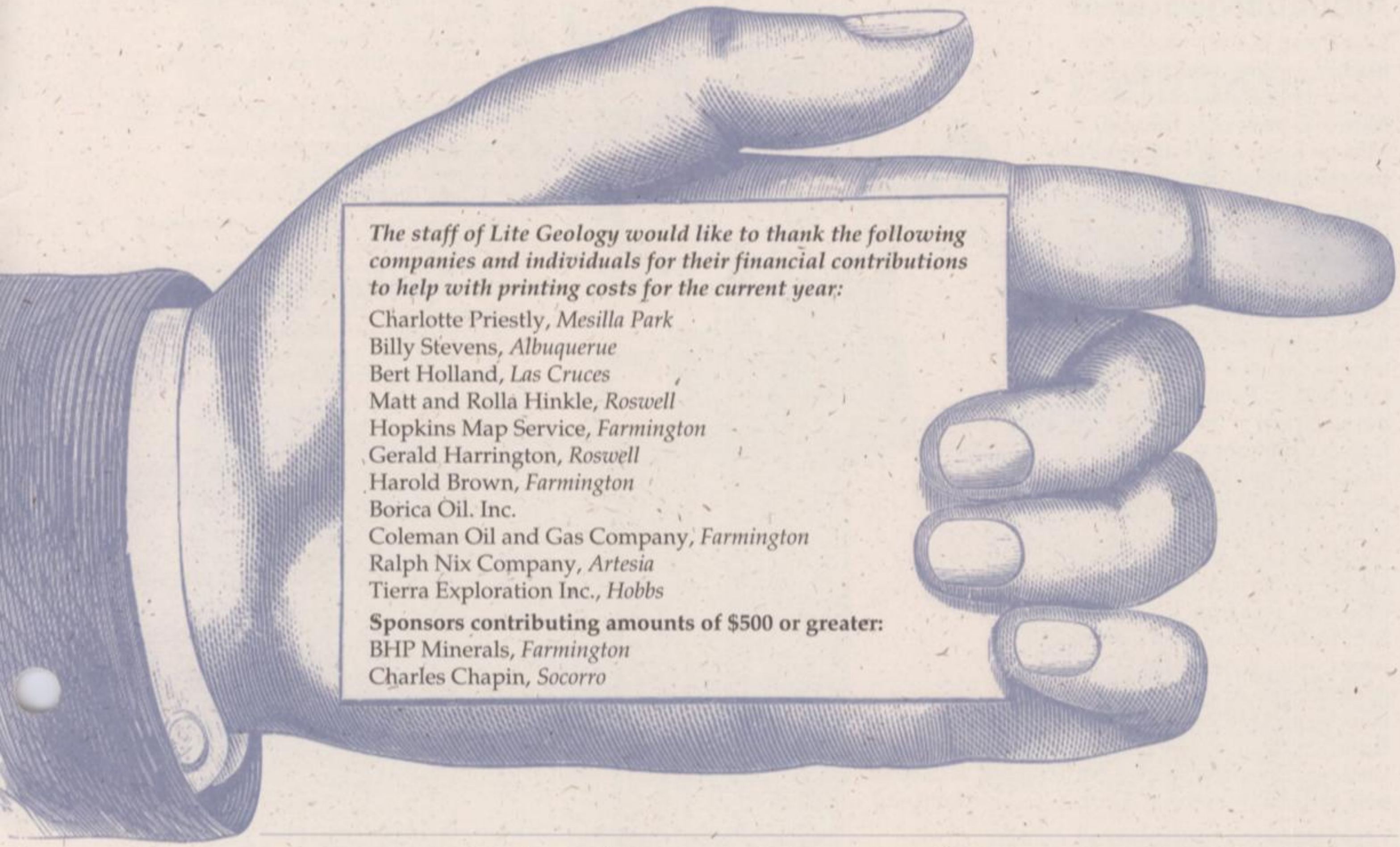
US Geological Survey
Earth Science Information Center (USGS ESIC)
Call 1-(800) USA–MAPS
web: http://mapping.usgs.gov/www/html/leducate.html

or in New Mexico, contact:

Amy Budge
Earth Science Information Center
Earth Data Analysis Center
University of New Mexico
Albuquerque, NM 87131
(505) 277–3622
e-mail: abudge@spock.unm.edu

Information on earthquakes in New Mexico is available by contacting:

Debra Pritchard
Program Manager
New Mexico Earthquake Preparedness Program
Department of Public Safety
P.O. Box 1628
Santa Fe, NM 87504
(505) 476–9617



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Lite Geology began as a small Earth-science publication designed and scaled for New Mexico. Our subscription list now includes a large number of out-of-state readers. In order to keep up with the demand for this publication from outside of New Mexico, we now charge **$4.00 per year for out-of-state readers**, which covers the cost of printing and mailing. **If you reside outside of New Mexico and wish to keep your subscription active, please return this form with a check for $4.00**. If you have questions, please call Debbie Goering at (505) 835–5490.

Lite Geology

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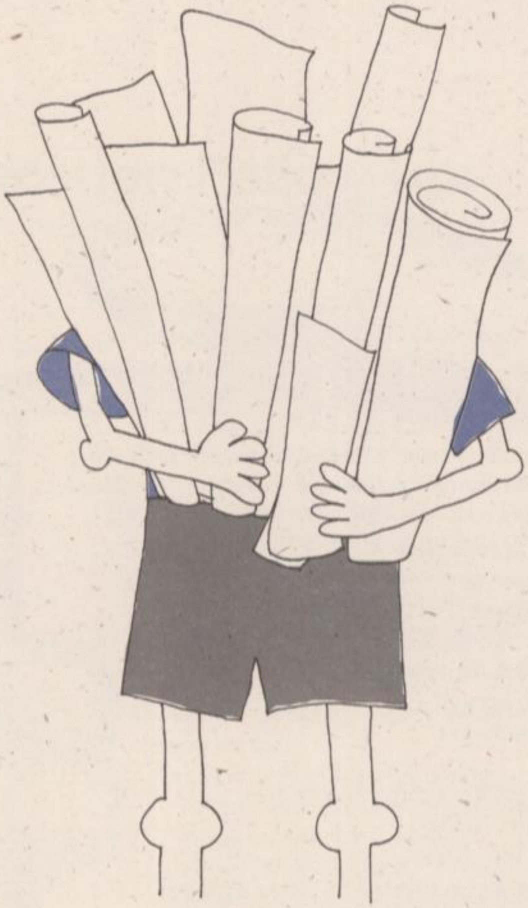
Teachers in the Albuquerque area



Please stop in and visit the new teacher resource center at the Albuquerque office of New Mexico Bureau of Mines and Mineral Resources. Educators can browse through our publication sales area, and also pick up free information on the geology and mineral resources of the state, including pamphlets, curricula, topographic maps, etc. We will have a computer set up to access seismic data and other geologic information. Funding for the development of the teacher resource center was provided by the Earthquake Program of the New Mexico Department of Public Safety (THANKS!!).

We are located at 2808 Central SE (on the corner of Vassar and Central, across from UNM). Please call 255-8005 to confirm the office hours, or to schedule an appointment. Ask for Dr. Bill Haneberg, NMBM&MR Engineering Geologist and Assistant Director (haneberg@nmt.edu). For further information, contact Susan Welch in Socorro at the Geologic Extension Service, NMBM&MR at (505) 835-5112 or (susie@nmt.edu). Our new earthquake website is http://tremor@nmt.edu. . .visit us on the web!

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Purpose: to build Earth Science awareness by presenting educators and the public with contemporary geologic 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 the source.

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