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Commercial travertine in New Mexico

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Introduction

Travertine is composed primarily of calcium carbonate ($CaCO_3$) as calcite and less commonly as aragonite. In broad terms, travertine is calcium carbonate deposited in a spring system that emits either warm or cold carbonate-charged water and deposits travertine at or near the surface. Travertine is typically related to faults and to nearby limestone source rocks.

Commercial travertine is hard, dense to vuggy, finely crystalline, compact, massive ☞

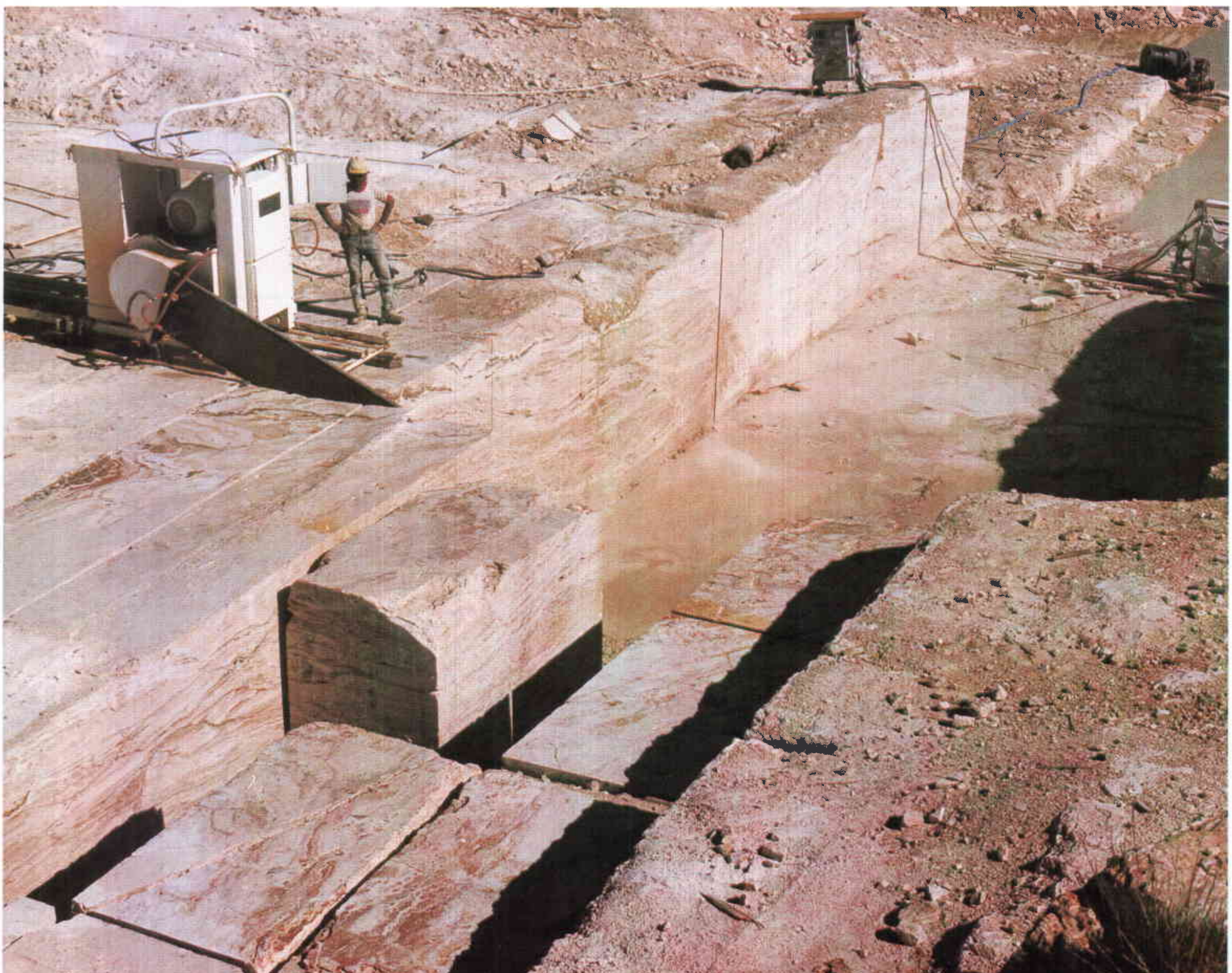

FIGURE 1—Scheherazade quarry at New Mexico Travertine quarries west of Belen, New Mexico. Diamond-impregnated belt saw in operation cutting $1^1/_2$-inch channel as deep as 10 ft. Wire saw at upper right is "pulling the floor" on block previously cut by belt saw. Photograph courtesy of Rocky Mountain Stone.

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to concretionary limestone that takes a polish. Impurities in travertine impart colors ranging from white to pink, tan, yellow brown, or dark brown. If variable impurities cause color banding in layered travertine, the stone is sometimes called tufa, calcareous sinter, marble, Mexican onyx, or onyx marble (Sanders and Friedman, 1967); true onyx is banded silica (SiO_2). Travertine, as quarried and marketed by New Mexico Travertine (NMT), includes all forms of calcite, aragonite, travertine, Mexican onyx, carbonate breccia, and altered limestone bedrock with oxidized iron on stylolitic surfaces. Mexican onyx will be called onyx below when used in textural descriptions.

NMT produces commercial varieties of stone including Temple Creme (white to creamy-white travertine), Scheherazade (pale-cream to pink travertine with onyx), Desert Creme (yellow to brown travertine with minor onyx and lilac- or pinkish-gray sections), Vista Grande (dark-reddish-brown to cream travertine with onyx), Desert Gold (yellow-gold travertine with abundant onyx), and Apache Golden Vein (altered stylolitic yellow- to reddish-gray limestone). Production of several sub-varieties is possible by cutting different directions in relation to bedding in the travertines. Testwell Craig Laboratories classified Temple Creme as travertine marble according to ASTM C–119 (Szypula, 1988).

Dimension stone, i.e., blocks, slabs, or sheets of stone cut and finished to specific dimensions for structural, ornamental, or monumental uses, has become popular for walls, fireplaces, patio floors, and as flagstones, especially where decorative accents and special architectural effects are desired (Austin et al., 1990). Some segments of the architectural market favor lightly colored travertine with a relatively even, muted texture. Variegated and brightly colored travertine often is considered less adaptable as preferred color combinations change over time. Other architects prefer the more vivid colors and textures, particularly for interiors of large buildings.

Travertine in New Mexico

NMT is one of three dimension-stone operations producing travertine in the United States; the other two are in Idaho and Montana. NMT quarries about 400 short tons (st) of stone per month from extensive, well-bedded, laminar lenses of travertine (Fig. 1) just east of Mesa Lucero in the eastern foothills of Mesa Aparejo. The travertine quarries are 25 mi west of Belen (Fig. 2) in secs. 12 and 13, T5N, R3W on U. S. Bureau of Land Management and private lands.

Travertine is widespread in New Mexico (Kottlowski, 1965). About 50 discrete deposits are known (Barker, 1986, 1988) with many additional ones occurring in the extensive limestone terrains of New Mexico. The nearest large deposit, on trend with the Mesa Aparejo travertine, is a few miles north of the NMT quarries on the Laguna Indian Reservation at Mesa Lucero. Other large occurrences (Fig. 2) are west of Sierra Ladrones (Barker, 1983) and at Mesa del Oro (Jicha, 1956, 1958). Minor production of travertine also occurred during the 1970's in south-central New Mexico about eight miles northwest of Radium Springs in sec. 23, T21S, R2W.

General geology of Mesa Aparejo

Limestone of the Pennsylvanian Madera Formation in the subsurface to the west is probably the primary source rock for the carbonate-rich water that formed the Quaternary travertine at the edge of Mesa Aparejo (Gray Mesa). The lower 800 ft of the Madera Formation are well exposed just west of the NMT travertine quarries (Kelley and Wood, 1946; Titus, 1963; Cooper, 1964) and probably represent the Gray Mesa Member of the Madera (Kelley and Wood, 1946; Kues and others, 1982). Other bedrock units nearby include Pennsylvanian Sandia Formation, Permian Abo and Yeso Formations, and Precambrian granite and schist. Kelley and Wood (1946), summarized by Titus (1963), showed the structural and stratigraphic relationships (Fig. 3) of Mesa Aparejo (Gray Mesa). Hammond (1987) summarized regional stratigraphy and structure south of Mesa Aparejo; Slack and Campbell (1976) summarized structure to the north. Cooper (1964) was concerned primarily with the travertine.

A large northeast-trending fault mostly west of the travertine (Fig. 4), mapped as a normal fault dipping 70° eastward by Cooper (1964),

Also in this issue

Coming soon

Monero coal field
1989 discover wells
Lava Creek B tephra

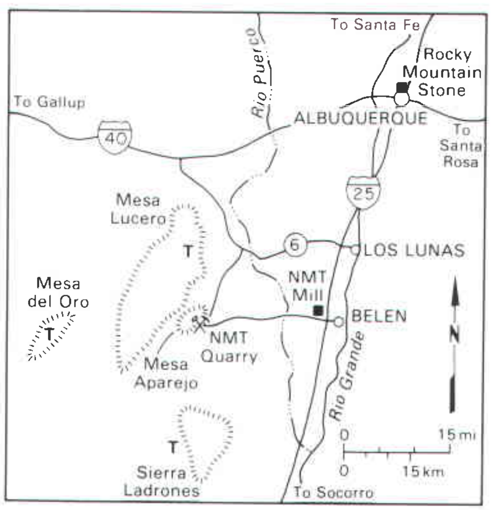

FIGURE 2—Location map of Mesa Aparejo in central New Mexico. **NMT Quarries** is the New Mexico Travertine quarry sites; **NMT Mill** is the finishing plant; **Rocky Mountain Stone** is the retail outlet for travertine and other stone; **T** indicates travertine occurrence. Area shown in Fig. 3 coincides with the area approximately covered by the mine symbol.

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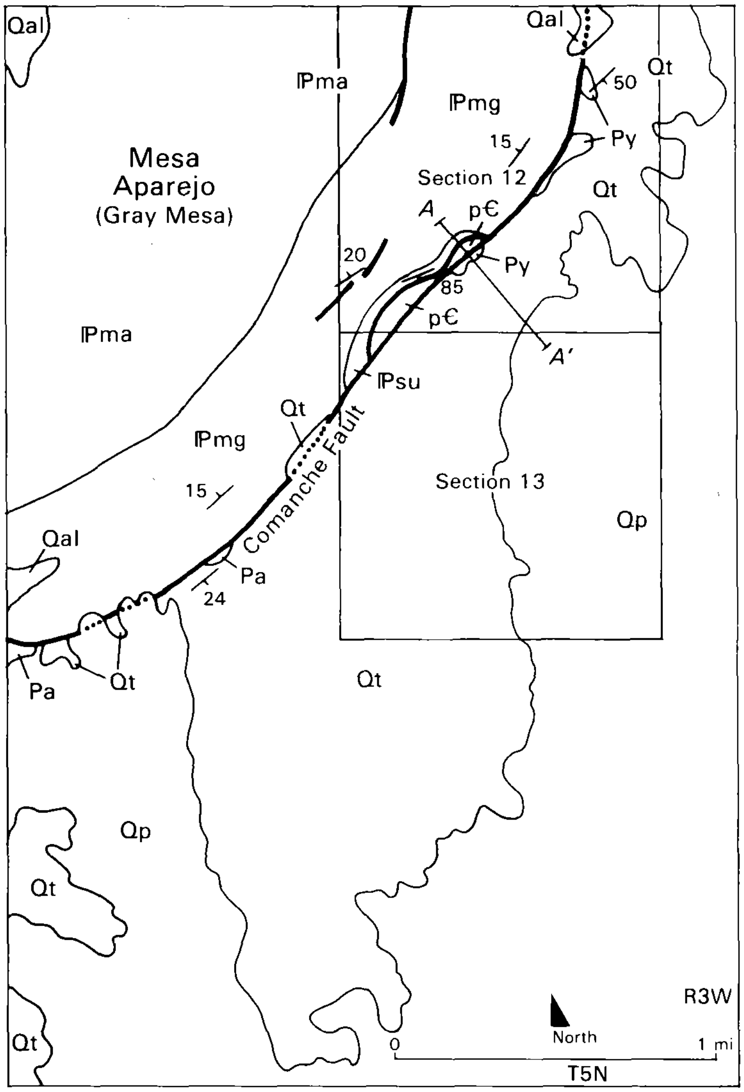
is the Comanche thrust fault of Kelley and Wood (1946), which dips shallowly to steeply westward. The dip of the fault varies considerably in the vicinity of Mesa Aparejo. Cooper's interpretation seems correct because it is based on drill-hole data, on observation of the fault plane in outcrop at the travertine quarries, and is consistent with the downdropped Paleozoic section just east of the fault.

With respect to rocks to the west, the Madera and other bedrock units east of Mesa Aparejo have dropped several thousand feet into the Albuquerque–Belen Basin portion of the Rio Grande rift. Sandstone, conglomerate, and mudstone of the Tertiary Santa Fe Group now overlie downfaulted older bedrocks units and lap onto Mesa Aparejo. The Comanche fault and associated minor faults acted as conduits and continue to influence ☞



DESCRIPTION OF UNITS

Qal **Alluvium (Quaternary)**—valley fill; sandy washes

Qp **Pediment gravel (Quaternary)**—several levels with some caliche interbeds

Qt **Travertine (Quaternary)**—spring deposits of calcium carbonate; banded, laminated, and fragmental; related to ancient springs along fault

Py **Yeso Formation, upper part of Los Vallos Member (Lower Permian)**—tan-brown, friable siltstone, sandstone, and shale with minor gypsum

Pa **Abo Formation (Lower Permian)**—red-brown, fine- to coarse-grained sandstone, siltstone, and shale with minor limestone interbeds

IPma **Madera Formation, Atrasado Member (Upper Pennsylvanian)**—gray to dark-gray limestone, shale, and conglomeratic sandstone

IPmg **Madera Formation, Gray Mesa Member (Middle Pennsylvanian)**—gray to dark-gray, predominantly cherty, thick- to thin-bedded limestone with minor shale and sandstone

IPsu **Sandia Formation, upper clastic member (Middle Pennsylvanian)**—gray to black arenaceous limestone, carbonaceous shale, conglomerate, and sandstone

p€ **Pink granite and associated green chlorite schist (Precambrian)**—highly fractured

FIGURE 3—Geologic map of Mesa Aparejo (after Kelley and Wood, 1946; Titus, 1963; Kues et al., 1982). **A-A'**, approximate line of the diagrammatic cross section for Fig. 4.

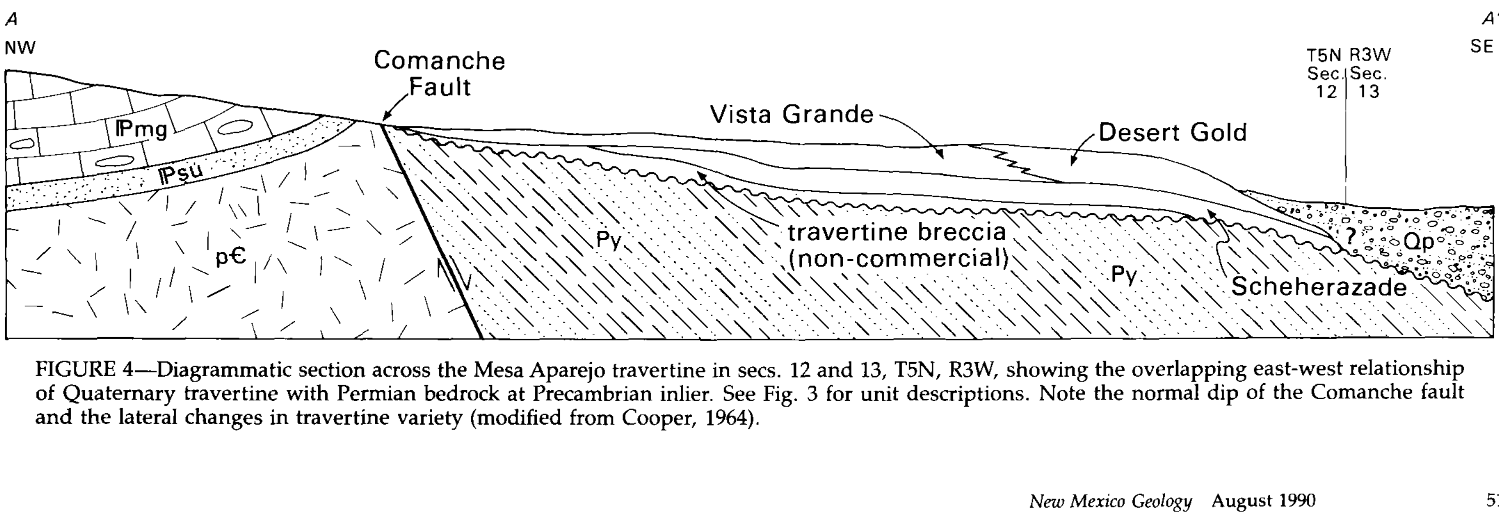


FIGURE 4—Diagrammatic section across the Mesa Aparejo travertine in secs. 12 and 13, T5N, R3W, showing the overlapping east-west relationship of Quaternary travertine with Permian bedrock at Precambrian inlier. See Fig. 3 for unit descriptions. Note the normal dip of the Comanche fault and the lateral changes in travertine variety (modified from Cooper, 1964).

circulation of carbonate-charged ground water and spring water.

Precipitation of calcium carbonate in a spring system occurs when carbonate-rich waters become supersaturated because of either evaporation of water or loss of carbon dioxide (CO_2) by degassing from pressure release, turbulence, or organic activity. The latter includes not only photosynthesis, principally by algae, mosses, or hepatica (Julia, 1983; Fisher, 1979), but also bacterial metabolism (Chafetz and Folk, 1984). Travertine was deposited as extensive, thick, laminar lenses at Mesa Aparejo. Travertine presently being deposited from springs just north of Mesa Aparejo in secs. 35 and 36, T6N, R3W illustrates one way older and larger deposits may have formed (Fig. 5).

The varieties of travertine at Mesa Aparejo are distinguished by color and structure, but the mineralogy and origin are fundamentally the same for each. Bedding is commonly laminated with characteristic serrations probably representing the forward surface of a micro-terraced rimstone dam that impounds a pool of spring water from which limestone is deposited (Fig. 5). Concretionary masses of various dimensions are largely due to algal activity. Rod-like structures, frequently upright and clustered in tufts or masses, may be algal or bacterial when microscopic, but most likely represent deposition around grass, stems, or branches. Holes within travertine may result from rapid accumulation over tufted or dimpled surfaces, gas bubbles encrusted by travertine, or voids produced by primary deposition of soluble salts later removed by dissolution. Shrub-like forms, composed of upward-radiating bacterial clumps in $CaCO_3$ (Chafetz and Folk, 1984), are locally abundant.

The highly variable color of the Mesa Aparejo travertine is a result of impurities. Pink and red are probably primary and result from inclusion in the travertine of red iron oxide from nearby Permian sandstone, siltstone, and shale. Yellow and brown are secondary and were produced close to the surface by percolating oxidizing waters during case hardening and weathering of the travertine.

Onyx is translucent calcium carbonate in which layers parallel the surfaces of infilled voids or laminae, and is intimately associated with travertine. Most onyx, now calcite, was deposited originally as aragonite, a metastable higher-temperature form of calcium carbonate. Local coarse-grained aragonite is associated with spring orifices mainly in the Apache Golden Vein portions of the Gray Mesa Member of the Madera Formation. Because aragonite is more soluble than the calcite, advanced dissolution forms soft crumbly zones and large voids later filled with clay or mud (Cooper, 1964).

Commercial varieties of NMT travertine

The six varieties of travertine produced by NMT (Fig. 6) vary in detail within a given layer but are laterally consistent for hundreds of feet. Several additional varieties of travertine have been identified in the Mesa Aparejo area but have not been quarried. Such a wide variety of types within one travertine deposit is very unusual. Cooper (1964) conservatively estimated that the NMT quarries contained reserves of about 49 million ft^3 of associated types of commercial-quality travertine and altered limestone (Table 1). Travertine of all types underlies about 1,140 acres and may total about 200 million short tons (st) in place (Barker, 1988).

FIGURE 5—Present-day formation of travertine near the northern end of Mesa Aparejo (SE1/4 sec. 35, T6N, R3W). The spring supplying this travertine issues from the Madera Formation and is about 1/8 mi upstream to the west. Note hammer handle in lower left for scale. View is to the northwest.

Travertine is quarried by NMT for **slabs** (typically 4′ × 8′ sheets, 3/4-inch thick) and **ashlar** (rectangular pieces of sawn or rough-hewn stone of non-uniform size). Travertine fragments are marketed as **rubble** (rough-hewn irregular blocks or boulders) and **crushed stone** (broken stone in smaller sizes).

Temple Creme (Fig. 6A), white to creamy-white travertine, resembles better grades of Italian travertine and normally occurs in layers less than 5 ft thick intercalated with other varieties. It also occurs in one sizable body containing 7–8 million ft^3 of stone (Cooper, 1964). However, the highest quality reserves are limited and the body has not yet been quarried economically.

Scheherazade (Fig. 6B) is a pale-cream to pink to gray travertine/onyx that, although present in large quantities, is variable in soundness or freedom from flaws (Power, 1983, p. 178). Cooper (1964) believed that deeper levels in the deposit would yield excellent commercial material. He estimated that the entire property contained about 8 million ft^3 of Scheherazade, making it the most abundant travertine/onyx variety at the NMT quarries.

Vista Grande (Fig. 6E) is formed by impregnation of Scheherazade travertine/onyx by secondary calcite and brown iron oxide. Cooper (1964) estimated reserves of 7.75 million ft^3 but stated that large production of Vista Grande as dimension stone could not be achieved. However, Vista Grande now supplies most of the rubble and crushed stone produced by NMT and only a limited amount of slabs and ashlar.

Desert Gold (Fig. 6D), a yellow-gold travertine, has abundant onyx within the dominant travertine. Many voids must be filled with epoxy or cement grout during finishing. The grout, along with case-hardening iron oxide, yields a pleasing appearance and increased strength. Cooper (1964) estimated reserves of 1.5 million ft^3 of Desert Gold.

Desert Creme travertine (Fig. 6C), as described by Cooper (1964), commonly underlies Desert Gold and varies from pale lilac gray through mauve to pinkish gray. Nearly every block and slab of Cooper's Desert Creme contained disseminated black limestone clasts generally less than 1 inch, but occasionally 6 inches in diameter. Cooper (1964) estimated reserves of about 4.2 million ft^3 of Desert Creme. Travertine quarried now as Desert Creme is higher stratigraphically than that described by Cooper but is not equivalent to Desert Gold. It is mainly yellow to brown with minor onyx and lilac- or pinkish-gray sections; limestone clasts are absent.

Apache Golden Vein (Fig. 6F) is a yellow- to reddish-gray limestone of the Gray Mesa Member of the Madera Formation. It forms

→

FIGURE 6—Polished slabs of the six varieties of commercial stone marketed by Rocky Mountain Stone: **A,** Temple Creme; **B,** Scheherazade; **C,** Desert Creme; **D,** Desert Gold; **E,** Vista Grande; and **F,** Apache Golden Vein. Each slab is 1 ft^2.

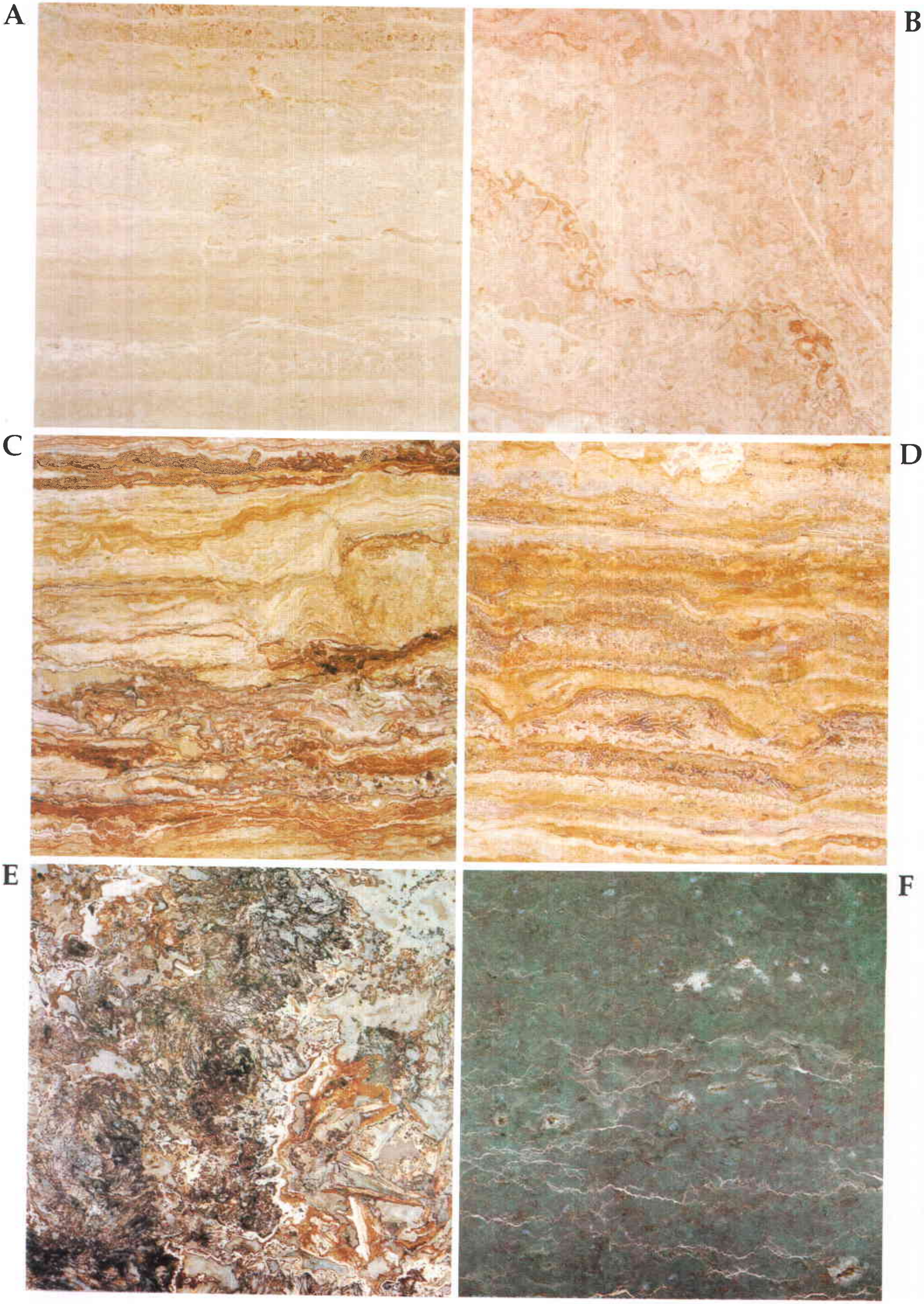

A
B
C
D
E
F

TABLE 1—New Mexico Travertine reserves by commercial name (Cooper, 1964; NMT, oral communication 1990).

	Composition and Texture	Reserves (million ft³)	Remarks
Temple Creme	travertine	7.7	Top grades mined out
Scheherazade	travertine/onyx	8	Most abundant type; variable soundness
Vista Grande	travertine/onyx	7.75	Case-hardened Scheherazade
Desert Gold	travertine/onyx	1.5	Onyx abundant; strong
Desert Creme	travertine/onyx	4.2	Disseminated black limestone clasts
Other varieties	travertine/onyx	14.7	Includes "Saladin Onyx," "Mescalero Onyx," and "Sioux Breccia"
	subtotal	~44 million ft³	
Apache Golden Vein	altered Madera limestone	5	Apache Golden Vein may be more widespread off NMT property; it is not travertine.
	TOTAL	~49 million ft³	

prominent but thin ledges mid-slope on Mesa Aparejo. The limestone has been partly altered, perhaps during emplacement of the travertine (Cooper, 1964) downslope to the east. Closely spaced and anastomosing stylolites of the original limestone have been oxidized to bright golden-yellow iron oxide. Apache Golden Vein varies from 0 to 16 ft thick at the NMT quarries. Several miles to the southwest similar limestone in the Gray Mesa Member can be 50 ft thick. Although Cooper (1964) estimated about 5 million ft³ could be recovered, he did not consider Apache Golden Vein to have sufficient market appeal to warrant extraction. NMT has succeeded in developing this market but only sells Apache Golden Vein as polished slabs, a relatively low volume activity.

Quarrying procedures at NMT

Blocks of travertine are cut with a wire saw, a belt saw, or both (Table 2). A Vermeer concrete saw is used to remove caprock overlying the travertine. During wire-saw operation, intersecting drill holes produce a path through which a wire impregnated with industrial diamonds is drawn. The wire is connected in a continuous moving loop and pulled under tension as it cuts through the travertine toward a wheel on tracks (Fig. 7). The wire saw is moved backward on the track as the cut is made, then is moved forward and the wire is shortened; this process is repeated as often as necessary to complete the cut (Fig. 8). The cut may be any orientation from horizontal to vertical. Large slabs of rocks are also prepared by a rail-mounted belt saw that cuts as deep as 10 ft (Fig. 1). Until recently, most cutting of travertine was done by the wire saw, but now much of the work is done with great precision and high output by the belt saw.

After being broken or cut loose, 150–300-st slabs are tipped over using hydraulic wedges. The blocks fall away from the working face and onto loose debris to lessen breakage (Fig. 9). They are split or sawed into 15–20-st blocks, graded, processed on site, or loaded onto flatbed trucks by large frontend loaders or forklifts and hauled to the dressing plant. Low-grade blocks and waste from the quarrying procedure are crushed on site by several methods. This material is marketed as palletized rubble (larger sized) or as crushed stone (smaller sized).

Milling procedures at NMT

The NMT finishing plant is about two miles west of Belen off Exit 191 of Interstate 25 (Fig. 2). The Belen plant can produce 2,000 to 3,000 ft³ of travertine slabs per day, but the variable amount of custom work commonly lowers output. Graded and stockpiled quarry blocks are trimmed square using a small wire saw, similar to the process at the quarry. Most blocks at the plant are cut into slabs in an adjustable Gaspari gang saw that has as many as 75 diamond-impregnated blades individually adjustable for width of cut (Table 2, Fig. 10). The gang saw usually is set to produce 3/4-inch-thick slabs that are then moved to an automatic Gregori polishing line.

TABLE 2—Saws used at the New Mexico Travertine quarry and mill west of Belen, New Mexico.

Saw	Cut Dimensions	Cutting Method	Abrasive	Remarks
Quarry				
Wire saw	25′ deep × 40′ long cable pull	3/16″ cable drawn through connected drill holes	industrial diamond	3/8″ × 3/8″ diamond segment every 1 1/2″ separated by spring spacers
Belt saw	10′ deep × 50′ long (rail in 10′ increments)	1 1/2″ belt on movable arm	industrial diamond	Automated advance and shutdown (water pressure lost or excess amps drawn); waterjets around perimeter of arm
Concrete saw	34″ deep × unlimited length (tracked vehicle)	7′ diameter wheel	tungsten carbide tips	Used to remove caprock waste
Mill				
Gang saw		as many as 75 reciprocating blades	industrial diamond	Spacing of blades is variable
Bridge saw		rotating blade	industrial diamond	Accurate to 0.2 mm; can cut special shapes

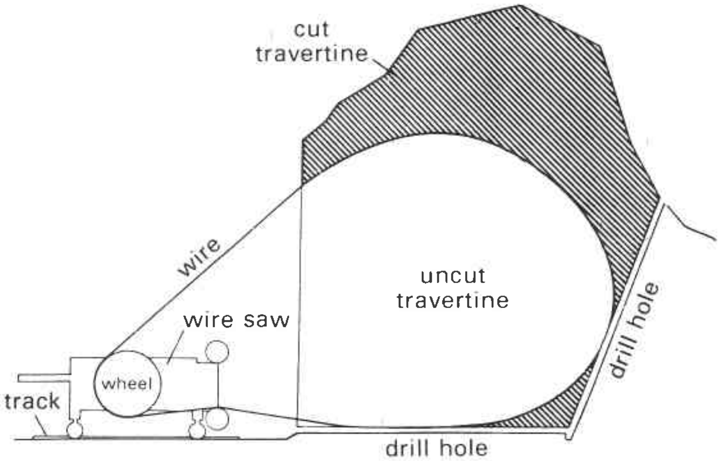


FIGURE 7—Diagrammatic representation of wire-saw operation during a vertical cut through connected drill holes. The cable loops from the motor through an inclined drill hole behind the face, through an intersecting horizontal drill hole near the base of the face, and back to the motor. (Source: Benetti Macchine, Italy).

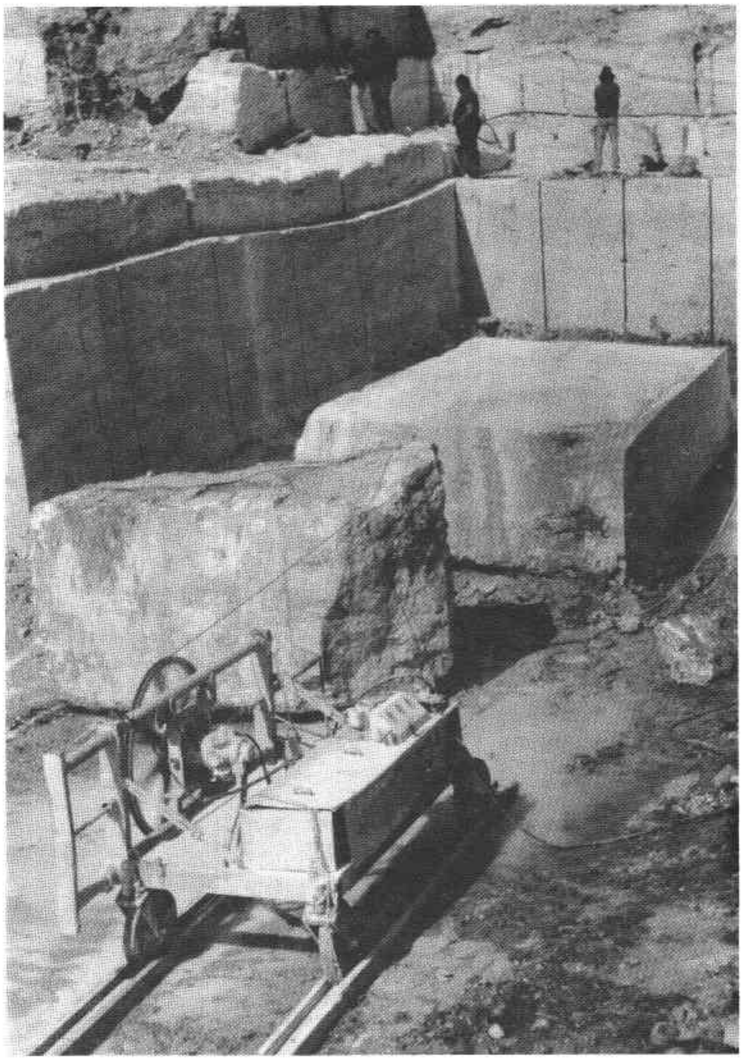


FIGURE 8—Wire saw, with diamond-impregnated cable, in operation at New Mexico Travertine quarry. Photograph courtesy of New Mexico Travertine.

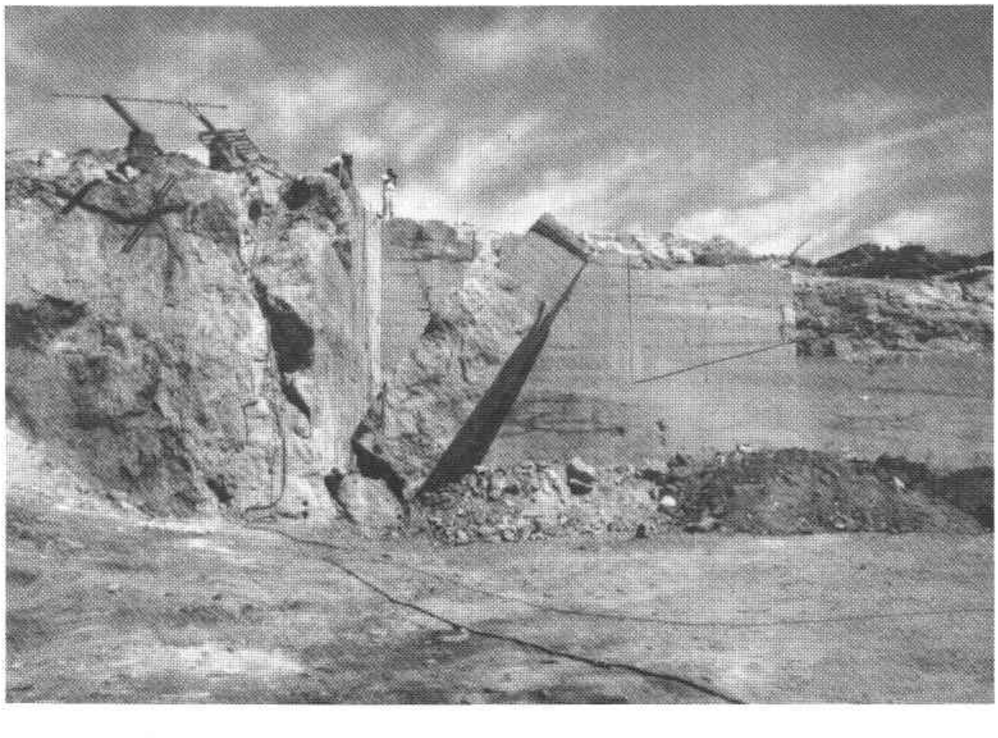


FIGURE 9—Large travertine slabs are tipped over using hydraulic wedges, then processed into blocks or rubble. Man on skyline for scale. Photograph courtesy of D. W. Love.

The Gregori polishing line removes small ridges produced by the gang saw, yielding a smooth, highly polished, flat surface (Fig. 11). During cutting and polishing, the stone is flushed with water, which removes clay and mud in the voids. Before final polishing, a waterproof, appropriately colored grout is applied, if needed, to the slab surface, filling the voids and partially cementing the stone. Epoxy grout has a shiny surface in polished travertine slabs. Cement grout-filled voids appear dull compared to the flat portions of the stone, but colors of either fill are chosen to blend well with the highly polished surfaces. Some slabs may be backed with fiberglas mesh and epoxy to strengthen them further.

Complex angle and other cuts are made with a computer-controlled Gregori Impala bridge saw (Fig. 12) accurate to 0.2 mm. The bridge saw is used to cut polished slabs into special shapes. Ashlar is made by breaking thick travertine slabs in a hydraulic knife or guillotine (Fig. 13). Finished slabs or blocks are packed or placed on pallets and shipped to customers.

Travertine is porous and its physical properties vary more than those of denser materials (Table 3). This is particularly true of its modulus of elasticity and coefficient of linear expansion. Much travertine is used as flooring; porosity is not deleterious for this end use as shown by the much higher abrasion resistance of porous Temple Creme compared to Apache Golden Vein with far fewer visible pores.

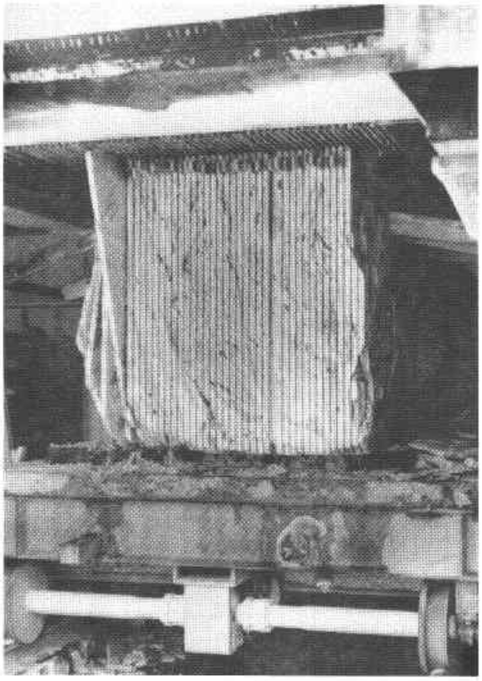


FIGURE 10—Adjustable Gaspari gang saw used to cut stone blocks into slabs. The block was about 4 ft wide before it was slabbed.

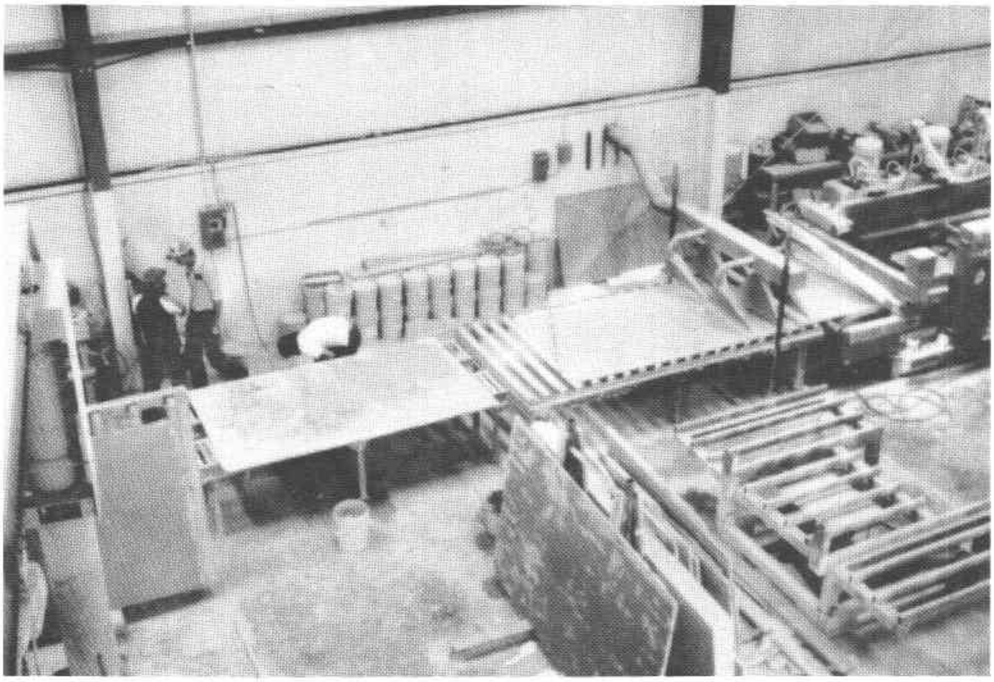


FIGURE 11—Gregori polishing line used to produce highly polished travertine slabs.

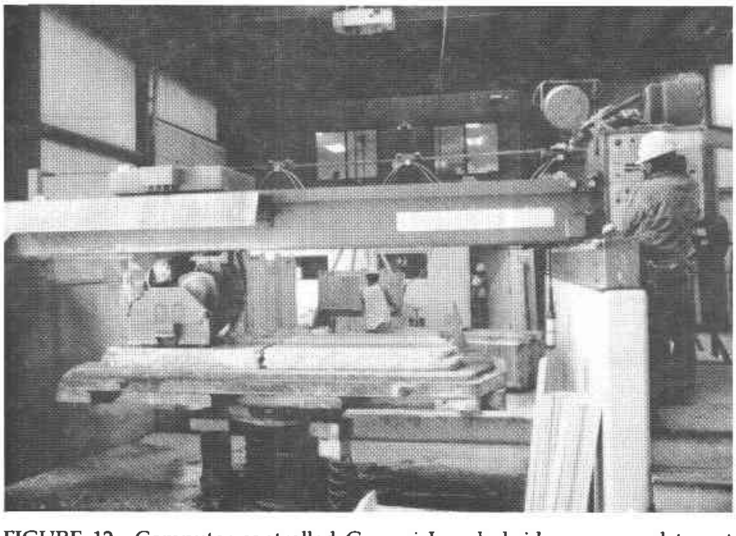


FIGURE 12—Computer-controlled Gregori Impala bridge saw used to cut complex angles and shapes to close tolerances.

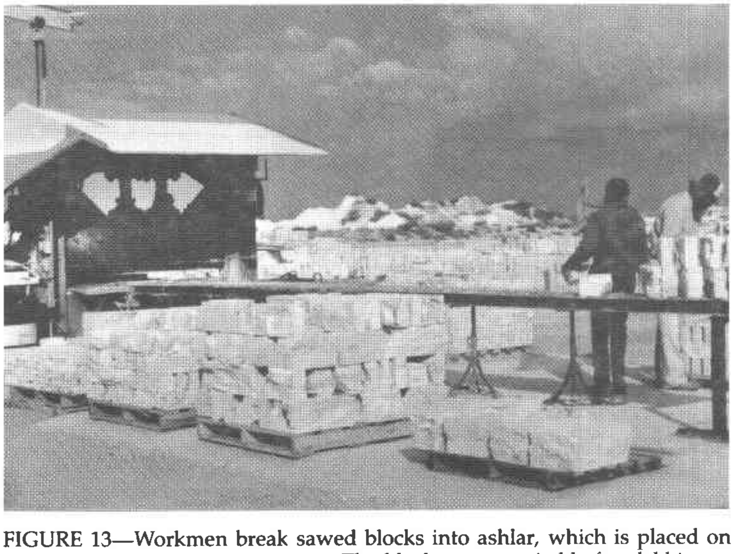


FIGURE 13—Workmen break sawed blocks into ashlar, which is placed on pallets for shipment to customers. The blocks are unsuitable for slabbing.

TABLE 3—Physical test data for NMT Temple Creme travertine reported by Albuquerque Testing Labs [ATL], unless noted as reported by Testwell Craig [TC]. NMT Apache Golden Vein [AGV], concrete, and marble data included for comparison. **a**, North Carolina (NC), Vermont, or Georgia marble; **b**, 0.2 of ultimate compression; —, not available.

Test	Procedure	Temple Creme		Other Materials			Remarks
		Mean Value	Range	Concrete	AGV	Marble[a]	
Compressive strength (psi)	ASTM C170–50	6110	3816 to 7536	2500 to 6000	—	7400 to 11,300	Large voids = 3815 horizontal grain
Shear strength (psi)	Tinius Olsen tester	1102	914 to 1442	1200[b]	—	1600[b]	
Modulus of rupture (psi)	ASTM C99–52	1105	992 to 1133	750 to 900	—	718 to 3133	Horizontal grain eastern marble (NC) 718–3133 ±20% from mean allowed = all pass
Modulus of elasticity	4" cubes in Tinius Olsen tester	0.92×10^6	0.56 to 1.3×10^6	3.5 to 5×10^6	—	7×10^6	Horizontal grain low due to porosity
Specific gravity	ASTM C97–83	2.37	2.37 [ATL] to 2.71 [TC]	2.32	2.48 [TC]	2.69 to 2.74	
Coefficient of linear expansion	heated 8 hours	1.391×10^{-6}	0.9686 to 1.67×10^{-6}	3.2 to 7.8×10^{-6}	—	5.6×10^{-6}	
Absorption	ASTM C97–83	0.92	0.89 to 0.97	—	—	—	sample rejected as >15% below mean
Abrasion resistance	ASTM C241	24.67 [TC]	—	—	11.37 [TC]	—	
Skid resistance	ASTM E303 (dry)	39 [TC]	—	—	—	—	
	(wet)	19 [TC]	—	—	—	—	
Scaling resistance	ASTM C672	0.1% loss	—	—	—	—	50 cycles

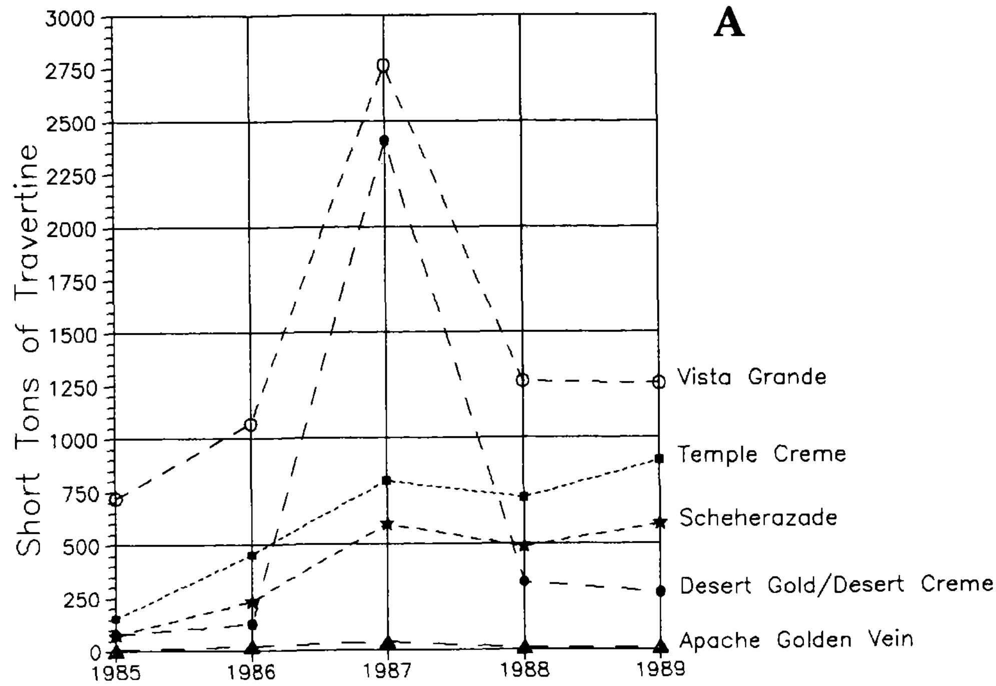
Production by NMT

Production records of NMT for the last five years (Table 4) show sales of six commercial varieties of stone and four types of product: slabs, ashlar, rubble, and crushed stone. Data for Desert Gold and Desert Creme are combined. Crushed travertine production was volatile over the five-year period. Production trends show a general increase in all travertine varieties since start up (Fig. 14A), particularly for Vista Grande, Temple Cream, and Scheherazade. Vista Grande and Desert Gold/Desert Creme were very popular in 1987, principally as crushed stone and rubble respectively (Fig. 14B). Production of slabs (the most expensive travertine product) has risen substantially for all varieties except Vista Grande. Temple Creme slabs are the most popular, but lack of high-quality reserves will limit future sales. The production of rubble has varied widely among the five types of stone used, but Vista Grande is most popular.

Rocky Mountain Stone Company (RMS) markets stone for NMT. Finished travertine is displayed at the RMS stoneyard in Albuquerque on the Pan American Highway (frontage road) west of Interstate 25 and south of the Jefferson exit. Some travertine is shipped to sculptors for carving or to marble shops and dealers primarily for distribution to furniture manufacturers. RMS aggressively markets their products in many parts of the United States and has sold large quantities of stone in such distant states as New Jersey and Washington. RMS travertine products are now beginning to penetrate international stone markets as well. ☞

TABLE 4—Travertine production by New Mexico Travertine. Data in short tons and by commercial name and product.

	1985	1986	1987	1988	1989
Temple Creme					
slabs	5.69	84.38	247.42	134.11	432.94
ashlar	0	0	312.50	313.24	301.12
rubble	124.58	369.60	190.41	246.00	159.71
crushed	23.00	0	47.50	25.40	0
total	153.27	453.98	797.83	718.75	893.77
Scheherazade					
slabs	1.13	7.98	35.39	29.41	46.96
ashlar	0	0	0	124.84	341.23
rubble	64.43	194.48	440.48	205.44	149.05
crushed	8.00	30.00	118.01	126.92	56.80
total	73.55	232.46	593.88	486.61	594.04
Vista Grande					
slabs	16.44	36.64	3.46	4.96	6.26
ashlar	0	0	0	0	10.15
rubble	397.28	302.47	478.29	390.55	494.92
crushed	304.45	730.84	2280.85	872.35	745.77
total	718.17	1069.95	2762.60	1267.86	1257.10
Desert Gold/Desert Creme					
slabs	11.07	25.25	5.00	11.16	60.01
rubble	64.48	102.61	2401.40	308.70	210.50
total	75.55	127.86	2406.40	319.86	270.51
Apache Golden Vein					
slabs	4.48	20.59	39.14	11.25	12.83
TOTAL	1025.03	1904.85	6599.85	2804.34	3028.25



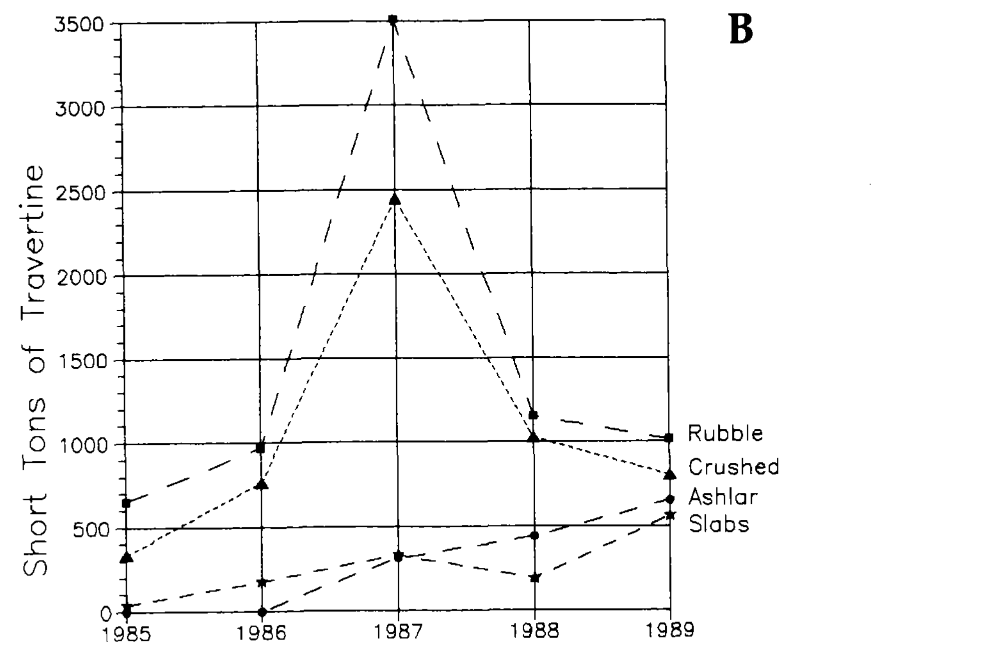


FIGURE 14—Travertine production, in short tons, for 1985–1989 by New Mexico Travertine by commercial name (A) and type of product (B).

The future

Vince Lardner, owner of NMT and RMS, has an interesting opinion about competition; he wants it. Several established travertine operations in New Mexico would help expand his own market by making the state, as well as his companies, better known to architects for dependable grades and quantities of high-quality stone. Lardner cautions that such operations must be well financed, use the latest technology, and be run by competent managers who would actively pursue sales. Without that commitment, they would stand little chance of success.

NMT has large reserves of quality material near Mesa Aparejo and looks forward to many more years of operation. They are developing other travertine deposits in the region. Given the abundance of travertine occurrences in New Mexico, several of very good quality, Lardner may get his wish for competition.

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References

Austin, G. S., Barker, J. M., and Smith, E. W., 1990, Building with stone in northern New Mexico: New Mexico Geological Society, Guidebook to 41st field conference, in press.

Barker, J. M., 1983, Preliminary investigation of the origin of the Riley travertine, Socorro County, New Mexico: New Mexico Geological Society, Guidebook to 34th Field Conference, pp. 269–276.

Barker, J. M., 1986, Travertine: New Mexico Bureau of Mines and Mineral Resources, Open-file Report 229, pp. 94–100.

Barker, J. M., 1988, Travertine quarries and deposits in New Mexico (abs.): New Mexico Geology, v. 10, no. 3, p. 68.

Chafetz, H. S., and Folk, R. L., 1984, Travertine—depositional morphology and the bacterial constructed constituents: Journal of Sedimentary Petrology, v. 54, pp. 289–316.

Cooper, B. N., 1964, Deposits of travertine, onyx, and marble along the east base of Mesa Aparejo, Valencia County, New Mexico: Unpublished report to Ultra Marbles, Inc., Albuquerque, 66 pp.

Fisher, R. A., 1979, A biochemical study of the Recent calcite deposits along the Lucero uplift, Valencia County, New Mexico: Unpublished M.S. thesis, New Mexico Institute of Mining and Technology, 152 pp.

Hammond, C. M., 1987, Geology of the Navajo Gap area between the Ladron Mountains and Mesa Sarca, Socorro County, New Mexico: Unpublished M.S. thesis, New Mexico Institute of Mining and Technology, 212 pp.

Jicha, H. L., Jr., 1956, A deposit of high-calcium lime rock in Valencia County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 36, 5 pp.

Jicha, H. L., Jr., 1958, Geology and mineral resources of Mesa del Oro quadrangle, Socorro and Valencia Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 56, 67 pp.

Julia, R., 1983, Travertines: American Association of Petroleum Geologists, Memoir 33, pp. 64–72.

Kelley, V. C., and Wood, G. H., 1946, Geology of the Lucero uplift, Valencia, Socorro, and Bernalillo Counties, New Mexico: U.S. Geological Survey, Oil and Gas Investigations, Preliminary Map 47, scale 1:63,360.

Kottlowski, F. E., 1965, Limestone and dolomite: New Mexico Bureau of Mines and Mineral Resources, Bulletin 87, pp. 345–353.

Kues, B. S., Lucas, S. G., and Ingersoll, R. V., 1982. Lexicon of Phanerozoic stratigraphic names used in the Albuquerque area: New Mexico Geological Society, Guidebook to 33rd field conference, pp. 125–138.

Myers, D. A., 1973, The upper Paleozoic Madera Group in the Manzano Mountains, New Mexico: U.S. Geological Survey, Bulletin 1372–F, 13 pp.

Power, W. R., 1983, Dimension and cut stone; *in* Lefond, S. J. (ed.), Industrial minerals and rocks: American Institute of Mining, Metallurgical, and Petroleum Engineers, New York, 5th edition, pp. 161–181.

Sanders, J. E., and Friedman, G. M., 1967, Origin and occurrence of limestones; *in* Chilingar, G. V., Bissell, H. J., and Fairbridge, R. W. (eds.), Carbonate rocks, origin and classification: Elsevier, New York, Developments in Sedimentology 9A, pp. 176–177.

Slack, P. B., and Campbell, J. A., 1976, Structural geology of the Rio Puerco fault zone and its relationship to central New Mexico tectonics: New Mexico Geological Society, Special Publication 6, pp. 46–52.

Szypula, A., 1988, Self evaluation of Temple Creme and Apache Golden Vein: unpublished report, Testwell Craig Laboratories, 4 pp.

Titus, F. B., Jr., 1963, Geology and ground-water conditions in eastern Valencia County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Ground-water Report 7, 113 pp. □