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Adobe brick production in New Mexico

by Edward W. Smith, Geologist/Planner, Eight Northern Indian Pueblos Council, San Juan Pueblo, NM

Introduction

In 1980, the New Mexico Bureau of Mines and Mineral Resources undertook a study of the adobe brick industry in New Mexico. The study included the distribution and location of the commercial adobe brick producers, soil types, geology and mineralogy, methods of production, market trends, and economic factors. Adobe samples, collected from 56 locations and the 48 active adobe producers (fig. 1), were tested in the Rock Mechanics Laboratory at the New Mexico Institute of Mining and Technology.

The 1980 estimated combined dollar value of production for the three major types of adobe bricks (traditional, semi-stabilized, and stabilized) totaled $1,174,598. This figure accounts for the commercial production of 4,133,000 adobe bricks (table 1) and places New Mexico as the leading producer of adobe bricks in the southwestern United States. Not included in the production totals are the values for the thousands of adobe bricks produced by individual homeowners for their own construction projects, which may represent an additional 3-4 million adobes per year.

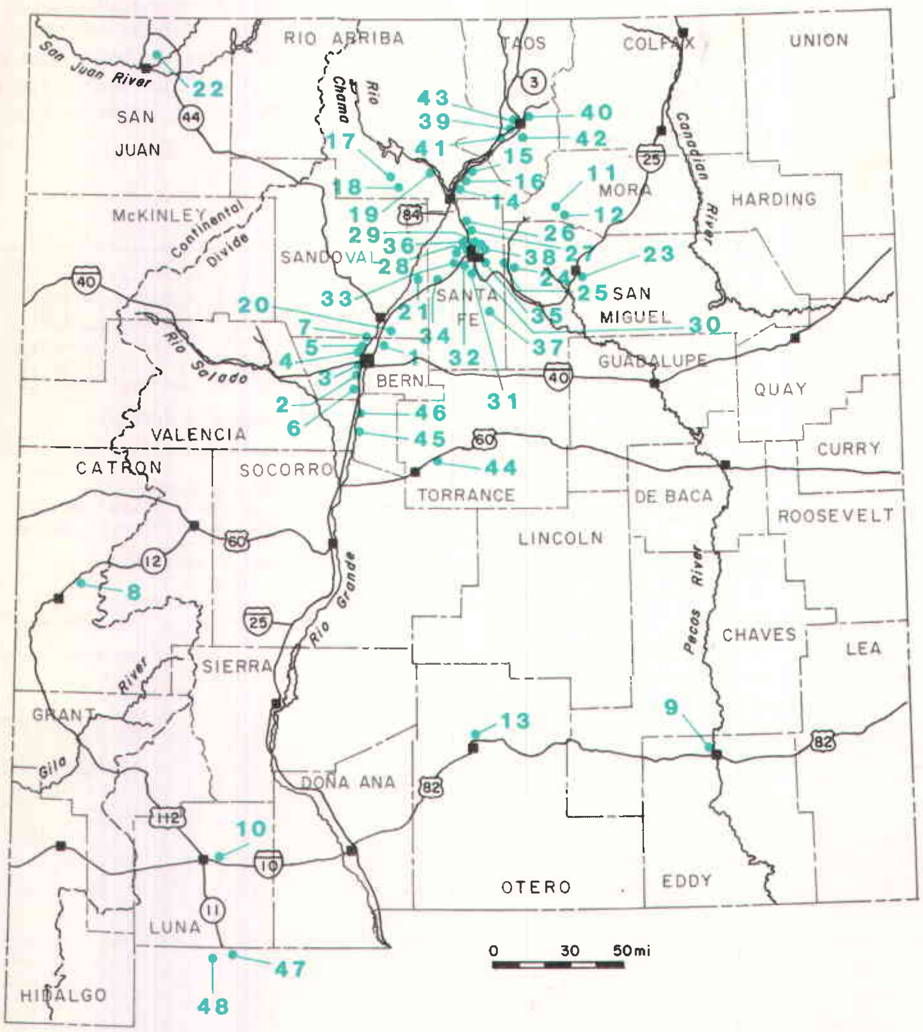

FIGURE 1—LOCATION OF ADOBE BRICK PRODUCERS ACTIVE IN 1980 (for names of producers and information, see table 3).

TABLE 1—ESTIMATED 1980 ADOBE BRICK PRODUCTION TOTALS.

Type of adobes	Average* price/adobe	Estimated production total	Estimated dollar value	Percentage of total production
Stabilized	36.9¢	460,000	$ 169,740.00	11%
Semistabilized	27.8¢	2,320,000	644,960.00	56%
Traditional	26.6¢	1,353,000	359,898.00	33%
Totals	30.4¢	4,133,000	$1,174,598.00	100%

*Summer adobe brick price averages for thirty-eight (38) traditional, eight (8) semi-stabilized, and six (6) stabilized adobe brick producers.

History

The word "adobe" has its roots in an Egyptian hieroglyph (fig. 2) denoting brick and evolved through Arabic and Spanish to its present form. Today, adobe is used to describe various earth-building materials and techniques, usually referring to the sun-dried adobe brick now most widely used in the United States. The word also applies to puddled structures, adobe-plastered logs or branches, and even to rammed-earth construction (pisé).

Among the oldest of technologies mastered by prehistoric man, the use of mud as a building material parallels the birth and spread of the great ancient civilizations of the world. To this day, soil remains the primary building material of at least 50 percent of the world's population. The Neolithic Period (10,000–3,000 B.C.) marks the beginning of stable, nonmigratory civilization, and with it efforts at building the world's first permanent structures. Remains of adobe structures have been found in Neolithic farming villages throughout the Near and Mid-East, dating as far back as 7,000 B.C. (Steen, 1972). Hand- and form-molded bricks from this era are seen in the ruins of structures throughout Mesopotamia, Crete, Egypt, and India. The use of mud construction rapidly spread eastward through Asia and westward through North Africa and the Mediterranean Basin; as the Ice Age receded in northern Europe, these peoples also began to use adobe in construction.

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FIGURE 2—REPRODUCTION OF EGYPTIAN HIEROGLYPH OF QUEEN HATSHEPSUT MAKING A MUD BRICK (Fathy, 1973).

Meanwhile, the New World was undergoing a similar development. Younger civilizations in the western hemisphere, dating from 3,000 B.C. in the Chicama Valley in Peru, used adobe (Steen, 1972). The first adobe construction in what is now the United States probably does not predate the 10th or 11th century A.D. Traces of hand-formed brick and puddled adobe along with stone masonry are evident in many of the famous archaeological ruins of the southwest United States, including old Picuris Pueblo, Sapawe and Pajarito Plateau sites (Steen, 1977) within the state of New Mexico. With the arrival of the Spanish colonials in the 16th century, the standard formed-adobe brick made by using a wooden mold was introduced to the southwest.

Adobe bricks are still made in the traditional way by hand methods at the site of construction. Today, however, even on smaller jobs, the trend has been to purchase the bricks ready-made. These bricks are manufactured commercially on a large scale at centrally located adobe yards where the right soil is available. The controlled conditions of manufacture assure a uniformly good product and a continuous supply of adobe bricks; the increasingly important commercial manufacture of adobes will be discussed in this paper.

Terminology and general characteristics

Some of the common terms used in the adobe trade are:

1) *Adobe soils*—A term applied to clay and silt deposits usually occurring in the basin areas of the state. Adobe bricks can be made from a wide variety of local soils, but the most suitable soil found in the Rio Grande basin area is a sandy loam composed of roughly 55-75 percent sand and 25-45 percent finer material (generally equal parts of silt and clay). A proper balance of clay and sand is critical to insure a quality adobe. Clay gives strength to the brick but in excessive amounts will cause shrinkage; sand is added to decrease the shrinkage and prevent cracking (California Research Corporation, 1963).

2) *Stabilizers*—Moisture reentering an adobe brick causes the clay to swell and release its bonding so that the entire mass disintegrates. To prevent disintegration, various soil stabilizers are added to the basic soil mix to waterproof or increase the weathering resistance of the adobe brick. The most commonly used stabilizers are sand, straw, portland cement, lime, and bituminous and asphalt emulsion (Clifton, 1977), although as many as 20 different materials have been found in usage (Wolfskill, 1970).

For commercial purposes in New Mexico, asphalt emulsion is used exclusively because of its superior mixing and waterproofing properties.

3) *Traditional adobe brick*—Often referred to as an untreated, unstabilized, or standard sun-dried adobe brick, the traditional adobe is made with soil composed of a uniform mixture of clay, sand, and silt. Usually straw is added to the adobe brick to prevent the brick from cracking while being cured.

4) *Semistabilized-adobe brick*—Essentially the same as a traditional brick, the semistabilized adobe is classified as a water-resistant brick because of the addition of a small amount of asphalt emulsion (4 percent or less by weight). The adobe contains a sufficient amount of stabilizer to protect stockpiled adobes from local rains and the production cost is significantly lower than that of a fully stabilized brick.

5) *Stabilized-adobe brick*—The fully stabilized adobe, referred to by the New Mexico Building Code as a treated adobe, is defined as containing a sufficient amount of stabilizer to limit the brick's water absorption to less than 2.5 percent. The fully stabilized adobe, usually manufactured with 5-12 percent asphalt emulsion, is a completely waterproof building material which will resist water even without a protective coating.

6) *Pressed-adobe bricks*—This type of adobe brick is manufactured from traditional or stabilized adobe materials pressed into dense bricks of various sizes using either a gasoline-powered hydraulically operated machine or a hand-operated press referred to as a "cinva-ram." Because of the high mechanical pressure applied by the press, the resultant bricks test very high on the compressive and modulus of rupture tests (these tests are explained in the section on physical properties).

7) *Terrone*—This Spanish word meaning "a flat clod of earth" refers to the type of adobe brick made of cut sod or turf material found in boggy river-bottom locations, particularly in the Rio Grande flood plain areas (McHenry, 1976). The terrone usually measures 8″ × 6″ × 14″, is cut from the sod areas using a flat spade, and then is stacked in a dry area to properly cure. Probably because of the sod-root structure and the high clay content of the soil, the terrones have a high compressive strength and modulus of rupture.

8) *Quemado (burnt adobe)*—Having the same soil composition as a traditional adobe, the quemado is simply a sun-dried adobe brick that has undergone a modified low-firing process. Combustible materials are burned in a stacked-brick-pile oven configuration, and the resultant burnt-adobe brick is much stronger in both compressive strength and modulus of rupture than a standard unfired brick. The majority of quemados used in New Mexico are produced in the northern border areas of Mexico and are shipped into the United States duty free.

Geology

Usable adobe materials are found in large areas of New Mexico and constitute a virtually inexhaustible reserve. The adobe materials are obtained principally from the Quaternary alluvial deposits in stream channels, flood plains, terraces and alluvial fans. The majority of deposits consist of clay, silt, sand, and gravel mixed in the same deposits.

The largest number of adobe-brick producers are located in the Albuquerque and Española basin areas of the Rio Grande valley where significant quantities of good adobe materials are obtained from the flood plains of the Rio Grande and adjacent terraces and plains. For detailed information on the major locations of adobe materials, see the geologic reports and maps of the Española and Albuquerque basin areas (Kelly, 1977 and 1978). Several large-scale adobe manufacturers located in the basin areas also use crusher waste or fines purchased from the local sand and gravel operations. These fines usually contain 15-18 percent clay which produces a good adobe brick.

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Mineralogy of adobe clays

Clay-size material is the chief binding agent in adobe bricks and the majority of the clay-size material consists of clay minerals. Four clay-mineral groups are commonly represented in New Mexico's adobe clays. The high-aluminum kaolinite group and the high-potassium illite group generally make up about one half of the clay present in the 39 samples tested. Both groups are regarded as nonexpanding or only slightly expandable in the presence of water. The calcium- or sodium-rich smectite group and the mixed-layer illite-smectite group contain varying expanding clay minerals and also make up about 50 percent of the clay minerals present. A member of the chlorite group was found in only one New Mexico adobe clay material and the vermiculite group was not represented.

The presence or absence of a particular mineral and total amount of clay minerals present affect the physical properties of the adobe bricks. A clay material with a high percentage of nonexpandable clay minerals, particularly the kaolinite group, tends to be more brittle than one with more expandable clay minerals. Similarly, a clay material with a large percentage of expandable minerals will produce a brick of greater compressive strength than one containing the same amount of clay, but with a larger percentage of nonexpandable clay minerals. Thus, an adobe material with more expandable clay minerals, but less total clay, will have a strength equal to one with more clay but fewer expandable clay minerals. However, a clay material with an abundance of expandable clay minerals, particularly the smectite group which is the most expandable, may make a poor adobe clay. In such clays, expansion and contraction of the clay minerals may cause excessive cracks in the adobe brick. More silt- or sand-size material, or even straw, can be added to the mix to minimize this effect.

Calcite ($CaCO_3$) is also found in the majority of the adobe-clay soils tested in New Mexico and is typical of adobe soils throughout the arid Southwest. Calcite in the clay-size fraction also may act as a binder in adobe bricks. If heat at moderate temperatures is applied, a brick of this type of clay may have increased strength. However, if the temperature is elevated to structural-brick temperatures (approximately 1,800° F or 1,000°C), the calcium ion of the calcite acts as a flux, lowering the firing temperature and narrowing the firing range to the point where a brick with relatively low bonding strength becomes a melted blob of glass in a very short range of temperatures. Therefore, such clays make very poor structural brick clays.

Physical properties

Certain minimum requirements or specifications have been developed regarding the durability, strength, thermal characteristics, and fire safety of various building materials used in construction (Long, 1946). In New Mexico the building of adobe structures is regulated by specifications adopted from the Uniform Building Code outlined in Section 2405 of the 1977 revision of the New Mexico State Code (Commerce and Industries Division, 1979). The sections of the code on unburned clay masonry state basic requirements concerning adobe brick, including regulations on soil composition, standards of water absorption, compressive strength, and modulus of rupture, as well as construction specifications. The New Mexico Code requires that an adobe brick have a compressive strength averaging 300 p.s.i. This standard assures that all units from the tested-brick batch will resist a compressive force equal to 300 lbs for each square inch of surface area. The importance of this test for a relatively heavy material such as adobe brick is apparent when considering the great amount of weight a typical wall unit must resist. In addition to the weight of the roof structure supported by a load-bearing wall, each layer of bricks must support all others above it and must depend on the compressive strength of the lower layers to support it.

The other test required on all types of adobe bricks is the rupture test. This test helps indicate the relative cohesion of the materials that make up the adobe and the ability of the material to resist the tension or shear forces that might result from settling of foundations or wind action. In testing for modulus of rupture, the adobe unit is placed on two supports and a force is applied to the center of the unit. Strength of the brick can be calculated from the amount of applied force that is taken to break it. Other tests are used on semistabilized and stabilized adobes to determine the water-resistance quality of the bricks. The water absorption test is important only if the bricks are left unplastered or if necessitated by a building requirement of the architect or federal housing agency. In general, a considerable range of values exists for the physical properties of the adobe bricks tested from 56 locations throughout the state. This variability in data is the result of differences in the composition of adobe soils, methods of producing adobe bricks, and the quality of workmanship. The range of compressive-strength values for the sun-dried adobe brick varied from a low of 196 to a high of 1,071 p.s.i. The modulus of rupture ranged from a low of 20 to a high of 89 p.s.i. Results of the seven-day water-absorption tests on the stabilized adobes ranged from 1.3 to 5.0 percent, and the moisture content of the adobes ranged from 0.4 to 1.5 percent. The New Mexico State Code requires that for a treated (stabilized) adobe brick the moisture content will not exceed 4 percent and the water absorption will not exceed 2.5 percent by weight. The physical test results on several different types and sizes of adobe bricks are shown in table 2.

Techniques of adobe brick production

The adobe brick operation is a labor-intensive, fuel-efficient industry employing easily extracted, indigenous materials. Production of adobe bricks is a seasonal operation and usually is limited by the number of frost-free days for that particular adobe yard. In general the production season varies from 5 to 9 mos, depending on the climate and weather conditions. Bricks are made in various sizes ac- ☞

TABLE 2—PHYSICAL TEST RESULTS ON VARIOUS TYPES AND SIZES OF ADOBE BRICKS (average of samples/test).

Type adobe brick	Size in inches	Compressive strength (p.s.i.)	Modulus of rupture (p.s.i.)	Remarks
Traditional	10 × 4 × 14	383	44.6	Average test results from 34 adobe makers
Traditional	8 × 3½ × 16	426	51	Adobe from Las Palomas, Mexico
Traditional	8 × 4 × 12	615	68	Adobe from Rancho de Taos area
Traditional	8½ × 4½ × 17	451	22	Old adobe (45+ yrs) from Chamisal
Terrone	8 × 6 × 14	303	53	Terrone from Isleta Pueblo
Terrone	7½ × 4 × 15½	261	20	Old terrone (145+ yrs) from Algodones, NM
Quemado	8 × 3½ × 16	644	180	Burnt adobe from Las Palomas, Mexico
Pressed	10 × 3 × 13 7/8	1,071	46	Machine-operated press located in Mora area
Pressed	5½ × 3¾ × 11½	769	69	Made using a cinva-ram press
Pressed	5½ × 3¾ × 11½	580	54	Asphalt emulsion added to adobe made using a cinva ram
Semistabilized	10 × 4 × 14	388	76	Average test results from 6 adobe makers
Stabilized	10 × 4 × 14	426	91	Average test results from 6 adobe makers
Stabilized	7½ × 3½ × 15	645	200	Test results from Hans Sumpf Company, CA
Traditional	10 × 4 × 14	314	51	Old adobe (100+ yrs) from San Juan Pueblo

cording to intended use; the principal standard-size adobe brick used in this state measures 4″ × 10″ × 14″ and weighs approximately 30 lbs. An average of one (1) cu yd of adobe soil is used to produce approximately 80 bricks. Other sizes and types of adobes usually are made upon special order. The three major techniques of adobe production have been classified as follows (University of New Mexico, 1970):

1) *Traditional handcrafted method*—This relatively simple process involves the mixing of soil, water, and sometimes straw in a shallow mud pit by using a hoe or by foot treading. Wooden forms that will produce a single brick or multiple bricks are laid out on smooth and level ground and the mud is placed in them and tamped into the corners. The top is smoothed off and the form removed. The forms are then washed clean and the process is repeated. As the bricks dry (2-3 days in summer) they are turned on edge, trimmed of excess material or rough edges and, sometime later, are stacked for delivery. This system, utilizing two to three adobe makers, can produce 300–500 adobe bricks per day.

2) *Semimechanized method*—This method of production is similar to the traditional handcrafted method except for the addition of mechanical equipment, most frequently a front-end loader. The loader is used to move or excavate the soil, to mix the soil in the mud pit, and to carry the adobe mud to the wooden forms. Depending on the weather, the bricks are allowed to dry in the forms for several hours or until they have shrunk from the form sides. The forms are then removed and the adobes allowed to dry for 2 to 3 days at which time they are turned on edge, trimmed, and later stacked for delivery or storage. The adobe makers may use as many as several hundred of the wooden forms at a time to achieve a production capacity of 1,500–3,000 adobes per day.

3) *Mechanized method*—Two large-scale mechanized techniques for adobe production include the use of the pugmill mixer with the mechanical adobe layer and the use of a ready-mix truck. Examples of the first type of operation are the Western Adobe Plant located in Albuquerque and the Eight Northern Indian Pueblos Native Products Division Plant at San Juan Pueblo. In both of these operations, the sandy loam soil of the area is removed either by grading and leveling of the production site or by delivery from nearby deposits. The soil is screened and conveyed to one end of the trough of the pugmill. Two shafts, studded with paddles, rotate in the trough of the pugmill, and an operator controls the feed of soil, water, and asphalt emulsion. The materials are thoroughly mixed in the trough and dumped into a mud pit where they are removed by a front-end loader which carries the mud mix to a nearby molding machine. This self-propelled mechanized adobe layer or molding machine, mounted on wheels, molds twenty-five 4″ × 10″ × 14″ adobe bricks at one time (fig. 3). Different molds of various sizes and brick shapes can be mounted on the machine. With good weather and no mechanical breakdowns, an average of 5,000 to 7,000 adobes per day can be produced.

The second mechanized method of large-scale adobe production uses a 7.5-cu-yd ready-mix truck. The adobe soil is loaded into the truck cement mixer and the proper amount of asphalt emulsion and water are added. The truck then delivers the mixed mud to a series of wooden forms laid out in the adobe yard. The owners of the Adobe Patch in Alamogordo have constructed a mechanical adobe layer (fig. 4) that attaches to the ready-mix truck and operates off its power equipment. The system molds adobes similarly to the self-propelled adobe layer.

FIGURE 3—SELF-PROPELLED MECHANICAL ADOBE LAYER LOCATED AT THE ADOBE YARD IN SAN JUAN PUEBLO, NEW MEXICO.

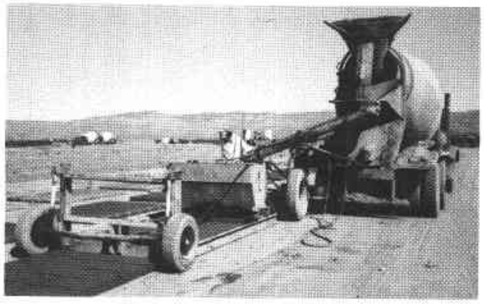

FIGURE 4—USE OF A 7.5-CU-YD READY-MIX TRUCK TO POUR MUD INTO AN ATTACHED MECHANICAL ADOBE LAYER AT THE ADOBE PATCH, LA LUZ, NEW MEXICO.

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TABLE 3—LIST OF ADOBE BRICK PRODUCERS ACTIVE IN 1980 (for locations, see fig. 1).

Map no.	County	Name and location	Telephone	Approximate annual production	Type production equipment
1	Bernalillo	New Mexico Earth P.O. Box 10506 Alameda, NM Richard Levine, Owner	898-1271	700,000	Front-end loaders, pugmill, wooden forms, and delivery trucks
2	Bernalillo	Western Adobe 7800 Tower Road, SW Albuquerque, NM Dean Leach, Owner	836-1839	250,000	Front-end loader, pugmill, Hans Sumpf type mechanical adobe layer, and delivery trucks
3	Bernalillo	Manuel Ruiz P.O. Box 104 Corrales, NM	898-1913	175,000	Front-end loader, wooden forms, and delivery trucks
4	Bernalillo	Frank Gutierrez N.S. Rt. Box 595 Corrales, NM	898-1913	20,000	Front-end loader, wooden forms, and delivery truck
5	Bernalillo	Pete Garcia Rt. 464, Box DOR Corrales, NM	898-2780	45,000	Front-end loader, wooden forms, and delivery truck

6	Bernalillo	Adobe Enterprises, Inc. 6000 Powerway, SW Albuquerque, NM Ernest Sanchez, Owner	877-4315	500,000	Front-end loader, wooden forms, and delivery trucks
7	Bernalillo	Lawrence Tenorio P.O. Box 555 Corrales, NM	898-8792	10,000	Front-end loader, plaster mixer, wooden forms, and delivery truck
8	Catron	Aragon/Garcia Adobes c/o General Delivery Aragon, NM	533-6411, 533-6313	15,000	Front-end loader, wooden forms, and delivery truck
9	Eddy	Adobeworks 1204 Dallas Ave. Artesia, NM Jerry and Gladys Holt, Owners	746-4455	30,000	Front-end loader, ready-mix truck, mechanical adobe layer, and delivery truck
10	Luna	Hachita Adobe 100 E. Peach St. Deming, NM Gordon Garland, Owner	546-6646	45,000	Front-end loader, cement mixer on tractor, wooden forms, and delivery truck
11	Mora	David Griego P.O. Box 66 Le Doux, NM	387-5183	7,000	Porta-press adobe machine
12	Mora	Robert Garcia c/o General Delivery Le Doux, NM	No phone	18,000	Hoe, shovel, wheelbarrow, and wooden forms
13	Otero	The Adobe Patch Rt. 1, Box 240 Alamogordo, NM Robert Godby and Howard Scoggins, Owners	437-9932	350,000	Front-end loader, ready-mix truck, mechanical adobe layer, and delivery truck
14	Rio Arriba	Eight Northern Indian Pueblos P.O. Box 969 San Juan Pueblo, NM Dennis Duran, Mgr.	753-4846	436,000	Front-end loader, pugmill, Hans Sumpf mechanical adobe layer, and delivery trucks
15	Rio Arriba	Robert Ortega c/o General Delivery Dixon, NM	579-4261	30,000	Hoe, shovel, wheelbarrow, and wooden forms
16	Rio Arriba	Medina's Adobe Factory P.O. Box 651 Alcalde, NM Joe and Mel Medina, Owners	852-2467	50,000	Front-end loader, ready-mix truck, mechanical adobe layer, and delivery truck
17	Rio Arriba	Antonio Serrano P.O. Box 64 Cañones, NM	638-5530	1,000	Hoe, shovel, wheelbarrow, and wooden forms
18	Rio Arriba	Felix Valdez c/o General Delivery Cañones, NM	638-5446	5,000	Front-end loader, wooden forms, and delivery truck
19	Rio Arriba	Andy Trujillo c/o General Delivery Abiquiu, NM	No phone	6,000	Hoe, shovel, wheelbarrow, and wooden forms
20	Sandoval	Big "M" Sand & Cinder P.O. Box 33 Bernalillo, NM Tim Montoya, Mgr.	867-5498	9,000	Front-end loader, wooden forms, and delivery trucks
21	Sandoval	D. Sandoval/E. Trujillo P.O. Box 1283 Peña Blanca, NM	455-2972	2,000	Hoe, shovel, wheelbarrow, and wooden forms
22	San Juan	D. T. Wiley P.O. Box 879 Aztec, NM	334-6341	12,000	Front-end loader, wooden forms, and delivery truck
23	San Miguel	Marino Romero 324 Commerce Rd. Las Vegas, NM	425-8202	10,000	Front-end loader and wooden forms
24	San Miguel	Danny Porter P.O. Box 18, Rt. 1 Pecos, NM	757-6422	14,000	Front-end loader and wooden forms
25	San Miguel	Robert Leyba P.O. Box 92 Rowe, NM	757-6234	8,000	Hoe, shovel, wheelbarrow, and wooden forms
26	Santa Fe	Adobe Farms Rt 1, Box 193B Española, NM Ralph Rivera, Owner	753-4628	300,000	Front-end loader, ready-mix truck, wooden forms, and delivery trucks
27	Santa Fe	Oliver Trujillo Rt. 1, Box 187C Santa Fe, NM	455-2414	60,000	Hoe, shovels, wheelbarrow, and wooden forms
28	Santa Fe	Charles Cde Baca Rt. 2, Box 246 La Cienega, NM	471-7949	4,000	Hoe, shovels, wheelbarrows, and wooden forms
29	Santa Fe	Edward Sandoval Rt. 1, Box 834 Santa Fe, NM	455-7447	5,000	Hoe, shovels, wheelbarrows, and wooden forms
30	Santa Fe	Ramon Valdez/James Lujan Rt. 1, Box 104-D Santa Fe, NM	455-2803	12,000	Hoe, shovels, wheelbarrows, and wooden forms
31	Santa Fe	Adrian Madrid 1580 Cerro Gordo Santa Fe, NM	983-8616	20,000	Hoe, shovels, wheelbarrow, and wooden forms
32	Santa Fe	Victor Montano Rt. 6, Box 79A Santa Fe, NM	471-2038	265,000	Front-end loader, wooden forms, and delivery trucks
33	Santa Fe	Eloy Montano Box 517 Santa Fe, NM	983-1532	235,000	Front-end loader, hoe and shovels, wooden forms, and delivery trucks

(continued on p. 24)

Geographic names

U.S. Board on Geographic Names

Bennett Mountain—mountain, highest point 2,187 m (7,175 ft) in the San Andres Mountains, extends north 5.6 km (3.5 mi) from Bear Canyon 37 km (23 mi) northeast of Las Cruces, Doña Ana County, New Mexico; T. 20 S., Rgs. 4 and 5 E.; New Mexico Principal Meridian 32° 34′ 50″ N., 106° 27′ 50″ W. (north end), 32° 32′ 20″ N., 106° 28′ 55″ W. (south end); *not:* Goat Mountain.

Compana, Cerro de la—mountain, elevation 1,741 m (5,712 ft) in Jornada del Muerto 17.7 km (11 mi) east-southeast of San Antonio; Spanish descriptive name meaning "Bell Mountain," Socorro County, New Mexico; sec. 25, T. 5 S., R. 2 E.; New Mexico Principal Meridian 33° 50′ 47″ N., 106° 41′ 41″ W.; *not:* Cerro Colorado, Cerro Colorado Mountain, Red Mountain.

Goat Mountain—mountain, highest elevation 2,073 m (6,800 ft) in the San Andres Mountains west of Bennett Mountain and 37 km (23 mi) northeast of Las Cruces, Doña Ana County, New Mexico; secs. 14, 23, and 26, T. 20 S., R. 4 E.; New Mexico Principal Meridian 32° 33′ 30″ N., 106° 29′ 55″ W.

Laborcita—populated place, in the Rio Grande valley, 3.2 km (2 mi) north of San Antonio; Spanish name meaning "small patch of tilled land" and originally applied to this area because it was a cluster of small farms; Socorro County, New Mexico; secs. 19 and 20, T. 4 S., R. 1 E.; New Mexico Principal Meridian 33° 56′ 45″ N., 106° 52′ 05″ W.; *not:* La Borcita, Lavorcita, River View.

Luis Lopez—populated place, in the Rio Grande valley, 8 km (5 mi) north of San Antonio; named for the eighteenth century owner of the land; Socorro County, New Mexico; sec. 1, T. 4 S., R. 1 W. and sec. 6, T. 4 S., R. 1 E.; New Mexico Principal Meridian 33° 59′ 20″ N., 106° 53′ 05″ W.; *not:* La Borcita, Luis Lopez Ranch.

Malone Draw—watercourse, 11.3 km (7 mi) long, in the Tularosa Valley, heads at the junction of an unnamed draw and La Luz Creek at 32° 57′ 53″ N., 106° 02′ 13″ W., trends southwest to join Ritas Draw at the head of Lost River 14.5 km (9 mi) west of Alamogordo; named for an early settler; Otero County, New Mexico; sec. 27, T. 16 S., R. 9 E.; New Mexico Principal Meridian 34° 54′ 02″ N., 106° 06′ 48″ W., *not:* Lost River.

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uplift (Chapin, 1979), exhumed the Socorro and Lemitar blocks and elevated them sufficiently to topographically disrupt the Popotosa Basin. During this period, a major south-flowing river (the ancestral Rio Grande) entered and began to fill the developing Socorro Basin. Gently tilted (0–10 degrees) early Pliocene to middle Pleistocene strata of the Sierra Ladrones Formation form westward-thickening wedges in the Socorro and La Jencia Basins to the east and west of Socorro Peak (fig. 1). Just east of the high-angle (65–75 degrees) range-bounding fault zone at the foot of Socorro Peak, the Sierra Ladrones Formation is at least 350 m thick and may be significantly thicker. About 4 m.y. ago, olivine basalt lavas that were erupted from vents near Sedillo Hill (basalt of Sedillo Hill) flowed eastward down a broad valley cut on the upper Popotosa playa facies and onto channel sands of the ancestral Rio Grande (Sierra Ladrones fluvial facies). Since 4 m.y. ago, the modern ranges have continued to rise and shed piedmont gravels that intertongue with the fluvial sands.

In late Quaternary time continued uplift, faulting, and entrenchment of tributaries to the Rio Grande have all enhanced the modern topography. Upper Popotosa playa claystones on the flanks of the Socorro Mountains are largely masked by landslide blocks derived from the *Socorro Peak Rhyolite*. Patterns of elevation variation in late Miocene and Pliocene lavas, when coupled with modern drainage patterns, suggest the possibility of late Quaternary magmatic doming along an axis trending west-southwest from Socorro Peak.

Conclusion

The primary control of recurrent magma intrusion, hydrothermal activity, and silicic volcanism at Socorro Peak has been the "leaky" Morenci lineament, expressed as a transverse shear zone of the Rio Grande rift. Eruptive periods in the Socorro Peak volcanic center have been dated at 33–29, 12–9, 7, and 4 m.y. In light of this past history, it is not surprising that geophysically defined magma bodies, which provide a heat source for the present geothermal anomaly, are again rising under the Socorro Peak volcanic center.

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Chaco Energy donates $6,500 to Bureau of Mines

Chaco Energy Co. has given $6,500 to the New Mexico Bureau of Mines and Mineral Resources, a division of New Mexico Institute of Mining and Technology, as second-year funding to study fossil plant remains near Hospah in northwest New Mexico.

The nature of the plants is significant in the formation of the coal deposits leased by Chaco Energy Co. These plant remains include ancient tree stumps, leaves, and roots fossilized in place in the Cretaceous swamps, as well as driftwood bar and beach deposits. Standing fossil tree trunks in growth position are known from scattered areas of the San Juan Basin.

A. T. Cross, professor of geology at Michigan State University, and co-worker A. Jameossanaie are interpreting the plant collections. John Taylor of the Chaco Energy staff has mapped the geology of the fossil localities and provided cores of fossil-bearing rocks from Chaco's drilling program. Studies of nearby vertebrate fossils in coal-bearing Cretaceous rock beds are being conducted by D. L. Wolberg and studies of marine fossils by S. C. Hook, both paleontologists with the New Mexico Bureau of Mines and Mineral Resources.

Adobe production *(continued from p. 21)*

Map no.	County	Name and location	Telephone	Approximate annual production	Type production equipment
34	Santa Fe	Al Montano Rt. 2, Box 224 Santa Fe, NM	471-4227	2,000	Hoe, shovels, front-end loader, and wooden forms
35	Santa Fe	Albert E. Baca Rt. 1, Box 99 Santa Fe, NM	455-7542	3,000	Hoe, shovels, and wooden forms
36	Santa Fe	Rodriguez Brothers Rt. 6, Box 22 Santa Fe, NM	471-7570	100,000	Hoe, shovels, front-end loader, wooden forms, and delivery trucks
37	Santa Fe	Tod Brown c/o General Delivery Cerrillos, NM	No phone	3,000	Hoe, shovel, and wooden forms
38	Santa Fe	Montoya Adobes 420 Arroyo Tenorio Santa Fe, NM	988-3504	10,000	Hoe, shovel, and wooden forms
39	Taos	Emilio Abeyta P.O. Box 177 Rancho de Taos, NM	758-3022	12,000	Hoe, shovels, wheelbarrow, and wooden forms
40	Taos	Taos Pueblo Native Products P.O. Box 1846 Taos, NM Marrion Threehawks, Mgr.	758-8761	47,000	Backhoe, hoe, shovels, wheelbarrow, and wooden forms
41	Taos	Joe Trujillo P.O. Box 633 Rancho de Taos, NM	758-9768	60,000	Front-end loader, ready-mix mounted on ground, wooden forms, and delivery truck
42	Taos	Ralph Mondragon P.O. Box 199 Rancho de Taos, NM	758-3644	15,000	Pugmill, mud vehicle, and wooden forms
43	Taos	Joe Pacheco P.O. Box 174 Taos, NM	758-9848	2,000	Hoe, shovel, wheelbarrow, and wooden forms
44	Torrance	Humberto Camacho P.O. Box 631 Mountainair, NM	No phone	5,000	Hoe, shovels, wheelbarrow, and wooden forms
45	Valencia	Rio Abajo Adobes 105 W. Aragon Belen, NM Jerry Sanchez, Mgr.	864-6191	150,000	Front-end loader, wooden forms, and delivery truck
46	Valencia	Otero Brothers Rt. 2, Box 774 Los Lunas, NM	864-4054	40,000	Front-end loader, wooden forms, and delivery trucks
47	State of Chihuahua, Mexico	Alfonso Carrillo Las Palomas, Mexico	No phone	30,000	Hoe, shovels, and wooden forms
48	State of Chihuahua, Mexico	Leonardo Duran Las Palomas, Mexico	No phone	5,000	Hoe, shovel, and wooden forms