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BUILDING WITH STONE IN NORTHERN NEW MEXICO

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Abstract—The stone industry in New Mexico began in the distant past. The Anasazi and cliff-dweller cultures, both of whom used stone extensively, evolved into the present pueblo culture. Spanish, Mexican, Territorial and present-day cultures all have used local stone for various building purposes, including foundations, footings, walls, wall veneers, flagging, landscaping and decoration. The two main divisions of the stone industry are *crushed stone* and *dimension stone*. Rock units in the northern part of New Mexico contain quality stone for both. Stone resources are large and include many major and minor rock types. Active quarries were more numerous in the past, particularly in the latter part of the 19th century.

The New Mexico State Highway Department has hundreds of quarries in northern New Mexico, primarily for limestone. Small stone producers operate additional dimension-stone quarries, principally for sandstone. Major producing quarries are in the Ribera, San Miguel, Las Vegas, Anton Chico, Tecolote, Abiquiu, Albuquerque and Santa Fe areas. Many local people quarry stone or collect "moss rock" from the surface. Stone is sold most commonly from pickup or flatbed trucks in metropolitan centers. As the price of other building materials continues to increase, energy-efficient stone should become more popular and competitive as a building material.

INTRODUCTION

Stone is the most basic and widely accessible building material available to man. It has been used throughout New Mexico for thousands of years and is the major component of many famous structures constructed by early Indian, Spanish, Territorial and modern cultures. Most northern New Mexico communities have nearby stone resources (Fig. 1). Building stone deposits have previously received limited study and evaluation. A continuous need exists to accumulate data on the occurrence, composition, physical characteristics, quarrying and marketing of the state's commercial stone. This study outlines the history of stone use in northern New Mexico, identifies various building-stone sources, examines current uses and scans the potential for increased stone production and consumption.

BRIEF HISTORY

New Mexico has sheltered and nurtured human beings for thousands of years. Early men were nomadic and did not construct permanent stone shelters. They used various natural caves usually formed in limestone and sandstone. Later, primitive pithouses were built in round or oblong excavations which were often lined with rock slabs for protection from frost.

Construction of multiunit dwellings above ground began about A.D. 700 as the Anasazi, or Pueblo, culture emerged. This culture has been divided into periods I–V (A.D. 700–1598) with the Pueblo III, the Great or Classic period (A.D. 1050–1300), the apogee of Anasazi culture (Bunting et al., 1964; Bunting, 1976). During this period the unique five-story pueblos of Chaco Canyon (Fig. 2) were constructed of local sandstone. Major Indian pueblo structures still in use today are constructed of local sandstone, limestone, river rock, tuff and adobe. They exist at several of the 19 active pueblos in New Mexico. Structures at the Santa Clara Pueblo, including the abandoned Puye Cliff Dwellings, and those at Bandelier National Monument, are good examples of the extensive use of local volcanic tuff in buildings. The tuff was shaped by stone (early) or metal hammers to adobe-brick size before use.

Spanish colonization began in 1598, but it is hard to distinguish between early Spanish and Indian building techniques. The Spanish soon introduced a wooden form permitting molding of a sized adobe brick. This adaptation allowed greater flexibility with stone footings and in construction of stone and adobe buildings (Fig. 3). The classic linear floorplan of the Spanish and Mexican Colonial Period (A.D. 1598–1848) began to appear, in some cases surrounding a central plaza for defense (Bunting et al., 1964; Bunting, 1976).

Notable architecture of the Spanish and Mexican Colonial Period includes "Fortress Churches." These solid, rectangular, adobe and stone churches, imposing in size and lacking fenestration, resembled fortresses (Fig. 4). Most churches were built of adobe, but several early churches (Abo, Quarai, Zuni and others) were built of stone from nearby sandstone and limestone outcrops.

Annexation of New Mexico Territory in 1848 greatly increased the influx of eastern building materials and experienced tradesmen producing the Territorial Period (1848–1880). During 1846–85, a series of military outposts built of stone and adobe were established at Forts Union, Burgwin, Wingate and others (Fig. 5).

The arrival of the AT&SF Railroad in 1880 brought additional modern materials and new attitudes towards architecture and led to Victorian construction gaining favor over adobe in the later American Period (1880–present). Near the end of the 19th century, several Italian master stonecutters and masons arrived in New Mexico. They used locally quarried sandstone and limestone to create imposing buildings including the Santa Fe Cathedral, Adele Ilfeld Auditorium in Las Vegas and Hodgin Hall at the University of New Mexico in Albuquerque. Also during this period, numerous other stone houses, barns and public structures were built throughout New Mexico mainly using randomly fit rubble masonry or precision-cut and finished masonry or "ashlar" (Fig. 6).

Buildings were constructed mainly of wood and mortar in the early 20th century. Around World War II, concrete-block construction predominated while retaining the outward appearance of the Spanish Territorial and Indian Pueblo styles. Since the early 1970's, energy efficiency has been of great importance. Stone construction requires little energy for manufacture of the materials. The only large amount of energy used is in transporting the materials to the building site. The public has become increasingly uncomfortable with logging, and the cost of wood construction has increased dramatically. The lower cost of heating and cooling properly constructed stone and adobe buildings has increased the percentage of homes constructed of natural materials.

BUILDING STONE TYPES

The stone industry is generally divided into two main branches, *crushed stone* and *dimension stone*. Crushed stone is used in concrete, road metal, asphalt, railroad ballast, riprap, filter beds, roofing granules, terrazzo and as decorative material in gardens, patios and landscaping. Large quantities of crushed and broken stone are used in the production of lime and cement, sugar refining and in metallurgical processes, but these will not be discussed.

Dimension stone consists of blocks, slabs or sheets of stone cut and finished to specific dimensions for structural, ornamental or monumental uses. Dimension stone is produced by cutting, fabricating or selecting stone for specific shape or size. It has become popular in rubble walls,

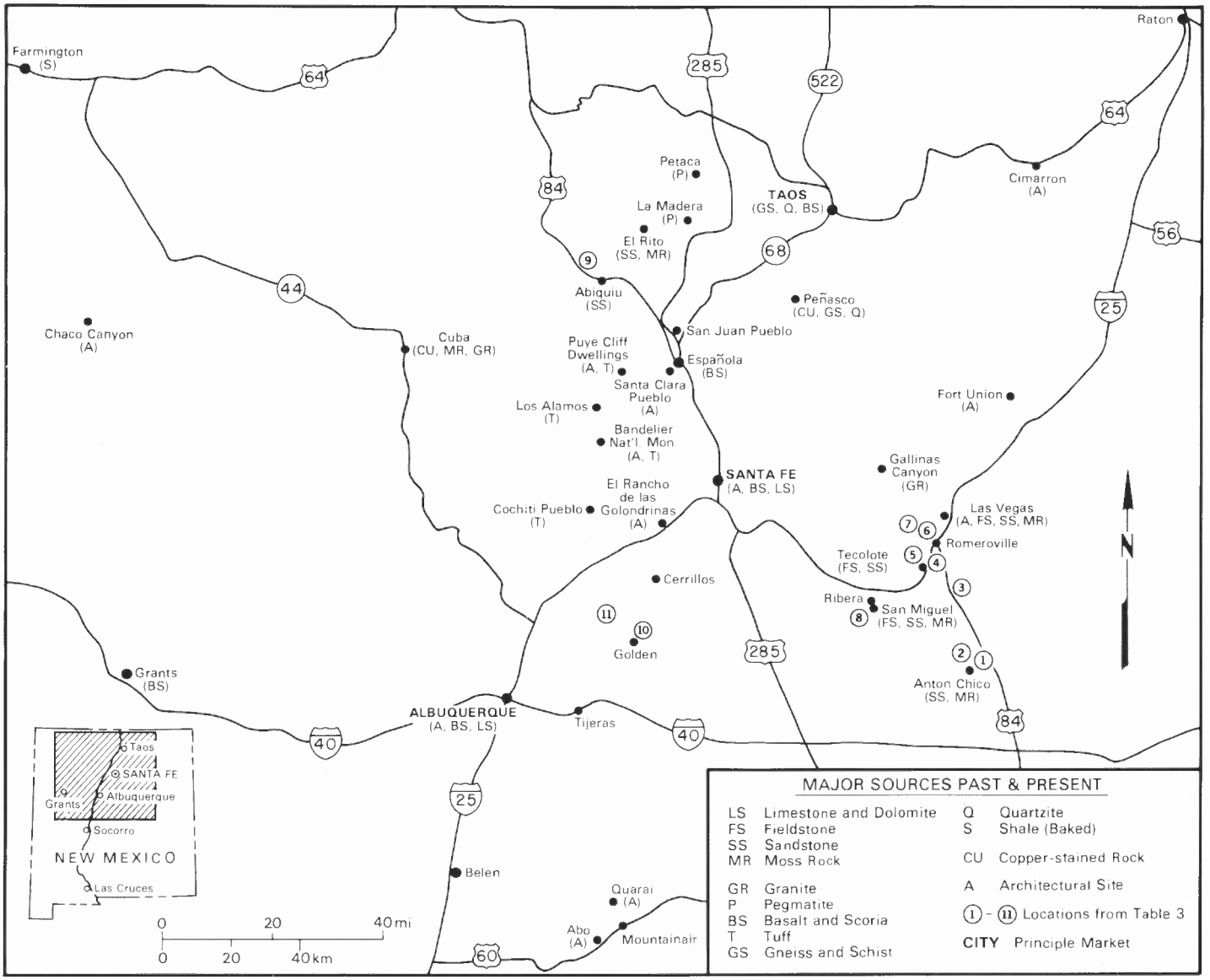


FIGURE 1. Map showing major sources of stone, past and present, in relation to principal northern New Mexico markets.

fireplaces, patio floors and as flagstones, especially where decorative accents and special architectural effects are desired.

Crushed stone

Crushed stone is produced from a variety of igneous, sedimentary and metamorphic rocks in New Mexico. The largest volume is produced from limestone, sandstone, scoria, basalt and siltstone. Desirable stone qualities include strength, durability and ease of quarrying, crushing and processing. The rock to be crushed should be firm and roughly equidimensional, producing minimal dust and powder. Bonding quality is important in crushed stone for aggregate. Limestone ordinarily makes an ideal concrete aggregate, and basalt and limestone generally adhere to bitumen better than granite or sandstone, although any of these rocks may serve. Rock for railroad ballast should be hard, durable and composed of sharp-edged particles. Stone for decorative purposes is selected chiefly for attractive appearance, but strength and durability are also important (Ault, 1989).

In 1987, crushed stone valued at $4.4 billion was produced by 1700 companies nationwide operating 3560 quarries in 49 states (Tepordei, 1988). About 63% was used as construction aggregate, mostly for highways and roads; 11% was used for cement and lime; 3% in agriculture; 1% for metallurgy; 2% for a variety of industrial uses; and 20% for miscellaneous and unspecified uses. Of the crushed stone produced in the U.S. in 1987, about 72% was limestone and dolomite; 15% granite; 8% traprock (dark-colored volcanic rock, commonly basalt); and 2% sandstone. The remaining 3% was shell, marl, volcanic cinder, slate and others.

Dimension stone

The U.S. Bureau of Mines includes all forms of building stone, whether for structural support, curtain walls, veneer, floor tile or strictly ornamental use, under the general classification of dimension stone. In the past, dimension stone was used extensively as building blocks to support the full weight of a structure. Large modern structures are mainly a steel or reinforced concrete core, often covered with a decorative stone veneer. Dimension stone is used in ashlar walls, and for decorative and ornamental stone, including interior and exterior wall panels, windows, window sills, mantels and tops for furniture and lavatories. A continuing demand exists for dimension stone monuments in cemeteries.

Dimension stone can be developed from a variety of rock types including sandstone, siltstone, limestone, marble, travertine, tuff, quartzite, granite, basalt and related igneous rocks. Rock type is not as important as color, durability, texture, ease of splitting and freedom



FIGURE 2. Anasazi stone construction at Chaco Canyon. Windows on the top tier are roughly 1 by 0.5 m.



FIGURE 3. Typical stone and adobe house built in the Spanish Colonial style on local river rock at El Rancho de las Golondrinas.



FIGURE 4. Ruins of Quarai "fortress church" near Mountainair in central New Mexico; built with local Permian sandstone and limestone.



FIGURE 5. Hospital at Old Fort Union, near Las Vegas, showing use of dimension sandstone in footings.

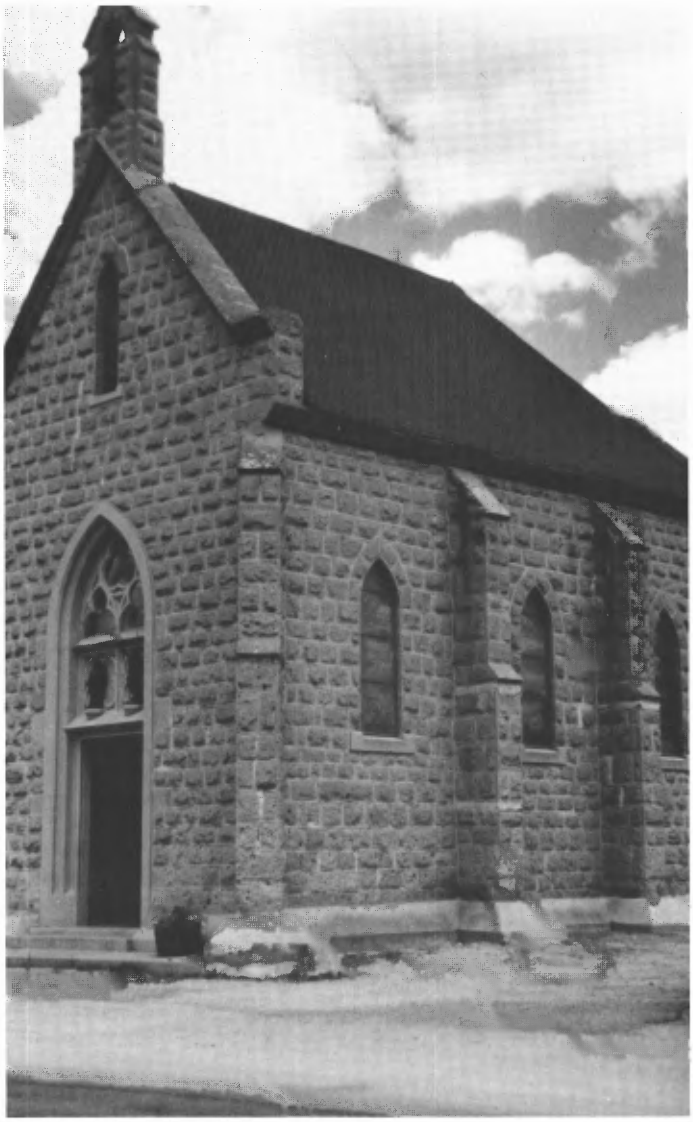


FIGURE 6. Example of precision-cut ashlar used in a 19th-century church at San Juan Pueblo.

from flaws. The stone deposits should support a large quarry and overburden should be thin. The visibility of the quarry, the equipment used, the processing method and reclamation plan are all environmentally significant.

The ease of entry into stone production allows many small producers to supply local markets. In 1987, about 200 companies in 36 states produced dimension stone at nearly 300 quarries (Taylor, 1988). About 47% was used as cut stone for construction of buildings, 26% in monuments, 14% as rubble, 8% in curbing, 4% in flagging and the remaining 1% in unspecified uses. Of the domestic total, 55% was granite, 25% limestone, 11% sandstone, 4% slate, 3% marble and 2% other.

Fieldstone

"Fieldstone," which includes garden or landscaping rock, is not technically classified as dimension stone. In New Mexico, it is used for many similar uses including walls, wall facings, foundations and, in some cases, complete buildings. Fieldstone is picked or pried off the ground without extensive quarrying. Fieldstone includes moss-covered sandstone, cobbles and boulders of basalt, limestone, gneiss, schist and granite. The most productive fieldstone operations in northern New Mexico are near Las Vegas, Ribera, San Miguel and Tecolote where extensive deposits of Triassic and Permian flagstone and moss-covered sandstone occur. The majority of stoneyards and landscapers in northern New Mexico have stockpiles of fieldstone, garden or landscaping rock which have been obtained locally. Fieldstone production in New Mexico is difficult to estimate, but is large in value and tonnage.

COMMERCIAL VARIETIES OF BUILDING STONE

Many varieties of building stone have been or now are quarried in northern New Mexico (Table 1). Only sandstone, limestone and basalt now are commonly produced. The Appendix lists the active and inactive construction material pits and quarries of the State Highway Department throughout northern New Mexico. About 90% of the pits and quarries are in limestone, granite and sandstone. Limestone has been quarried from 75 sites and is the major source of road aggregate.

In general, the production of dimension stone in the state is related to the condition of the construction industry. Construction in Santa Fe and Albuquerque drives demand for sandstone used for flagstone, landscaping and decorative purposes. Over 2600 tons of flagstone, moss rock and rubble were sold in 1989.

The names of *commercial* stone do not always convey the same meaning as do the *geological* names of rocks. Some explanation may be necessary and is given below.

Igneous rocks

Granite

Commercial granite includes all feldspathic intrusive rocks of visibly granular or gneissic texture. It includes the granite family plus syenite, monzonite, gabbro, anorthosite, other intrusive igneous rocks and their metamorphic equivalents. Commercial fine-grained igneous rocks, even with diabase or basalt composition, may be called "black granite" (Power, 1983). Commercial granite has high strength, is impervious to water and takes an excellent polish, making it a very useful and popular building stone.

No "granite" is quarried commercially in New Mexico as a dimension stone. New Mexico Granite Corporation of Las Vegas produced several grades of granitic rocks, principally for monuments, into the 1970's (Fig. 7). The granite was sold throughout New Mexico, Texas and the Southwest. This stone came from the western edge of the Sangre de Cristo batholith in Gallinas Canyon about 42 km west of Las Vegas. Granitic rocks there are not highly weathered or fractured, and occur as massive exposures with thin overburden and as residual boulders. The stone was quarried by hand or air drilling and wedging along a major zone of weakness ("rift") and by drilling and blasting in other directions. Mainly red and gray granite were produced, although a less popular black "granite" (probably diorite) was quarried nearby.

Precambrian granite is exposed immediately north of the Nacimiento Copper Mine about 3 km south of Cuba in Sandoval County (Fig. 8). It has been quarried for road metal and shows potential for both crushed



FIGURE 7. Granitic dimension-stone rubble from abandoned New Mexico Granite Corporation millsite near Las Vegas, New Mexico.

TABLE 1. Selected active or recently inactive commercial northern New Mexico stone pits and quarries. See Table 2 for data on major active sandstone and fieldstone quarries.

Granite	
Gallina Canyon	- Precambrian granite - Las Vegas area Quarry inactive - San Miguel County
Agua Zarco	- Precambrian granite - Cuba area Quarry inactive - Sandoval County
Pegmatites	
Petaca	- Precambrian pegmatites - Rio Arriba County - Inactive
La Madera	- Precambrian pegmatites - Rio Arriba County - Inactive
Nambe/Aspen Ranch	- Precambrian pegmatites - Santa Fe County - Inactive
Cordova	- Precambrian pegmatites - Santa Fe County - Inactive
Priest Mine	- Precambrian pegmatites - San Miguel County - Inactive
Ojo Caliente	- Precambrian pegmatites - Rio Arriba County - Inactive
Mica Schists	
Picuris	- Precambrian schists - Taos County
Pilar/Embudo	- Precambrian schists - Taos County
Comalas Canyon	- Precambrian schists - Taos County
Volcanic Tuff (Bandelier Tuff)	
Chupaderos Canyon	- Quaternary tuff - Rio Arriba County - Los Alamos area
El Rito Canyon	- Quaternary tuff - Rio Arriba County - Youngsville area
Bandelier National Monument	- Quaternary tuff - Los Alamos County - Inactive
Basalt (Trap Rock)	
Caja del Rio	- Tertiary basalt - Santa Fe County
Black Mesa	- Tertiary basalt - Rio Arriba County
Taos Plateau	- Tertiary basalt - Taos County
Wagon Mound	- Tertiary basalt - Mora County
West Mesa	- Tertiary basalt - Bernalillo County
Grants Area	- Tertiary basalt - Cibola County
Sandstone (Flagstone)	
Anton Chico	- Triassic and Permian sandstone - Guadalupe County
Tecolotito	- Triassic and Permian sandstone - San Miguel County
Los Montoyas	- Triassic sandstone - San Miguel County
Romeroville	- Triassic sandstone - San Miguel County
Tecolote	- Pennsylvanian/Permian and Triassic sandstone - San Miguel County
Kearny Gap	- Triassic sandstone - San Miguel County
San Miguel	- Permian sandstone - San Miguel County
Ojitos Frios	- Triassic sandstone - San Miguel County
Camp Luna	- Triassic sandstone - San Miguel County Inactive
Ribera	- Pennsylvanian/Permian sandstone San Miguel County
San Cristobal	- Triassic sandstone - Santa Fe County Inactive
Abiquiu/El Rito	- Triassic and Permian sandstones - Rio Arriba County
Gallegos Ranch	- Triassic and Permian sandstone - Santa Fe County
Lone Mountain Ranch	- Triassic sandstone - Santa Fe County
Clayton	- Cretaceous Dakota Sandstone - Union County - Inactive
Raton	- Tertiary sandstone - Colfax County - Inactive
Sandstone (Fieldstone, Rubble, Dimension)	
Glorieta Mesa	- Permian and Triassic sandstone - San Miguel County - Moss rock
Tecolote	- Permian moss rock - San Miguel County
Ribera	- Permian moss rock - San Miguel County
Lamy	- Permian Glorieta Sandstone - Santa Fe County - Inactive
Las Vegas	- Permian and Triassic sandstone - San Miguel County
Limestone	
Santa Fe	- Pennsylvanian Madera limestone - Santa Fe County - Inactive
San Cristobal Ranch	- Permian San Andres limestone - Santa Fe County
Tres Ritos	- Pennsylvanian Madera limestone - Taos County - Inactive
Miscellaneous	
Santa Clara Pueblo Canyon	- Tertiary latites - Rio Arriba County
Old Timer Mine	- Pennsylvanian Madera marble - Santa Fe County
Mina del Tiro	- Tertiary monzonite - Santa Fe County



FIGURE 8. Alan Jager (left) and Harvey Chavarria in granite quarry (inactive) north of the Nacimiento (Agua Zarca) Copper Mine near Cuba, New Mexico.

and dimension stone. The stone is red granite with coarse crystals of feldspar, blue quartz and partly altered ferromagnesian minerals.

Today, several granite and gneiss quarries are operated "as needed" by the State Highway Department (Appendix). The rock is usually crushed for concrete aggregate, roadbase, riprap and road metal.

Pegmatites

Most pegmaties have granite composition with abundant quartz and orthoclase feldspar. Other minerals, notably muscovite or white mica, may be abundant. In the past, muscovite was mined from pegmatites in New Mexico. Many small mines are present, particularly in north-central New Mexico. Old roads to abandoned mines, especially in the La Madera and Petaca areas, make them accessible to enterprising stone dealers. Coarsely crystalline texture and rough exterior make pegmatite attractive for landscaping. Many stone companies stock pegmatite as large boulders that are moved to the building site by flatbed truck.

Basalt and scoria

In northern New Mexico, Tertiary and Quaternary basaltic rocks are exposed for hundreds of square miles near Grants, Albuquerque, Santa Fe, Española and Taos where large quantities of basaltic stone have been produced. Great volumes of basalt and scoria are in volcanic terrains east and west of the Sangre de Cristo Mountains. Major outcrops are at Caja del Rio, Black Mesa, West Mesa and the Taos Plateau. The majority of basalt is on federal land, so permits for removal must be obtained.

Basalt is fine-grained, hard, tough, dense and durable. It is well suited for use as aggregate, dimension stone (Fig. 9), railroad ballast

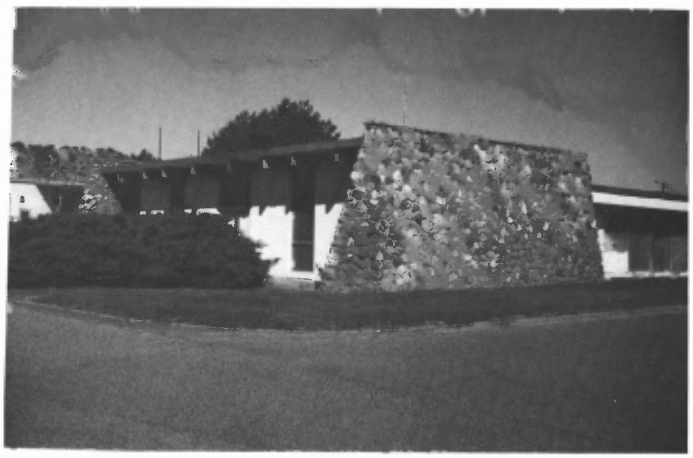


FIGURE 9. Wall of local basalt cobbles on the headquarters of Jemez Mountain Electrical Cooperative at Española.

and riprap. At present basalt is mainly obtained from the many State Highway Department pits where the rock is quarried and sized for road aggregate. The proximity of basalt to major cities allows use of rough and rounded basalt in walls and wall facings, and in landscaping. Prices for the basalt vary from $50 to $100 per ton.

Scoria is a lighter weight, less dense, vesicular equivalent of basalt. It is used mainly in cinder blocks and for landscaping. Other uses are as dimension stone, lava rock in barbecues and anti-skid material on icy highways.

Rhyolite

Rhyolite is not commonly used as dimension stone, but is used as crushed stone, particularly in highway sub-grades. It does not make good concrete or asphalt aggregate because of possible reactions with water in the mix. New Mexico has some rhyolite quarries (Appendix), but there is less use for it than other rock types.

Tuff

Tuff is a rock formed of lithified volcanic (pyroclastic) fragments. Particles are generally ash-size (<2 mm), but particles as large as several tens of centimeters are found in some near-vent deposits. Highly explosive eruptions produced clouds of gas and light-colored ash, deposited up to hundreds of miles away from their vents, that hardened into white to yellow-gray tuff beds. Most tuffs are rhyolite or dacite in composition. Tuff is usually moderately hard when quarried and will increase in hardness upon exposure to air (Purtymun and Koopman, 1965).

Tuff near Los Alamos is an attractive buff or pink to gray. If large pieces of latite and rhyolite are absent, it is easily worked into specified shapes with power saws or handtools (Fig. 10). Extensive outcrops are in the Santa Fe National Forest in Chupadero and El Rito Canyons and in the Cochiti area, and throughout the north, east and south flanks of the Jemez Mountains.

Some commercial tuff is marketed as "cantera stone," "adoquin" or many other trade names (Kuiper, 1988). It is imported from Italy or Mexico, respectively, as tile and building blocks. It is used for floor tile, particularly in Florida, California and Arizona. Domestic production has begun in Arizona, and suitable deposits have been found in the Jemez Mountains of northern New Mexico.

Latite

Latite is an extrusive fine-grained igneous rock in which potash feldspar and plagioclase are present, but no quartz. Augite or hornblende is typically present, in some cases accompanied by biotite plus accessory apatite and opaque oxides (Gary et al., 1968). Extensive outcrops of gray to dark latite are on the east and north sides of the Jemez Mountains. Latite is widely used by Santa Clara Pueblo because it crops out in nearby canyons to the west. The rock in Santa Clara Canyon has been used to construct picnic ramadas, chimneys, walls and the local ranger station (Fig. 11).

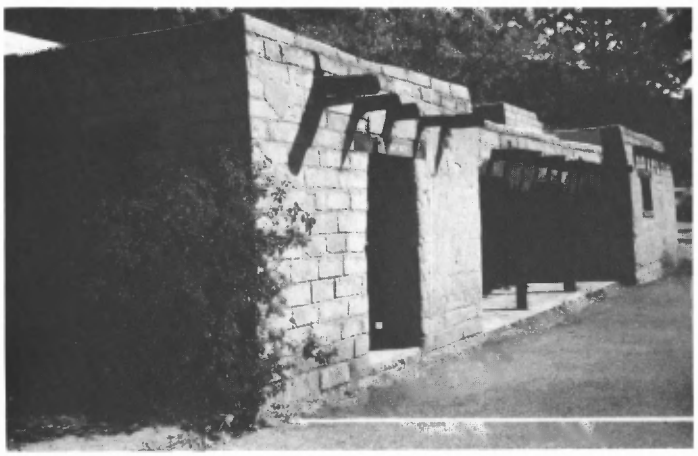


FIGURE 10. Shaped Tertiary-age Bandelier Tuff in Bandelier National Monument buildings built in the 1930's by the CCC.

Sedimentary rock

Sandstone and siltstone

Good dimension and flagging sandstone has been produced in northern New Mexico for hundreds of years. It is the rock type with the largest volume and number of active quarries in New Mexico (Table 2). Commercial sandstone consists of both sandstone and siltstone. The dominant grain size ranges in diameter from $^1/_{16}$ to 2 mm in sandstone and from $^1/_{256}$ to $^1/_{16}$ mm in siltstone. Color variations in commercial sandstones are due largely to iron oxide. Color gradations in the quarries of northern New Mexico range from white to buff, although purple to red are dominant. Color variations are common vertically and laterally. Most sandstone beds in quarries are nearly flat-lying. Folding and faulting locally have tilted beds to dips of 45° or more.

The strength and durability of sandstone are determined by interstitial

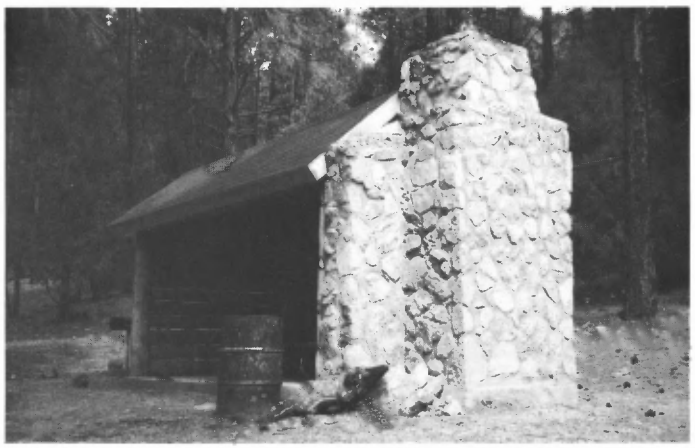


FIGURE 11. Tertiary latite rocks used in picnic ramada at Santa Clara Canyon.

TABLE 2. Major active sandstone quarry and fieldstone production locations in northern New Mexico.

Map Locality	Name and Location of Deposit	Type of Deposit	Main Products	Remarks
1	Anton Chico Anton Chico Grant San Miguel County	Permian Glorieta and Bernal Sandstone, Triassic Santa Rosa Sandstone; white and brown sandstone	flagstone, rubble, and fieldstone	extensive deposits of sandstone
2	Tecolotito Anton Chico Grant San Miguel County	Permian Glorieta and Bernal Sandstone, Triassic Santa Rosa sandstone; white and brown sandstone	flagstone, rubble, and moss rock	extensive deposits of sandstone over a wide area
3	Las Montoyas Tecolote Grant San Miguel County	Triassic Chinle Formation; red and brown sandstone	dimension and rough construction stone	deposits on the west side of NM Highway 84
4	Romeroville Tecolote Grant San Miguel County	Triassic Chinle Formation; red and brown sandstone	dimension, rubble, and rough construction stone	several quarries north and south of Romeroville
5	Tecolote Tecolote Grant San Miguel County	Permian Abo, Bernal, and Glorieta sandstone; red and brown sandstone	dimension, rubble, rough construction stone, and fieldstone	large deposits of moss rock and rough construction sandstone
6	Ojitos Frios Ranch, Smith and Trujillo quarries San Miguel County	Triassic Chinle Formation; red sandstone	dimension, rubble, and rough construction stone	sandstone quarries along crests and in valleys
7	Kearny Gap, Taylor Ranch, City of Las Vegas (owner), San Miguel County	Triassic Chinle Formation and Permian Glorieta Formation; red and brown sandstone	dimension, rubble, rough construction stone, and fieldstone	several quarries operated many years; Taylor Ranch owned by City of Las Vegas
8	Ribera/San Miguel Rivera Brothers, Al Lopez, Henry Ortiz Romero Bros. quarries San Miguel County	Permian Sangre de Cristo (Abo) and Glorieta formations; red and brown sandstone	flagstone, rubble, dimension and rough construction stone, and fieldstone	major sandstone quarries; contact owners for access
9	Abiquiu Carson Natl. Forest Rio Arriba County	Triassic Chinle and Permian Abo Formations; red and brown sandstone	flagstone, rubble, dimension and rough construction stone, and fieldstone	U.S. Forest Service quarries; permit to remove obtained from El Rito Ranger Station
10	Lone Mountain Ranch Golden, NM Santa Fe County	Triassic Chinle Formation; red and brown sandstone	flagstone, rubble, and fieldstone	private permit to remowe building stone obtained from Ranch Manager
11	Gallegos Brothers Ranch Sandoval County	Triassic Chinle and Permian formations; red and brown sandstone	flagstone, rubble, rough construction stone, and fieldstone	private ranch with many quarries; contact owners for access

cement, which includes silica, iron oxide, calcite and clay. Feldspathic sandstone contains 10 to 25% feldspar; arkose contains more than 25% feldspar. Both feldspathic sandstone and arkose make good quality building stone. Micaceous sandstone is commonly weak owing to aligned mica flakes. Ferruginous sandstone contains abundant iron-oxide grain coatings. If clay particles are abundant, the sandstone is argillaceous and may be less durable (Keith, 1969).

Few test data are available on New Mexico sandstones. Hodgman (1958) lists general physical properties for commercial sandstones: bearing capacity of 69,000 lbs/ft^2; thermal conductivity 8–16 Btu/hr/ft^2; density 134–146 lbs/ft^3; and porosity approximately 5–19%.

Stratification in sandstones produces zones of weakness called "rift" by sandstone producers. These are important commercially because they determine the direction in which the stone splits most easily. Spacing of the rift determines the thickness of the quarried layer. Bed seams, joints, cutters, reeds and runs are additional terms used in the sandstone industry to describe other natural planes or directions in which the stone most easily splits or can be cut (Bowles and Barton, 1963).

The largest and most extensive use of dimension sandstone occurred during the Territorial Period. During this time, stone was used in many churches, government, commercial and residential buildings. Large pieces of sandstone were cut, split or sawn into shaped blocks called "ashlar" for wall facings, chimneys, fireplaces and general decorative landscaping.

The major use of sandstone today is for flagstone which is most popular for floor and patio tiles, stepping stones and walkways. Some flagstone is broken by hydraulically operated guillotines to desired sizes and shapes, usually for facing. Quarrying of flagstone produces large amounts of waste rock. Large tonnages of this rubble are shipped to Albuquerque, Santa Fe, Taos and Las Vegas where it is widely used on hillsides and at level building sites for walls and landscaping.

Santa Fe, San Miguel and southern Rio Arriba Counties are New Mexico's principal producing areas. In 1989 they produced 2641 tons of all types of sandstone with a retail value of $245,225. The estimated retail price per ton of sandstone ranges from $80 to $125. The dominance of low-cost rubble and other rough construction stone lowers the average price.

"Moss rock," a popular sandstone, is found throughout the flagstone areas where it occurs as loose fieldstone on surface outcrops (Fig. 12). Moss rock is also collected near Cuba. It usually is partially covered with plant growth that gives the rock an aged patina. The algae, mosses, lichen and fungi that give moss rock its unusual appearance are supported by moisture in the stone. Moss rock is used for landscaping, retaining walls and fireplaces.

Most sandstone used by the building industry (Table 2) is quarried near Las Vegas, Ribera, San Miguel, Anton Chico and El Rito (Fig. 13). The flagstone and dimension stone here are Permian and Triassic. They easily split into smooth flagging of 3- to 5-cm-thick slabs and blocks of various sizes in colors varying from white to brown to red. The Anton Chico quarries are noted for their white-to-buff sandstone. The Abiqui–El Rito quarries produce flagging that is primarily buff to brown. Flagstones of various reds are widely produced in the Ribera, San Miguel, Las Vegas and Tecolote areas.



FIGURE 12. Typical means of selling moss rock in Santa Fe.



FIGURE 13. Permian flagstone quarry of Al Lopez near San Miguel in San Miguel County; source of most flagstone produced in New Mexico.

Flagstone rubble and moss rock from local quarries and fieldstone sites are hauled to nearby major cities and sold to contractors and the general public directly from pickup and flatbed trucks. Flagstone prices range from $1 to $2 per square foot. Moss rock and rubble range in price from $50 to $100 per ton.

Limestone and dolomite

Limestone and dolomite, which are usually marine in origin, crop out throughout northern New Mexico. Dolomite is commonly crushed for use as aggregate. Limestone is used widely as a building stone in the U.S., but has not been mined commercially in the northern part of the state for over 50 years.

Limestones are usually light gray, but range from white through gray or buff to tan. Crystallinity, bed thickness, ease of polishing (3 to 3.5 on the Mohs scale) and fossils make many limestones attractive as building stones (Harben and Bates, 1990). Mineral impurities making limestone darker include iron carbonates, iron oxide, chert, silica, clay and carbonaceous matter (Kottlowski, 1965). Calcite crystals in limestones range in size from fine- to coarse-grained. Bedding is thin to massive and is important in determining the architectural use of limestone (Patton, 1989). Limestone commonly splits along bedding planes making it suitable for walls or flagstone.

Major limestone units are in the Mississippian and Pennsylvanian (Madera), Permian (Yeso and San Andres), Jurassic (Todilto) and Upper Cretaceous (Fort Hays and Greenhorn). Minor Cenozoic limestone, mainly travertine and calcareous tufa, were precipitated near springs, in lakes and as caliche caps (Kottlowski, 1965).

Pennsylvanian Madera limestone near Santa Fe and Albuquerque was quarried for dimension stone used in buildings such as the federal courthouse in Santa Fe and in numerous wall veneers, such as the U.S. Post Office in downtown Albuquerque. Limestone riprap is used for erosion control in arroyos and channels. During the 1930's the CCC built retaining walls of limestone for erosion protection. Madera limestone in the Sandia Mountains, including some high-calcium limestone, are as much as 38 m thick. Similar limestone, with interbedded shale, is quarried near Tijeras in the northern Manzano Mountains by Ideal Basic Industries for cement raw materials.

Madera limestone was quarried in Taos County and northeast of Santa Fe in the 1900's. The interbedded clays were mined for tile manufacturing at the old State Prison. These quarries were abandoned, and the areas have been developed into expensive homesites.

The Upper Cretaceous section, which crops out in northeastern New

Mexico, contains relatively thick (6–12 m) limestone in the Fort Hays Limestone Member of the Niobrara Formation of eastern Colfax and northwestern Union Counties. It also contains the Greenhorn Limestone of northwesternmost Union County.

Metamorphic rock

Gneiss and schist

Gneiss or granitic gneiss in the Sangre de Cristo Mountains of northern New Mexico is quarried for crushed stone in Rio Arriba County (Appendix). It has characteristics similar to granite, and its use is nearly the same. Gneiss is not now quarried in New Mexico; it was used only for aggregate in the past.

Mica schist tends to break along mica-rich surfaces resulting in elongate boulders covered with light-colored mica that imparts a very attractive sheen. Precambrian schist of the Vadito Group in the Picuris Range was quarried on a small scale for use in landscaping and for walls (Fig. 14). Localities near Peñasco and in the Taos Range offer good potential.

Marble

Marble is metamorphosed carbonate with a coarsely crystalline sugary texture. The ability to take a polish is central to designation as commercial marble. The highest grade exceed 99% calcite and has brilliant white color. Impurities cause various shades of yellow, red and gray. Commercial marble also includes both noncarbonate rocks such as verde antique and unmetamorphosed carbonates, such as some coarsely crystalline limestone, travertine and calcareous tufa (Harben and Bates, 1990).

Well-known uses of marble include dimension stone and carving. Dimension marble is used for columns, wainscotting, floors and trim. Carving marble is used for sculpture. No metamorphic marble has been produced in New Mexico, but some coarsely crystalline limestone near Alamogordo and travertine west of Belen have been marketed as marble. Only the travertine west of Belen now is exploited.

Quartzite

Quartzite is siliceous sandstone or chert cemented with silica or thoroughly recrystallized through heat and pressure. It breaks with a vitreous fracture through original grains, matrix or cement. Quartzite has low porosity and a relatively smooth surface. It ranges from gray to black with red, blue, pink and green hues depending on impurities.

Quartzite used in the Española, Taos and Peñasco areas is usually rough stone that is stacked into walls (Fig. 15), used as riprap or crushed for road aggregate. Major quartzite sources, such as the Precambrian Hondo Group, crop out in the Sangre de Cristo Mountains and the Brazos uplift.



FIGURE 14. Use of Precambrian Vadito Schist near Peñasco, New Mexico.



FIGURE 15. Pastel Precambrian quartzite slabs used in wall paneling in Española building. Rectangles are roughly 1 by 0.5 m.

Baked shale

Shale beds heated to sufficient temperatures to recrystallize form "baked shale," "clinker" or "red dog." The heat is most commonly from a burning coal bed. Overlying and, on occasion, underlying shales, are altered to baked shale that is usually red or gray. Baked shale is generally used as abrasive or lightweight aggregate. Baked shale near Farmington is used as an anti-skid treatment for icy roads.

Copper-stained rock

Rocks containing or coated with oxidized copper stains are used throughout the state for rough building stone, wall facings, fireplaces and landscaping. Desirable copper minerals are blue-green chrysocolla or malachite and blue azurite. The value of stained rock for building and decorative stone exceeds the value of contained copper. Sources of copper-stained sandstone and quartzite are copper mines, past and present, in northern New Mexico.

Pale-greenish copper-stained, translucent, hydrothermally metamorphosed quartzite of the Precambrian Ortega Formation crops out in the northern Picuris and the eastern Truchas Ranges (Miller et al., 1963). Permian and Triassic sandstone associated with the copper deposits of the Nacimiento Mountains near Cuba, New Mexico, contains finely disseminated copper minerals producing blue and green sandstone used for landscaping and decoration.

SUMMARY

Use of stone for building today is small in comparison to the latter part of the 19th century. Major stone quarries in northern New Mexico are near Ribera, San Miguel, Anton Chico, Tecolote, Abiquiu, Albuquerque and Santa Fe. Many local people are engaged in quarrying, collecting and selling flagstone and fieldstone. A major stone industry has developed using moss rock for landscaping, walls, veneer and using flagstone for walkways. For ten years steadily increasing demand for New Mexico's colorful and varied stone products (Fig. 16) has existed. With increased availability and low-cost stone, the market will continue to grow with the building industry.

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FIGURE 16. Use of Tertiary monzonite from the quarry (inactive) at the Mina de Tiro mine near Cerrillos, New Mexico, for wall construction.

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APPENDIX: NEW MEXICO HIGHWAY DEPARTMENT CONSTRUCTION-MATERIAL PIT AND QUARRY SUMMARY FOR NORTHERN NEW MEXICO

Modified from Rutz (1966), Sprague (1967) and New Mexico Highway Department (n.d.). Rock units are classified using New Mexico Highway Department designation.

County	State Pit No.	Rock type	Rock Unit	Location
Granite and related intrusives				
Bernalillo	0697	granite	PЄg	SE1/4 sec. 12, 10N, 4E
Colfax	0150	diorite	Ti	Maxwell Grant
Colfax	0159	monzonite porphyry	Tdp	Cimarron Canyon Wildlife Refuge
Colfax	6101	diorite	Ti	NW1/4 sec. 3, 25N, 26N
Colfax	6423	diorite	Ti	NW1/4 sec. 16, 26N, 27E
Colfax	6606	monzonite	Ti	NE1/4 sec. 1, 27N, 24E
Colfax	6616	monzonite	Ti	NE1/4 sec. 1, 27N, 24E
Colfax	6802	syenite	Ti	SW1/4 sec. 6, 27N, 25E
Rio Arriba	0648	leptite	PЄm	NW1/4 sec. 34, 27N, 8E
Rio Arriba	0657	porphyritic granite	PЄgp	Carson National Forest
Rio Arriba	0664	olivine latite	Tc	S1/2 sec. 35, 32N, 7E
Rio Arriba	0728	granite	PЄg	SW1/4 sec. 21, 21N, 12E
Rio Arriba	0781	diorite	Qti	Juan Jose Lobato Grant
Rio Arriba	0869	lamprophyre dike	Ti	NE1/4 sec. 17, 31N, 1W
Rio Arriba	0874	lamprophyre	Ti	Jicarilla Apache Reservation
Rio Arriba	0897	granite	PЄ	SW1/4 sec. 15, 21N, 1E
Rio Arriba	5931	monzonite	Ti	E1/2 sec. 30, 30N, 2W
San Juan	0802	monchiquite	Ti	Navajo Indian Reservation
San Juan	0860	diorite	Ti	S1/2 sec. 18, 30N, 9W
San Miguel	0805	granite	PЄ	NW1/4 sec. 5, 14N, 15E
Santa Fe	0636	monzonite	Ti	NW1/4 sec. 28, 13N, 9E
Santa Fe	0637	monzonite	Ti	SE1/4 sec. 2, 12N, 9E
Santa Fe	0681	hornblende monzonite	Ti	SW1/4 sec. 5, 14N, 8E
Santa Fe	0742	monzonite	Tm	SW1/4 sec. 32, 16N, 8E
Santa Fe	0746	micaceous granite	PЄg	Sec. 5, 19N, 10E
Santa Fe	5820	granite	PЄg	E1/2 sec. 3, 17N, 10E
Santa Fe	6043	metamorphic	PЄg	W1/2 sec. 2, 17N, 10E
Santa Fe	6814	monzonite	Tm	SE1/4 sec. 27, 15N, 8E
Santa Fe	55105	granite	PЄg	SE1/4 sec. 3, 17N, 10E
Taos	0146	granite talus	PЄg	Sangre de Cristo Grant
Taos	0150	diorite	Ti	Maxwell Grant
Taos	0723	granite	PЄm	SE1/4 sec. 7, 23N, 12E
Taos	0724	diabase	Ti	SW1/4 sec. 18, 23N, 12E
Taos	0901	granite	PЄg	Carson National Forest
Taos	0905	granite	Tgr	Carson National Forest
Taos	5903	granite	PЄm	Las Trampas Grant
Cibola	5563	granite	PЄ	Sec. 36, 9N, 10W
Cibola	5564	granite	PЄ	SW1/4 sec. 34, 9N, 10W
Basalt, cinders and other fine-grained, dark-colored extrusives				
Bernalillo	5513	cinder and rhyolite	Qr	Atrisco Grant, 9N, 1W
Bernalillo	5538	basalt	Qb3	Atrisco Grant, 9N, 1W
Colfax	0908	dacite	Tdp	Philmont Scout Ranch
Colfax	0155	andesite	Tdp	Maxwell Grant
Colfax	6108	basalt	QTb	W1/2 sec. 23, 29N, 27E
Colfax	6228	dacite-andesite	Ti	SW1/4 sec. 25, 30N, 24E
Colfax	6229	dacite	Ti	NE1/4 sec. 36, 30N, 24E
Colfax	6455	basalt	QTb	NE1/4 sec. 20, 24N, 16E
McKinley	5739	basalt	Ti	NW1/4 NW1/4 sec. 3, 14N, 19W
McKinley	7116	andesite	Ti	SE1/4 sec. 31, 10N, 17W
McKinley	7119	basalt	Qb	NE1/4 sec. 17, 10N, 18W
Mora	5266	cinders	QTb	Mora Grant
Mora	5414	cinders	QTb	Mora Grant
Mora	5976	basalt	QTb	Mora Grant
Mora	6554	basalt	QTb	Mora Grant
Mora	6604	basalt	QTb	SW1/4 sec. 33, 22N, 21E
Mora	6608	basalt	QTb	SW1/4 sec. 21, 21N, 21E
Mora	6614	basalt	QTb	John Scolly Grant
Rio Arriba	0658	basalt	QTb	SE1/4 sec. 29, 30N, 9E
Rio Arriba	0659	andesite	Qa	Sec. 6, 30N, 9E
Rio Arriba	0661	amygdaloidal basalt	Tlpj	W1/2 sec. 35, 31N, 7E
Rio Arriba	0662	basalt	Qb	S1/2 sec. 26, 32N, 8E
Rio Arriba	0671	andesite	Tia	W1/2 sec. 13, 32N, 2W
Rio Arriba	0779	basalt	QTb	Black Mesa Grant
Rio Arriba	0782	basalt	Qbt	Polvadera Grant
Rio Arriba	0784	dacite	Tt	Juan Jose Lobato Grant
Rio Arriba	0872	basalt	Qb	Tierra Amarilla Grant

County	State Pit No.	Rock type	Rock Unit	Location
Rio Arriba	0893	basalt	QTb	SE¼ sec. 28, 22N, 4E
Rio Arriba	0894	dacite	Tt	NE¼ sec. 32, 22N, 4E
Sandoval	0673	basalt	Qb	E½ sec. 15, 14N, 4E
Sandoval	0674	basalt and igneous	Qal	Secs. 10 & 11, 14N, 5E
Sandoval	0735	basalt	Tb	NE¼ sec. 3, 18N, 4E
Sandoval	0736	andesite	Ta	San Miguel Mountains
Sandoval	0738	basalt	Tvv	Jemez Indian Reservation
Sandoval	0739	basaltic andesite	Qa	Caja del Rio Grant
Sandoval	0740	basalt	Qb(1&2)	La Bajada Grant
Sandoval	0741	basalt	Qb(33)	La Bajada Grant
San Juan	0822	metabasalt	Qls	Navajo Indian Reservation
San Juan	0837	basalt	Tb	Navajo Indian Reservation
Santa Fe	0732	basalt	Qb	NW¼ sec. 7, 18N, 8E
Santa Fe	0740	basalt	Qb	La Bajada Grant
Santa Fe	0741	basalt	Qb	La Bajada Grant
Santa Fe	5429	cinders	Qc	W½ sec. 14, 15N, 7E
Taos	0143	andesite	Tv	Carson National Forest
Taos	0144	basalt	Qtb	Sangre de Cristo Grant
Taos	0148	andesite	Tv	Carson National Forest
Taos	0153	dacite	Tv	Sangre de Cristo Grant
Taos	0177	cinders	Qc	S½ sec. 26, 30N, 9E
Taos	0179	basalt	Qafv	SE¼ sec. 13, 29N, 10E
Taos	0186	cinders	Qc	SE¼ sec. 21, 31N, 9E
Taos	0187	volcanics	Qafv	SW¼ sec. 3, 30N, 9E
Taos	0188	andesite	Qa	W½ sec. 13, 29N, 11E
Taos	0716	basalt	Qbt	SE¼ sec. 30, 25N, 11E
Taos	0898	basalt and rhyolite	Tam	Sangre de Cristo Grant
Taos	0899	volcanics, andesite and latite	Tv	NW¼ sec. 22, 29N, 13E
Taos	0902	basalt	Qtb	E½ sec. 27, 28N, 10E
Taos	0904	basalt	Tb	Sangre de Cristo Grant
Union	5642	basalt	QTb	NW¼ sec. 6, 27N, 31E
Union	5757	basalt	Tb	NE¼ sec. 20, 29N, 28E
Union	6435	basalt	QTb	NW¼ sec. 10, 26N, 33E
Union	6917	basalt	QTb	NW¼ sec. 29, 26N, 35E
Union	6919	basalt	QTb	N½ sec. 22, 26N, 34E
Union	6923	basalt	QTb	NE¼ sec. 9, 24N, 29E
Union	6924	basalt	QTb	NW¼ sec. 20, 24N, 29E
Union	7304	basalt	TQb_2	NE¼ sec. 26, 29N, 29E
Union	7702	basalt	QTb	NE¼ sec. 7, 30N, 29E
Cibola	5779	basalt	Qb	NE¼ sec. 33, 9N, 3W
Valencia	6529	dacite	Qb	San Clemente Grant
Valencia	57136	basalt and dacite	Qb	San Clemente Grant
Rhyolite				
Los Alamos	5769	rhyolite	Qp	Santa Fe National Forest
Sandoval	0733	rhyolite	Qvr	E½ sec. 10, 19N, 4E
Sandoval	0734	rhyolite	Qr	Baca location No. 1
Sandoval	0737	rhyolite	Tr	Jemez Indian Reservation
Taos	0152	rhyolite	Tv	Sangre de Cristo Grant
Tuff				
Colfax	0156	rhyolite tuff	Tv	Maxwell Grant
Los Alamos	0731	tuff	Qbt	NW¼ sec. 23, 19N, 6E
San Juan	0829	minette and tuff breccia	Ti	Navajo Indian Reservation
Rio Arriba	0665	welded tuff	Ttm	NW¼ sec. 7, 31N, 7E
Rio Arriba	0666	tuff breccia	Ttm	Carson National Forest
Rio Arriba	0730	pumice tuff	Qb	SE¼ sec. 20, 20N, 7E
Rio Arriba	0731	tuff	Qbt	NW¼ sec. 23, 19N, 6E
Rio Arriba	0780	tuff	Ta	Plaza Blanco Grant
Rio Arriba	0895	tuff	Qbt	SW¼ sec. 5, 21N, 3E
Taos	0147	rhyolite tuff	Tam	Sangre de Cristo Grant
Sandstone and conglomerate				
Colfax	6460	sandstone	PP	Sec. 21, 24N, 16E
Colfax	6461	sandstone	PP	NW¼ sec. 23, 24N, 15E
Guadalupe	0613	conglomerate	Qpc	NW¼ sec. 20, 9N, 16E
San Juan	0787	sandstone	Tkoa	NW¼ sec. 17, 26N, 12W
San Juan	0791	sandstone	Kch	NW¼ sec. 18, 22N, 12W
San Juan	0793	sandstone	Kkf	SW¼ sec. 29, 24N, 13W
San Juan	0796	sandstone	Kmf	Navajo Indian Reservation
San Juan	0804	sandstone	Kmf	Navajo Indian Reservation
San Juan	0824	sandstone	Kg	Navajo Indian Reservation
San Juan	0825	sandstone	Kpl	Navajo Indian Reservation
San Juan	0826	sandstone	Kmf	Navajo Indian Reservation
San Juan	0830	sandstone	Kmf	Navajo Indian Reservation
San Juan	0831	sandstone	Kpc	Navajo Indian Reservation
San Juan	0832	sandstone	Kd	Navajo Indian Reservation
San Juan	0834	sandstone	Trc	Navajo Indian Reservation
San Juan	0836	sandstone	Trc	Navajo Indian Reservation
San Juan	0838	sandstone	Tc	Navajo Indian Reservation
San Juan	0841	sandstone	Kch	Navajo Indian Reservation
San Juan	0842	sandstone	Kmf	Ute Mtn. Indian Res.
San Juan	0846	conglomerate	Qp	Ute Mtn. Indian Res.
San Juan	0847	sandstone	Kkf	Ute Mtn. Indian Res.
San Juan	0853	sandstone	Kkf	Navajo Indian Reservation
San Juan	0856	conglomerate	Koa	NE¼ sec. 29, 27N, 12W
San Juan	6110	sandstone	Kmf	Navajo Indian Reservation
San Miguel	7414	sandstone	Kd	Las Vegas Grant
Rio Arriba	0655	conglomerate	Tr	Tierra Amarilla Grant
Rio Arriba	0663	conglomerate	Tlp	S½ sec. 19, 32N, 8E
Rio Arriba	0668	conglomerate	Tr	W½ sec. 12, 26N, 6E
Rio Arriba	0871	conglomerate	Tbb	Tierra Amarilla Grant
Rio Arriba	0672	sandstone	Tsj	NE¼ sec. 20, 30N, 2W
Rio Arriba	6712	sandstone	Tsj	SE¼ sec. 17, 29N, 3W
Rio Arriba	6713	sandstone	Tsj	SE¼ sec. 6, 28N, 3W
Taos	0722	sandstone conglomerate	MD	Rancho del Rio Grant
Taos	5747	conglomerate	PP	Rancho del Rio Grant
Torrance	5561	conglomerate	Qpcg	NE¼ sec. 15, 9N, 11E
Limestone				
Bernalillo	0691	limestone	PPm	SW¼ sec. 36, 10N, 6E
Bernalillo	0693	limestone	PPm	SE¼ sec. 24, 10N, 5E
Bernalillo	0698	gypsiferous limestone	J	SW¼ sec. 36, 11N, 5E
Sandoval	0700	limestone	PPm	S½ sec. 12, 12N, 4E
Sandoval	0701	limestone	PPm	Sec. 12, 12N, 4E
Bernalillo	0916	limestone	Psa	NW½ sec. 12, 8N, 4E
Bernalillo	5726	limestone	PPm	N½ sec. 8, 10N, 6E
Bernalillo	5809	limestone	PPm	SE¼ sec. 9, 10N, 6E
Bernalillo	5843	limestone	PPm	Secs. 14 & 23, 10N, 4E
Bernalillo	5915	limestone	PPm	SE¼ sec. 34, 10N, 5E
Bernalillo	6124	limestone	PPm	Sandia Mountains
Bernalillo	6245	limestone	PPm	NE¼ sec. 34, 11N, 6E
Bernalillo	6330	limestone	PPm	Sec. 2, 9N, 5E
Bernalillo	6556	limestone	PPm	SE¼ sec. 10, 10N, 6E
Bernalillo	58129	limestone	PPs	Sandia Mountains
Colfax	0906	limestone	PP	Cimarron Canyon Wildlife Area
McKinley	5670	limestone	Jet	Center sec. 33, 15N, 14W
McKinley	5722	limestone	Jet	NW¼ sec. 33, 15N, 14W
McKinley	5737	limestone	Psa	Ft. Wingate Military Reserv.
McKinley	5796	limestone	Jet	S½ sec. 33, 15N, 14W
McKinley	5868	limestone	Tru	NW¼ sec. 18, 15N, 16W
McKinley	6058	limestone	Jet	SE¼ sec. 18, 14N, 12W
McKinley	6113	limestone	Psa	W½ sec. 27, 13N, 16W
McKinley	6469	limestone	Jt	Not sectionalized
McKinley	7111	limestone	Psa	SW¼ sec. 16 & SE¼ sec. 17, 13N, 14W
McKinley	55111	limestone	Jt	NE¼ sec. 18, 14N, 12W
McKinley	56113	limestone	Jet	NE½ sec. 31, 13N, 9W
McKinley	57101	limestone	Km	SE¼ sec. 31, 10N, 17W
McKinley	57145	limestone	Jet	SE¼ sec. 12, 14N, 14W
McKinley	59103	limestone	Jt	SW¼ sec. 33, 15N, 14W
Mora	7613	limestone	PP	Mora Grant
Rio Arriba	0884	limestone	Kmgl	SW¼ sec. 6, 25N, 4E

County	State Pit No.	Rock type	Rock Unit	Location
Rio Arriba	0896	limestone	ℙ	NW¼ sec. 5, 21N, 2E
Rio Arriba	7015	limestone	Kmgs	Tierra Amarilla Grant
San Juan	0799	limestone	Km	Navajo Indian Reservation
San Miguel	0633	limestone	ℙm	Los Trigos Grant
San Miguel	0641	limestone	Psa	NE¼ sec. 20, 12N, 12E
San Miguel	0757	limestone	Psa	NW¼ sec. 30, 15N, 12E
San Miguel	0809	limestone	Psa	Tecolote Grant
San Miguel	5971	limestone	Psa	NE¼ sec. 32, 10N, 12E
San Miguel	6253	limestone	ℙm	NW¼ & SW¼ sec. 18, 14N, 14E
San Miguel	6255	limestone	ℙm	SW¼ sec. 9, 14N, 13E
San Miguel	6328	limestone	ℙm	N½ sec. 25, 14N, 14E
San Miguel	6439	limestone	ℙm	SW¼ sec. 27, 14N, 15E
San Miguel	6442	limestone	ℙ	Las Vegas Grant
San Miguel	6463	limestone	ℙm	N½ sec. 17, 14N, 13E
San Miguel	6702	limestone	Psa	NE¼ sec. 6, 12N, 17E
San Miguel	6703	limestone	Psa	SW¼ sec. 5, 12N, 17E
San Miguel	7122	limestone	ℙ	Las Vegas Grant
Santa Fe	0640	limestone	Psa	San Cristobal Grant
Santa Fe	0646	quartzitic limestone	ℙ	NW¼ sec. 23, 10N, 10E
Santa Fe	0685	limestone	Psa	Ortiz Mine Grant
Santa Fe	5920	limestone	ℙ	NW¼ sec. 36, 16N, 11E
Santa Fe	6243	limestone	Psa	S½ sec. 31, 10N, 10E
Santa Fe	6464	limestone	ℙm	SE¼ sec. 27, 10N, 7E
Santa Fe	6815	limestone	ℙ	NE¼ sec. 31, 16N, 11E
Santa Fe	6922	limestone	ℙm	NW¼ sec. 35, 10N, 7E
Taos	0185	limestone	ℙ	NE¼ sec. 35, 25N, 14E
Torrance	0705	limestone	ℙs	Lo de Padilla Grant
Torrance	0701	limestone	Psa	Sec. 3, 9N, 14E
Torrance	0813	limestone	Py	NE¼ sec. 18, 9N, 14E
Torrance	6246	limestone	ℙm	SW¼ sec. 1, 9N, 7E
Torrance	5579	limestone	Psa	SW¼ sec. 23, 9N, 11E
Torrance	5592	limestone	Pyl	S½ sec. 14, 9N, 13E
Torrance	6119	limestone	Psa	NW¼ sec. 26, 9N, 11E
Valencia	0919	limestone	Psa	Tome Claim
Cibola	5518	limestone	Psa	NW¼, SW¼ sec. 32, 12N, 10W
Cibola	5558	limestone	Psa	SE¼ sec. 3 & NE½ sec. 10, 11N, 11W
Cibola	5562	limestone	Psa	S½ sec. 37, 9N, 10W
Cibola	5777	limestone	Jet	S½ sec. 14, 9N, 5W
Cibola	6115	limestone	Psa	SW¼ sec. 4, 12N, 12W
Cibola	6450	limestone	Psa	NE¼ sec. 16, 9N, 12W
Cibola	6451	limestone	Jet	SE¼ sec. 20, 11N, 9W
Cibola	6729	limestone	Psa	Sec. 36, 12N, 11W
Cibola	6730	limestone	Psa	SE¼ sec. 3 & NE¼ sec. 10, 11N, 11W
Cibola	6731	limestone	Psa	SE¼ sec. 20, 11N, 10W
Cibola	54115	limestone	Psa	Sec. 29, 11N, 10W
Shale (baked)				
San Juan	0792	baked shale	Kmf	Navajo Indian Reservation
San Juan	0816	baked shale	Kkf	NE¼ sec. 20, 22N, 10W
San Juan	0827	baked shale	Kf	Navajo Indian Reservation
Gneiss and schist				
Bernalillo	0699	mica schist	P€u	W½ sec. 2, 11N, 4E
Rio Arriba	0650	hbl-chl schist	P€m	SW¼ sec. 5, 28N, 7E
Rio Arriba	0651	quartz diorite gneiss	P€m	SE¼ sec. 33, 29N, 7E
Rio Arriba	0652	granitic gneiss	P€m	Sec. 32, 29N, 7E
Taos	0182	phyllite	P€m	Maxwell Grant
Quartzite				
Bernalillo	0694	quartzite	P€q	S½ sec. 6 & N½ sec. 7, 9N, 5E
Bernalillo	0696	quartzite	P€q	NE¼ sec. 21, 10N, 5E
Colfax	0184	quartzite	P€q	Maxwell Grant
Colfax	6025	quartzite	P€q	Maxwell Grant
Rio Arriba	0649	muscovite quartzite	P€q	W½ sec. 6, 26N, 9E
Rio Arriba	0654	specularite quartzite	P€q	Tierra Amarilla Grant
Rio Arriba	6558	quartzite	P€q	Tierra Amarilla Grant
Taos	0149	quartzite	P€q	Carson National Forest
Taos	0175	quartzite	P€m	Carson National Forest
Taos	0720	quartzite	P€q	NW¼ sec. 29, 24N, 10E
Taos	0900	quartzite	P€q	SE¼ sec. 18, 29N, 13E
Valencia	0920	quartzite	P€q	Tome Claim



Philip T. Hayes, USGS, describing the Bernal Formation (Permian) at its type locality on Bernal Butte, 19 October 1956. Stop 4 of first day of NMGS 7th Field Conference, located 15 mi SW of Las Vegas, New Mexico. View to SE. Photo by James W. Adams.