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Second-day road log, from Lordsburg to Deming via Little Hatchet Mountains and Victorio Mountains

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2000, pp. 17-30. https://doi.org/10.56577/FFC-51.17

in:

Southwest Passage: A trip through the Phanerozoic, Lawton, T. F.; McMillan, N. J.; McLemore, V. T.; [eds.], New Mexico Geological Society 51 st Annual Fall Field Conference Guidebook, 282 p. https://doi.org/10.56577/FFC-51

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SECOND-DAY ROAD LOG, FROM LORDSBURG TO DEMING VIA LITTLE HATCHET MOUNTAINS AND VICTORIO MOUNTAINS

T. F. LAWTON, N. J. McMILLAN, V. T. McLEMORE, and J. W. HAWLEY

FRIDAY, OCTOBER 20, 2000

Assembly Point: Holiday Inn Express, Lordsburg
Departure time: 7:30 a.m.
Distance: 156 mi
Stops: 3; 1 optional

Summary

The route for Day 2 makes a circuit of the Little Hatchet Mountains and a stop at the mining district of the Victorio Mountains. The Little Hatchet Mountains contain the most complete Upper Jurassic to Lower Cretaceous and Laramide sections in southern New Mexico. Laramide structural features are also well displayed in the range. In the southern end of the range, basement plutonic rocks of Proterozoic or Cambrian age are thrust over Upper Paleozoic strata deposited in the Pedregosa basin. The first stop of the day provides an overview of the Laramide structure and Mesozoic stratigraphy, as well as Neogene and Quaternary basin development, Basin-and-Range structure, and ground-water systems of the Hachita Valley. The second stop is a hike through the upper part of a Late Jurassic fan-delta and volcanic succession in the Broken Jug Formation. Laramide strain fabrics are well exposed, as are Jurassic(?) and Tertiary intrusive relationships and faulting. The route then traverses the range, crossing important Laramide folds and reverse faults, passes south along the west side of the mountains, and stops near Granite Pass at a major reverse fault and skarn deposit at the junction of Proterozoic or Cambrian granite, upper Paleozoic carbonate rocks, and Tertiary granite. A final, optional stop in the Victorio Mountains provides a view of Laramide structure and carbonate-hosted replacement mineral deposits in lower Paleozoic rocks.

Mileage

0.0 Holiday Inn Express in Lordsburg. **0.1**

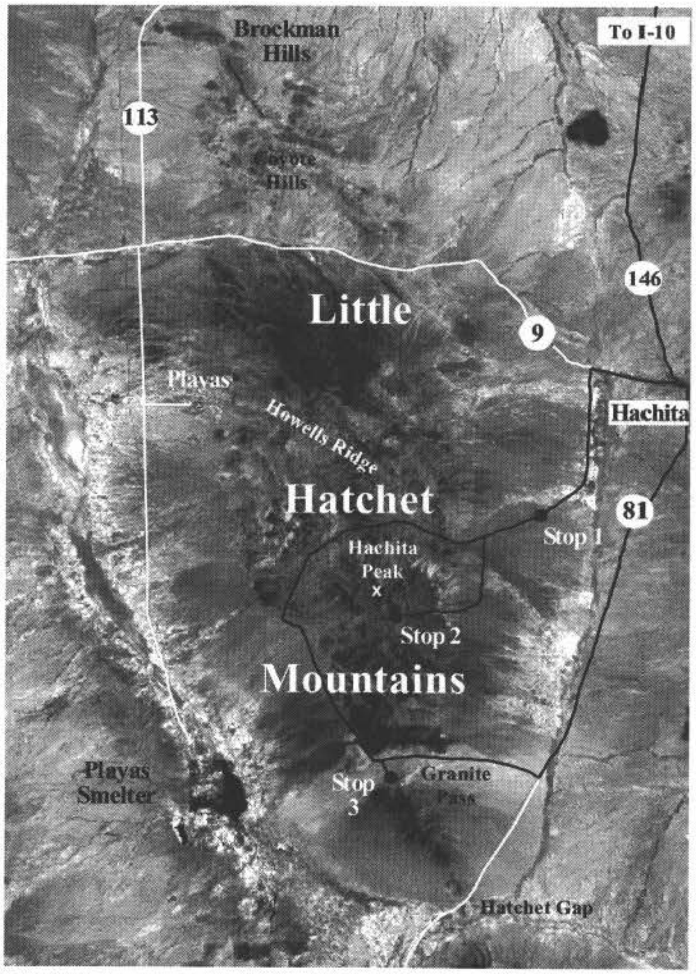
0.1 I-10 east. **4.1**

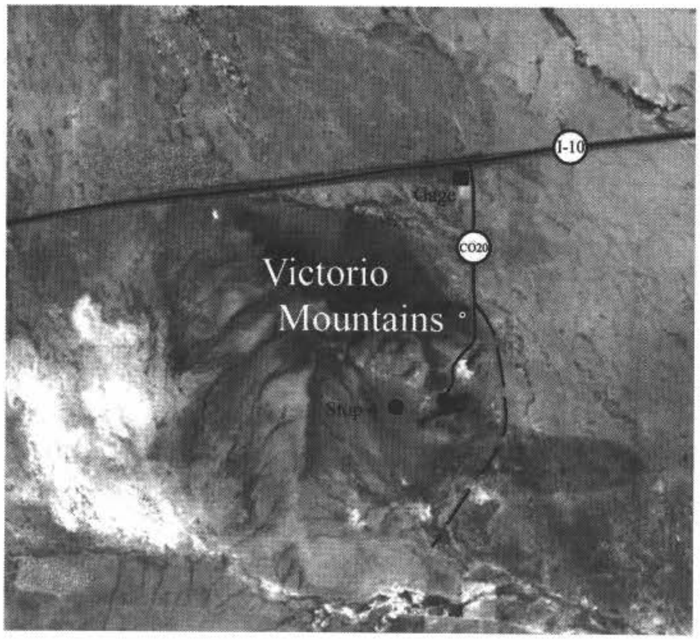
4.2 Bridge over Lordsburg Draw, which drains south into Animas basin. **2.3**

6.5 Exit 29. Turbine plant for El Paso Natural Gas Company. **5.3**

11.8 Exit 34, Playas. Grant County line. Muir, located near this exit, was a railroad camp named for Colonel John T. Muir (1861–1945), a local pioneer scout, rancher, businessman, miner, banker, and state representative for Hidalgo county.

Pyramid Mountains at 3:00–4:00 (south) are dominated by Oligocene volcanics. From this vantage point, the Pyramid Mountains appear to be continuous with Animas Mountains to south. Burro Mountains at 9:00 (north) are underlain by Proterozoic granite, gneiss, schist, quartzite, and amphibolite, locally overlain unconformably by Lower Cretaceous Beartooth





Quartzite and Upper Cretaceous Mancos Shale. Laramide and mid-Tertiary plutons, dikes, and plugs locally intrude the older rocks. In the Early Cretaceous, this basement complex formed an elevated flank to the Bisbee rift basin, whose strata onlap northward onto Proterozoic rocks. This low-relief uplift long formed a barrier between the Tethyan marine realm to the south and the Boreal realm of the Western Interior basin of the Rocky Mountains. It was probably an important topographic barrier as early as Triassic time. Lordsburg Mesa, the prominent bajada west of the Burro Mountains, consists of coalesced Quaternary alluvial fans derived from the Burro Mountains (Clemons et al., 1980). **2.9**

14.7 MP-37. Cedar Mountains form low hills at 1:00 (southeast). **3.0**

17.7 MP-40. Pigeon Hills at 3:00 are 6.5 mi to south, with Brockman Hills beyond them in distance. In the Brockman Hills, strike ridges underlain by folded Mojado Formation extend for several miles along an east–west trend. A north-vergent reverse fault emplaces Mojado Formation on volcanic rocks that are probably equivalent to the Upper Cretaceous Hidalgo Formation of the Little Hatchet Mountains (Corbitt et al., 1977; Thorman, 1977). **2.4**

20.1 Exit 42, Separ. The Janos Trail, an old Spanish route from the copper mines at Santa Rita to Mexico, crossed the route followed by I-10 here (Julyan, 1996). Separ, a railroad camp founded about 1882, was originally called Sepas, possibly derived from the Spanish cepas, for tree stumps (Clemons et al., 1980; Julyan, 1996). **2.7**

22.8 Bridge over Burro Cienega (Spanish for marsh), a major tributary to Lordsburg Draw. **0.3**

23.1 Bridge for railroad to Playas smelter, which ceased operation in 1999. Victorio Mountains visible at 12:00–1:00, Florida Mountains at 1:00–2:00. **4.4**

27.5 Exit 49, Hachita (NM-146). **Exit I-10.** Cookes Range at 11:00, Grandmother Hills at 10:00–11:00. NM-146 south, running straight through grassland and yucca stands, offers one of the most splendid and expansive vistas in the Southwest. Above the highway's vanishing point, the Big Hatchet Mountains loom over the horizon. The Big Hatchet Mountains contain the most complete Paleozoic section in southwestern New Mexico (Zeller, 1965; Drewes, 1991). The range is flanked on the south by southwest-vergent Laramide structures (Seager and Mack, 1986) that represent inversion of the Bisbee rift basin (Lawton, 1996, this volume).

Cedar Mountain Range at 10:00 contain Rubio Peak volcanics and Oligocene tuffs and rhyolites. Prominent cinder cones are at 12:00–1:00. The Little Hatchet Mountains are at 1:00, with Hachita Peak forming the highest point in the range. The small hill of the Saltys is at 2:00, where the Marshal Young Unit #1 well encountered a reverse fault that emplaces Paleozoic strata on Tertiary conglomerate of the Lobo Formation (Lawton and Clemons, 1992; Lawton, this volume). This fault represents an eastward continuation of the Brockman Hills structural trend. **12.2**

39.7 MP-7. Black Mountain, a middle Miocene basaltic-andesite cone (~17.9 Ma; Thorman and Drewes, 1979), is a mile from road at 3:00. **0.8**

40.5 Continental Divide sign (elevation 4520 ft). This sign is mislocated on the highway. The true Continental Divide is south of South Well Road. **0.4**

40.9 Road to South Well of Victorio Cattle Company. Cedar Mountain (6210 ft) of Cedar Mountain Range at 9:00. Western end of Cedar Mountain Range at 10:00. **1.8**

42.7 MP-4. Continental divide lies just north of this mile marker. **1.0**

43.7 MP-3. Hachita basalt, with an age of 11.8 Ma (Seager, et al., 1984), at 11:00. The basalt chemistry indicates both lithospheric and asthenospheric mantle attributes, suggesting that the basalt was erupted at onset of asthenospheric magmatism. Sierra Rica and Apache Hills in background lie in Hidalgo County and Chihuahua, Mexico, and contain mid-Tertiary volcanic rocks unconformable on Cretaceous and Paleozoic strata. **3.0**

46.7 Junction NM-9 and NM-114, Hachita. **Turn right**. After consolidation of the field trip caravan to four-wheel-drive vehicles in Hachita, the route continues west on NM-9.

About 1875, a mining camp was established at Eureka, also known as Hachita, in the Little Hatchet Mountains about 4 mi west-southwest of here. By 1882–1884, the camp had approximately 300 residents (Julyan, 1996; Hilliard, 1998). A U.S. Post Office was established at Old Hachita in 1882 (Julyan, 1996) and closed in 1898 (Hilliard, 1998) as the town began to decline with depletion of the ore. About 1899, the Arizona and New Mexico Railroad Company located a settlement at the present site of Hachita. The El Paso and Southwestern Railroad met the Arizona and New Mexico Railroad at the new settlement, where both railroads shared facilities. A railroad camp grew up and people slowly moved from Old Hachita to the new town, called Hachita Junction, or simply Junction. In 1902, a U.S. Post Office was established at the new town of Hachita (Hilliard, 1998). New Hachita saw its best days in the next 20 yrs when it boasted a hotel, a boarding house, stores, a few saloons, a barber shop, a blacksmith shop, a variety of railroad facilities, and numerous homes. It grew further in 1912, when a group of Mormons relocated from northern Chihuahua. In the 1870s and 1880s, the Mormons had settled in northern Mexico at Colonia Diaz and several other colonies to escape persecution in the United States (Hilliard, 1998). Around 1912, many of them fled the Mexican Revolution and returned to the United States. Some settled at Poverty Flats at Hachita, although many left for other parts of southern New Mexico and Arizona. In 1917, the U.S. Army established Camp Shannon north of Hachita to protect the valley from raids by Mexican revolutionaries. The camp grew to nearly 50 buildings (Hilliard, 1998). In 1920, Hachita had 777 residents. A Civilian Conservation Corps (CCC) camp was established in 1933 and closed in 1942. The railroad was abandoned in 1959. Today, a few businesses and houses make up Hachita.

Coyote Hills form skyline at 1:00–2:00, underlain by northeast-dipping Oligocene tuffs that unconformably overlie conglomeratic strata of the Ringbone

FIGURE 2.1. Panorama from stop 1. View south and west of Hachita Peak (center, just to left of road) and Howells Ridge (right).

Formation. Dated tuffs in the Coyote Hills range in age from 35.1 to 31.8 Ma (McIntosh and Bryan, this volume). Small hill at 12:00 underlain by Oligocene volcanics dipping 40° to northeast. **1.9**

48.6 Little Hatchet Draw drains southward into Laguna Playa. **0.4**

49.0 Little Hachett (sic) Mountains Road. **Turn left** and travel south on dirt road. Little Hatchet Mountains visible from 1:00 to 3:00. Ghost town of old Hachita lies at 3:00. **3.1**

52.1 Basin fill. **0.9**

53.0 Road intersection, continue straight (southwest). **0.8**

53.8 **STOP 1. Overview of geology of Little Hatchet Mountains.** Hachita Peak at 12:00 (Fig. 2.1); Howells Ridge at 1:00–2:00 (Figs. 2.1, 2.2). Old Hachita townsite at 4:00 (Fig. 2.1). Hachita Peak is underlain by strata recently included in the revised Broken Jug Formation (Fig. 2.3; Lawton and Harrigan, 1998), a term initially applied to a diverse suite of rocks in the central part of the range by Lasky (1947). The Broken Jug Formation consists of 4026 ft of sedimentary and volcanic strata that underlie the Lower Cretaceous Hell-to-Finish Formation, exposed on the summit of Hachita Peak. The sedimentary strata include of marine conglomerate, sandstone and siltstone capped by 770 ft of subaerial basalt flows. The lower slopes of Hachita Peak are underlain by the lowermost dolostone member of the Broken Jug Formation, which is thrust over younger members of the formation (Lawton and Harrigan, 1998). Locally, the dolostone member rests unconformably on cherty thick-bedded carbonate grainstones of the Horquilla Limestone.

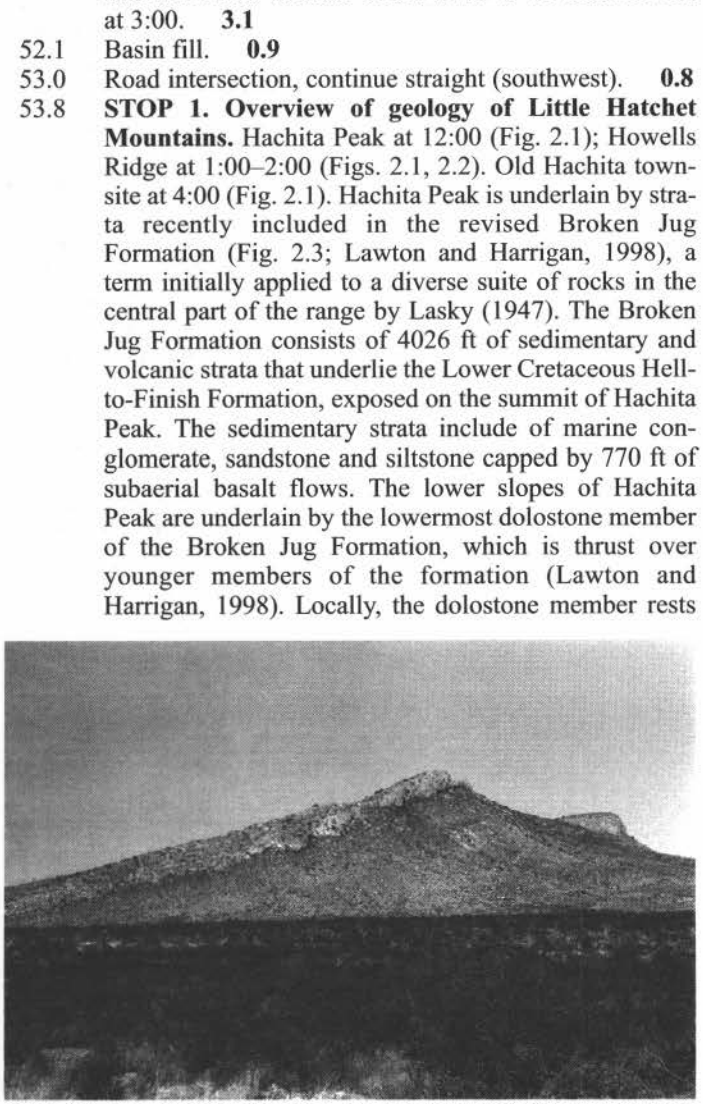


Figure 2.2. Howells Ridge, view west. Capping limestone bed is Howells Ridge member of U-Bar Formation.

The age of the Broken Jug Formation, although presently speculative, is likely Late Jurassic (Lucas and Lawton, this volume). Stratigraphic position indicates that it is post-Pennsylvanian and pre-Aptian. Lucas et al. (1996) suggested that the dolostone member is equivalent to the Permian Epitaph Dolomite, whereas Lawton and Harrigan (1998) suggested a Late Jurassic age by comparison with sub-Cretaceous strata exposed in the Chiricahua Mountains of southeast Arizona. A coral collected approximately 500 ft below the top of the formation (Harrigan, 1995) resembles a species (*Thamnasteria* c.f. *T. imlayi*) described from the Oxfordian Smackover Formation (H. Filkhorn, personal commun., 2000; Lucas and Lawton, this volume) and the Jurassic of northern Chihuahua (Reyeros de Castillo, 1974), supporting a Late Jurassic age for the upper part of the formation.

The Copper Dick fault trends east–west at the northern base of Hachita Peak. It is a steep fault that separates Jurassic strata and Cretaceous plutons on the south from Lower Cretaceous sedimentary rocks of the Bisbee Group in the Howells Well syncline on the north. In the foreground, the skyline of Howells Ridge is a prominent limestone, the Howells Ridge Member of the U-Bar Formation (Fig. 2.3; Lucas and Estep, 1998), that overlies thinner beds of the slope. These include the lower marine members of the U-Bar Formation and the upper part of the Hell-to-Finish Formation, which consists mainly of interbedded red siltstone, sandstone and conglomerate. The Howells Ridge member rests on progressively older rocks to the northwest along Howells Ridge. Zeller (1970) regarded this contact as a thrust fault. The resultant thrust geometry is an unusual younger-on-older relationship; other possible interpretations of this contact include a low-angle normal fault or an unconformity (Lawton and Lucas, this volume). Many stratigraphic contacts in the range have been modified by bedding-plane faults that are probably the result of flexural slip during Laramide folding. North of Howells Ridge, the Hell-to-Finish is thrust over the Hidalgo Formation, a succession of andesitic flows and volcaniclastic rocks that underlie the low ground northeast of the slope. The base of the Hidalgo is 70–71 Ma (Lawton et al., 1993; Young, 1996; Young et al., this volume).

A major regional unconformity separates Upper

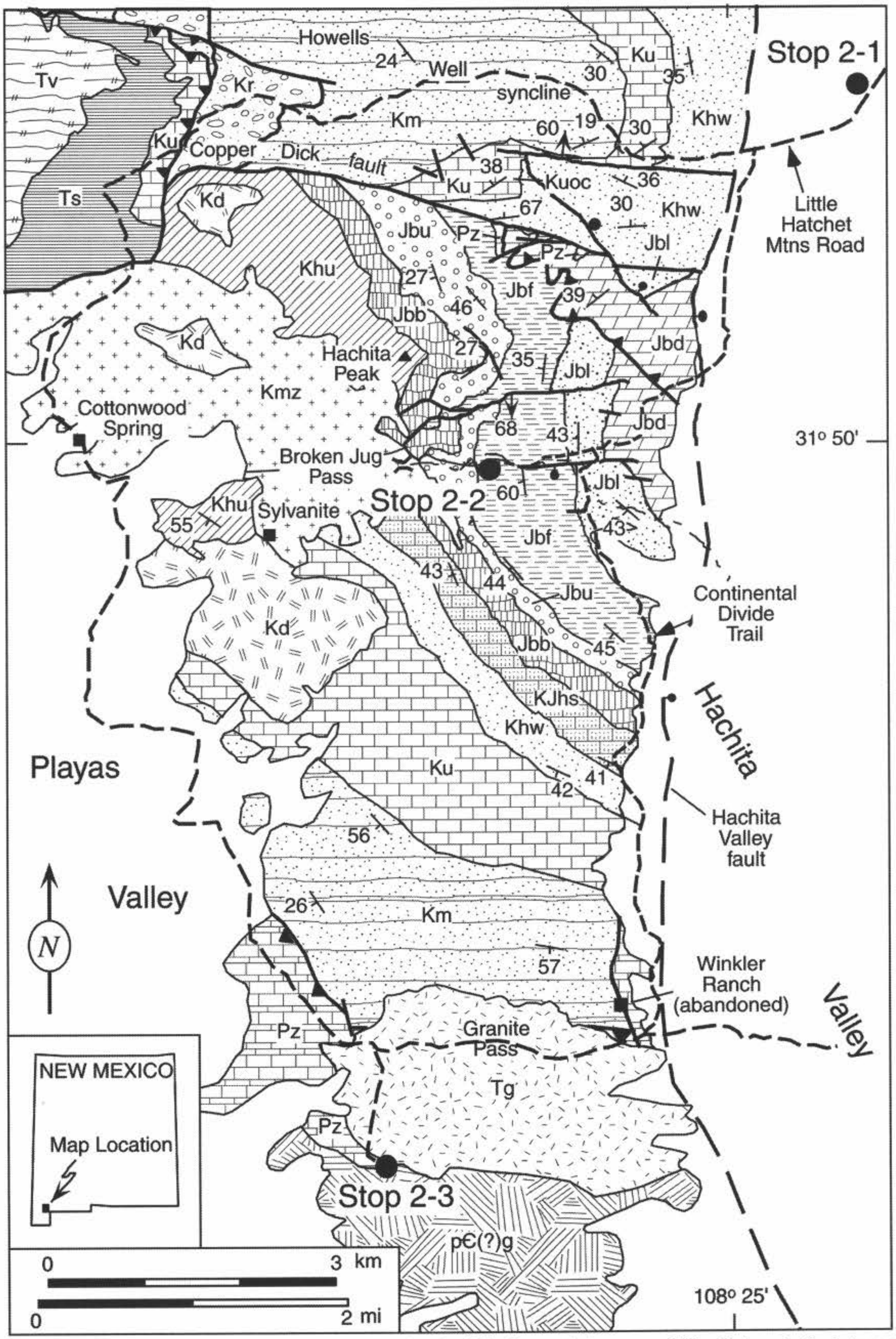


Figure 2.3. Geologic map of central and southern Little Hatchet Mountains showing field trip stops in the range. **p€(?)g**, Proterozoic-Cambrian granite; **Pz**, undifferentiated Paleozoic strata. Bisbee Group: Broken Jug Formation-**Jbd**, dolostone member; **Jbl**, lower conglomerate member; **Jbf**, fine-grained member; **Jbu**, upper conglomerate member; **Jbb**, basalt member; Hell-to-Finish Formation-**Khu**, undifferentiated Hell-to-Finish Formation; **KJhs**, Stone Cabin Gulch Member; **Khw**, Winkler Ranch Member; **Ku**, U-Bar Formation; **Km**, Mojado Formation. **Kr**, Ringbone Formation; **Kmz** and **Kd**, cogenetic monzonite and diorite plutons generalized from Zeller (1970) and Channell et al. (this volume); **Ts**, Skunk Ranch Formation; **Tg**, Tertiary granite; **Tv**, Tertiary volcanic rocks. Adapted from Zeller (1970) and Lawton and Harrigan (1998).

Cretaceous strata of the Bisbee Group from sedimentary and volcanic strata deposited during the Laramide orogeny. The Hidalgo and underlying Ringbone formations, deposited during Laramide deformation, onlap from west to east onto eroded Lower Cretaceous strata. The Hidalgo exposed in our view rests unconformably on U-Bar Formation north of Howells Ridge (Zeller, 1970), where the U-Bar is exposed in low hills to the west at 3:00. Further northwest, the Ringbone, which depositionally underlies the Hidalgo, rests unconformably on U-Bar and Mojado formations.

Howells Ridge Cave (elevation ~5510–5540 ft) near the summit of the ridge contains one of the most complete paleoecological records of latest Quaternary plant and animal communities in the American Southwest. This vertical chimney in the reef limestone facies of the U-Bar Formation was discovered by Bob Zeller about 1960. According to Van Devender and Worthington (1978, p. 85), "the chimney has been filled to within 1 m of the opening with a matrix [including abundant plant material] that is extremely rich in bones of various vertebrates including birds (Howard 1962), mammals (…; Harris et al., 1973), reptiles, and amphibians." They further state (p. 87) that "the cave configuration is such that the faunal materials were probably carried in by predators [including large birds] or packrats and does not represent a natural trap." The dated fossils include California Condor (13,460 $\pm$ 200 ^{14}C yrs B.P.), camel and mammoth (12,000–14,000 ^{14}C yrs B.P.; Connin et al., 1998), and horse (*Equus* sp.). A succession dated by the ^{14}C method in a 6.5 ft section of mid- to late-Holocene cave deposits contains at least three species that require relatively permanent water (Van Devender and Wiseman, 1977). These are tiger salamander, leopard frog, and *Gila robusta*, a fresh-water minnow. Ages of this fauna suggest that perennial or intermittent lakes, marshes or streams were present in adjacent Lower Playas Valley, about 7.5 mi west of the cave, 500–1100 yrs ago, 3000 yrs ago, and prior to 4500 yrs ago.

Hachita Valley is a topographically open intermontane basin (semibolson of Tolman, 1909) with a through-going axial stream (Hachita Draw) and a half-graben structure (Schwennesen, 1918; Trauger and Herrick, 1962; Hawley et al., 2000). Basin blocks are tilted southwestward and westward, respectively, toward the Big Hatchet and Little Hatchet ranges, and away from the Sierra Rica-Apache Hills uplift to the east. Hatchet Gap, a low pass between the Big and Little Hatchet Mountains, allows some surface water and ground water to spill from the Playas Valley into the mid-section of Hachita Valley. Basin-fill thickness appears to be as much as 2000 ft in the deepest half-graben areas based on interpretation of gravity and seismic surveys (Klein, 1995). A major fault zone at the western edge of Hachita Valley was inferred in the shallow subsurface at Hatchet Gap by Schwennesen (1918), and by Trauger and Herrick (1962) at the base of the Big Hatchet Mountains. The northern extension of this zone has been recognized recently by Lawton and Harrigan (1998) at the base of the Little Hatchet Mountains. This neotectonic feature, which they named the Hachita Valley fault, cuts Pleistocene piedmont deposits (Machette et al., 1998) and is crossed at mileage 62.5 and 78.4 on today's tour route. Seismic reflection data from the south end of the Little Hatchet Mountains indicate that the fault there has a listric geometry that creates the westward tilt of the hanging wall (Chang et al., 1999).

Hachita Draw ends in Chihuahua just east of the International Boundary in a large, but very shallow depression that includes the ephemeral lake plain of Laguna Los Moscos. During Late Quaternary pluvial intervals, this depression was flooded by lake Hachita (Schwennesen, 1918), which had a maximum surface area of about 58 mi^2 based on relict high-shoreline features at an elevation of 4140 ft (Hawley, 1993). Since the Rio Casas Grandes Valley is located only 6 mi east of the low depression rim (<4164 ft elevation), a recent (latest Pleistocene–early Holocene?) interconnection of surface water as well as ground-water flow systems is very likely (Hawley et al., 2000).

The closed and partly drained Hachita-Moscos basin system covers an area of about 973 mi^2, with about 425 mi^2 in Mexico. The system consists of three subbasins, Upper Hachita, Wamel-Moscos and Lower Hachita, which converge in a large closed depression occupied by the ephemeral lake plain of Laguna los Moscos. Bordering highlands, Sierra Alta and the Cedar Mountain Range to the east and northeast and the Big and Little Hatchet Mountains to the west separate this basin system from the Mimbres and Playas basin systems except at Hatchet Gap. Ephemeral axial streams (draws) carry surface runoff from highland areas to Laguna los Moscos.

Maximum fill thickness in the half-graben subbasins appears to be 2000–3000 ft, but the primary aquifer system consists of basin-floor and piedmont-slope deposits of the Upper and Middle Gila Group that are unconsolidated to partly indurated and no more than 660 ft thick. A small annual underflow component (less than 8 acre-ft) also spills from the Upper Playas subbasin into the Hachita Valley through Hatchet Gap. Ground-water flow follows the general basin axial trends eastward toward Laguna los Moscos. This ephemeral-lake plain appears to have both phreatic and vadose flow components, with a partial underflow drainage connection with the Lower Valley of Rio Casas Grandes, which is located only 6 mi to the east across a very low topographic divide.

Return to vehicles and continue southwest on Little Hachett Mountains Road. **0.2**

THE EUREKA MINING DISTRICT, GRANT COUNTY, NEW MEXICO

Virginia T. McLemore

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Modern prospectors discovered the Eureka (Hachita) mining district in the northern part of the Little Hatchet Mountains in 1871; however, stone tools found in old turquoise pits are evidence of much earlier activity by Native Americans. The American, Hornet, and King claims in the district were located in 1877–1878 (Fig. 2.4) at the same time that the Sylvanite district in the southern part of the mountains was prospect-

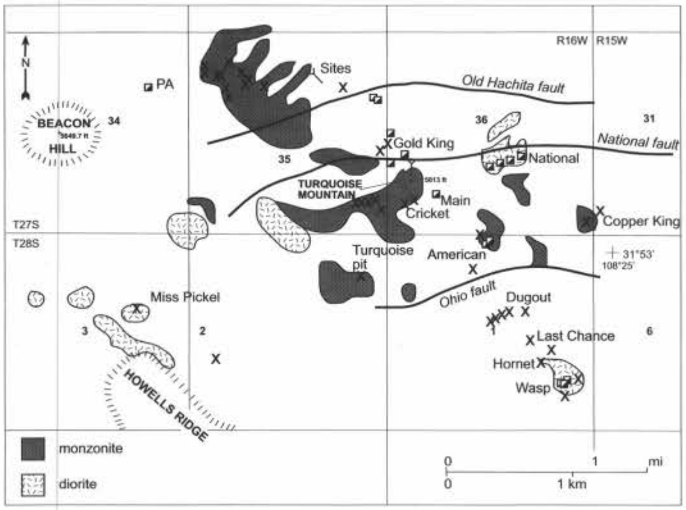

FIGURE 2.4. Mines and prospects in the Eureka district, Grant County, New Mexico (modifed from Lasky, 1947; Zeller, 1970).

ed. The Eureka and Sylvanite mining districts were originally subdistricts of the Hachita district; the name Hachita is no longer used as a district name.

The earliest mining was at the Hornet mine (Fig. 2.4), but Apache Indians were hostile to mining and prospecting and made things difficult. By late 1878, when the U.S. Army visited the district, only 20 people resided there. Protection afforded by the army allowed the miners to return, and in 1881, ore was shipped from the American mine. In the early 1880s, smelters were built at both the American and Hornet mines, but neither smelter operated for very long due to technical difficulties. In 1885, a drop in the price of silver caused mining activities to subside until 1902, when the railroad connected the smelter towns of Douglas, Arizona, and El Paso, Texas, and stimulated production. The total value of ore produced to 1906 was not more than $500,000 (Lindgren et al., 1910). Total estimated production from the district is approximately $1.59 million, including 2.9 million lbs Pb, 1.7 million lbs Zn, 500,000 lbs Cu, 5,000 oz Au, and 450,000 Ag (McLemore et al., 1996b).

In the district, the mountains consist of Cretaceous sedimentary and Upper Cretaceous–lower Tertiary volcanic rocks intruded by Upper Cretaceous to Tertiary stocks, dikes, and sills. The oldest rocks in the district are Cretaceous sedimentary rocks consisting of thinly bedded limestone, dolomite, and shale. Between Howells Ridge and Old Hachita, the Hidalgo Formation of Late Cretaceous to early Tertiary age crop out. These rocks consist of altered andesite and andesite breccia with a few sedimentary units consisting of andesitic detrital sediments. A hornblende andesite near the base of the section has an age of 71.44 ± 0.19 Ma (^{40}Ar/^{39}Ar, hornblende; Lawton et al., 1993). The Eureka diorite has a ^{40}Ar/^{39}Ar-isochron age of 34.7 ± 1.8 Ma (whole rock, see Channell et al., this volume). South and west of Old Hachita, the Eureka quartz monzonite and diorite stocks have intruded the Hidalgo Formation. Throughout the Little Hatchet Mountains, several Upper Cretaceous–Tertiary stocks, dikes, and sills intruded the Cretaceous sedimentary rocks, and the most highly mineralized areas are associated with these intrusive rocks.

Mineral deposits in the Eureka district consist of Laramide veins in limestone and monzonite, Laramide skarns and replacements in metamorphosed limestone along the edge of the intrusive rocks, turquoise deposits, and disseminated quartz-specularite deposits. Lasky (1947) divided the mineral deposits into seven types based on mineralogy: (1) disseminated pyrite in Tertiary intrusive rocks; (2) quartz-specularite deposits (secs. 2, 11, T28S, R16W); (3) lead-zinc skarns and replacements (Hornet); (4) arsenopyrite-lead-zinc veins (American, Miss Pickel); (5) manganosiderite-galena veins; (6) manganosiderite-tetrahedrite-galena veins (King 400, Silver King, Howard); (7) quartz-pyrite-chalcopyrite veins (Copper King, Stiles).

Ore deposits at the American mine occur along a vein in metamorphosed limestone near the contact with a monzonite stock (Lasky, 1947). The limestone was metamorphosed to marble and garnet. The vein strikes N50°E and dips 58–75°NW and can be traced in outcrop for approximately 1000 ft before either end is buried by arroyo gravels. In the mine, the vein varies from 2.5–23 ft wide. Mineralized vein material contains galena, sphalerite, pyrite, arsenopyrite, stibnite?, and a trace of chalcopyrite. Gangue material includes manganosiderite, calcite, and sericite.

One example of an ore deposit that formed in the district without developing calc-silicate, skarn-type alteration occurs at the Hornet mine. The Hornet mine was one of the earliest mining locations in the Little Hatchet Mountains and for a while it was the site of the greatest mining activity in the mountain range. The host rocks at the mine include limestone, Hidalgo Formation, and an irregular diorite sill that intrudes the contact between the limestone and the volcanic rocks. Ore at the mine consisted of three types: (1) lead carbonate ore stained black by manganese oxides and averaging 857 ppm Ag; (2) galena ore that was even richer in silver; and (3) zinc carbonate ore also rich in silver. The grade of material shipped between 1905 and 1927 was approximately 754 ppm Ag, 3.5% Zn, less than 1% Pb, and 0.05% Cu. Gangue was almost entirely coarse-grained calcite; pyrite occurred in unoxidized material.

Turquoise deposits were rediscovered about 1885 and worked intermittently for 25 yrs or more. Total production is unknown. Blue and green turquoise is found in veins in altered trachyte, andesite, and ash-flow tuff. Some bands were up to 6 ft wide (Sterrett, 1911); but most are smaller. Impurities include jarosite, sericite, iron oxides, pyrite, and clay (Lasky, 1947; V. T. McLemore, unpubl., field notes, July 1, 1995).

Zones of disseminated pyrite occur in the monzonite in the district. The monzonite is altered to and replaced by jarosite, iron oxides, and pyrite. Unaltered, pre-ore lamprophyre dikes cut the altered monzonite in the Sylvanite district to the south, suggesting that the alteration is older than the mineralization (Lasky, 1947). A zone of disseminated quartz-specularite occurs in secs. 2, 11, T28S, R16W in the anticline of diorite and andesite breccia (Lasky, 1947). Iron was produced and used in the Hornet and American smelters. The rock is locally completely sericitized and replaced by quartz, sericite, and specularite.

54.0 Cross Grant-Hidalgo County line near here. Howells Ridge at 2:00. **1.2**

55.2 **Turn left** on Continental Divide Trail. Four-wheel-drive vehicle recommended.

Congress established the Continental Divide Trail in 1978. The trail follows the continental divide through five states, mostly within the Rocky Mountains from Canada to Mexico, and is approximately 3050 mi long. The trail is protected and recognized as a National Scenic Trail, one of only eight such trails in the United States. The Continental Divide Trail is about 70% complete, with many connections (mostly in New Mexico) yet to be established. **0.8**

56.0 Road crosses major arroyo. Hills at 3:00 underlain by Hell-to-Finish and U-Bar formations. In saddle to south of hills are Paleozoic rocks (white exposures) where the east-west-trending Copper Dick fault crosses saddle. **0.9**

56.9 East shoulder of Hachita Peak at 12:30. Broken Jug Formation is exposed on hill slopes to west of road (Fig. 2.5). The lower tan hillside is underlain by the basal dolostone member, a thin-bedded tan-weathering sandy dolostone with wave-ripple cross-laminations. Mafic dikes cut the dolostone member on the lower hill slope. The distant hillside is underlain by the fine-grained member, an interval of silty carbonate and calcsiltite

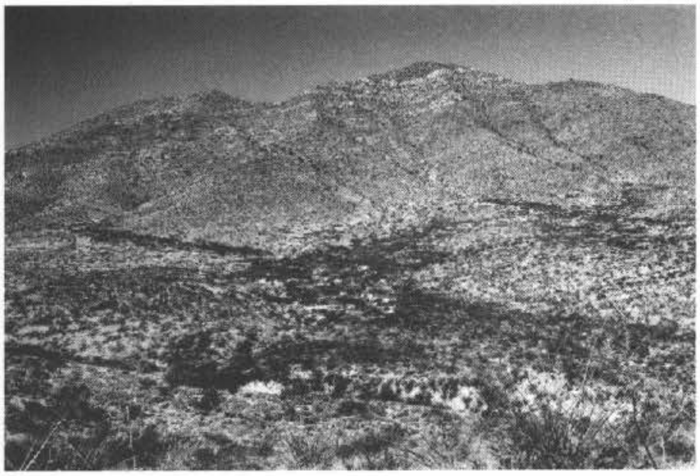

FIGURE 2.5. East flank of Hachita Peak (left-hand summit). Basalt member of Broken Jig Formation caps right summit, underlain by light gray ledges of conglomerate in upper conglomerate member.

deposited in a prodelta setting. The upper hill slopes of the mountain are underlain by ledges of limestone-clast conglomerate beneath the upper dark slope, which is underlain by the basalt member. **0.3**

57.2 Intersection. **Turn left** to follow Continental Divide Trail. Crest hill in exposures of dolostone member. Road descends steep hillside into arroyo. Turn left in arroyo and proceed downstream. Ascend far hillside after proceeding 0.2 mi down stream bed. **0.4**

57.6 Road intersection, **turn left**. **0.2**

57.8 Road follows ridge along outcrops of steeply dipping, thin beds of dolostone member intruded by mafic dikes and sills. **0.2**

58.0 Top small rise. Contact of dolostone member and lower conglomerate member of Broken Jug Formation. **0.1**

58.1 Intersection of Continental Divide Trail, which continues left (south), with road up Broken Jug Canyon. Bear right (straight) at this intersection. Views to northwest at 2:00–3:00 are of Hachita Peak. Prominent ledges are in upper conglomerate member of Broken Jug Formation. **0.4**

58.5 Enter Broken Jug Canyon. Fine-grained member, dipping west, on both sides of arroyo. The upper part of this unit includes graded carbonate and chert litharenite turbidites with rip-up mudstone intraclasts (Fig. 2.6). The pocked nature of the exposures results from weathering of soft mudstone clasts from the outcrop. Note caliche-cemented gravels to right. **0.1**

FIGURE 2.6. Exposure of fine-grained member of Broken Jug Formation, north side of Broken Jug Canyon.

58.6 Drive out of arroyo on left and climb grade. Park near cattle tank at end of road, about 0.2 mi further. **0.2**

58.8 **STOP 2. Geology of Broken Jug Canyon.**

This stop involves a 1-mi, round-trip walk to view stratigraphy, igneous rocks, and structural fabrics of the upper part of the Broken Jug Formation. We will also see felsic dikes of probable Oligocene age and some surficial deposits. From the parking area near the cattle tank, proceed directly downhill to the arroyo and then left up the arroyo. In just under 0.3 mi, there is a confluence of two arroyos, each forming a jump, or dry waterfall. Climb out of the arroyo on the north (right) side and climb up through the conglomerate ledges, working left to the right-hand arroyo. Watch for rattlesnakes (Fig. 2.7). A west-trending rhyolite dike forms part of the north wall of the arroyo at this point. Upon attaining the right arroyo above the jump, proceed up the arroyo.

The conglomerate ledges along the arroyo are beds in

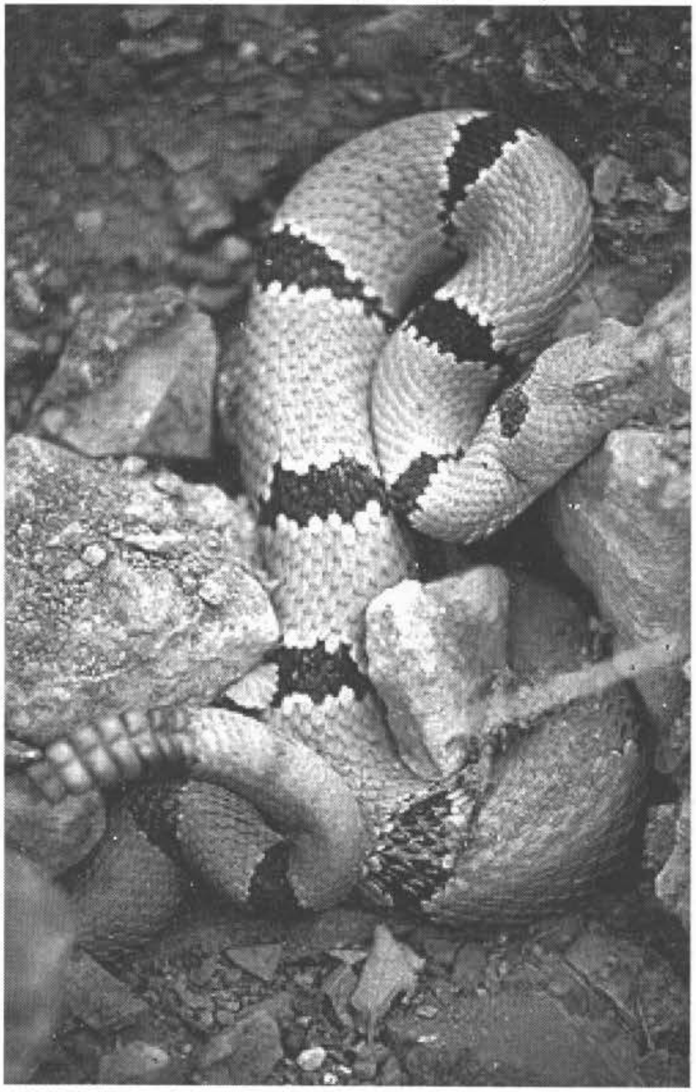

FIGURE 2.7. Banded Rock Rattlesnake (*Crotalus lepidus klauberi*), Little Hatchet Mountains.

FIGURE 2.8. Deformed conglomerate in upper conglomerate member of Broken Jug Formation, stop 2. Limestone clasts (generally dark gray) are deformed against fractured chert clasts (light gray, high relief).

the upper conglomerate member of the Broken Jug Formation (Fig. 2.3). The conglomerate beds in the member are 10–75 ft thick and consist of 80% limestone clasts and 10–20% chert clasts. The conglomerate beds are interbedded with sandstone that ranges from quartz arenite to carbonate litharenite. Shallow-water features such as hummocky cross-stratification, wave ripples and trough cross-beds are present in the sparsely fossiliferous sandstone.

In the vicinity of Broken Jug Canyon, the conglomerate beds are strongly deformed, with the limestone clasts elongated in a roughly north–south direction. Resistant chert clasts are not stretched, although many are fractured consistent with north–south elongation. Limestone clasts are locally deformed and compacted around chert clasts (Fig. 2.8). An east–west-trending rhyolite dike cuts the conglomerate on a sharp contact (Fig. 2.9) not far upstream of the jump. East-trending rhyolite dikes are conspicuous features of Zeller's (1970) map in this area; just north of this traverse, parallel east-trending normal faults that the upper members of the Broken Jug Formation from the ridge to the north to the elevation of the arroyo here.

At 0.4 mi, young sheetflood and debris-flow deposits are exposed in a cutbank in the arroyo (Fig. 2.10).

FIGURE 2.10. Young gravels exposed in arroyo cutbank, stop 2.

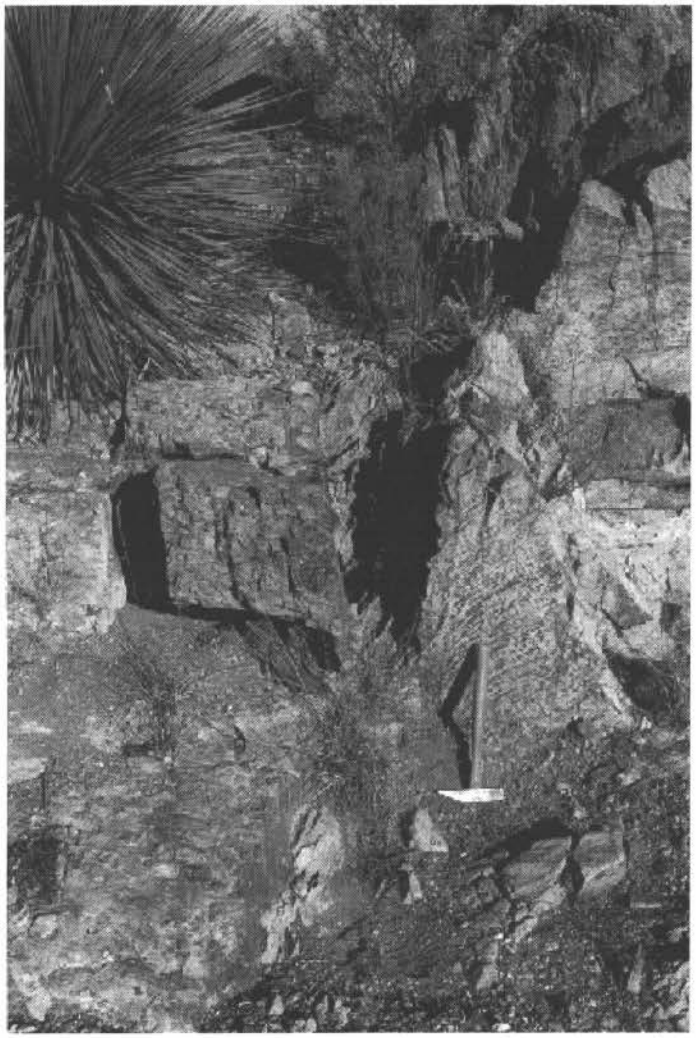

FIGURE 2.9. Rhyolite dike (behind hammer) in contact with conglomerate bed, stop 2. Contact just left of hammer handle, which is 14 in. long.

These cuts were excavated in the summer of 1999 by floods that affected every arroyo in the range.

At 0.45 mi, black basaltic dikes cut the upper conglomerate member of the Broken Jug Formation (Fig. 2.11). The dikes probably are part of a feeder system for the overlying basalt member, although at least one of the dikes cuts the lowermost flow. The dikes trend 273° and may indicate the extension direction during rift formation in the Late Jurassic.

The end of the traverse is at the mouth of the left arroyo just beyond the mafic dikes, a distance of 0.5 mi from the parking area. Here, the basal flow of the basalt member rests on a green tuff with relict glassy shards and abundant plagioclase lapilli above a bed of mottled calclithite. Although mapped as an intrusive unit by Zeller (1970), vesicle zonation and long-distance concordance of stratigraphic contacts indicate that the basalt member is a succession of subaerial lava flows. Moreover, the basalt flows are interbedded with conglomerate and sandstone in the middle part of the member.

Return to vehicles and retrace route to Little Hachett Mountains Road. **0.7**

59.5 Road intersection, **keep left (straight)**. **0.1**

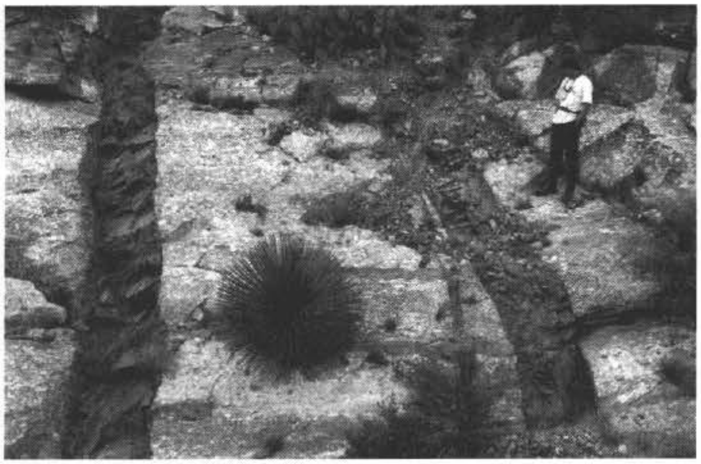

FIGURE 2.11. Mafic dikes cutting uppermost conglomerate bed of upper conglomerate member of Broken Jug Formation, stop 2. Jeff Amato looks on.

59.6 Ascend small hill. Cedar Mountains at 11:00, Apache Hills at 12:00, Sierra Rica (near distance) and Sierra Alta at 1:00. **0.3**

59.9 Road intersection. **Turn right** for descent into the arroyo. **0.3**

60.2 Road intersection, **turn right**. **2.1**

62.3 **Turn left** on Little Hachett Mountains Road. **0.2**

62.5 Scarp, about 20 ft high, of range-bounding Hachita Valley fault (Lawton and Harrigan, 1998). Fault cuts Quaternary deposits with stage III–IV caliche. U-Bar Formation caps Howells Ridge at 1:00–2:00. **0.4**

62.9 Road junction, **keep right**. Hill on left (12:30) capped by Howells Ridge Member of U-Bar Formation, which dips northward to form the southern limb of the Howells Well syncline. **0.2**

63.1 Road crosses onto Howells Ridge Member of U-Bar Formation, which forms low exposures adjacent to road. **0.2**

63.3 Cattle guard at Howells Well. Mojado Formation forms cuestas directly ahead on lower slopes, U-Bar Formation on higher slopes of Howells Ridge. **0.7**

64.0 Enter arroyo. **0.1**

64.1 Leave arroyo. Exposures of quartz arenite beds of lower member of the Mojado Formation of Galemore (1986) form dip-slope exposures at 3:00, directly north of main arroyo. These strata were deposited in a shoreface setting. **0.4**

FIGURE 2.13. Hill capped by basal conglomerate of Ringbone Formation (gray shrubs) near hinge of Howells Well syncline. Lower grass-covered slopes are underlain by Cenomanian marine shale of Mojado Formation.

FIGURE 2.12. Fault (at head of hammer) in Mojado Formation, north side of arroyo. Hammer handle is 14 in. long.

64.5 Pass Maxwell silica pit. The Maxwell silica pit was established in July 1995, and closed in September 1999, after the Playas smelter closed. It supplied silica sand from the Cretaceous Mojado Formation to the Playas smelter, owned by Phelps Dodge Corporation. Silica sand, along with lime, were used by the smelter as flux components to reduce the melting temperature of the slag (see Gundiler, this volume, p. 263). The mine had a capacity of 6000 short tons (st) /month and employed 4–5 men. The material was blasted and screened; fragments 0.25–6 in. in diameter were trucked to the smelter. The finer material was used as road fill and also to backfill the pits. The economic beds are 10–30 ft thick consist of nearly pure quartz sandstone, and are interbedded with siltstone and shale. **0.5**

65.0 Exposure of thrust ramp in middle member of Mojado Formation on north side of road (Fig. 2.12). Slickensides indicate oblique slip on this fault, with hanging wall up and to west. Mojado is exposed discontinuously for next 0.1 mi, dipping to northeast. **0.2**

65.2 Hill at 1:00 is capped by basal conglomerate of the Upper Cretaceous Ringbone Formation (Fig. 2.13; Hogdson, this volume), which rests unconformably on dark-gray marine shale of Mojado Formation. Conglomerate in the lower part of the Ringbone contains boulders as much as 3 ft long. Clasts include cross-bedded quartzarenite, rudistid limestone, and pebble conglomerate of Paleozoic limestone and chert (Fig. 2.14). These lithologies indicate derivation from the Mojado, U-Bar and Hell-to-Finish formations, respectively. Underlying thin-bedded Mojado consists of shale, siltstone, and sandstone folded and thrusted along northwest trends. Oysters, inoceramid bivalves, and ammonites are present in the sandstone and shale beds. These fossils indicate a Cenomanian age for the Mojado Formation here (Lucas and Lawton, this volume). Thin beds of biotite tuff are locally present in the shale. **0.3**

65.5 Road crest. Ringbone-capped hill on right (north). Thick-bedded limestone of Howells Ridge Member of U-Bar Formation is visible to west (straight ahead),

FIGURE 2.14. Basal boulder conglomerate of Ringbone Formation in Figure 2.13. Clasts are limestone of U-Bar Formation, quartzarenite of Mojado Formation, and limestone-clast conglomerate of Hell-To-Finish Formation (near hammer head). Hammer handle is 14 in. long.

beyond which Oligocene tuff (32.7 Ma Gillespie Tuff; McIntosh and Bryan, this volume) form the skyline. **0.2**

65.7 Thin beds of shale and sandstone in upper member of Mojado Formation exposed in arroyo to west. Beds dip north. **0.1**

65.8 Road crosses Ringbone-Mojado contact. Small hill at 9:00 is underlain by conglomerate of lower member of the Ringbone Formation. Conglomerate beds dip moderately to the northwest. **0.2**

66.0 Intersection, **turn left**. Little Hachett Mountains Road continues to the right. Playas Peak, composed of Oligocene ash-flow tuff is visible at 1:00. The low country surrounding Playas Peak is underlain by the middle and upper members of the Ringbone Formation, which totals 5246 ft thick in the vicinity of Playas Peak (Basabilvazo, this volume). In the winter of 1990, while doing field research for his M.S. thesis, George Basabilvazo discovered an impression of dinosaur skin in the middle member of the Ringbone Formation on the southeast flank of Playas Peak, a locality visible from this vantage point. Excavation of the site in 1996 yielded a section of hadrosaur tail roughly 11.5 ft long, consisting of skin and skeletal remains, described in the following minipaper. **0.2**

DINOSAUR SKIN IMPRESSIONS FROM THE UPPER CRETACEOUS RINGBONE FORMATION, LITTLE HATCHET MOUNTAINS, NEW MEXICO

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New Mexico Museum of Natural History, 1801 Mountain Road N.W., Albuquerque, NM 87104

In 1990, George T. Basabilvazo, then a graduate student at New Mexico State University, discovered dinosaur skin impressions and associated skeletal remains in the Little Hatchet Mountains. These fossils, all from a single dinosaur individual, were located in a sandstone bed of the middle member of the Ringbone Formation near Playas Peak. They are now housed in the New Mexico Museum of Natural History, where they are catalogued as NMMNH P-2611.

Anderson et al. (1998) described NMMNH P-2611, which is part of the tail skeleton and skin impressions from the tail region (Fig. 2.15) of a duckbill dinosaur (hadrosaur). This association is important, because the skin impressions are in the rock encasing the bones, so they clearly are from the same individual hadrosaur; many putative dinosaur skin impressions in the literature lack a clear association with bone, so their identity as skin impressions is not certain.

The skeletal elements of NMMNH P-2611 are 20 articulated vertebral centra, several disarticulated centra and ossified tendons, all from the mid- to distal caudal region. They identify the dinosaur as hadrosaur, but in the absence of cranial remains a more precise identification is not possible.

The skin impressions are six discrete patches of apical, circular to ovate tubercles (Fig. 2.15). The tubercles range in size from 3 x 12 mm to 10 x 16 mm on the short and long axes, respectively. All of the tubercles have radiating ridges and grooves that converge at their apices.

The middle member of the Ringbone Formation was deposited in a relatively deep lake during the late Campanian, about 71 Ma (Basabilvazo, 1991). The sandstone bed that contained NMMNH P-2611 probably represents the distal portion of a deltaic channel near the lake margin. Evidently, part of a hadrosaur carcass was rapidly buried in such a general setting, but we do not precisely understand the relatively unique conditions that preserved the skin impressions.

The skin impressions of NMMNH P-2611 resemble those of other hadrosaurs (e.g., Lull and Wright, 1942) but are notable for their exqui-

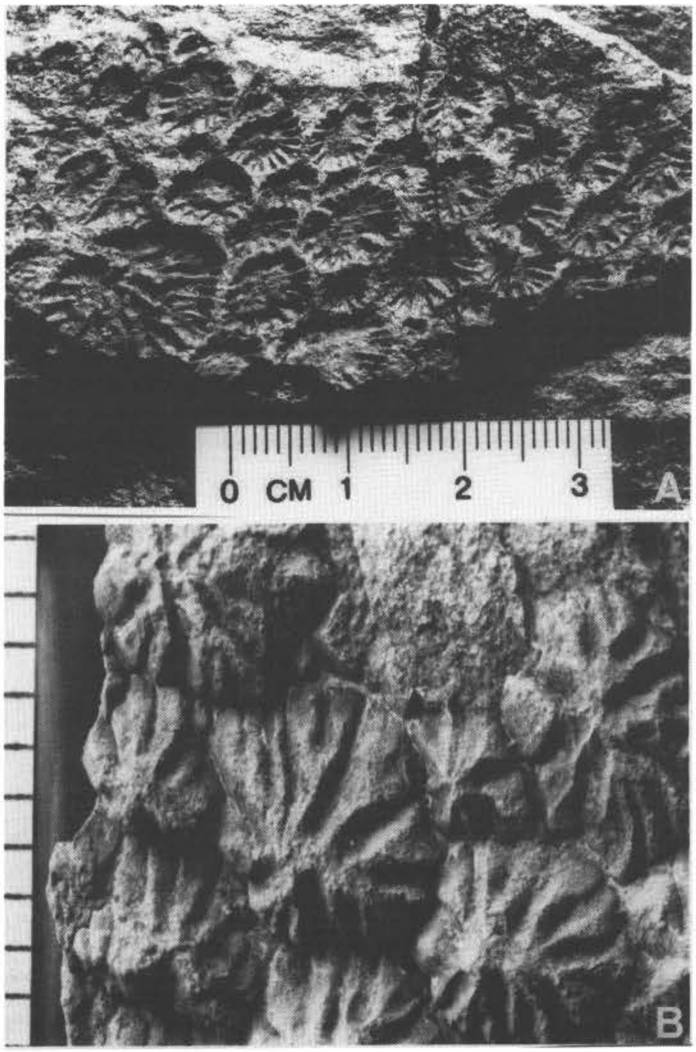

FIGURE 2.15. Dinosaur (hadrosaur) skin impressions from the Ringbone Formation, Little Hatchet Mountains, NMMNH P-2611. **A**, Overview of negative relief impressions. **B**, Tubercles preserved in positive relief; note radiating grooves and ridges extending from the top to the base of each tubercle; scale in mm.

site detail. The function of the tubercles in hadrosaur skin is unclear, but the ridges and grooves would have increased the surface area of the skin to provide more efficient heat exchange. The tubercles would have also increased the resistance of the skin to tearing and puncturing.

66.2 Intersection with road to windmill. **Continue straight**. Howells Ridge Member of U-Bar Formation exposed on right. **0.4**

66.6 Cross north–south fault. **0.1**

66.7 Fork in road, **keep right**. **0.3**

67.0 Depositional contact of basal conglomerate of Skunk Ranch Formation with underlying Howells Ridge Member of the U-Bar Formation at 9:00, west side of arroyo. Basal conglomerate of the Skunk Ranch Formation forms exposures on both sides of the arroyo for the next 0.2 mi. The Skunk Ranch Formation, of probable Paleocene–Eocene age (Lawton et al., 1993; Hodgson, this volume), overlies U-Bar strata near here, but overlies Upper Cretaceous Ringbone Formation north of a reverse fault between here and Playas Peak. These relations indicate post-Campanian and pre-Paleocene uplift along the reverse fault. **0.2**

67.2 Leave arroyo. **0.6**

67.8 Directly north of the gate and cattleguard, the road crosses the Copper Dick fault, which strikes west here. It separates Skunk Ranch Formation on the north from Hell-to-Finish Formation to the south. Hodgson (this volume) describes blocks of granite and quartzarenite, interpreted as Precambrian granite and Bliss Sandstone, respectively, along the fault. The presence of rocks in the fault zone older than strata of either footwall or hanging wall is suggestive of reactivation or inversion of a basement-involved fault (Lawton, this volume), or significant transcurrent movement along the fault (Hodgson, this volume). Along the fault, the Copper Dick and smaller mines form the northern part of the Sylvanite district (McLemore and Elston, this volume). **0.1**

67.9 Playas smelter at 12:00 (see Gundiler, this volume, p. 263). Animas Range forms skyline in distance. **0.5**

68.4 Hills of Hell-to-Finish Formation conglomerate at 12:00. **0.5**

68.9 Mine dump on left. Broken Jug Pass at 10:00. **0.1**

69.0 Road intersection. **Continue straight**. **0.3**

69.3 Approaching Cottonwood Springs. White tufa deposits exposed on both sides of the road. **0.1**

69.4 Cottonwood Springs. Placer gold deposits were worked here in the late 1880s. Mine waste piles suggest that this was a shipping point for the ores from the Sylvanite district. **0.1**

69.5 Road fork, **keep left**. Broken Jug Pass at 9:00. **0.4**

69.9 Ranch driveway on left (straight). **Continue sharp right on main road**. **0.1**

70.0 Road on left to Sylvanite mining district. **Continue right (straight)**. Skarn, vein, and placer deposits occur in the district and production from 1902 to 1957 is estimated as 6100 st of ore containing 2500 oz Au, 35,000 oz Ag, 130,000 lbs Cu, and 80,000 lbs Pb (McLemore and Elston, table 1, this volume). At the Eagle Point mine, 5632 st of scheelite-garnet ore grading 0.44% WO_3 was produced from a small skarn in 1943 (Dale and McKinney, 1959).

Prospecting began in the Sylvanite district in the late 1870s; copper was discovered near the old mining town of Sylvanite in the 1880s (Lindgren et al., 1910). However, there was not much activity until about 1899, when the El Paso and Southwestern Railroad met the Arizona and New Mexico Railroad at what is now known as Hachita, where both railroads shared facilities. With the railroad close by, prospecting and mining in both the Sylvanite and Eureka districts in the Little Hatchet Mountains intensified. The earliest activity was in the Eureka district, which was discovered in 1871 (McLemore, this road log).

In 1908, Sol Camp, a worker at the Wake Up Charlie claims, discovered gold and tetradymite (Bi_2Te_2S) in a small gulch east of Cottonwood Spring (Martin, 1908; Lasky, 1947). The tetradymite was misidentified as the mineral sylvanite, a gold telluride, which the prospector had seen at Cripple Creek. This led to the naming of the Sylvanite mining camp and to a gold rush (Jones, 1908a, b; Dinsmore, 1908; Martin, 1908). The news spread quickly and soon there were nearly 1000 prospectors in the area.

A camp, Sylvanite, was quickly established and grew into a town. By November 1908, Sylvanite had a general store, assay offices, a newspaper (*Sylvanite Sun*), and hotels. Most of the accommodations were tents; some wooden structures were built with tent coverings (Martin, 1908). Water was and still is scarce with only a few springs near the former town site. However, by June 1909, the gold deposits played out and only 70 people remained in town. **2.3**

72.3 Cattleguard. Lower part of Mojado Formation exposed on hill at 9:00. Contact with Howells Ridge Member of U-Bar Formation lies on left flank of hillside. Big Hatchet Peak at 12:00 above exposures of Precambrian(?) granite at south end of Little Hatchet Mountains. Paleozoic roof pendants in Tertiary granite at 1:00. Paleozoic strata thrust over Mojado Formation at 12:30. **0.9**

73.2 Cattleguard. U-Bar Formation underlies exposures on skyline at 12:00. **1.0**

74.2 Fault contact between Mojado Formation (in distance) and upper Paleozoic carbonate strata (nearby white exposures) at 9:00. **0.1**

74.3 Intersection, **continue left**. **0.7**

75.0 Gate. Fault contact of Paleozoic carbonate strata with Mojado Formation on left. **0.1**

75.1 Windmill. **0.1**

75.2 Intersection. **Turn right** to leave main road. **0.5**

75.7 **STOP 3. Eagle Point mine and contacts between Precambrian–Cambrian granite, Cretaceous Horquilla Limestone, and mid-Tertiary granite**

J. H. Winslow discovered the Eagle Point skarn deposit in 1940 and claims were staked in 1941. In 1943, Keyner Mines, Inc., shipped 650 stof 0.44% WO_3 from the mine (Dale and McKinney, 1959). The workings consist of an open trench, 72 ft long, leading to an adit, 58 ft long (Fig. 2.16). Several trenches and shallow pits have also been dug in the skarn alteration. Scheelite and powellite occur as thin veinlets and disseminations in small lenticular bodies of garnet-magnetite skarn in Horquilla Limestone at and near the intrusive contact with a mid-Tertiary granite (Fig. 2.3). The granite has been dated by $^{40}Ar/^{39}Ar$ as 32.33 ± 0.18 Ma (biotite, feldspar, NMBMMR Geochronology Laboratory; Channell et al., this volume). Surface exposures and subsurface data suggest that the limestone block may be a roof pendent in the mid-Tertiary granite. Other minerals present include epidote, pyrite, calcite, malachite, chalcopyrite, and quartz. The largest skarn body is only several feet in diameter and is interlayered with recrystallized limestone and marble. The skarn is thin; subsurface drilling at the main workings indicates that the granite is 12–15 ft below the surface (NMBMMR file data). Two dikes, diorite and rhyolite, truncate the scheelite and skarn-bearing zones. The dikes are postskarn because they are relatively unaltered. The fault contact between the limestone and Precambrian-Cambrian granite is not mineralized. Additional scheelite occurrences are present along the northern intrusive contact between the mid-Tertiary granite and Horquilla Limestone (Dale and McKinney, 1959).

The Playas Valley to the west of this stop is an intermontane basin system with a pronounced half-graben structure, with the major basin blocks tilted eastward, away from the Animas. The Upper Playas Valley to the south is an open (semibolson) geomorphic feature with a broad axial drainage, the South Playas Draw, that discharges northward both to the Playas Lake area in the closed Lower Playas Valley, and to Hachita Valley via Hatchet Gap. Basin-bounding faults along the western bases of complex horst blocks that form the Dog-Alamo Hueco-Big Hatchet-Little Hatchet mountain chain may or may not offset Pleistocene piedmont deposits.

The partly closed, partly drained Playas basin has an area of about 925 mi^2, which is almost entirely in New Mexico, and it comprises two subbasins. The Upper Playas subbasin in the south is an open and drained geohydrologic system that primarily discharges to the closed and partly drained Lower Playas subbasin in the north, but a small amount of surface flow and ground-water underflow (<8 acre-ft) also spills through Hatchet Gap between the Big and Little Hatchet Mountains into the Upper Hachita subbasin. Most of the ground-water and surface-water flow in the Playas basin system is toward a large ephemeral-lake plain, or phreatic and vadose playa complex, which is periodically flooded to form Playas Lake (Hawley et al, 2000). During Late Pleistocene glacial-pluvial states, this depression was flooded by lake Playas (Schwennesen, 1918) which had a maximum surface area of about 25 mi^2 based on high-stand-shoreline features at approximately 4300 ft elevation.

Maximum thickness of Neogene and Quaternary basin fill, mostly Gila Group, is estimated to be approximately 2000 ft (Klein, 1995), but the primary aquifer system consists of basin-floor and piedmont-slope deposits of the Upper and Middle Gila Group that are consolidated to partly indurated and no more than 1000 ft thick. The major recharge sources for the Playa basin aquifers are the high Sierra San Luis and Animas mountain ranges that border the basin on the west. Prior to development of intensive irrigation agriculture in the 1940s and subsequent mineral processing activities related to Phelps Dodge Playas Smelter operations, much of the northward-flowing ground-water system was consumed by evaporation and transpiration in an area of springs, seeps, and marshes at the southern end of Playas Lake. A small amount of pre-development underflow also appears to have spilled from the Lower Playa Valley area into aquifers of the northern Animas basin system via fracture and/or basin-fill conduits beneath the Continental Divide to the northwest (Schwennesen, 1918; Reeder, 1957). Doty (1960), who made the definitive geohydrological study of the Playas Valley, as well as Schwennesen (1918), documented a northward slope of the potentiometric surface beyond the phreatic playa zone, which is limited to the southwestern margin of historic Playas Lake. The pre-development vadose zone at the north end of the lake was at least 50 ft thick, and Doty (1960) noted the absence of evaporites in older lake beds encountered in bore holes throughout the Lower Playas Valley area. All these observations support the hypothesis of at least some pre-development ground-water leakage to contiguous parts of the Animas Valley, where pressure heads are lower (Reeder, 1957). A provisional estimate of annual northward flow from the Upper to Lower Playas subbasins in the Middle to Upper Gila basin-fill aquifer

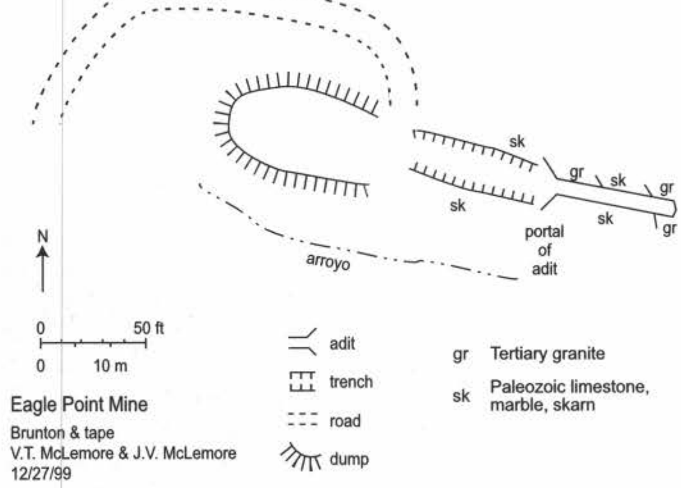

FIGURE 2.16. Geologic plan map of the Eagle Point mine, Little Hatchet Mountains.

FIGURE 2.17. View north from Granite Pass. Tertiary granite of foreground exposures intrudes Mojado Formation of ridge in middle distance.

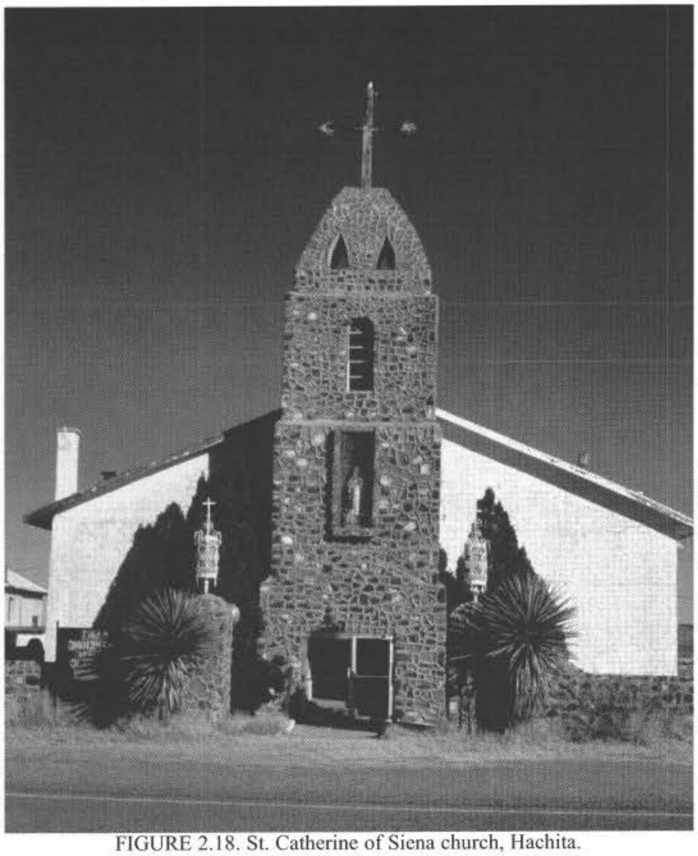

FIGURE 2.18. St. Catherine of Siena church, Hachita.

system is approximately 4730 acre-ft.

Return to vehicles and retrace route to main road. **0.8**

76.5 Road intersection, **turn right**. Crossing Tertiary granite. **0.8**

77.3 Gate at Granite Pass. **Please leave gates as you find them**, whether open or closed. To north is the contact of mid-Tertiary granite with Mojado Formation, the upper unit of the Bisbee Group (Fig. 2.17). Granite forms rounded outcrops in foreground, Mojado forms orange-weathering slopes. Playas smelter and Animas Range visible in west. View east is toward Sierra Rica and Sierra Alta in Mexico. **1.0**

78.3 Intersection with Continental Divide Trail. Continue straight (east) on Granite Pass Road. **0.1**

78.4 Cross Hachita Valley fault. This structure continues south to merge with the southeast-striking Big Hatchet boundary fault zone south of Hatchet Gap (Schwennesen, 1918; Trauger and Herrick, 1962). **0.5**

78.9 Cattleguard and road junction, keep left. **1.0**

80.9 Intersection with NM-81 at MP-34 between Hachita and International Boundary at Antelope Wells. **Turn left** (north). **0.4**

81.3 Dirt road on right to Hatchet Mountain Wildlife Area. Continue straight on paved road. **1.6**

82.9 MP-36. **5.1**

88.0 Grant County line. **2.9**

90.9 Hachita cemetery. **0.7**

91.6 Hachita village limits. **0.4**

92.0 St. Catherine of Siena Catholic Church (Fig. 2.18), once the high school of Hachita. **0.2**

92.2 Intersection with NM-9. **Turn left**. **0.2**

92.4 Junction NM-146. **Turn right** (north). **19.1**

111.5 Junction of NM-146 and I-10. **Bear right** on nearly invisible access ramp where road begins to ascend toward overpass. **Proceed east on interstate**. **1.8**

113.3 Continental Divide sign (elevation 4585 ft). The correct Continental Divide is at mile 117.4. **1.6**

114.9 Rest area. **1.4**

116.3 Luna County line. **1.3**

117.4 Exit 55, Quincy, a former railroad camp. This is the correct location of the Continental divide. **2.3**

119.7 MP-58. Victorio Mountains at 2:00. Visible on peak with radio transmission towers are dip slopes of north-dipping andesite flows and breccias of Rubio Peak Formation (42.7 Ma; Thorman and Drewes, 1980; McLemore et al., this volume, p. 267) which overlie volcaniclastic conglomerates of Lobo Formation (Eocene). The Bisbee Group section beneath the Lobo here is very thin, measuring a total of 750 ft thick (Kottlowski, 1960). Clastics of the Hell-to-Finish Formation are unconformable on the Cutter Member of the Ordovician Montoya Formation (Kottlowski, 1960; R. E. Clemons, personal commun., 1990). **4.8**

124.5 Gage exit 62. **Exit I-10 and proceed south** on paved road CO20 past Dairy Queen. Gage was settled in 1880 as a railroad camp and was named after William Gage, one of several developers of the Victorio mining district. Gage had a Post Office from 1882 to 1965 (Julyan, 1996). Today it is a stop on the railroad and an interchange on I-10. **0.4**

124.9 Cattleguard. Florida Mountains at 10:00, Tres Hermanas Mountains at 11:00. **0.2**

125.1 Cross cattleguard. **2.0**

127.1 Road junction, **keep right** onto dirt road. Quarry in East Hills at 12:00 in El Paso Group limestone and dolostone (Fig. 2.19). **0.3**

127.4 Saddle between East Hills at 3:00 and Middle Hills at 9:00 (Fig. 2.20). Cross the east-trending, south-dipping Victorio Mountains fault, which is interpreted as a reverse fault (Kottlowski, 1960; Griswold, 1961), thrust fault (Corbitt and Woodward, 1973), and strike-slip or polyphase normal fault (Thorman and Drewes, 1980; see McLemore et al., this volume, p. 267). **0.2**

127.6 Road junction, **keep right**. **0.1**

127.7 Road junction, **keep right**. Road to left to rock quarry.

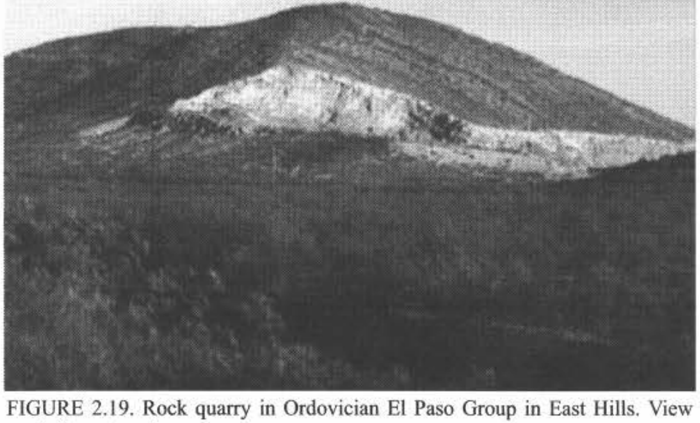

FIGURE 2.19. Rock quarry in Ordovician El Paso Group in East Hills. View north form stop 4.

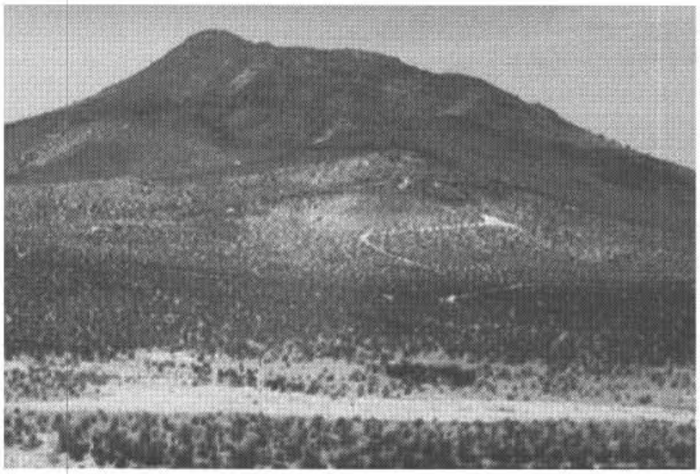

FIGURE 2.20. View north from stop 4 of Central Hills in the Victorio Mountains.

0.1

127.8 Road junction, **keep right**. Mine Hill on left. **0.3**

128.1 Road junction, **keep left**. **0.1**

128.2 Road junction, **keep right**. **0.2**

128.4 Road junction, **turn left**. **0.1**

128.5 **STOP 4 (optional). Mine Hill.**

The mines on the side of Mine Hill are in Fusselman Dolomite, which Kottlowski (1960, 1963) divided into four units. Walk up to the mine with the wooden structure, an ore-loading chute constructed of railroad ties and boards and lined with tin sheets (Fig. 2.21). Notice outcrops of Fusselman Dolomite. The mine workings are in a jasperoid lens that has replaced the dolostone (Fig. 2.22). The Abandoned Mine Lands Bureau (AMLB) reclaimed many of the mines on Mine Hill, including this one. At this mine, AMLB used bat grates to seal the portal of the adit. The bat grates keep people out, but allow bats and birds to fly in and out of the adit. Abandoned mines have become home to a variety of wildlife and the AMLB checks each feature for wildlife habitation before closure. Some of the mines east of here were closed by wire nets with holes large enough to let bats and birds pass through.

West of the mine lie the foundations of Chance City, a mining camp established in 1880. The Chance mine was owned by George Hearst (father of William Randolph Hearst). Rock quarry in East Hills to the east. Retrace route to CO20. **1.3**

FIGURE 2.22. Lens of sufides (chalcopyrite, galena) surrounded by secondary copper and lead minerals at the portal of adit at stop 4.

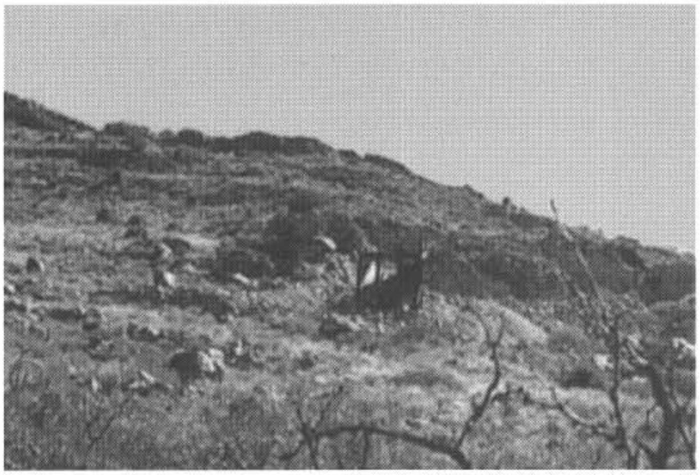

FIGURE 2.21. Ore-loading chute adjacent to mineralized jasperoid, stop 4.

129.8 Junction with paved road CO20. Continue north. **2.2**

132.0 Junction with I-10. **Turn left** (east) onto I-10 toward Deming. **5.2**

137.2 Exit 68 (NM 418). Continue east on I-10. NM-418 is an alternate route to Deming. Black Mountain at 11:00 with Cookes Peak forming the skyline. Compressor station for El Paso Natural Gas Company at 9:00. **4.0**

141.2 MP-72. Black Mountain at 10:00. Red Mountain at 9:00. **8.9**

150.1 Exit 81. West exit to Deming. Continue east on I-10. **1.0**

151.1 Exit 82A. Continue east on I-10. **0.5**

151.6 Exit 82B (Cedar Street). Continue east on I-10. Black manganese tailings to the north (left) of the interstate are remains of the Deming manganese stockpile (see Gundiler, this volume, p. 279). **1.2**

152.8 Bridge. Holocene Mimbres River valley fill exposed in a reclaimed gravel pit and city park south of interstate. Manganese mill at 9:00. **1.2**

154.0 Exit 84. **Exit I-10**. Proceed straight on business loop. **0.6**

154.6 NM 159 to left. Continue straight on business loop. **0.4**

156.0 Grand Motor Inn on right.

End of Day 2 Road Log.