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SECOND-DAY ROAD LOG, FROM PHILMONT TO CIMARRON, EAGLE NEST, ELIZABETHTOWN AND ANGEL FIRE

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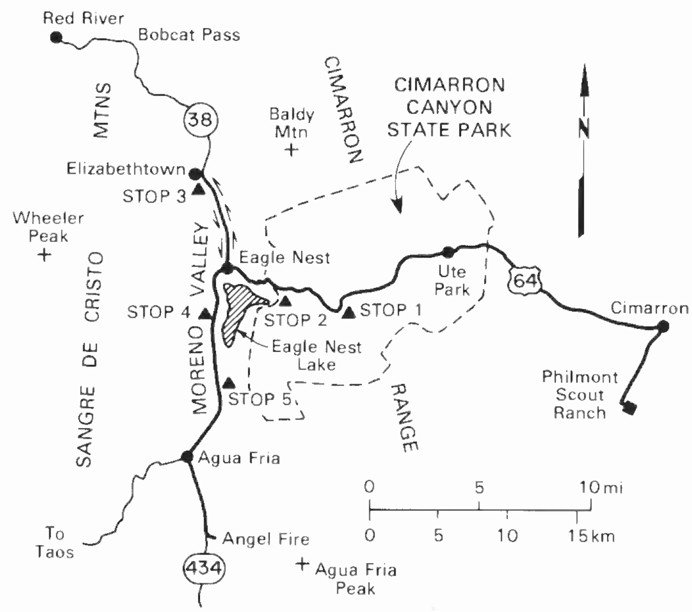
FRIDAY, SEPTEMBER 14, 1990

Assembly point: Parking lot of Philmont Scout Ranch training center, Cimarron, New Mexico.
Departure time: 8:30 a.m.
Distance: 60.5 mi
Stops: 5



SUMMARY

On Day 2, the trip departs from Philmont Scout Ranch and travels north back to Cimarron. At Cimarron we turn west to follow the Cimarron River into Cimarron Canyon, where characteristic slopes and cliffs of the Cretaceous-Tertiary sedimentary section are exposed north of the river. South of the river, extensive Quaternary landslide deposits encircle mesas capped by the Raton Formation. Stop 1 is at the Palisades sill, a Tertiary intrusive body that forms spectacular, vertically columnar-jointed cliffs in Cimarron Canyon. As we continue westward, we cross major high-angle, north- to northwest-trending faults that mark the central mass of the Proterozoic-cored Cimarron Range. At Stop 2, at the western end of Cimarron Canyon near Eagle Nest dam, we examine the 72-year-old dam and discuss Proterozoic tectonics.

As we climb out of Cimarron Canyon we cross a complexly faulted zone that separates the Cimarron Range from the asymmetric Moreno Valley graben. On the western skyline towers Wheeler Peak of the Taos Range, the highest point in the state. From Eagle Nest we drive northward to Stop 3 and lunch at the site of the ghost town of Elizabethtown. There, in the shadow of Baldy Mountain, we discuss the mining history of the district and the potential for undiscovered mineral resources in the area.

Next, we travel south down the axis of the Moreno Valley, an asymmetric graben bounded by rift-related normal faults that cut Laramide thrust faults. At Stop 4, in the central Moreno Valley, we discuss the stratigraphy and large-scale structural geology of the valley and examine Triassic(?) rocks tectonically(?) juxtaposed on Proterozoic crystalline rock along flat-lying thrust faults. The second-day road log ends at the southern end of the Moreno Valley, at Angel Fire ski area, and our lodgings at The Legends Hotel.

Mileage

0.0 Assemble in the Philmont Scout Ranch training center parking lot. **Turn right** onto NM-21, and **proceed north** toward Cimarron. **0.4**

0.4 Philmont Administration area on right. **0.1**

0.5 Crossing over Cimarroncito Creek. **1.2**

1.7 All of the high mesas on the skyline from about 9:30–12:30 are capped by nearly flat-lying Raton and Poison Canyon Formations (Fig. 2.1). The large canyon cutting the mesa at about 11:30 is Ponil Creek, along which a narrow gauge railroad line nearly 20 mi long served the sawmill town of Ponil Park from 1908–1923. At 9:00, the pyramid-shaped peak is Antelope Mesa, a ridge capped by the lower part of the Raton Formation. Behind and slightly to the left of Antelope Mesa is Deer Lake Mesa, capped by sandstones of the Poison Canyon/Raton Formations undivided. The canyon at 9:30 contains Cimarron Creek and the road we will be following to Eagle Nest. **1.4**

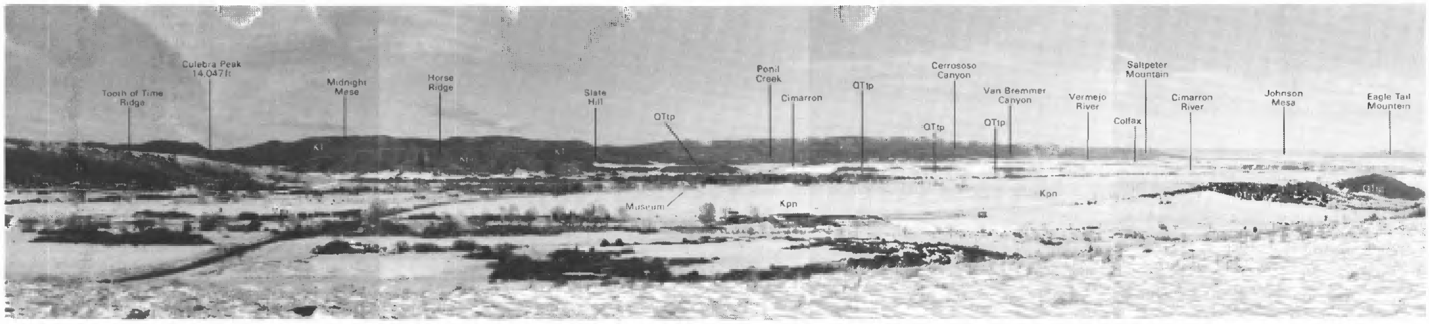


FIGURE 2.1. View north to Cimarron from 3 mi south of Philmont Headquarters. Philmont buildings are in the middle distance. The escarpment in the far distance consists of flat-lying Cretaceous and Tertiary rocks of the Raton basin. Kpn = Pierre Shale and upper part of Niobrara Formation; KT = Trinidad Sandstone, Vermejo Formation, Raton Formation and Poison Canyon Formation; Ti = dacite porphyry of the Cimarron pluton; QTtp = sand and gravel of terrace pediments. Photo by P. W. Bauer.

3.1 At 12:00, the water tank sits on old terrace deposits. **0.5**

3.6 The historic St. James Hotel is on the right. **0.1**

3.7 Crossing over the Cimarron River (Fig. 2.2). **0.3**

4.0 **Intersection** with NM-64 and stop sign. **Turn left** and **proceed west on NM-64. 0.4**

4.4 Village limit. **0.4**

4.8 To the right, at about 2:00, is the Slate Hill section with Pierre Shale exposed in the lower slopes. As we drive past this section, note the prominent cliff of Trinidad Sandstone at midslope above the shale; the Vermejo Formation forms the slope above the Trinidad and is overlain by the basal conglomeratic sandstone of the Raton Formation, which makes a minor ledge in the slope. The Cretaceous portion of the Raton forms the slope above the conglomerates and is capped by the upper cliff-forming sandstones of the Tertiary barren series of the Raton Formation. As we proceed westward up Cimarron Canyon note that the Raton becomes predominantly sandstone as we approach its source area. Large lenses and tongues of sandstone appear lower in the section until the Raton Formation consists entirely of Poison Canyon–like thick arkosic sandstones. **0.6**

FIGURE 2.2. A late summer freshet has swollen the Cimarron River to the point where the Oxford Hotel is in danger, 13 August 1909. A temporary embankment has been thrown up against the upstream side while a string of planks forms a makeshift bridge. Scenes such as this may have been common along the Cimarron River prior to completion of the Eagle Nest dam in 1918, so common that the photographer seems to be more of a curiosity than the floodwaters. Courtesy Museum of New Mexico. Neg. no. 146899.

5.0 From 9:00–10:30 is a view of the northern side of Tooth of Time Ridge. **0.15**

5.15 Milepost 308. Antelope Mesa at 10:30–11:00. Deer Lake Mesa at 11:30. **0.75**

5.9 West end of the Slate Hill section on the right at about 3:00 where the upper part of the Pierre Shale, the Trinidad Sandstone, the Vermejo Formation and the lower coal zone and the sandstone cliffs of the barren zone of the Raton Formation (see Fig. 1.39) are well exposed in a small landslide. At this section, the basal Raton sandstone is a distinctive ledge-forming, white, quartz-pebble conglomerate about 10 ft thick, consisting nearly exclusively of quartz and quartzite pebbles 0.5–1.0 in. in diameter, with minor amounts of chert pebbles. A small waste pile from a coal prospect is visible just above the Trinidad. Cretaceous pollen was recovered from a 6-in.-thick coal bed just below a sandstone bed at the base of the barren zone, indicating that the K-T boundary interval was probably eroded before deposition of the sandstone. Measuring and describing this section constituted one of several geologic problems given to the Apollo astronauts during a geologic training program at Philmont Ranch in 1964. **0.6**

6.5 Excellent exposure of characteristic Upper Cretaceous section of Raton basin at 3:00–4:00 (Fig. 2.3). **1.0**

7.5 Entering Philmont Scout Reservation. **0.1**

FIGURE 2.3. Excellent and characteristic exposure of the Upper Cretaceous strata at the west end of Slate Hill, mile 5.9. Kp = Pierre Shale, Kt = Trinidad Sandstone, Kv = Vermejo Formation, Krlc = basal conglomerate of Raton Formation, Krl = lower coal zone of Raton Formation, Krb = barren zone of Raton Formation. Photo by C. L. Pillmore.

7.6 Turkey Creek Canyon. The thin blocky ledge at 2:00 at midslope is the basal conglomerate of the Raton Formation. The upper massive cliffs are composed of the Tertiary part of the Raton Formation. The Cretaceous/Tertiary boundary lies on the slope beneath the upper cliffs. Mosasaur (marine lizard) and invertebrate fossils from the Pierre Shale in this area have been collected by the New Mexico Museum of Natural History. Highway now begins climb through the Trinidad Sandstone, Vermejo Formation and lower Raton Formation seen on the latter part of Day 1. **0.5**

8.1 Milepost 305. Official Scenic Historic Marker reads:
Cimarron Canyon. You are now at the Great Plains-Rocky Mountain boundary. The Cimarron Range, one of the easternmost ranges of the Sangre de Cristo Mountains in this part of New Mexico. Elevation 6,800 feet.
0.5

8.6 At 12:00, the Raton Formation consists almost entirely of cliff-forming sandstone beds. In this vicinity, the canyon is filled with landslide deposits covering Pierre Shale. **0.3**

8.9 At 1:00, near the road, is a cliff of Trinidad Sandstone; the Vermejo Formation forms the lower slopes above, up to the sandstone cliffs of the Raton Formation. **0.7**

9.6 On the right, the Trinidad Sandstone is near the highway as we proceed up-section. The dark ledge at the top of the Trinidad was commonly thought to be rich in organic material. However, this is an ilmenite/magnetite-rich, black-sand-beach deposit in the marine Trinidad that is high in iron, titanium, vanadium, chromium, manganese, cobalt, zirconium and thorium. **1.0**

10.6 Near the base of the Trinidad Sandstone, at the transition zone from the Pierre Shale into marine sandstone. **0.1**

10.7 Sharp peak at 12:00 on skyline is composed of Poison Canyon Formation surrounded by landslide deposits. **0.6**

11.3 At 3:00, black-weathering Trinidad Sandstone is overlain by relatively sandy Vermejo Formation beneath cliff-forming sandstone bed of the Raton Formation. **0.1**

11.4 Cross over Cimarron Creek. **0.3**

11.7 Recross Cimarron Creek. **0.4**

12.1 Good exposure of Trinidad Sandstone at road level on right. **0.1**

12.2 The Raton conglomerate, the small blocky ledge that we have been following high on the slope, is now at road level. At Bear Canyon, just ahead on right, the Raton Formation consists almost entirely of sandstone. **0.3**

12.5 The rocks exposed in the roadcuts along US-64 in Cimarron Canyon include the Raton and Poison Canyon Formations. The fluvial deposits of the Raton Formation consist of *en echelon* channel sandstones grading laterally into organic-poor floodplain deposits of sandstone, siltstone and mudstone. The channel sandstones consist of point-bar sandstone and siltstone (a succession of lateral accretion and vertical accretion units). The point-bar sandstone is characterized by medium- to large-scale trough crossbeds, and local zones of planar crossbeds and ripple laminations. These characteristics suggest that the channel sandstones were deposited in highly sinuous or meandering streams.

The complex of meandering-stream deposits laterally and vertically grade into elongate to sheetlike sandstone bodies. The sandstone bodies consist of multiscoured bodies, each containing lag conglomerate (pebble- to cobble-size clasts) and showing trough and planar crossbeds. The geometry and succession of conglomeratic bar and channel-fill sequences of the sandstones suggest deposition in braided or high-bedload, low-sinuosity streams. These deposits coarsen westward to conglomerate units that probably represent alluvial fan deposits (Fig. 2.4). The alluvial fan and braided stream deposits represent the major basin-margin depositional systems. However, high-bedload, low-sinuosity streams locally joined with high-sinuosity streams. The increased sediment load in these fluvial systems (e.g., alluvial fan and braided stream) suggests higher stream gradients, resulting from uplift and subsequent erosion of a source area to the west.

The diverse fluvial deposits in this vicinity represent a variety of hydrocarbon reservoirs. The alluvial fan and braided stream deposits are characterized by reservoir-rich and seal-poor units. The meandering fluvial deposits contain moderate amounts of sandstone reservoirs and sealing units. Reservoir continuity is excellent for the alluvial fan and braided stream deposits, in contrast to that of the meandering stream deposits, which are internally heterogeneous and have good permeability. The floodplain facies of the meandering fluvial systems contain insignificant quantities of woody organic deposits, unlike their basinward counterparts, and may not become gas-prone source rocks. However, fluvial reservoirs rely on adjacent depositional systems for oil-prone sources (e.g., truncated marine shales providing a seal and probably a source). **0.2**

12.7 At road level on right is the old railroad grade for the Ute Park extension of the St. Louis, Rocky Mountain and Pacific Railway Co. (Fig. 2.5). Ahead, the grade climbs to above the road level until near Ute Park. **0.2**

12.9 The massive unit in the roadcut resting on dark clays and dark siltstones is the basal conglomerate of the Raton Formation. The conglomerate lies in erosional unconformity on Vermejo. From here on up into Ute Park the basal Raton climbs the slope and then swings up to the right to the upper slopes. The basal contact cuts progressively lower through the Vermejo and Trinidad, until it finally rests on Pierre Shale up the valley only a few miles. **0.1**

13.0 Coal-bearing Vermejo Formation on right contains channel-sandstone bodies. **0.1**

13.1 Small bridge across river to left. **0.1**

13.2 Milepost 300. **0.1**

13.3 Thick sandstone on right just above road level is base of Raton Formation. **0.6**

13.9 Ahead are landslide deposits on both sides of road. **0.3**

14.2 Milepost 299. **0.1**

14.3 Entering **Ute Park.** Entrance to New Mexico State Forestry Headquarters on the right. Ute Park is a broad open valley formed in Cretaceous shales. South of Ute Park and directly ahead to the west, there is a complex sequence of rhyodacite sills intruded into Permian to Cretaceous age strata (Sangre de Cristo Formation to Pierre Shale). To the south (left and straight ahead), Robinson et al. (1964) mapped an intrusive sill com-

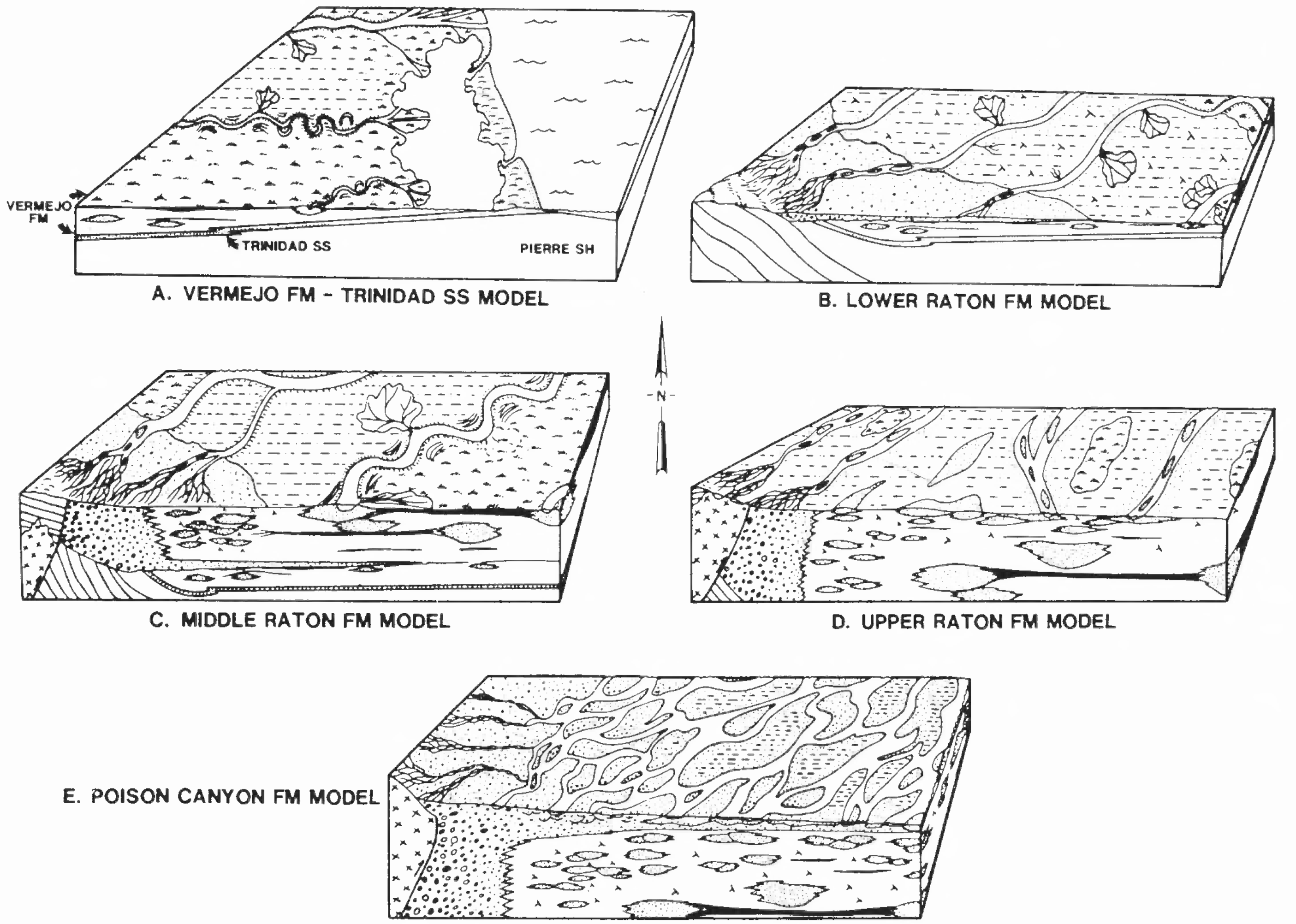


FIGURE 2.4. Evolutionary models of the depositional and tectonic settings of the Raton basin from Late Cretaceous to early Tertiary. Environments of deposition in barred and non-barred coastline (A) were transformed into an alluvial plain that was drained by meandering, anastomosed and braided streams as well as into alluvial fans (B to E). From NMGS Guidebook 38 article by Flores (1987).

FIGURE 2.5. St. Louis, Rocky Mountain & Pacific locomotives 101 and 103 ease away from the water tank at Ute Park on a dreary summer day, 18 June 1911. Despite the inclement weather, the railroad enjoyed an excellent turnout for this excursion as witnessed by the double-headed motive power and at least six passenger cars. Older engine No. 1, relegated to yard and light freight service, sits "in the hole" waiting for the main line to clear. All trains are flying white flags which indicate that they are running "extra"—that is, they are not regularly scheduled trains. Both locomotives were "consolidation" types (2-8-0 wheel arrangement) built by Baldwin in 1906 and eventually sold to the AT&SF railroad. Renumbered 870 and 872, respectively, the former was sold to the Albuquerque & Cerrillos Railroad for service on the Madrid line where it was on display until recently moved to Heritage Park in Santa Fe Springs, California. The 872 made its final run in Albuquerque in 1940. Courtesy of the Museum of New Mexico. Neg. no. 146902.

plex that includes stringers and beds of Upper Cretaceous rocks of the Dakota, Graneros, Greenhorn, Niobrara and Pierre Formations. On the right, at the head of the valley, is Baldy Mountain (12,441 ft), the site of the Aztec gold mine, active during the late 1800's and early 1900's (Fig. 2.6). This was the richest lode mine in the Elizabethtown District, and one of the oldest. It was discovered in 1868, and $1.25–1.5 million of gold (1868 value) was extracted. Gold was mined from conglomerates at the base of the Poison Canyon Formation (the western coarse-grained facies of the Raton Formation), which lies on Pierre Shale. Baldy Mountain is now owned by the Philmont Scout Ranch. The Aztec mine was on the right-hand side of the cirque valley at about 10,500 ft. The town of Baldy was at the head of Ute Creek at the foot of the mountain. Logging roads form the zigzag pattern on the rounded tree-covered slope dead ahead on the skyline. On the mountain ridge between the highway and Baldy Mountain is a rock glacier. **1.0**

15.3 Milepost 298. **0.2**

15.5 Outskirts of Ute Park. **0.2**

15.7 On the right is the entrance to Ute Creek Ranch, and the road to the high country near Baldy. **0.3**

FIGURE 2.6. Aztec mine, Elizabethtown District, Colfax County, New Mexico. Tracing placer gold deposits upstream along Ute Creek led Matthew Lynch to the famed Aztec lode in June of 1868. The bonanza ore of the Aztec was so rich that a primitive 15-stamp mill occasionally yielded $21,000 per *week* in bullion. Of the mine's total production of over $3 million, $1 million was produced during the first four years of operation—that's $250,000 or over 11,000 troy ounces per year. Today that production would be valued at over $4 million per year. The mine was operated in later years by the Maxwell Land Grant Company, but closed permanently in 1940. In this 1905 view by L. C. Graton, the Aztec mill is visible at lower right and some buildings in Baldy Town at center. Note also the 1/4-mile tramway leading from the mine to the mill. L. C. Graton is best known in New Mexico as one of the authors of the 1910 U.S. Geological Survey Professional Paper 68 titled "The Ore Deposits of New Mexico." The Baldy Town area is now owned by the Philmont Scout Ranch. Courtesy of U.S. Geological Survey.

16.0 The ridges to the right and straight ahead are composed of rhyodacite intrusions. The rhyodacite intrudes undifferentiated rocks of the Pierre/Niobrara Formations in various parts of the valley. **0.3**

16.3 Milepost 297. **0.1**

16.4 Sandstone hogback on right is Mesa Rica Sandstone of Dakota Group of Kues and Lucas (1987), Lucas and Kisucky (1988) and Lucas (this guidebook). As discussed in the third-day road log and by Lucas (this guidebook), the late Albian Mesa Rica Sandstone represents most of the Dakota Group in northeastern New Mexico. **0.2**

16.6 **Ute Park Post Office** on left. **0.4**

17.0 Mesa Rica Sandstone on right dips east at 40°, and forms a hogback that crosses the road at about this point. Rhyodacite sills intrude the Mesa Rica and lower Mesozoic rocks above this point in Cimarron Canyon. **0.1**

17.1 Crossing Sawmill Canyon fault which has down-dropped sediments and intrusive complex on the west side. **0.1**

17.2 Bridge over **Cimarron River.** Entering Colin Neblett Wildlife Area and Cimarron Canyon State Park. **0.2**

17.4 Official Scenic Historic Marker on right reads:

Cimarron Canyon State Park. This high mountain park is part of a state wildlife area and is managed by the New Mexico State Park Division in cooperation with the New Mexico Department of Game and Fish. Trout fishing is excellent in the Cimarron River and the park offers fine opportunities for back country hiking and wildlife viewing. The crenellated granite formations known as the Palisades are popular with rock climbers.

0.3

CIMARRON CANYON STATE PARK AND THE COLIN NEBLETT WILDLIFE AREA

Virginia T. McLemore

New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico 87801

Cimarron Canyon State Park occupies Cimarron Canyon along the Cimarron River and US-64. It is part of the Colin Neblett Wildlife Area and extends from Eagle Nest dam eastward to Ute Park (Fig. 2.7), consisting of 33,116 acres of the central Cimarron Range of the southern Sangre de Cristo Mountains. The state park is managed jointly by the New Mexico State Park and Recreation Division and the New Mexico Game and Fish Department which also administers the wildlife area.

Cimarron Canyon has long been a major route through the Cimarron Range connecting the Taos area with the eastern plains. Nomads came to the area hunting mammoths; mammoth bones have been found on the Philmont Ranch to the east (Murphy, 1972). Indians, Spanish explorers and later mountain men, hunters and trappers traveled through Cimarron Canyon. In 1867, miners from Elizabethtown improved the Cimarron Canyon Road, and the first stagecoach lines ran through the canyon between Cimarron and Elizabethtown. The Cimarron Canyon road was a major route between Elizabethtown and Raton and saw a large amount of traffic, which contributed to numerous robberies and other violence. A railroad was built from Cimarron to Ute Park but was never completed through the entire canyon. The road was paved in the 1940's and designated US-64, and soon after electric lines were built through the canyon to Eagle Nest.

The Colin Neblett Wildlife Area was once part of the Beaubien and Miranda Land Grant, granted by the Mexican government to Guadalupe Miranda and Charles Hipolite Troter de Beaubien in 1841. Lucien B. Maxwell inherited part of this land grant and later purchased the rest. He also added additional acreage until the grant, commonly known as the Maxwell Land Grant, grew to the size of about 1.75 million acres of land by 1866 (Pearson, 1961; Keleher, 1984).

In 1870, Maxwell sold the land grant to a European syndicate which organized the Maxwell Land Grant and Railway Company (often simply called The Company). Despite the vast timber, mineral and other natural resources of the land grant, The Company could not make a profit. Different groups of investors gained control over the years, but none profited. The Eagle Nest dam was completed in 1918, forming Eagle Nest Lake and thereby creating a popular summer vacation spot. These last-ditch efforts were not enough and finally in 1929, the Dutch investors began selling off portions of the land grant.

Waite Phillips, a Tulsa oilman, purchased a tract of land to the east of the wildlife area which he called the Philmont Ranch. In 1941, Phillips donated 123,395 acres to the Boy Scouts of America, an area now called the Philmont Boy Scout Ranch (Zimmer, this guidebook).

The Company realized the natural beauty of the Cimarron Canyon

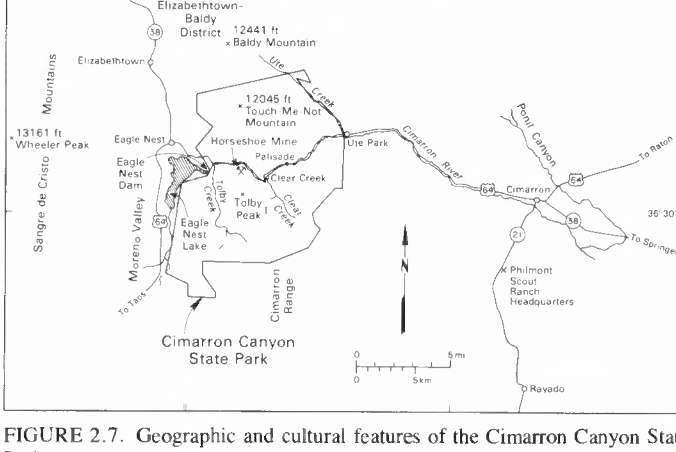


FIGURE 2.7. Geographic and cultural features of the Cimarron Canyon State Park country.

area and sought to protect it from timbering, hunting and real estate development. They hoped to sell the Cimarron Canyon tract to the state or federal government to be used as a game preserve. Finally, in 1949, the New Mexico Game and Fish Department purchased the 33,116-acre Cimarron Canyon tract for $374,532 (New Mexico Department of Game and Fish, Annual Report, July 1, 1987 to June 30, 1988, p. 77).

The Colin Neblett Wildlife Area was originally known as the Cimarron Canyon Wildlife Area. This name was changed in later years to honor Colin Neblett, a Santa Fe judge, sportsman and conservationist who helped form the New Mexico State Game and Fish Commission. Neblett served on the commission in 1936 (Young, 1984).

In 1979, 33,000 acres along the Cimarron River were transferred to the State Park and Recreation Division to form Cimarron Canyon State Park. Activities in the park include trout fishing, hiking, picnicking, camping, rock climbing and in winter, ice skating and ice fishing. Some of the camp sites along the river are accessed by short trails for walk-in camping with tents. Seasonal hunting is allowed in the wildlife area where the clevation ranges from 7400 ft in the canyon to 12,045 ft at Touch-Me-Not Mountain. Deer, elk, bear, antelope, turkey and other wildlife are commonly found throughout the area. Cimarron Canyon State Park is the only state park in New Mexico where the camping and day use fees are waived as long as one member of a group holds a valid New Mexico hunting or fishing license. Facilities include several campground and picnic sites, RV facilities, restrooms and drinking water. In 1988, about 200,000 people utilized these facilities, and thousands of other visitors passed through while traveling on US-64.

The oldest rocks in the wildlife area are Proterozoic metamorphic and igneous rocks (Wobus, 1989). Granite in the area has been dated by Rb-Sr whole-rock methods at about 1500 Ma (Brookins and Leyenberger, 1981; Leyenberger, 1983). Paleozoic and Mesozoic sedimentary rocks overlie the Proterozoic rocks in profound angular unconformity. However, the most spectacular geologic feature of the wildlife area, and one of the most spectacular in all of northern New Mexico, is the Palisades. This line of cliffs is formed by a Tertiary sill that intruded into Paleozoic sediments and Proterozoic rocks about 34 Ma (K-Ar isotopic age on impure biotite separate: Armstrong, 1969). Geologists have called the Palisades rock type monzonite porphyry (Smith and Ray, 1943), biotite-diorite porphyry (Armstrong, 1969), granodiorite porphyry (Goodknight, 1973) and dacite porphyry (Robinson et al., 1964; Cannon, 1976). The rock is best described as either trachydacite (Kish et al., this guidebook) or biotite-diorite porphyry.

17.7 High slopes ahead consist of complex intrusive of dacitic porphyry within layers of Permian through Cretaceous sedimentary rock. Some of these intrusions have the shape of Christmas-tree laccoliths. **0.3**

18.0 Cross to south side of river. Ponderosa Campground on left. **0.1**

18.1 Maverick Campground and Gravel Pits Lakes on right. **0.2**

18.3 Milepost 295. **0.2**

18.5 First glimpse of the Palisades to the right. Columnar jointing is well developed. **0.4**

18.9 Bridge over Cimarron River. Road is now on north side of river. **0.4**

19.3 Milepost 294. **0.1**

19.4 Bridge crosses to south side of river. Palisades picnic area on left. **Turn right** into rest stop on right for **STOP 1.** Official Scenic Historic Marker reads:

Palisades Sill. These spectacular cliffs are cut by the Cimarron River through igneous rock known as a sill and composed of the rock type monzonite which was emplaced some 40 million years ago as these Southern Rocky Mountains were being uplifted. Elevation 8,000 feet.

The Palisades is actually developed in a Tertiary trachydacite porphyry sill (Kish et al., this guidebook). This area was mapped by Smith and Ray (1943). Armstrong (1969) published a K-Ar age from an impure biotite separate of about 35 Ma. Chuck Naser (oral commun., 1989) cites a zircon-fission-track date of about 25 Ma for the sill.

FIGURE 2.8. Spectacular columnar-jointed trachydacite porphyry of the Palisade in Cimarron Canyon near Stop 1. Photo by C. M. Mawer.

THE PALISADES OF CIMARRON CANYON

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Laccoliths may be the most common igneous intrusive body emplaced in the crust of the Earth. Originally described by Gilbert (1877), the world "laccolith" is from the Greek meaning "stone cistern" (Corry, 1988). They are forcible intrusions that are initially enclosed by bounding planar surfaces such as bedding planes or shear zones, except for their narrow basal feeder dike(s), though locally the intrusion boundaries can transect these surfaces. Though the intrusions remain essentially parallel to the Earth's surface, the floors of large laccoliths (e.g., the Bushveld intrusion, the Duluth gabbro) may sag as the body grows. The bodies tend to be circular or elliptical in plan view after uplift and erosion. There is a complete size gradation between sills and laccoliths at the small scale, and between laccoliths and batholiths at the large scale. It has recently been proposed (Mawer, 1990; Clemens and Mawer, unpubl., 1990) that the mechanisms of intrusion of laccoliths and many batholithic-sized granitoid bodies are identical.

The Palisades of Cimarron Canyon is developed in part of a Tertiry laccolith complex (Robinson et al., 1964). The laccolithic body here has apparently intruded along the unconformity separating Proterozoic rocks from Pennsylvanian-Permian and younger strata. At this locality, the laccolith is composed dominantly of porphyritic trachydacite (Kish et al., this guidebook), and is dated at 34.7 Ma on a very impure biotite separate (Armstrong, 1969, corrected using decay constants of Steiger and Jäger, 1977). Similar laccoliths form many of the resistant ridges in the area, such as the Tooth of Time Ridge west of the Philmont Scout Ranch headquarters. The porphyritic trachydacite, even though heavily columnar-jointed, is resistant to erosion.

The Palisades (from the French *palisser,* "to enclose with pales or stakes") is formed by pervasive, planar and continuous columnar jointing (Fig. 2.9). The penetrative character and planarity of the jointing attests to the lithological homogeneity of the trachydacite at this location. Columnar jointing is due to thermal contraction of crystallized magma, which has cooled rapidly near or at the Earth's surface. The joints form essentially perpendicular to the intrusion boundaries as the body cools, due to tensile stresses developed parallel to inward-migrating isotherms. Thus, early columnar joint patterns developed close to the intrusion's periphery should faithfully record the intrusion's external shape, whereas those developed later in the body's center may not. That the columnar jointing in the Palisades is vertical and extremely regular indicates that the laccolith in this area approximates closely to a sill-like form, with essentially planar and parallel top and bottom contacts.

The laccolith complex in which the Palisades is developed is cut by several north-south- to northwest-southeast-trending faults. These commonly show normal-sense offset and are interpreted as Tertiary in age, but at least one of these structures (the Fowler Pass fault) is interpreted to have both Proterozoic strike-slip (Grambling and Dallmeyer, this guidebook) and Laramide reverse (Robinson et al., 1964) movement along it. Furthermore, the Fowler Pass fault seems to have functioned as one of the feeder channels for the laccolith complex, implying Tertiary normal movement during crustal extension (Robinson et al., 1964). Normal faults acting as magma channels seem to be common features in areas of laccolith development (Hutton et al., 1989; Clemens and Mawer, unpubl., 1990).

An aside: The mania for coining new names where existing ones would suffice provoked a classic geological definition. Hunt et al. (1953, p. 151) defined a variety of laccolith, the cactolith, as "a quasi-horizontal chonolith composed of anastomosing ductoliths whose distal ends curl like a harpolith, thin like a sphenolith, or bulge discordantly like an akmolith or ethmolith." Hunt and his co-workers were kidding. Probably!?

See accompanying paper on the Cimarron pluton (Kish et al., this guidebook) for more detailed information on the igneous rocks in this area. **Continue westward** on the highway. **0.4**

19.8 Cross to north of river; pass into sequence of Proterozoic metamorphic rocks. Wobus (1989) and Grambling and Dallmeyer (this guidebook) described the Proterozoic geology of the Cimarron Range. In brief, the Proterozoic rocks define three distinct tectonometamorphic blocks. The easternmost block, exposed here and named the Cimarron River tectonic block, contains mafic and felsic supracrustal rocks together with a variety of plutons. Except in narrow contact aureoles around the plutons, the supracrustal rocks record metamorphism in the greenschist facies. The Fowler Pass fault, exposed upriver in Cimarron Canyon, is a northwest-trending Proterozoic right-slip ductile shear zone that separates the greenschist-facies rocks of the Cimarron River block from granulite-facies rocks to the southwest. A granulite-grade crustal block, the Eagle Nest tectonic block, preserves peak metamorphic conditions of 750–850°C, 7.5–8.5 kb, and is overprinted by retrograde metamorphism on a P-T path of simultaneous cooling and decompression, toward 550°C, 4 kb. A folded but approximately horizontal ductile shear zone separates underlying granulites from overlying amphibolite-facies rocks near Tolby Meadow. The rocks at Tolby Meadow define the Tolby Meadow tectonic block with peak P-T conditions near 520°C, 4 kb. **0.2**

20.0 Large outcrop of dark rock to the right of the road beneath the sill is Precambrian metagabbro, intrusive into the Cimarron River tectonic block. **0.2**

20.2 Ahead along the road are scattered outcrops of Precambrian metadiorite, also intrusive into the Cimarron River tectonic block. **0.1**

20.3 Milepost 293. **0.7**

21.0 Roadcut into Precambrian rock on right. **0.2**

21.2 Cross to north of river. Approximate site of old Clear Creek store. A large Precambrian granodiorite pluton cut by diabase dikes crops out throughout an area of about 5 km^2. The pluton contains large, ovoid, recrystallized quartz megacrysts in a matrix of quartz-plagioclase-K-feldspar. It intrudes the Cimarron River tectonic block and preserves a narrow (50 m) contact-metamorphic aureole in which mafic rocks attained the lower amphibolite facies. In this area, high on the hillside, a rhyodacite sill irregularly intrudes the low-angle reverse fault between the Chinle Formation and Precambrian rocks. **0.2**

21.4 **Hairpin turn right.** Cross river to south. **0.3**

21.7 Day-use park area on right. Outcrops of Precambrian rock above on the right. For a couple of miles along this stretch, Precambrian rocks consist of a bimodal metavolcanic sequence of the Cimarron River tectonic block, greenschists and chlorite schists interlayered with feldspathic metavolcanic rocks. Some of the feldspathic metavolcanic units show pyroclastic welded fabric with relict eutaxitic texture and contain doubly terminated euhedral quartz phenocrysts up to 1 cm long. **0.6**

22.3 Road crosses to north side of river. **0.1**

22.4 Milepost 291. **0.05**

22.45 Road crosses to south side of river. **0.15**

22.6 Road crosses to north side of river. **0.2**

22.8 Road crosses to south side of river. **0.1**

22.9 Road crosses to north side of river. **0.2**

23.1 Day-use park area on left. Roadcut in Quaternary colluvium on right. **0.1**

23.2 The Horseshoe mine is located in the roadcut on the left. This mine was probably a gold prospect as there are many deformed quartz and carbonate veins in low-grade sheared mafic phyllites here. **0.1**

23.3 Road crosses to south side of river. **0.1**

23.4 Milepost 290. **0.3**

23.7 Precambrian outcrops in cliffs to right. **0.2**

23.9 Approximate position of Fowler Pass fault, which separates greenschist-facies rocks of the Cimarron River tectonic block from granulite-facies quartzite, mafic gneiss and felsic gneiss of the Eagle Nest tectonic block. The Fowler Pass fault also shows brittle deformation, and was therefore probably reactivated during Laramide and/or Rio Grande rift times. Preliminary $^{40}Ar/^{39}Ar$ geochronology suggests that this fault may record Grenville movement, dated at 1100–1295 Ma (see Grambling and Dallmeyer, this guidebook). **0.5**

24.4 Milepost 289. **0.3**

24.7 **Turn right and park** in paved lot at south end of Tolby campground for **STOP 2.** This stop involves an easy walk along a dirt road for about 0.5 mi to Eagle Nest dam. The purpose of the stop is to examine the Eagle Nest dam and discuss the local Proterozoic geology. **Cross the highway and walk west** past the dirt road along Tolby Creek, across the Cimarron River, and **turn left** into the gated driveway that leads to the large house. NOTE: **THIS IS PRIVATE PROPERTY** AND PERMISSION MUST BE GAINED FROM THE CS CATTLE COMPANY BEFORE ENTERING. When on this land, please respect the privacy of the owners. The following four entries are a walking log from the front gate to Eagle Nest dam.

0.0 Just inside the gate, on the right, is an outcrop of Proterozoic felsic gneiss of the Eagle Nest tectonic block (see Grambling and Dallmeyer, this guidebook). The gneiss contains deformed fine-grained pegmatites and melt-filled extensional features. **0.2**

0.2 Small rock-wall dam to right of road. **0.05**

0.25 Road passes through the center of a small group of white cabins. **0.15**

0.4 End of track under dam. Bluffs to either side are highly deformed, variably foliated Proterozoic granitic gneisses of the Eagle Nest tectonic block. Foliation dips moderately southwestward. Numerous kinematic indicators show that south-side-up ductile shearing has affected the gneisses. There are many deformed thin pegmatite dikes and quartz veins in the rocks, which are strongly retrogressed in places (see Grambling and Dallmeyer, this guidebook).

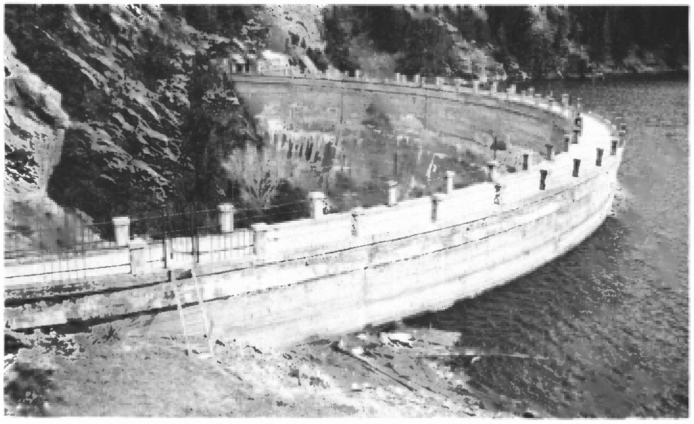

FIGURE 2.9. Eagle Nest dam, April 1990. The abutments are sealed today as soundly as they were 72 years ago. This concrete dam, perhaps the largest privately owned dam in the U.S., is 140 ft high, 400 ft long and 9.5 ft wide at the walkway. The dam is owned and operated by the CS Cattle Company of Cimarron. Photo by C. K. Mawer.

EAGLE NEST DAM AND RESERVOIR

Orin J. Anderson

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Eagle Nest dam is located approximately 2.5 mi southeast of the village of Eagle Nest (Colfax Co.) at the headwaters of the Cimarron River, a tributary of the Canadian River, with its confluence about 50 mi downstream. The idea for a dam at this locality came from Frank and Charles Springer of Cimarron. The Springer brothers, being from Iowa, undoubtedly had in mind a dam that would provide some flood control and a dependable water supply for the downstream farming. In the 1920's, the brothers considered the project a failure. Today, however, the dam is considered a great success. In addition to the obvious recreational benefits, the dam is currently used for water storage for local irrigation projects, as a municipal water supply for the city of Springer, 43 mi downstream, and as an alternate source for the city of Raton which constructed a 42 mi, 14-inch-diameter water pipeline from Cimarron to Raton in 1985. The dam is unsuitable for hydroelectric production because of the highly variable annual run-off.

Completed in June 1918 (Fig. 2.9), with Springer's financial backing and under the design and direction of Bartlett and Ranney Inc., Consulting Engineers of San Antonio, Texas, the dam is a concrete arch structure that rises 140 ft above the creek bed. At the crest, at approximately 8200 ft elev., the dam is 400 ft long and 9.5 ft wide. Its width at footing level is 45.2 ft. The upstream face of the dam is vertical. The ends abut into Precambrian gneisses; the abutments have remained sound and well sealed for 72 years, a credit to the design engineers who were working without federal guidelines. Water release is controlled through outlet works at the right abutment. An ungated spillway 40 ft in width is cut in bedrock at the left abutment with a crest elevation 7 ft below the top of the dam.

Storage capacity at spillway-crest-elevation of 78,800 acre-ft. At this stage, the reservoir surface area is 2825 acres, with maximum depth at the old channel thalweg being about 90 ft. This maximum storage capacity was reached only once, during the wet years of 1941–42. The drainage area for the dam is 182 mi^2. Annual release from the reservoir is variable; the maximum recorded release of 29,430 acre-ft of water occurred in 1963.

For those interested in sport fishing, the reservoir is stocked with rainbow trout, cutthroat trout and kokanee salmon. The reservoir normally freezes over about mid-December and remains so until late March. Ice thicknesses may reach 2.5–3.0 ft, though fishing continues through the ice for those who wish to brave the cold. More than 47,000 fisherman visits were estimated by State Game and Fish Department officials in 1988.

The dam is owned and operated by CS Cattle Company of Cimarron, which was incorporated in 1915 as the Charles Springer Cattle Company. The dam is listed on the National Dam inventory as a "high-hazard dam," meaning that the potential for loss of life and damage to property is high in the event of a dam failure. The U.S. Army Corps of Engineers (Albuquerque District) has delegated the responsibility for periodic inspection of privately owned dams in the state to the New Mexico State Engineer's Office. High-hazard dams get an annual visual inspection. (Much of the above information was provided by the State Engineer's Office in Santa Fe and Les Davis of the CS Cattle Company, Cimarron.)

The dirt road that follows Tolby Creek southward, upstream from its confluence with the Cimarron River, is part of the Colin Neblett Wildlife Area. It offers direct access to granulite facies Proterozic rocks and a tectonic boundary separating the granulites from overlying lower amphibolite facies quartzites. The tectonic boundary is a folded subhorizontal ductile shear zone that preserves top-to-the-southeast shear indicators (see Grambling and Dallmeyer, this guidebook, figs. 1, 2). Granulites beneath the shear zone define the Eagle Nest tectonic block, which crops out along Tolby Creek from its mouth to 9000 ft elevation and then reappears farther upstream at elevations above 9500 ft. The block of crust that overlies the shear zone crops out between 9000 ft and 9500 ft in Tolby Meadow and has been named the Tolby Meadow tectonic block.

The Eagle Nest tectonic block contains quartzofeldspathic gneiss along with minor mafic gneiss, quartzite and a tectonized granitic pluton. Much of the quartzofeldspathic gneiss shows alternating layers rich in plagioclase, K-feldspar or quartz, with accessory FeTi oxide minerals; layering may represent primary bedding. Migmatites, apparently produced by in-situ partial melting, are sparsely distributed throughout these rocks. Some layers have semipelitic and pelitic compositions. The former contain sillimanite-K-feldspar-plagioclase-quartz-ilmenite, whereas the latter have sillimanite-garnet-biotite-spinel-plagioclase-quartz-ilmenite ± K-feldspar. The spinel is green in plane-polarized light; electron microprobe analyses show it to be a solid solution between $FeAl_2O_4$ and $ZnAl_2O_4$. Peak metamorphic conditions of these rocks were 750–860°C, 7.5–8.5 kb, but the rocks were highly deformed along a retrograde P-T path that records simultaneous cooling and decompression from peak conditions to 500–550°C, 4 kb.

The Tolby Meadow tectonic block, which overlies the granulite facies gneisses, consists largely of quartzite with rare aluminous layers. Mineral assemblages indicate a metamorphic grade of 500–530°C, 3.5–4.5 kb, and this metamorphism was syntectonic to emplacement of these rocks atop the underlying quartzofeldspathic granulites. Excellent exposures of the shear zone that separates the two tectonic blocks can be found in the cliffs flanking Tolby Creek immediately below Tolby Meadow.

Sillimanite is aligned in the extension direction in both tectonic blocks, requiring that they were deformed and presumably juxtaposed at temperatures above 500°C. The peak metamorphic pressure difference between the two tectonic blocks shows that 10–15 km of crust were cut out along the shear zone; retrograde P-T conditions of the Eagle Nest block are the same as the peak conditions of the overlying Tolby Meadow block. The shear zone may represent a mid-crustal extensional fault separating an actively extending and cooling lower crust from an upper crust that was heating at constant pressure while moving southeast across the underlying rocks. A hornblende $^{40}Ar/^{39}Ar$ isotopic age of 1400 Ma may record the time when the shear zone was active. **Return to Tolby campground and continue drive westward on highway. 0.1**

24.8 Last bridge across the Cimarron River. Leaving Cimarron Canyon State Park. **0.1**

24.9 Road on left leads to Eagle Nest dam. The house and access road to the dam are privately owned by the CS Cattle Company. Dam is visible from just ahead (Fig. 2.11). **0.5**

25.4 Milepost 288. **0.1**

25.5 At bend in road, deformed Bridge Creek Member of Greenhorn Formation crops out on right (Fig. 2.10). It contains several, thin bentonites and fossils of the characteristic Bridge Creek inoceramid *Mytiloides mytiloides*. The sedimentary rocks here are folded. The shales are somewhat baked, and there are rhyolitic dikes on the west side of the horseshoe bend that intruded along faults in the shales. **0.1**

FIGURE 2.10. The Bridge Creek Member of the Greenhorn Formation is folded and intruded by rhyolite dikes (light-colored rocks in left of photo) at mile 25.5. View northward. Photo by C. K. Mawer.

25.6 Entrance to Eagle Nest Reintegration Center on right. White quartz porphyry is intruded into Cretaceous shale. **0.2**

25.8 Top of McElvoy Hill. Ahead is Moreno Valley and Eagle Nest Lake (Figs. 2.11, 2.12). The Moreno Valley is an extremely complex asymmetric graben with the eastern side downdropped along late Tertiary normal faults. The valley is partially filled with Quaternary sediments. On the skyline, due west, is Wheeler Peak, highest point in New Mexico at 13,161 ft, and part of the Taos Range. Wheeler Peak is composed of Early Proterozoic granitic and supracrustal rocks. South of Wheeler Peak, Pennsylvanian strata overlie Proterozoic rocks. At 3:00 is Baldy Mountain, and at 4:00 is Touch-Me-Not Mountain (elev. 12,044 ft). On the northeastern edge of the lake, near the dam, is a poorly exposed Mesozoic section of Triassic red beds overlain by Jurassic Entrada Sandstone and Cretaceous Pierre Shale (Wanek and Read, 1956, p. 92; Clark and Read, 1972, pl. 1). When Eagle Nest Lake is full, the water elevation is 8218 ft. Annual precipitation in the valley averages 17.5 in. **0.3**

26.1 Roadcut in alluvial deposits on right. **0.3**

26.4 Old Eagle Nest Lodge on left. **0.9**

27.3 Entering Eagle Nest, gateway to the Enchanted Circle. The resort town of Eagle Nest (elev. 8220 ft), originally named Therma (Greek for "hot"), was established in 1920. In 1935 the name was changed to Eagle Nest in honor of the golden eagles that inhabit the nearby mountains.

At 2:30 is the canyon of Willow Creek, where gold was originally discovered in 1866. The rounded mountain at 12:00 in the near distance is Scully Mountain. The ghost town of Elizabethtown sits just to the right of Scully Mountain. **0.7**

28.0 **Junction** with NM-38. **Turn right** onto NM-38 toward Red River. Official Scenic Historic Marker reads:

> Elizabethtown. The discovery of gold on Baldy Mountain in 1866 brought such a rush of fortune-seekers to the Moreno Valley that "E'town" became a roaring mining camp almost overnight. Because of water and transportation problems, and a decline in ore quality, it had become virtually a ghost town by 1875.

0.4

28.4 Crossing Willow Creek, which is not a very impressive drainage here. **0.9**

29.3 Gravel pit on right in alluvial fan gravels. **0.2**

29.5 Milepost 28. At 3:00 is Touch-Me-Not Mountain. At 8:30, forested slopes on west side of Moreno Valley are Pennsylvanian arkosic limestone, feldspathic sandstone and shale at least 5000 ft thick. At 9:30 is Comanche Creek, eroded into the Comanche Creek transverse fault (see Colpitts and Smith, this guidebook). **0.3**

29.8 To the right is mainly rhyodacite intruding Cretaceous rocks of the Pierre-Niobrara. The hill at about 1:00–2:00 is composed predominantly of Cretaceous shale. To the left, the rounded knoll is Scully Mountain composed of quartz diorite porphyry capped by Dakota Group. The general stratigraphic sequence here is right-side-up. Dakota rocks dip back under the younger rocks of the Pierre-Niobrara sequence. A short distance to the west of Scully Mountain, Mesozoic rocks are folded and overturned beneath the Sixmile thrust. **0.15**

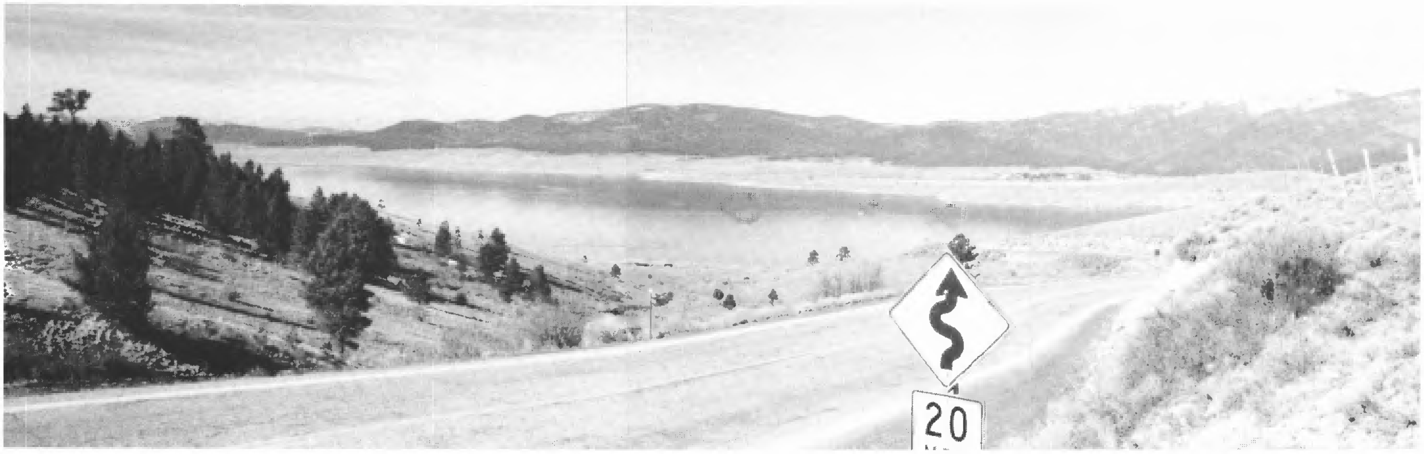

FIGURE 2.11. Vista from McElvoy Hill; view southwest to west. Eagle Nest Lake in middle distance. Sangre de Cristo Mountains on skyline. Wheeler Peak and surrounding peaks are snow capped on far right. Photo by R. M. Colpitts, Jr.

29.95 County Road B22 on left. **0.8**

30.75 Rock exposed in cliffs in valley to left is Tertiary quartz diorite porphyry. The relatively resistant diorite intrusive forms a knickpoint in the profile of south-flowing Moreno Creek. Compare the entrenched stream bed south of Scully Mountain with the ground level stream bed immediately north of the knickpoint. **0.25**

31.0 At 3:00, just below the trees part way up the slope, are old mine dumps and a chute of the Iron Mountain prospects. Upper Cretaceous shales (part of Smoky Hill Marl and Pierre Formation) are intruded by quartz diorite porphyry sills. Prospects are in local auriferous contact-pyrometasomatic iron deposits (mainly magnetite and hematite) along contact between monzonite sills and shale. **0.3**

31.3 Roadcut in quartz diorite porphyry sill. Good view of meandering Moreno Creek to the left. **0.2**

31.5 Milepost 26. **0.2**

31.7 The small outcrop of the Fort Hays Limestone Member of the Niobrara Formation on the right (Fig. 2.13) was mapped by Clark and Read (1972, pl. 1). It is mostly olive-gray to light olive-gray, fossiliferous limestone. A characteristic Fort Hays inoceramid collected at this outcrop is *Inoceramus* aff. *I. labiatoidiformis* (Fig. 2.14) *sensu* Scott et al. (1986). The Fort Hays Limestone is of late Turonian age in the Raton basin and is as much as 7 m of ledge-forming gray limestones and interbedded gray, calcareous shales. Deposition of the Fort Hays during transgression of the Niobrara cyclothem (Kauffman, 1969) much resembled that of the earlier Greenhorn Formation, especially its Bridge Creek Member. Rhythmically bedded limestones and shales of the Fort Hays reflect orbitally forced climatic variations (Laferriere, 1987).

Roadcuts ahead on right expose diorite porphyry sill that has intruded Upper Cretaceous gray limestone of the Fort Hays Member. On the left are gravels in Moreno Creek which were dredged for gold in the late 1800's. **0.1**

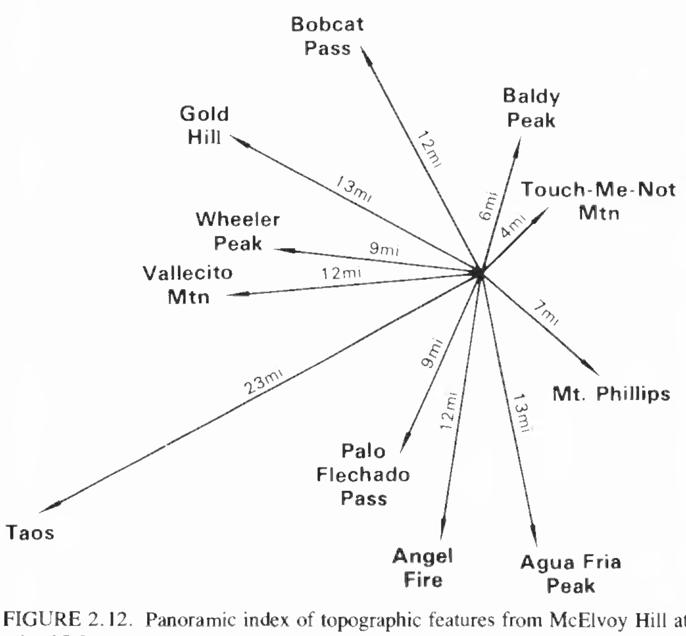

FIGURE 2.12. Panoramic index of topographic features from McElvoy Hill at mile 25.8.

31.8 In Moreno Valley to left are old piles of placer gravels, now revegetated. **0.3**

32.1 County Road B24 on left. **0.2**

32.3 Cross Grouse Gulch, one of the most productive placer

FIGURE 2.13. Typical gray, fossiliferous and rhythmically bedded limestone of the Upper Cretaceous Fort Hays Limestone Member of the Niobrara Formation at mile 31.7. Rock hammer for scale. Photo by S. G. Lucas.

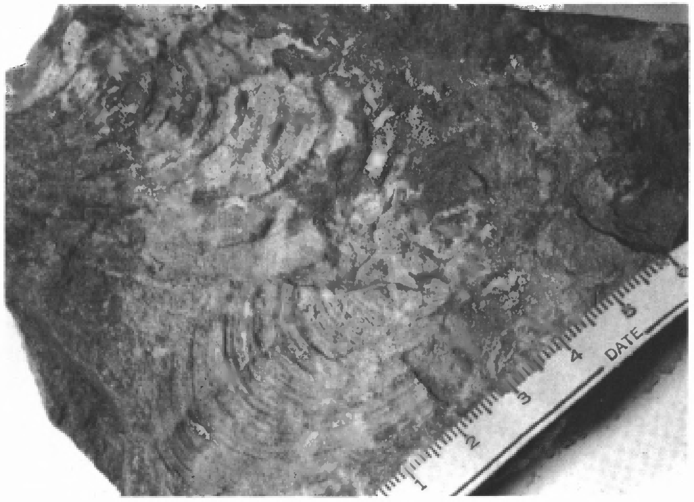

FIGURE 2.14. Fossils of a characteristic Fort Hays inoceramid clam—*Inoceramus* aff. *I. labiatodoidiformis*—collected at mile 31.7. Scale is in cm. Photo by S. G. Lucas.

gulches in the district. Gravel mounds on both sides of road are remnants of placer mining. Outcrops upgulch are of Tertiary quartz diorite porphyry. **0.2**

32.5 Milepost 25. **0.1**

A FALSE ALARM IN ELIZABETHTOWN

The construction industry in general, and placer mining in particular, have in the course of time developed a code of steam whistle signals, which have become general and universally recognized. One long + one short blast = start work; two long + one short = shut down; three long = water wanted, start the pumps; four long = Boss Call, break down or accident; five long = Fire! Everyone turn out to fight fire!

Where no steam plant is in operation, the signal is given by firing rifle or revolver shots in rapid succession. The giving of a false alarm, especially for fire, is punishable by immediate discharge from the employ of the company.

Such an incident, where the guilty parties avoided just punishment, happened at the workings of the Moreno Valley Gold and Gravel Company at their camp on Six Mile Creek, a mile or so northwest of Elizabethtown in western Colfax County, in the fall of 1890. E'town had passed the boom days of the '70's but there was still considerable placer mining on the creeks in the Moreno Valley. The miners spent most of their money and idle time in the saloons and other resorts of the village.

Late in the fall of 1890, nights began to get pretty cold at the camp of the company, so the superintendent, E. L. Hall, put on a night foreman, George Kelly, to keep up steam and keep the pumps from freezing. One cold night, Kelly and George Johnson (the night watchman at the sluice) got tired of just sitting around the fire room and crawled up on top of the boilers to sleep.

Along toward morning, when the fire had burned down and the fire room cooled down to about the outside temperature, they both woke up.

Said George, "Say, Ed, is the fire all out? Have we any steam left?"

"How the hell do I know?"

"Well, try the whistle and find out."

Johnson jumped to the floor, grabbed the whistle cord, and pulled down for one long blast, and then, excited by his success, blew four more long ones, making five long ones, the universal fire alarm.

They could see a dozen lights come to life in the camp and several in the neighboring village of E'town. Realizing his mistake Johnson said:

"Now we've done it! What the hell will we do?"

Said Kelly, "Begorra, I know, we'll both go out looking for the fire! You go up the creek and I'll go down toward camp, if you meet anybody ask them where the fire is."

So they separated and left before the arrival of a rush of rudely awakened miners.

They kept off the trails, circled around and returned to the pump house. They found the superintendent and a bunch of miners, mostly half dressed and packing guns of every description.

They began asking, "Where is the fire?" "Who blew the alarm," and so on.

The miners began asking one another, "Did you hear the alarm, Mr. Hall?"

"No," said the superintendent, "but Mr. Carrington (the bookkeeper) told me he heard it."

And so on with everyone, including the two guilty birds, swearing that they had not heard the alarm. Finally, they found a Spanish-American boy, Pedro Archuleta, who admitted that he had heard the alarm.

"You're the only one that heard it! You must be the hombre who blew the whistle, and you deserve a good swift kick." Which they proceeded to give him, and then they started back to camp, grumbling with disgust over their broken rest.

The two guilty rascals squared their consciences by buying the poor boy all the whiskey he could drink the next time they met him in E'town, and so the incident passed into history.

Personal experience of Harry E. Anderson of Raton, as related to James A. Burns, WPA, July 1936. Courtesy of New Mexico State Records Center and Archives.

A SELF-MADE REPUTATION

In all countries, and especially in frontier districts, the seriousness of crime, and the punishment due for law violation, is generally measured by way of the living and working of the people in the community.

In the East, the stealing of a farmer's horse was only a little above petty larceny, just a little more serious than chicken stealing. In the old West, among the cattlemen, it became the one unpardonable sin, punishable by death by hanging if caught. Not so much for the value of the horse, or even the forty dollar saddle on the ten dollar horse, but because the loss of a horse, miles from nowhere, put the cowboy in danger of death from starvation, and more particularly thirst, before reaching a habitation.

Among the gold miners, especially the placer miners, the most detested crime, and warranting immediate death if caught in the act, was the stealing of amalgam (quicksilver and gold) from the riffles in the sluice boxes. These were of necessity left exposed in the open until the regular weekly or monthly cleanup, when the amalgam was gathered from the riffles, retorted, the quicksilver returned to the riffles, and the gold, the miners' harvest, shipped to the mint.

Where the placer workings were located near small mining towns, far from law and order, it became necessary to employ watchmen, usually trusted employees, deputized by the sheriff to patrol the line of sluice boxes from dark until daylight. With some of those quick-triggered watchmen, it was dangerous for anyone, even superintendents or owners, to approach the line of sluice boxes during the night. Many of those deputies worked on the theory "shoot first and investigate afterward."

How a young miner took advantage of this situation by an act of shrewdness through apparent dumbness was related to the writer as follows:

In 1889, E. H. Johnson, then a young man, was night watchman for the Moreno Valley Gold and Gravel Company at their placer workings on Six Mile Creek, north of Elizabethtown. The president of the company, Mr. Bloomer, had come up to watch the cleanup but they had not finished by quitting time, leaving about $4000 worth of amalgam on the riffles with about 4 inches of water running through the sluice boxes.

The superintendent, E. L. Hall, had given Johnson orders to arrest anyone coming near the sluice boxes. So, buckling a six gun on his hip and calling his dog, who was a better watchman than he himself, he started making his rounds up and down the line. About 11 o'clock, as a late moon rose, his dog gave a growl. Looking down the creek bed he saw Mr. Bloomer, the president, who had a habit of taking a stroll before bedtime, slowly making his way along the line of sluices.

So he let Mr. Bloomer approach a little closer, then he shouted, "Grab for the stars! Pronto!" Mr. Bloomer, startled, came to a sudden stop and saw himself covered by an old style Colt .45. He exclaimed "Don't shoot, Johnson, it is me, Mr. Bloomer, don't you know me?"

"I don't know anybody this time of night. You're under arrest, march."

"My God, man, what are you going to do?"

"I'm going to put you where my dog won't bite you."

So Johnson marched the president ahead of him to the camp office, a sturdily built log building, opened the door, shoved Mr. Bloomer in, and locked the door with both the key and the padlock used whenever the camp was temporarily abandoned.

Johnson whistled to the dog. "Come on, Perro, let's get back to work" and started back up the gulch until out of earshot of the curses erupting from the office.

He and the faithful dog resumed their lonely patrol of the sluice boxes without further incident until daylight released them from their watch.

Coming to the boarding house for breakfast he met the superintendent, E. L. Hall.

"Good morning, Ed, did anything happen during the night?"

"Nothing much, I arrested one man about 11 o'clock for prowling around the sluice boxes."

"The hell you did, did you know him?"

"O yeah, know him as well as I know you, it was Mr. Bloomer!"

"My God! Didn't you know any better than that."

"You said to arrest anyone coming near the sluice boxes."

"Well, we'll see what we can do about it. Where did you put him, in jail?"

"No, I didn't want to walk that far, and had to get back to work, so I locked him in the camp office."

So the superintendent and Johnson walked back to the office and Hall unlocked the door, then noticed the padlock was still on.

"What were you afraid of, that someone would break in? Give me the other key."

They unlocked and finally opened the door and found Mr. Bloomer, with his clothes somewhat mussed up and dirty, but otherwise none the worse for wear.

Said Hall, "How do you feel, Mr. Bloomer?"

"O, not so worse, but those planks in that empty bunk aren't so damned soft." Then, catching sight of Johnson behind Hall, "Say, that's a damned faithful watchman you have got, but he takes his orders too damned literally. Say, has the cook anything left for breakfast?"

"If he hasn't, we'll have Ed here cook you up something."

"All right," dubiously, "but be sure and tell him not to put in any rat poison."

That was the last Johnson ever heard of the incident, except for good natured kidding by Hall and his fellow miners. But his job was good as long as he wanted to stay. He had "made himself a reputation" with the company.

Personal experience of Harry E. Anderson of Raton, as related to James A. Burns, WPA, July 1936. Courtesy of New Mexico State Records Center and Archives.

32.6 Roadcut on right exposes quartz diorite sill with mafic inclusions. On left, across the creek, similar sills occur beneath hummocky hillsides. **0.1**

32.7 Cross Humbug Gulch, location of another of the most important placer deposits on Baldy Mountain. The ter-

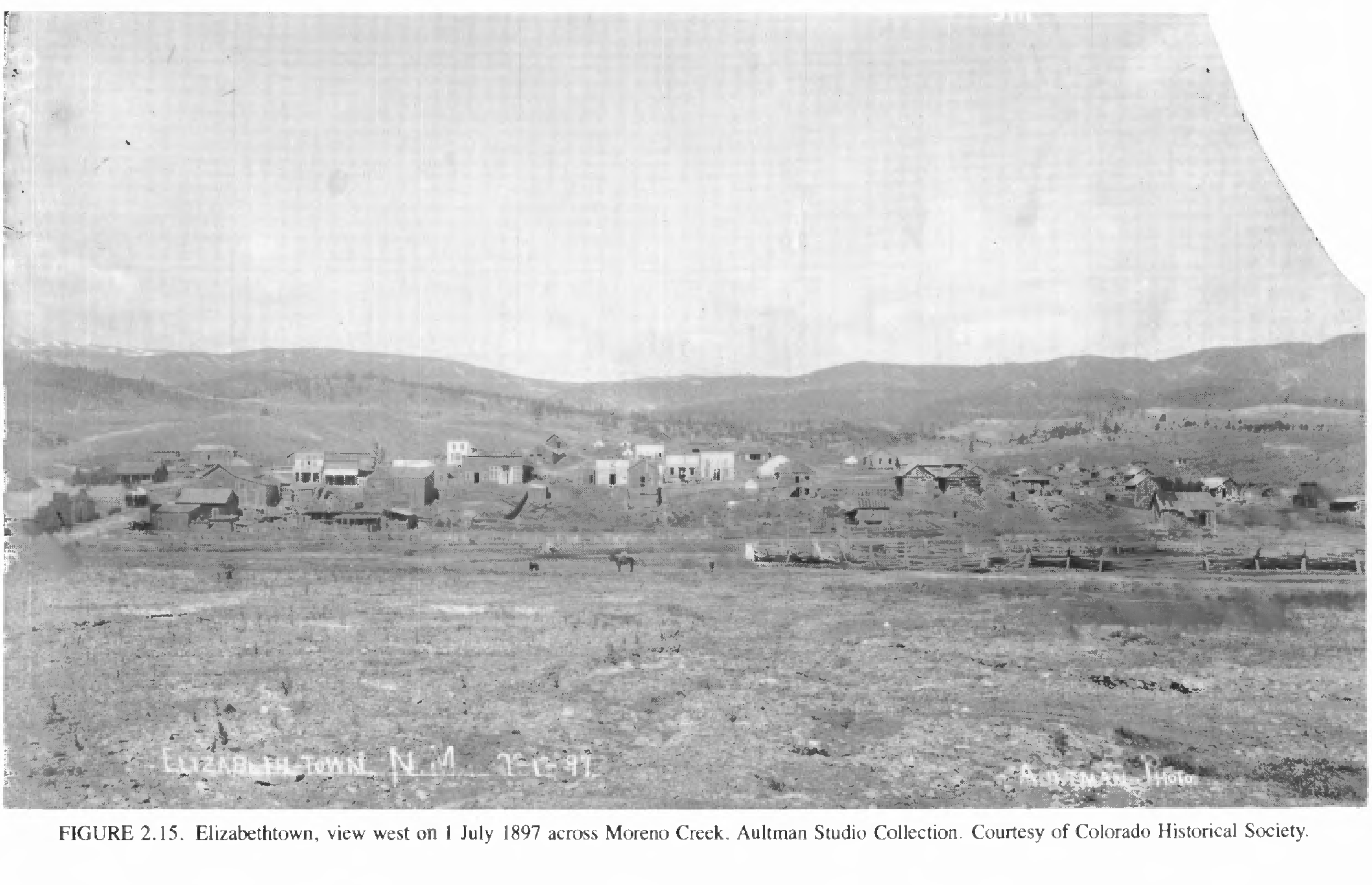

FIGURE 2.15. Elizabethtown, view west on 1 July 1897 across Moreno Creek. Aultman Studio Collection. Courtesy of Colorado Historical Society.

race at 9:00, on west bank of Moreno Creek, is one of four surfaces cut into Moreno Valley sedimentary fill by the ancestral Coyote River. This river drained most of the Sangre de Cristo Mountains area during Pleistocene time. The southward drainage of the ancestral Coyote River was disrupted by basalt flows that blocked the southern end of the valley, followed by headward erosion and stream capture by the Cimarron River. **0.3**

THE BALDY DEEP TUNNEL MINE

Robert W. Eveleth

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"Those who seek investment in mines are generally careful to look up the most reasonable propositions and those which are most apt to bring returns, and at the earliest date. In presenting the stock of the Gold and Copper Deep Tunnel Mining and Milling Company to the prospective investor, we wish it understood that the veins of this great district run directly into Old Baldy Mountain from all sides, and every reasonable indication justifies the belief that this mountain contains the great mother lead [sic] of the entire district. . . ." So began a monumental project perhaps unique in the annals of New Mexico's mining history—a project which would require over three decades and the expenditure of some $2 million to complete: the driving of the "Baldy Deep Tunnel" through Baldy Peak near Elizabethtown in Colfax County, New Mexico.

Early prospectors had discovered rich placer gold deposits on Willow Creek on the south flanks of Baldy soon after the Civil War. Additional placers quickly located along Moreno Creek led to the establishment of the first settlement of Virginia City, and, one year later, Elizabethtown farther upstream. Additional prospecting led to more placer discoveries east of Elizabethtown in Grouse and Humbug Gulches which again led the prospectors up the west flanks of Baldy. The inevitable question arose—where did all the gold come from? Obviously from deposits long eroded from rocks cropping out on Baldy Peak.

Rich copper "float," doubtless at Copper Park, led to the initial gold discoveries in 1866, and within a year dozens of prospects with showings of yellow metal had been found. Even deposits of tungsten and molybdenum had been located in the area. One such prospect, the Chester claim (Maxwell Survey #76), had evoked particular interest during the earlier days of the district. The Chester was developed through several hundred feet of drifts and stopes that had produced some high grade gold ores prior to 1881. Early day thinking held that if the Chester produced bonanza ores at or near the surface, the vein or contact at depth should prove to be a treasure trove indeed. Such at least were the thoughts of a group of men long associated with gold mining in the Elizabethtown area, including James Lynch, L. J. Burt, W. P. McIntyre and Brice M. Blackwell. A tunnel through Baldy Peak, they reasoned, would tap not only this bonanza and other undiscovered veins as well, but most importantly, reveal the source of the mineral wealth surrounding Old Baldy.

This was, for sure, an infectious dream, and the idea bore the stamp of logic all over it. After all, the gold had to come from somewhere, and that somewhere was surely deep within the rocks of Baldy Peak. Accordingly, these men organized the Gold and Copper Deep Tunnel Mining and Milling Company, under the laws of the Territory of New Mexico, on 10 October 1900, to run a deep tunnel "into Old Baldy Mountain . . . to cut and expose the great orebodies at a depth of over 2000 feet. . . ."

A site in Pine Gulch at an elevation of 10,600 ft was chosen for the location of the west portal. The Maxwell Land Grant Co., which held title to the land, liked the idea and agreed to convey title to certain tracts upon completion of the tunnel. This was a most ambitious undertaking indeed, but the organizers were unfazed by the magnitude of the project. Stock was sold (Fig. 2.16), much of it locally, and by the end of 1901, a road had been constructed, blacksmith's shop, cabins and other ancillary buildings erected, and the tunnel collared. Apparently, plans called for driving a two-mile tunnel in three major segments, the first of which would total 3600 ft. The company was originally capitalized at just $200,000, so it is apparent that several recapitalizations would be necessary.

Initially, nearly all work was done by hand and using mule haulage, but the company planned to take full advantage of state-of-the-art technology as soon as funds would permit. The tunnel advanced rapidly enough given the times and the equipment available, but progress was painstakingly slow by modern standards, averaging about 300 ft per year through about 1912 when the 3600 ft mark was probably achieved (capital was increased to $500,000 during this year). By 1905, the company had installed a steam generation plant (for power and shop facilities), and a small experimental mill. A gasoline power plant was added the following year, along with a 20-stamp mill. A flurry of excitement was generated in 1907 due to the discovery of a six-foot vein system, at 2300 ft from the portal, which initially showed some gold and copper potential. Further exploration would prove it to be without significant value, however. The five-year span beginning in about 1912 was marked by idle periods, and in fact very little of the operational history of this project from about 1916 until it was completed has been preserved. One investigator with an excellent reputation noted that all the old information and sampling records, accumulated while the tunnel was being driven, were said to have been destroyed by a storm near Houston, Texas.

The First World War doubtlessly interfered with the project, and, in fact, the Mines Handbook shows the same total footage (4400 ft) through 1925, whereupon the figure was finally adjusted to 6200 ft. Obviously much work was done from 1912 through 1925 (some 1800 ft of tunnel) but little was said about it.

After many delays, the tunnel reached a depth of 6995 ft in late 1929, and a major decision was made. An adequate supply of fresh air could not be delivered to the face with the ventilation equipment available, so the company moved its entire operation to the east side of Baldy and began driving from the other direction (Fig. 2.17). This was then, even as it is now, risky business since the breakthrough point must be projected strictly on the basis of an unclosed traverse—in this case a traverse running from the face of the west tunnel and over the top of Baldy Peak for a distance of at least three miles. Not only must the two headings intersect at the exact latitude and longitude but at the proper elevation as well. Since both tunnels were driven on a slight upgrade to facilitate drainage, precision grade control was critical. Again, we know nothing of the trials of the engineers making the survey (note that the weather is rarely, if ever, "pleasant" on Mt. Baldy); we can only gauge the success based upon the evidence at hand. In that regard the survey was obviously done with great accuracy, for the breakthrough took place exactly as planned.

The market crash of 1929 exacted a toll on the Gold and Copper Deep Tunnel Mining Co., and it went under soon thereafter. What possible incentive did they have to keep going? Certainly the prospects of developing any significant gold deposits were dim at this point. The prize was title to the lands promised by the Maxwell Land Grant Co. upon breakthrough, and with just 1500 ft to go, the company was not about to give up. Accordingly, and with little pretense as to purpose, the stockholders reorganized as the Deep Tunnel Mining Company in about 1934 with capital stock of $1 million (but no par value) and drove on.

With little fanfare the tunnel was finally completed in February 1936, encompassing a total length of 9170.8 ft after an incredible 35 years of effort and an expenditure of some $2 million without fulfilling any of the visions and dreams of the original incorporators. Every significant show of mineralization encountered during the driving of the tunnel had been thoroughly sampled and evaluated. Before abandoning all work in 1938, the company re-examined some of the more promising showings hoping to develop some minable gold reserves (remember that gold prices had increased by 69% with the devaluation of the dollar in 1934). These were all to no avail. In the final analysis, driving a 5×7 ft tunnel 2 miles through a mountain is not the proper way to

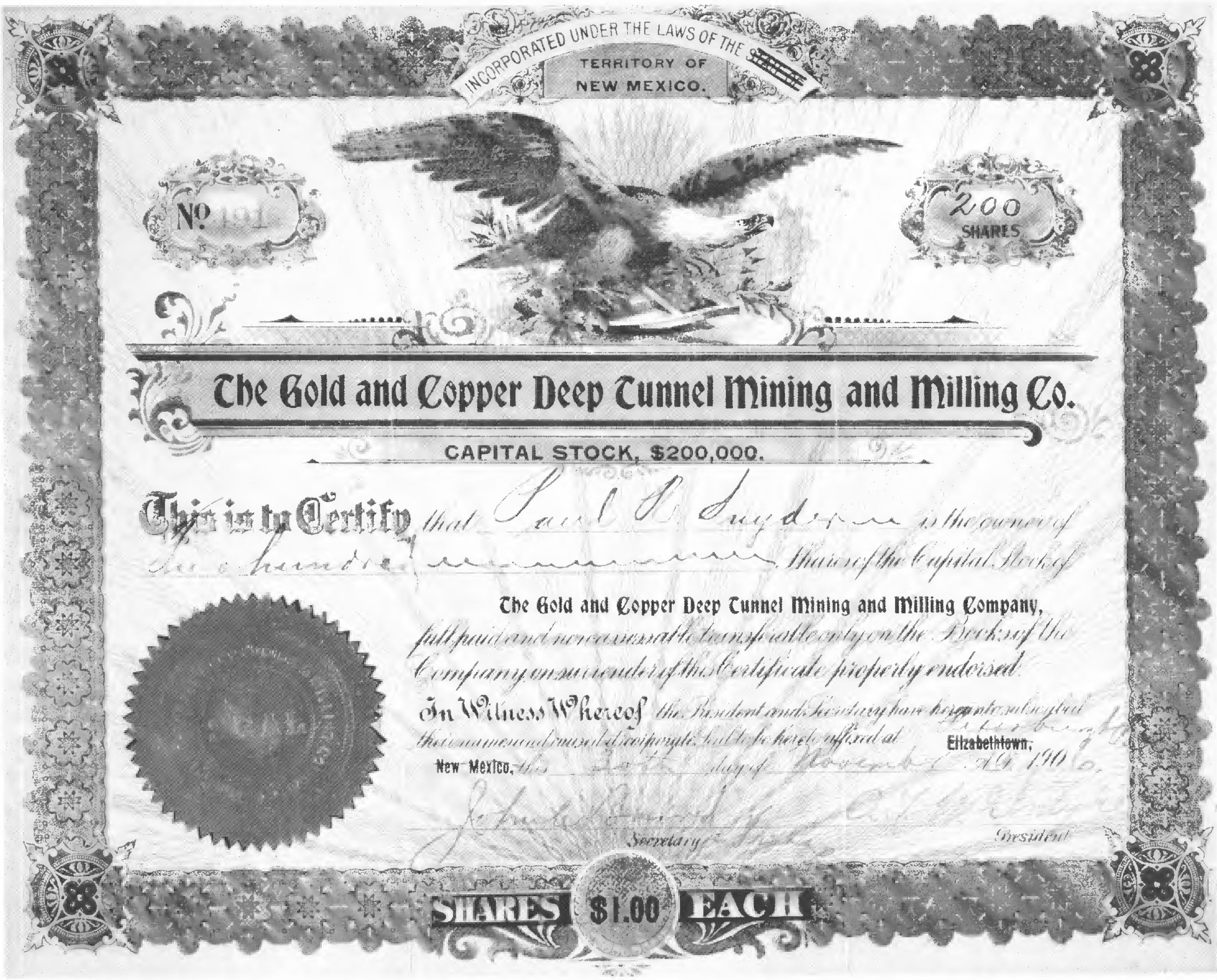

FIGURE 2.16. Original certificate of the Gold and Copper Deep Tunnel Mining and Milling Company. Note that the company's offices were originally located at Elizabethtown but were soon moved to an eastern capital center (Pittsburgh) to facilitate raising funds. From the collection of R. W. Eveleth.

explore for mineral deposits, but it was certainly indicative of the pioneering spirit of the times. The Deep Tunnel remains as a monument to the men and women investors who were willing to risk all in an effort to find the great mother lode, which even the most conservative among them agreed must surely be there. There are no guarantees in the mining game, and Lady Luck smiles on very few. Sadly, the stockholders of the Gold and Copper Deep Tunnel Mining and Milling Company were not among them.

33.0 **Turn left** on County Road B20 to Elizabethtown for **STOP 3. Cross cattleguard and bear left** at fork. Outcrop of quartz diorite porphyry ahead. **0.1**

33.1 Dirt road crosses Moreno Creek. **0.1**

33.2 **Cross cattleguard and bear left** along fence. **0.1**

33.3 Road turns to right. **Park at corner.** Walk up the road 0.1 mi west to the stone ruins of the old Mutz Hotel. Gold was discovered near Elizabethtown in 1866. The present ghost town was a bustling mining camp during the boom days of 1867–1872. Placer mining was concentrated in the gulches west of Baldy Mountain and along Moreno Creek. Vein deposits were soon discovered on the west flank of Baldy Mountain. Water for the hydraulic mining and sluicing was delivered by a 41-mi-long transmountain aqueduct that ran from the headwaters of the Red River to the upper part of Humbug Gulch, a map distance of 11 miles. A large dredge, the "Eleanor," successfully worked Moreno Creek below Elizabethtown at the turn of the century. Galena, pyrite, molybdenite, rhodochrosite, fluorite and other minerals can be found in the dumps in the area.

About 2 mi SW of Elizabethtown on the NW tip of Scully Mountain is the Triassic section described by Clark and Read (1972, p. 141). The Triassic red beds are very poorly exposed here, but mottled strata can be discerned directly on the Permian Sangre de Cristo Formation. Above that are trough-crossbedded quartzarenites and conglomerates of the Santa Rosa Formation (units 1–3 of Clark and Read), followed by covered strata of the Garita Creek Formation (units 4–5 of Clark

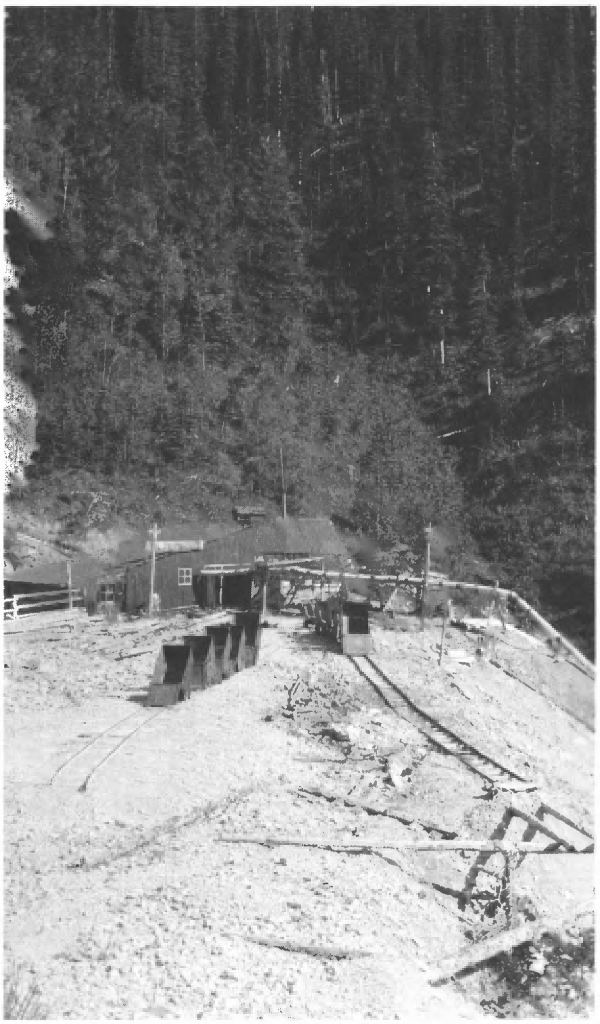

FIGURE 2.17. West portal, Baldy Deep Tunnel mine. At this point the tunnel was 6200 ft in length and the company would soon move to the east portal. From the collection of R. W. Eveleth; photo by Eldred Harrington, 8 August 1926.

and Read) and then the sandstones of the Trujillo Formation (units 6–12 of Clark and Read). Poorly exposed red beds above this may include the Bull Canyon and Johnson Gap Formations. For a complete discussion of Triassic stratigraphy along the southern Sangre de Cristo front range, see Lucas et al. (this guidebook).

ELIZABETHTOWN

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There is considerable bustle and business air to be seen, and especially should you go into "Arbor's Saloon" you will be convinced that it is a stirring place. There are several stores, two restaurants, and as many saloons, as also a drug store, a billiard table, barber shop, and gambling houses where the miner can deposit all his hard earnings of weeks in a few hours. That house across the street, in which you notice two smiling faces, you would do well to give a wide berth, and you will be richer in pocket, better in health, and wiser in mind.

Elizabethtown, American Journal of Mining, May 16, 1868

Elizabethtown in the late 1860's was a bawdy, robust, rip-roaring, gold mining town where fortunes could be made and lost overnight. Today, evidence of the boom days has nearly disappeared. All that remains are the decaying shells of long-abandoned frontier buildings, and the nearly indistinguishable piles of worked-over gravel. But for four frenzied years, thousands of miners feverishly clawed the earth in search of the fabulous riches that awaited below.

As the story goes, in the early 1860's Captain William H. Moore of Fort Union received a gift of several attractive rocks from a Ute Indian friend. Moore identified the specimens as high-grade copper ore, traced the ore to its source high on Baldy Mountain, and along with William Kroenig and associates, staked what is now the Mystic claim. In October 1866, Moore sent out three men to perform annual assessment work on the copper prospect. While Larry Bronson and Peter Kinsinger set up camp, R. P. Kelly idly panned some gravel along nearby Willow Creek. Imagine his surprise, and then enthusiasm, when the bottom of the pan displayed a glitter of color! Unfortunately for the men, a snowstorm soon descended that forced them to leave the mountains. They chiseled "Discovery Tree" into a nearby large pine, swore one another to secrecy, and headed for lower ground. Despite their well-intentioned but poorly kept pledge, by the early spring of 1867 swarms of men with gold fever were eagerly anticipating the melting of the snowpack on Baldy Mountain. Nearly every inch of potential paydirt was quickly staked, and the riches were soon revealed. Gold was found in nearly every gulch on the west side of Baldy Mountain, the most productive of which were Grouse Gulch, Humbug Gulch and Last Chance Gulch. Captain Moore also staked claims and opened a grocery store. The community grew explosively, and was soon named Elizabethtown (commonly shortened to E'town) in honor of Elizabeth Moore, Captain Moore's young daughter; their descendants still live in the valley. The land in the E'town region was owned by Lucien B. Maxwell, who, apparently undaunted by the hordes descending on his land, staked claims of his own, collected claims fees and even backed a number of mining endeavors. One of the first miners in this early rush as Matthew Lynch, who discovered the first lode deposit in the district and operated the first hydraulic mining system in the state.

Although some of the early gold was produced from lode deposits, most came from placers, involving a form of mining that required an abundance of water. During dry summers the rich gravels near E'town could not be worked for lack of water. Because the dry gulches on Baldy Mountain had a totally insufficient water supply, a plan was devised to pirate water from the headwaters of the Red River, 11 miles to the west. A transmountain aqueduct constructed for this purpose, known as "The Big Ditch," was one of the most remarkable engineering projects ever attempted in New Mexico. Although the ditch was never as successful as planned, it did deliver water to the placer fields for a number of years.

Another feat that attests to the tenacity of the early miners was the 9000+ ft tunnel driven by the Gold and Copper Deep Tunnel and Milling Company completely through Baldy Mountain. The project, started in 1900, took 36 years to complete.

Estimates of the E'town population during the boom years range from 2000 to 7000. Regardless, the town was certainly one of the largest in New Mexico in the late 1860's, and in 1870 became the first incorporated town in the state, as well as the county seat of newly created Colfax County. In its glory days, E'town boasted seven saloons, five general mercantiles, two hotels, three dance halls and three different stagecoach lines. The town's best year for gold profits was probably 1868. The total amount of gold extracted from the Elizabethtown district is difficult to estimate, but a value of $3 million in 1870 dollars is certainly conservative; the present-day value of this gold would be about $54 million.

The bonanza days would end all too soon for many. In 1872, Cimarron replaced E'town as the county seat, and by 1880, less than 400 people lived in the town. The town's fortunes continued to decline until February 1901, when H. J. Reiling of Chicago organized El Oro Dredging Company to construct and operate a floating dredge on Moreno Creek. He proceeded to dam Moreno Creek three miles from E'town to float his dredge. It took two weeks for the dredge's 21,000 lb boilers to be hauled 55 miles from the railroad at Springer to E'town. In August 1901, during an elaborate ceremony, the completed dredge was christened "Eleanor" in honor of the visiting Miss Eleanor Robinson of New York. Eleanor cost $100,000 to produce, contained 65 large buckets with a total capacity of 4000 cubic yards per day, and could work to 15 ft below water level (Fig. 2.18). The dredge operated around the clock and proved to be enormously successful. As the dredge worked slowly upstream, piling gravel in its wake, it extracted $0.30 to $3.00 of gold per cubic yard of dirt. Reportedly, the Eleanor cleared $100,000 in her first year, and E'town was blessed with a second season of prosperity. In 1905, the grade of dredged gravel had dropped to a level that forced the company into bankruptcy, and in September of that year the Eleanor was sold. She never dredged again, although purchased in April of 1913 by Charles Springer of Cimarron. When dredging was abandoned in 1905, Eleanor had traveled nearly to E'town, collecting about $200,000 in gold along the way. The method of her demise is uncertain. One story has it that after a local boy drowned in the ponded stream, the pond was allowed to drain, and Eleanor began her decline. All of her wooden planking was salvaged, and her iron skeleton slowly sank into the sandy creek bed (Fig. 2.19) until she disappeared totally from view in the 1930's or 1940's.

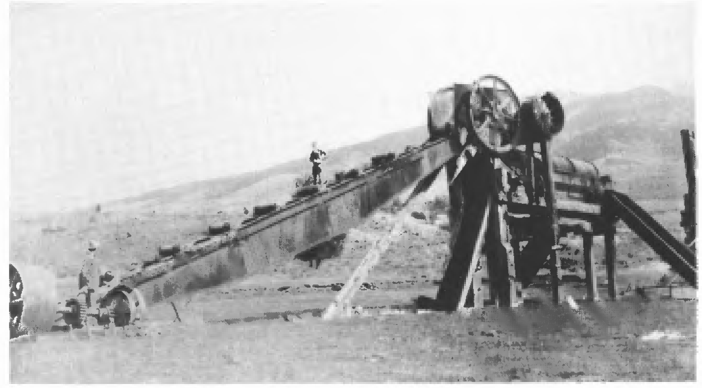

FIGURE 2.19. Skeleton of the dredge "Eleanor" after planking, dredge buckets and equipment had been salvaged. She sank into the gravels along the Moreno River just south of Elizabethtown. Baldy Mountain is in the background. Courtesy of Kit Carson Foundation.

E'town never completely recovered from a disastrous fire that swept through the town in September of 1903. In 1919, Eagle Nest dam was built at the head of Cimarron Canyon, and the town of Eagle Nest was incorporated shortly thereafter. Many residents of E'town relocated to this kinder and gentler spot, and in 1931 the Elizabethtown Post Office was closed. Minor mining in the district continued until World War II, though Elizabethtown continued to fade away. Vandals destroyed many of the old buildings (Fig. 2.20), and in 1956 the old schoolhouse was sold for scrap. The majestic stone walls of the two-storied Mutz Hotel still stand (Fig. 2.21), and the Mutz family now owns the townsite. Although a great deal of placer gold was extracted over the course of the boom years, the mother lode was never located. Perhaps someday Elizabethtown will again rise to fame and fortune. Sources for this paper included Pettit (1946), Claussen (1948), Woods (1966) and Sherman and Sherman (1975).

THE BIG DITCH

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One of the most astonishing engineering feats of the early West was undertaken near Elizabethtown. Shortly after the rush to the E'town gold fields in 1867, miners realized that vast amounts of water were

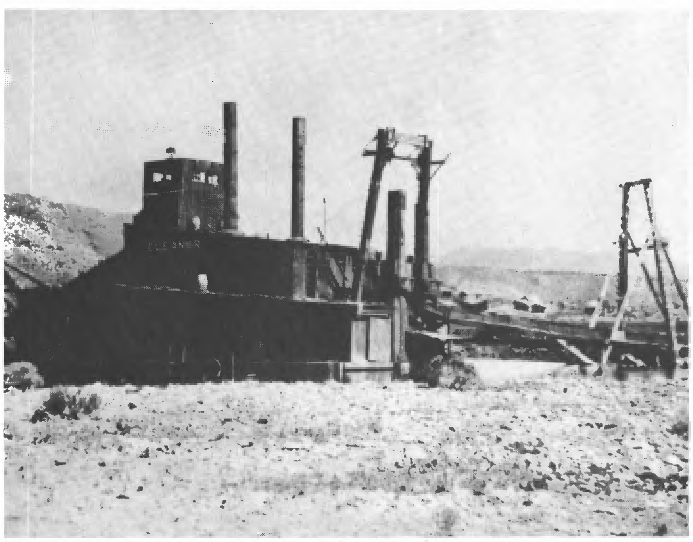

FIGURE 2.18. How best to honor a lady? In recent times the lauching of a fine ship might be cause for commemoration, but in the past, towns, locomotives, mining claims and even dredges might be so named. Such was the case with Oro Dredging Company's rig christened in honor of Miss Eleanor Robinson, visiting New York friend of manager R. J. Reiling. "Eleanor" was quite a dredge for her day. Commissioned in 1901, the 65 five-cubic-yard buckets of the $100,000 machine generally processed about 3000 cubic yards of gravel in a 20-hour period. The bucket elevator could work a 25-ft bank to a depth of 15 ft. Gold was recovered by screening out the oversized material and the fine particles amalgamated in the long tail sluice seen to the right in the above view, circa 1905. By August 1905, the dredge had worked about half of Oro's holdings and had encountered subgrade gravels above the mouth of Grouse Gulch. Sold in September of 1905, the dredge would never work again. Interestingly, Eleanor was not scrapped, but, aided by her massive boilers, slowly sank into the gravels of Moreno Creek where she presumably lies today. Courtesy of Museum of New Mexico. Neg. no. 128761.

FIGURE 2.20. The church at Elizabethtown, circa 1950. The church was salvaged for lumber several years later. Photo by Tyler Dingee. Courtesy Museum of New Mexico. Neg. no. 74107.

FIGURE 2.21. Remains of the old Mutz Hotel in Elizabethtown, with Baldy Mountain in the background to the east. Photo by C. K. Mawer.

needed to mine profitably the deep placer gravels on the west flank of Baldy Mountain. Due to a lack of water, many of the richest claims could only be worked a few months of the year. A consortium of interested parties promptly contracted Capt. N. S. Davis, a U.S. Army engineer, to locate and evaluate potential water sources for the hydraulic mining operations. Davis concluded that it would be possible to divert the headwaters of the Red River, 11 miles to the west, to the placer fields. By December 1867, The Moreno Water and Mining Company had been organized. The owners were Lucien B. Maxwell, William Kroenig, W. H. Moore, Capt. N. S. Davis, Col. V. S. Shelby, John Dold and M. Bloomfield. A route was surveyed, and work commenced on 12 May 1868. Incredibly, by 13 November, the project was nearly completed, at a cost of only $280,000.

All work was done by hand, and employment peaked at 420 men. The ditch itself attained a length of 41 miles, 660 ft, although the airline distance from beginning to end was only 11 miles due to the mountainous terrain and the fact that the ditch would have to contour around the north end of the Moreno Valley (Fig. 2.22). For over 3 miles of this distance, aqueducts and side hill flumes had to be constructed. The longest aqueduct spanned 2376 ft across a canyon near Red River Pass at an elevation of 79 ft above the creek bed. Elsewhere, along 5 miles of its length, the ditch was blasted into bedrock, in places to a depth of 10 ft. In places, it was necessary to attach the flume to vertical cliffs. For the first 12 miles, along which the ditch dropped approximately 1 ft/mile, the flume was 2.5 ft wide at the bottom, 5.5 ft wide at the top and 2 ft deep. Along the remaining 29 miles, where the grade was 4 ft/mile, the flume was 4 ft wide at the bottom, 7 ft wide at the top and 2 ft deep.

The ditch tapped the headwaters of the Red River at three lakes: Ditch Lake #1 (now known as Horseshoe Lake), Ditch Lake #2 (Lost Lake) and Ditch Lake #3 (Middle Fork Lake). Approximately 8 miles of branch flume connected these lakes with the Big Ditch. The ditch was designed to divert about 600 miners-inches of water under 5 inches of pressure (in New Mexico, 1 ft^3 per sec = 50 miners-inches; so 600 miner-inches approximately equal 720 ft^3 per min or 7.65 million gallons per day).

On 9 July 1869, the first water was delivered to Martin and Scott's claim on Humbug Gulch. However, instead of the eagerly awaited deluge, only about 100 miners-inches reached the placers, the rest having been lost to leakage and evaporation. The company owned no placer land, and thus when revenues from the sale of water proved insufficient, and the company became "financially embarrassed," it transferred to Col. Shelby of Santa Fe who had put up much of the cost of construction. Shelby, in turn, soon sold the unprofitable ditch to Lucien B. Maxwell.

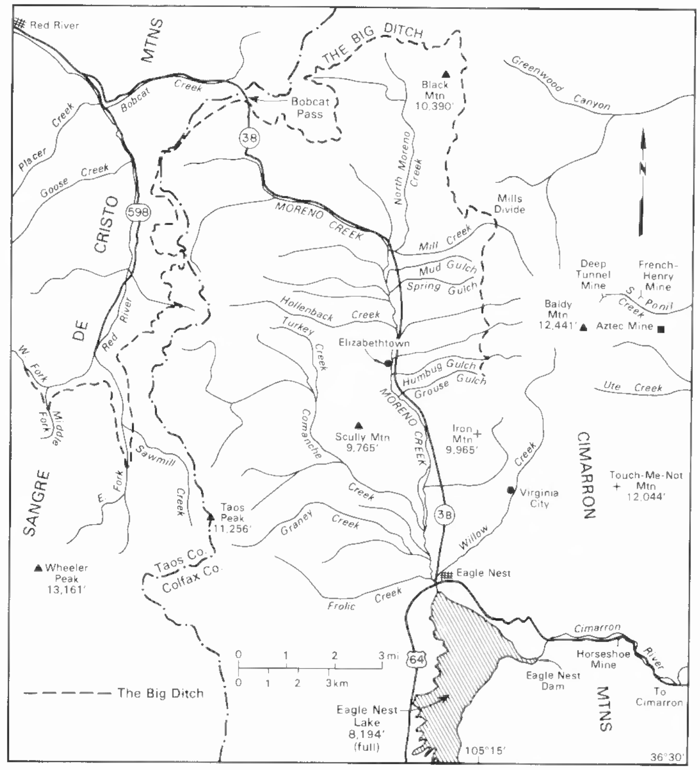

FIGURE 2.22. Map of the Elizabethtown area showing the route of the Big Ditch transmountain aqueduct, mines and geographic features. Although the distance from the headwaters of the Red River to the placer workings on Grouse Gulch was only 11 mi, the Big Ditch contoured northward around the Moreno Valley for a distance of 41 mi. Remains of the flumes and ditches can still be seen along the flanks of the valley.

In the placer fields, "first water" (first-use water from the ditch) was sold for $0.50/inch; "second water" and "third water" (previously used, reclaimed placer water) were generally sold by contract. Two cabins were built, 10 miles apart along the ditch, and workmen patrolled the banks, repairing leaks and removing debris. Early each spring, hundreds of miners would swarm into the hills to clear the ditch of ice and rocks so water could arrive at their placers as soon as possible.

In April of 1875, Maxwell traveled from Ft. Sumner to Rayado and sold the ditch to Matthew Lynch of Trinidad, Colorado. Several years before, Lynch had discovered the fabulously rich Aztec mine on Baldy Mountain. At the time he bought the ditch he was one of the most successful placer miners in E'town. Lynch repaired the ditch, which had been neglected for several years, and proceeded to revitalize and modernize hydraulic mining in the area (Fig. 2.23). Lynch apparently charged high rates for his water, and his own sluice boxes were never dry. Reportedly, ground in one claim on Willow Creek yielded as much as 40 oz of gold per box (a box being equivalent to an area 12 ft by 24 ft). Lynch died in 1880. Although his brothers continued to operate the placer mines, the Big Ditch was eventually abandoned, and hydraulic mining declined and ultimately ceased. Today, remnants of flume and rusted old nails are all that remain of this extraordinary engineering project.

Retrace route to the highway. 0.3

33.6 **Turn right** (south) back toward Eagle Nest. **0.3**

33.9 Old stone retaining wall visible on hillside to the left. Mounds of gravel are remains of placer operations. Slopes ahead on the right are Tertiary quartz diorite porphyry. Scully Mountain contains a sequence of Triassic-Jurassic-Cretaceous sedimentary rock that has been intruded by Tertiary porphyrys. Most of the Moreno Valley

FIGURE 2.23. Hydraulicking on the Lynch placer in either Humbug or Grouse Gulch (Lynch's placer lease covered both gulches) east of Elizabethtown in the late 1870's. The top-hatted gentleman on the left bears a strong resemblance to Matthew Lynch himself, who is generally regarded as the father of hydraulic mining in all of New Mexico. According to Fayette Jones, Lynch (who also owned the Big Ditch) ran three or four very successful hydraulic operations each season until his untimely death in 1880, not from a mining accident as one might expect, but by virtue of Mr. Lynch's itinerary coinciding with that of a falling tree. Photo by F. C. Warnky. Courtesy Museum of New Mexico. Neg. no. 14860.

south of here is filled by Quaternary-Tertiary sands and gravels that were shed off the mountains.

Somewhere beneath the river gravels in the creek bed to the right is buried the skeleton of the dredge "Eleanor." Several old photographs (Fig. 2.21) show that she was stripped of all planking before the steel skeleton, including the buckets, subsided. **1.0**

34.9 At 12:00 are the Cimarron Mountains south of the Cimarron River. **0.7**

35.6 Eagle Nest Lake is visible ahead. At 1:00 on the skyline are the Rincon Mountains. Past the lake, the cleared swaths on the forested slopes of the Cimarron Range are ski runs of the Angel Fire Ski Area. Tertiary quartz-diorite porphyry in slopes on the right. **0.5**

36.1 At 9:00–9:30, the high barren peak is Touch-Me-Not Mountain. **0.4**

36.5 From 1:00–3:00 the forested hills on the west side of the valley are underlain by Pennsylvanian to Cretaceous sedimentary rocks. Pennsylvanian and Permian rocks are juxtaposed against younger rocks by the Sixmile Creek thrust. **1.0**

37.5 Gravel quarry on left. **1.1**

38.6 **Junction** with US-64. **Turn right. 0.2**

38.8 Road on right to community of Idlewild. **0.5**

39.3 Green tanks on hill at 3:00 store drinking water for the Eagle Nest municipal water system. Water is obtained from two wells located in the town that produce from valley alluvium. **0.7**

40.0 Milepost 284. At 9:00 is a good view of the head of Cimarron Canyon. Eagle Nest dam, just out of sight in the canyon, built between 1916–1919 at the head of the canyon by Frank and Charles Springer, created Eagle Nest Lake. The lake is about 5 miles long and 2 miles wide. **0.2**

40.2 County Road B11 on right. **0.4**

40.6 The high peaks in the Wheeler Peak Wilderness at 3:00 display the effects of Pleistocene glacial sculpting. **0.4**

41.0 Milepost 283. **0.4**

41.4 Sixmile Creek USGS gaging station at 9:00. Discharge peaks in May. The high grass-covered surface at 3:00 is pediment 2 of Ray and Smith (1941). Surface in foreground is pediment 3. The lower Sixmile Creek flood plain is composed of recent alluvium. **0.6**

HYDROGEOLOGY OF THE MORENO VALLEY—AN OVERVIEW

James A. Saye III

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The Moreno Valley encloses three drainage basins. From north to south they are: the Moreno Creek drainage basin, the Central Valley drainage area and the Cieneguilla Creek drainage basin. All streams are tributary to Eagle Nest Lake. Stream flow usually occurs in the months April through October. Maximum mean flow occurs in April or May during peak snowmelt. Flow generally decreases consistently through the summer months.

The Moreno Creek drainage basin covers 73.8 mi^2 in the northern part of the valley. Average mean flow at the Moreno Creek gaging station during the years 1976–1988 was 9.72 cfs. Maximum discharge for this period was 135 cfs on 26 May 1979. The Central Moreno Valley drainage area covers 37.2 mi^2 in the vicinity of Eagle Nest Lake. Sixmile Creek drains a 10.5 mi^2 sub-basin west of Eagle Nest Lake. Average mean discharge at the Sixmile Creek gaging station for months of flow during the years 1976–1988 was 4.12 cfs. Maximum discharge for this period was 51 cfs on 26 May 1979. The Cieneguilla drainage basin occupies 56 mi^2 in the southern portion of the valley. The drainage area includes the Angel Fire and Agua Fria developments. Average discharge in the Cieneguilla Creek gaging station during the months of flow for the years 1976–1988 was 14.48 cfs. Maximum discharge for this period was 191 cfs on 25 April 1987. Discharge at each of the three gaging stations in the valley frequently falls below 1 cfs in August.

More than 250 water wells have been drilled in the Moreno Valley (Fig. 2.24). Water-bearing zones in the Moreno Valley can be classified into four aquifers. The following classification generally follows that of Abbot et al. (1983) with some modification. The aquifers are: (1) unconsolidated Tertiary valley fill; (2) Tertiary dikes and sills; (3) Mesozoic and Paleozoic sandstone and siltstone; and (4) Precambrian crystalline rocks.

The Precambrian aquifer consists of faulted and fractured granite gneiss and metasediments exposed north of the Saladon Creek fault and in the northwest quadrant of the valley. More than 18 wells produce water from the Precambrian aquifer. Precambrian aquifer quality is directly related to the extent of fracturing in the subsurface.

The Paleozoic-Mesozoic aquifer includes the Madera Group, the Sangre de Cristo Formation, the Triassic sequence, the Entrada Sandstone, the Morrison Formation and the Dakota Sandstone. The Paleozoic-Mesozoic aquifer is the primary source of fresh ground water for wells in the Moreno Valley. Each of the units within the aquifer is utilized mainly in the outcrop area of that unit. The Madera Group consists of gray to brown sandstone, siltstone, conglomerate and limestone. Porosity is reduced by clay and calcium carbonate cement in the sandstone, siltstone and conglomerate. Limestones are cemented with calcite spar (Clark and Read, 1972). The Sangre de Cristo Formation is recognized in the subsurface as red siltstone, mudstone arkose and conglomerate. Cements consist of hematite, clay, sericite and calcite. Arkose zones within the Sangre de Cristo are frequently referred to as "granite wash" on driller's logs. The Triassic in the Moreno Valley consists of a lower sandstone which is roughly equivalent to the Santa Rosa Formation and an upper predominantly shale member. The sandstone overlies the Sangre de Cristo and is approximately 160 ft thick. The upper shale member is approximately 175 ft thick and may serve as an aquiclude in the subsurface. The Entrada Sandstone consists of a basal buff sandstone approximately 100 ft thick and an upper sequence

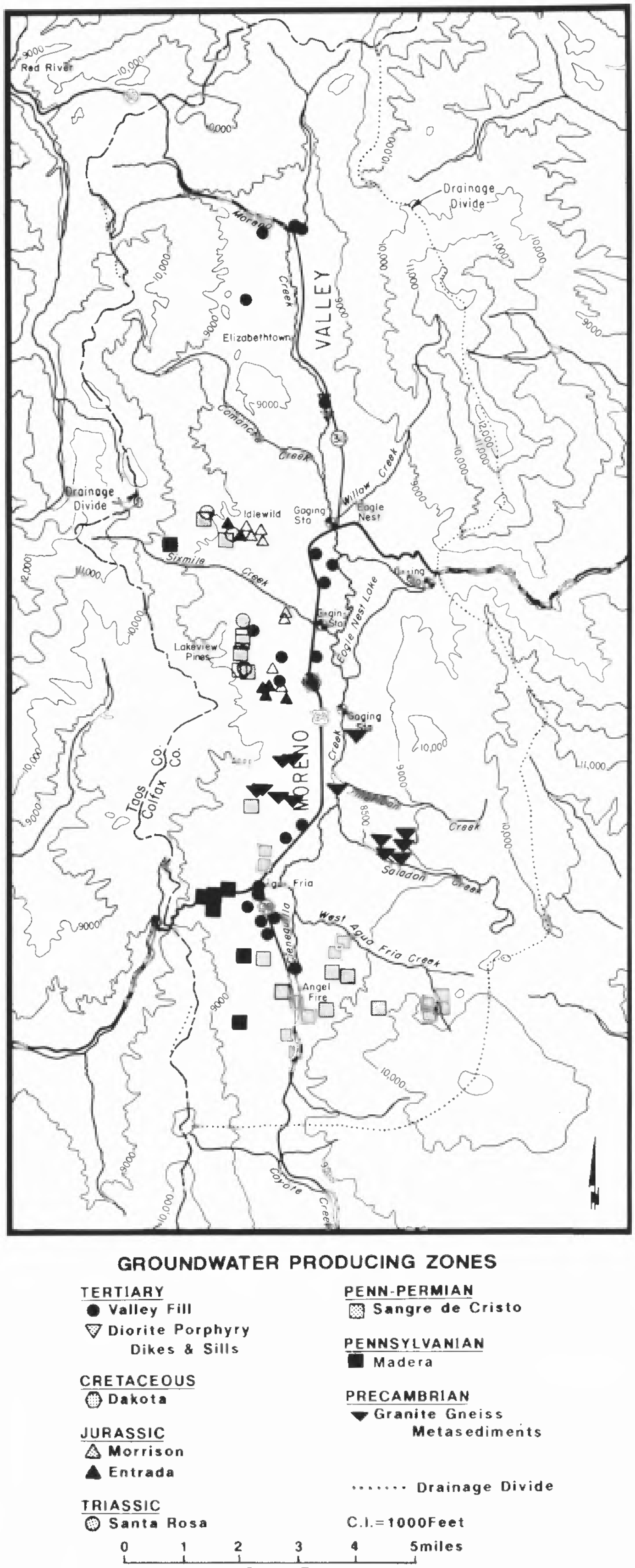

FIGURE 2.24. Location map of selected water wells in the Moreno Valley. Primary ground-water-producing zones are indicated by the symbols.

of red and buff shale and thin limestone about 30 ft thick. The sandstone is loosely cemented with sericite and clay. In the subsurface the Entrada is described as a white sandstone with gray or red shale stringers. The Morrison Formation consists of interbedded fine-grained sandstone and siltstone. In the subsurface the Morrison is recognized on driller's logs as a sequence of red, gray, green purple and white sandstone and shale. The Dakota Sandstone is gray to brown, medium-grained, crossbedded sandstone. Approximate thickness of the Dakota Sandstone is 100 ft.

The Tertiary igneous aquifer consists of fractured quartz-diorite-porphyry dikes and sills in the area of Scully Mountain. At the surface the porphyry is heavily fractured with limonite stains along fractured surfaces. In the subsurface it is described as white, yellow or gray granite on driller's logs.

The unconsolidated Tertiary valley-fill aquifer underlies the grass-covered slopes and flatlands in the center of the valley throughout its entire length with the exception of a narrow zone immediately north of the Saladon Creek fault. The valley fill is described on driller's logs as interbedded red and brown clay, sand and gravel. The clay intervals within the valley fill attain a thickness of 100 ft, and where present, serve as a confining layer for underlying water-bearing zones. Thickness of the valley fill is known to be more than 400 ft.

Wells at the Mutz and Moreno Ranches in the valley north of Scully Mountain produce water from the valley fill at depths ranging from 40–150 ft. Four wells located along Moreno Creek immediately east of Scully Mountain are completed in the fractured Tertiary quartz-diorite porphyry at depths of 30–100 ft below the surface. Estimated yield to these domestic wells of the fractured porphyry is 1–6 gallons per minute (gpm).

The Tertiary valley fill serves as the exclusive source of water at Eagle Nest. Water levels in the valley fill are approximately 30 ft below the surface. Several hand-dug water wells are visible from US-64 in the vicinity of the town. These wells are no longer in use. Water is supplied to the municipal system by three large capacity wells located immediately north of the town.

Water wells at Idlewild utilize the Paleozoic-Mesozoic aquifer which is exposed on the slopes in and around the community. Idlewild is located within the recharge zone for the Paleozoic-Mesozoic aquifer. The aquifer dips to the east and is covered on the lower slopes by the valley-fill gravel and clay. The Madera Group sandstones supply water to at least one well located west of the community. Domestic well yields from the Sangre de Cristo range from 2–25 gpm. Triassic sandstone and conglomerate is utilized on the west side of the community where it is found at depths of 50–200 ft. Preliminary comparison of water levels from the Triassic sandstone and the overlying water-bearing zones indicates a significant difference in head between the units. This is probably due to the influence of the upper shale member of the Triassic sequence. Domestic well yields for wells screened in the Triassic range from 3–60 gpm. The Entrada Sandstone is a source of ground water at Idlewild and Lakeview Pines where it is exposed at the surface and to the east where it underlies the Morrison Formation. Depth to the screened interval in Entrada wells ranges from 100–260 ft below the surface. Domestic well yields range from 2–30 gpm. The Morrison Formation is utilized in the outcrop zone at Idlewild and Lakeview Pines and to the east where it underlies the Dakota Sandstone. The screened interval in the Morrison typically extends from 200–250 ft below the surface. Domestic well yields range from 2–32 gpm. Flow at the surface was encountered in two Morrison wells located on the grass-covered lower slopes 1000 ft south of Sixmille Creek and 4000 ft west of US-64. These wells encountered the Morrison Formation below 200 ft of valley-fill clay. The Dakota Sandstone is water-bearing in the Idlewild and Lakeview Pines vicinity. It is not widely used as a source of ground water due to the location of the recharge zone within the communities and the resulting potential for contamination of the reservoir from septic systems and other surface activities. The valley-fill aquifer is a source of fresh water for wells located along US-64 east of Lakeview Pines. Three wells immediately south of Lakeview Pines produce water from the Precambrian fractured granite gneiss at depths of 100–200 ft. Domestic well yields are 1–35 gpm.

The Precambrian aquifer is also utilized at the American Creek subdivision located on the east side of the valley north of the Saladon Creek fault. Wells in this area are typically screened at depths of 200–400 ft below the surface. Domestic well yields are estimated at 5–85 gpm.

The Paleozoic-Mesozoic aquifer is the primary source of ground water for wells located south of the Saladon Creek fault. The Madera Group is utilized on the southwest flank of the valley where it is encountered below 3–10 ft of soil. Domestic well yields for 8 representative wells located west of Agua Fria range from 7–15 gpm. Wells located in the DAV Memorial area produce water from the Sangre de Cristo Formation. The red Sangre de Cristo siltstone is also the source of water for the Angel Fire development. The Sangre de Cristo is encountered below approximately 70–100 ft of alluvium and valley-fill sediments in the flat, grass-covered area south of Agua Fria. Nineteen large capacity wells have been drilled in this area south of Agua Fria and in the surrounding slopes since 1968 to supply water to the Angel Fire resort, snow-making system, country club, golf course and other facilities. The Angel Fire wells are typically screened over 200–300 ft intervals from 200–500 ft below the surface. Sustained yield of the individual wells ranges from 5–278 gpm.

The valley fill is also an important source of water in the Agua Fria vicinity. Wells are typically screened between 50–150 ft below the surface. The "Airport" well located at the north end of the Southern Colfax County airport encountered 480 ft of valley-fill gravel, sand and clay. Thickness of the valley fill decreases rapidly to the west. Wells in the Agua Fria Estates development south of the US-64/NM-434 intersection encountered 100 ft or less of valley-fill sediments before reaching the underlying Sangre de Cristo siltstone. Domestic well yields from the valley fill in this area range from 5–15 gpm. Surface flow occurred at one well in the Agua Fria Estates when drilled in 1973.

Water quality in the Moreno Valley is monitored periodically at various locations by the U.S. Geological Survey and the New Mexico Environmental Improvement Division (EID). Average total dissolved solids concentration as measured at the Cimarron River below Eagle Nest dam gaging station was 187 mg/l for the water years 1974–1984. Water in the valley is hard to very hard. Hardness of water at Eagle Nest dam was generally between 130–190 mg/l during the 10-year USGS sampling period. Surface water pH varies from 6.8–8.4 and averages 7.9. Ground-water samples from 32 domestic wells located in all areas of the valley and collected by the EID in June 1989 showed a pH range of 6.5–8.0 and an average of 7.1. Nitrate concentration (as N) at Eagle Nest dam during the period 1974–1980 was 0.0–3.0 mg/l. Nitrate concentration in ground-water samples from 32 wells ranged from 0.05–4.5 mg/l and averaged 1.7 mg/l. The concentrations of selected dissolved heavy metals were monitored by the USGS at Eagle Nest dam in 1981–1984 and by the EID at the three stream gaging stations in the valley in 1985. No levels above drinking water standards were discovered during these sampling periods.

The Moreno Valley is not a closed hydrogeologic environment. Clark and Read (1972) noted that the intruded Mesozoic sequence of the Cimarron Range probably rests on east-dipping Sangre de Cristo siltstone and sandstone. The Sangre de Cristo and to some degree the overlying intrusive sequence probably represent a ground-water-flow pathway. It has been shown that the Precambrian crystalline rocks exposed at the American Creek development are highly fractured. This fractured section probably represents an additional ground-water-flow pathway. Flow in these units is expected to be to the east, out of the valley. Estimates of the volume of water involved may be the subject of future research.

42.0 Milepost 282. **0.1**

42.1 County Road B9 on right leads to development of Lakeview Pines. At 2:00 in field at 1000 ft is a small knob of Dakota Sandstone. **0.1**

42.2 **OPTIONAL STOP 4. Pull off on the right** at the Official Scenic Historic Marker. On the left is an entrance to one of the fishing and recreation areas of Eagle Nest Lake. Official Scenic Historic Marker reads:

Wheeler Peak. Across Moreno Valley stands Wheeler Peak, 13,161 feet, highest peak in New Mexico. Rocks of Wheeler Peak and the Taos Range are highly resistant granites and gneisses of Precambrian age. Moreno Valley is underlain by soft sandstones and shales which are covered by stream and glacial deposits. Placer gold was mined at Elizabethtown north of here during the 1860's.

The purpose of this stop is to discuss the stratigraphy and structural geology of the Moreno Valley (Fig. 2.25). To the west (in the direction of Wheeler Peak), the tree-covered lower slopes are underlain by Pennsylvanian through Cretaceous strata that have been cut by east-verging thrust faults. Two fault surfaces have been recognized. The upper one is named the Sixmile Creek thrust (Clark and Read, 1972) and displaces Pennsylvanian, Permian and Precambrian rocks in the Sixmile thrust sheet eastward over Permian through Tertiary sedimentary rocks. Below the Sixmile Creek thrust lies the Cimarron thrust sheet which has been displaced eastward over Precambrian rocks along the Cimarron thrust. The small hill at about 10:00 is composed of rocks belonging to the Dakota Group. Strata dip 41°E (Clark and Read, 1972) and form the west limb of a syncline which underlies this part of Moreno Valley. Approximately 1000 ft west of this outcrop, cuttings from water wells indicate that valley alluvium is underlain by red- and green-colored sandstones and mudstones of the Morrison Formation. These strata are allochthonous and probably lie on Precambrian granitic or gneissic rocks similar to those seen through an erosional window in the Cimarron thrust sheet at Lakeview Pines. In the Cimarron Range to the east, Triassic strata have been mapped by Clark and Read (1972) and Goodknight (1976) as resting directly on Precambrian rocks. Colpitts and Smith (this guidebook) interpret these Triassic outliers as klippe belonging to the Cimarron thrust sheet. More evidence for this interpretation will be presented at Stop 5. **Continue south along US-64 toward Angel Fire. 0.8**

43.0 Milepost 281. **0.7**

43.7 Road on left leads to another Eagle Nest Lake recreation area. **0.3**

44.0 Milepost 280. **0.5**

44.5 Monte Verde Ranch on left includes beautiful stone ranch house with green roof. **0.2**

44.7 County Road B6 on right. This road leads to a quarried exposure of Proterozoic, orange-colored, granitic rock

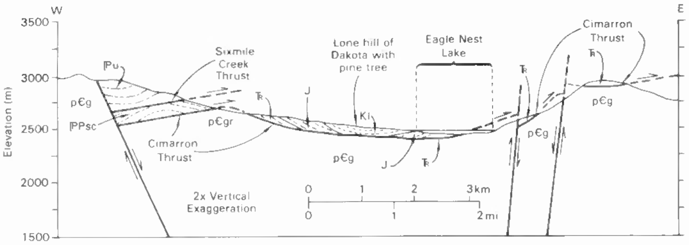

FIGURE 2.25. Schematic cross section across the Moreno Valley in the vicinity of Optional Stop 4 (mile 42.2) showing structural and stratigraphic relationships. From the stop, the lone hill at 10:00 is composed of Dakota Sandstone as indicated on cross section. p€g = Precambrian gneisses; PPsc = Permo-Pennsylvanian Sangre de Cristo Formation; Pu = Pennsylvanian undivided; T = Triassic; J = Jurassic; Kl = Lower Cretaceous. Modified from Colpitts and Smith (this guidebook).

on the west flank of the valley. The exposure contains subhorizontal shear zones that are probably related to the Sixmile Creek thrust. **0.4**

45.1 **Turn left** into front yard of ranch house **and park** for **STOP 5.** This stop is on private property. The purpose of this stop is to examine the southern edge of the Cimarron thrust sheet. Wanek and Read (1956) suggested that reddish outcrops east of Cieneguilla Creek at 11:30 to 1:00 had been thrust over steeply dipping Proterozoic strata. The low cliff in the cut bank north of American Creek at 10:30 consists of limestone-pebble conglomerate and quartzose sandstones belonging to the Johnson Gap and/or Trujillo Formations (Fig. 2.26). These strata dip northwestward and are on the east limb of the Moreno Valley syncline described at Stop 4. Colpitts and Smith (this guidebook) suggest that these outcrops were once continuous with Triassic outliers east of the valley in the Cimarron Range. These outliers lie on quartzofeldspathic gneiss and are similar to the outcrops we are visiting at this stop. The Triassic outliers in the western edge of the Cimarron Range were mapped by Clark and Read (1972) and Goodknight (1976) as being in depositional contact with the underlying Proterozoic rocks. However, regional work on the Triassic by Lucas et al. (this guidebook) indicates that Triassic strata should lie unconformably on Permian rocks (Sangre de Cristo Formation in this valley, Glorieta Sandstone and San Andres Formation farther south and east; Fig. 2.27). Because this area was not active tectonically during Triassic time, these outliers are probably klippe of the Cimarron thrust sheet. Given the structural setting, this appears to be the best interpretation.

Return to US-64, turn left and continue southward. 0.1

45.2 Small hill to left of road consists of weathered Proterozoic quartzites and muscovite-sillimanite-kyanite schists probably of the Early Proterozoic Hondo Group. **0.4**

45.6 A few hundred yards to the east is a sequence of interbedded quartzite and muscovite-sillimanite-kyanite schist that is overlain by Triassic(?) strata (Fig. 2.28). The metamorphic rocks are folded into an antiform with an eastward-dipping axial surface. This sequence is surrounded by weakly foliated quartzofeldspathic gneiss. The contact between Precambrian and Triassic is thought to be tectonic. **0.3**

45.9 County Road B36 on left. **0.1**

46.0 Sand and gravel operation to the left. **1.0**

47.0 Milepost 277. **0.2**

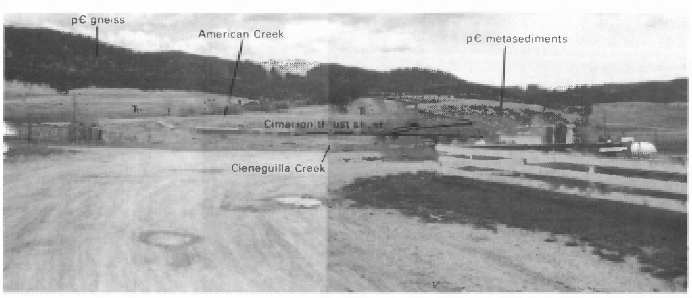

FIGURE 2.26. Photo showing structural and stratigraphic relationships of the Cimarron thrust sheet with underlying rocks at Stop 5 on American Creek. Photo by R. M. Colpitts.

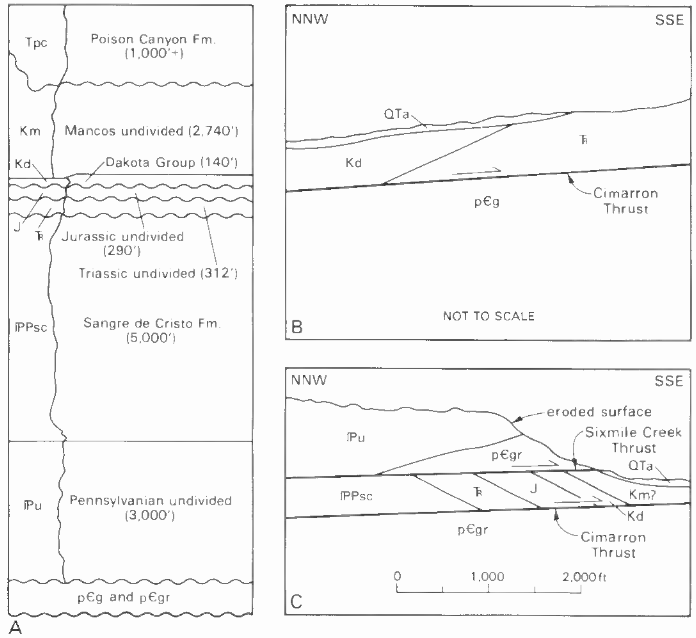

FIGURE 2.27. Structural and stratigraphic relationships in the Moreno Valley. A, The "normal" stratigraphic section for the Moreno Valley. B, Generalized cross section showing structural and stratigraphic relationships in the Lakeview Pines area, west of Optional Stop 4. C, Generalized structural and stratigraphic relationships at Stop 5 near American Creek.

47.2 Turnoff to Vietnam Veterans Memorial (Fig. 2.29). Official Scenic Historic Marker reads:

DAV Vietnam Veterans National Memorial. This chapel was erected in 1968 by Dr. Victor Westphal in memory of his son and all other U.S. personnel killed in the fighting in Vietnam. It was first dedicated as the Vietnam Veterans Peace and Brotherhood Chapel, and on May 30, 1983 it was rededicated as the DAV Vietnam Veterans National Memorial.

On left is the north end of the Angel Fire airstrip. **0.2**

47.4 At 8:00, Precambrian rocks on the north side of Saladon Creek are in fault contact with Permo-Pennsylvanian Sangre de Cristo Formation. This Saladon Creek fault is covered by Tertiary basalts to the east and south. Eastward movement of the northern block during Proterozoic time is probable, but recent movement appears to be normal (down-to-the-south). **0.7**

FIGURE 2.28. View northward up the axis of the Moreno Valley graben from just south of Stop 5. Baldy Mountain and Touch-Me-Not Mountain of the northern Cimarron Range are the snow-capped peaks in the distance. Rounded peak on the left skyline is Scully Mountain. Eagle Nest Lake is just past the ranch house. Photo by C. K. Mawer.

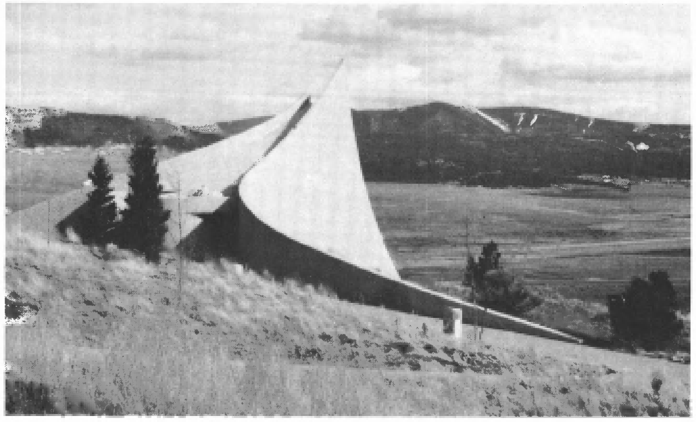

FIGURE 2.29. Photo of the DAV Vietnam Veterans National Memorial. Background view to the southeast shows snow-covered ski runs of Angel Fire Ski Area. Photo by C. K. Mawer.

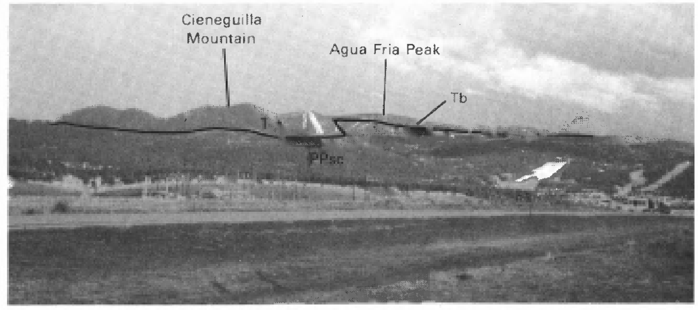

FIGURE 2.30. View southeastward of Angel Fire Ski Area. The Tuff of Cieneguilla Mountain (Tct) and the Ocate basalt flow (Tb) overlie the Permo-Pennsylvanian Sangre de Cristo Formation (PPsc) in the vicinity of Cieneguilla Mountain and Agua Fria Peak. Photo by R. M. Colpitts.

48.1 **Junction** with NM-38. **Turn left** to Black Lake and Angel Fire Ski Area. Supplemental Road Log 3 begins here and continues straight on US-64 over Palo Flechado Pass to Taos. **0.1**

48.2 High mesa from 8:00 to 10:30 is capped by basalts that range in age from 4–5 Ma (O'Neill, 1988). In the middle distance, a 3-km-long, west-dipping slump block of basalt overlies Quaternary(?) alluvium. The block was probably part of the flow on the tree-covered mesa immediately behind it that was undermined by headward erosion of Cieneguilla Creek following its capture by the Cimarron River. The basalt flow capping the high, tree-covered mesa lies at an elevation of about 9680 ft and may correlate with small flow remnants north of Palo Flechado Pass on the western side of the Moreno Valley (see Colpitts and Smith, this guidebook, for discussion). **0.6**

48.8 Milepost 36. **0.7**

49.5 Entrance to Angel Fire airport on left. The four rounded peaks to the left of the chair lift at 11:00 are Cieneguilla Mountain. The area at the top of the chair lift and Cieneguilla Mountain are made up of a slightly welded ash-flow crystal tuff. The gently rounded mountain mass to the right of the lift is Agua Fria Peak (11,086 ft). It is capped by basalt flows ranging in age from greater than 5 Ma to about 4 Ma. Agua Fria Peak is probably the source for the older flows of the Ocate Volcanic Field (O'Neill, 1988). Slopes at 3:00 are underlain by steeply dipping fluvial deltaic and marine strata of the Sandia and Porvenir Formations (Pennsylvanian). Slopes at 12:00 are composed of Permo-Pennsylvanian Sangre de Cristo Formation (dark red soils and slope debris). **0.5**

50.0 County Road B16 on right. **0.2**

50.2 Angel Fire city limit. **0.9**

51.1 Sign for Angel Fire resort. **Turn left. 0.2**

51.3 The slopes ahead in ski area are composed of east-dipping Permo-Pennsylvanian Sangre de Cristo Formation (Fig. 2.30). **0.3**

51.6 Water tank on hill at 2:00 is water storage for snow making and drinking water. Water is obtained from a number of wells that produce from fractured Sangre de Cristo Formation. **0.2**

51.8 Either **turn right** to hotel check-in and parking lot of Angel Fire Legends Hotel **or continue straight** for Optional Stop 6. Strata in roadcuts are micaceous sandstones, siltstones and mudstones of the Sangre de Cristo Formation. **0.1**

51.9 Base lodge development area is on the right. Front "bump" slope area at 12:00 is underlain by red Permo-Pennsylvanian Sangre de Cristo Formation. **Caution, road curves sharply to left. 0.3**

52.2 Steeply dipping micaceous sandstones of Sangre de Cristo Formation in roadcuts on right. These rocks are deformed by a down-to-the-west normal fault that lies to the left of the road. The nested piezometer was set in 1978 as part of a water-resource evaluation project for Angel Fire Corporation. The height of each piezometer indicates relative depth to screened interval; shortest pipe is the deepest piezometer, tallest pipe is shallowest. **0.4**

52.6 Outcrop on right exposes sandy mudstone with nodular limestone (paleosol horizon?) in the Sangre de Cristo Formation. Beds dip to the west. Winding road ahead. **0.6**

53.2 Sandstones and siltstones of Sangre de Cristo Formation are here dipping to the east. **0.4**

53.6 Switchback. **0.1**

53.7 Outcrop of mudstone and sandstone of Sangre de Cristo Formation. **0.1**

53.8 Roadcut exposes east-dipping strata of Sangre de Cristo Formation. **0.2**

54.0 Switchback. **0.3**

54.3 Poorly exposed siltstone and mudstone of the Sangre de Cristo Formation. **0.1**

54.4 Switchback. **0.6**

55.0 Nested piezometer set in 1979 during water-resource evaluation for Angel Fire. **1.0**

56.0 These are the last outcrops of Sangre de Cristo Formation that we will see before encountering outcrops of the Tuff of Cieneguilla Mountain on the right. **0.2**

56.2 **OPTIONAL STOP 6.** On right is a quarry in the tuff. This material was being used as road metal during early development of the ski area. Road metal is now obtained from the quarry at Stop 5. The Tuff of Cieneguilla Mountain is generally light bluish gray, finely crystalline, with phenocrysts of weathered biotite, sanidie and amphibole(?) in a groundmass of glass and quartz(?). To date, no isotopic age determinations have been made on this unit. **Retrace route to Legends Hotel. 4.3**

60.5 Arrive at the parking lot of Legends Hotel.

End of Second-Day Road Log.