FIRST DAY

ROAD LOG FROM LORDSBURG TO DOUGLAS VIA GRANITE GAP AND SAN BERNARDINO VALLEY WITH AN EXTENSION TO THE SOUTHERN END OF THE MULE MOUNTAINS

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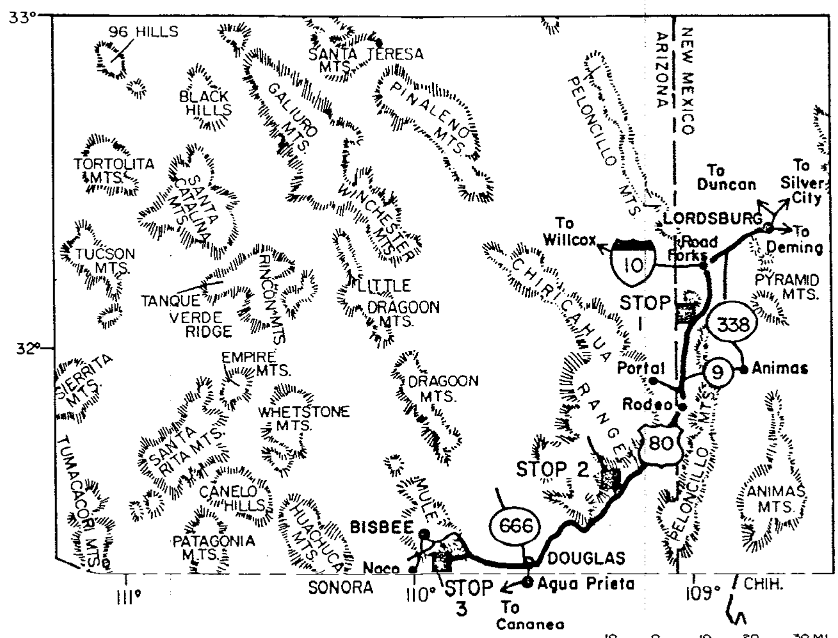
THURSDAY, NOVEMBER 9, 1978

ASSEMBLY POINT:	1 mile west of Bel Shore Motel in west Lordsburg.
TIME:	8:00 a.m.
DISTANCE:	130.5 miles
STOPS:	3



Route Map: Lordsburg to Douglas.

INTRODUCTION

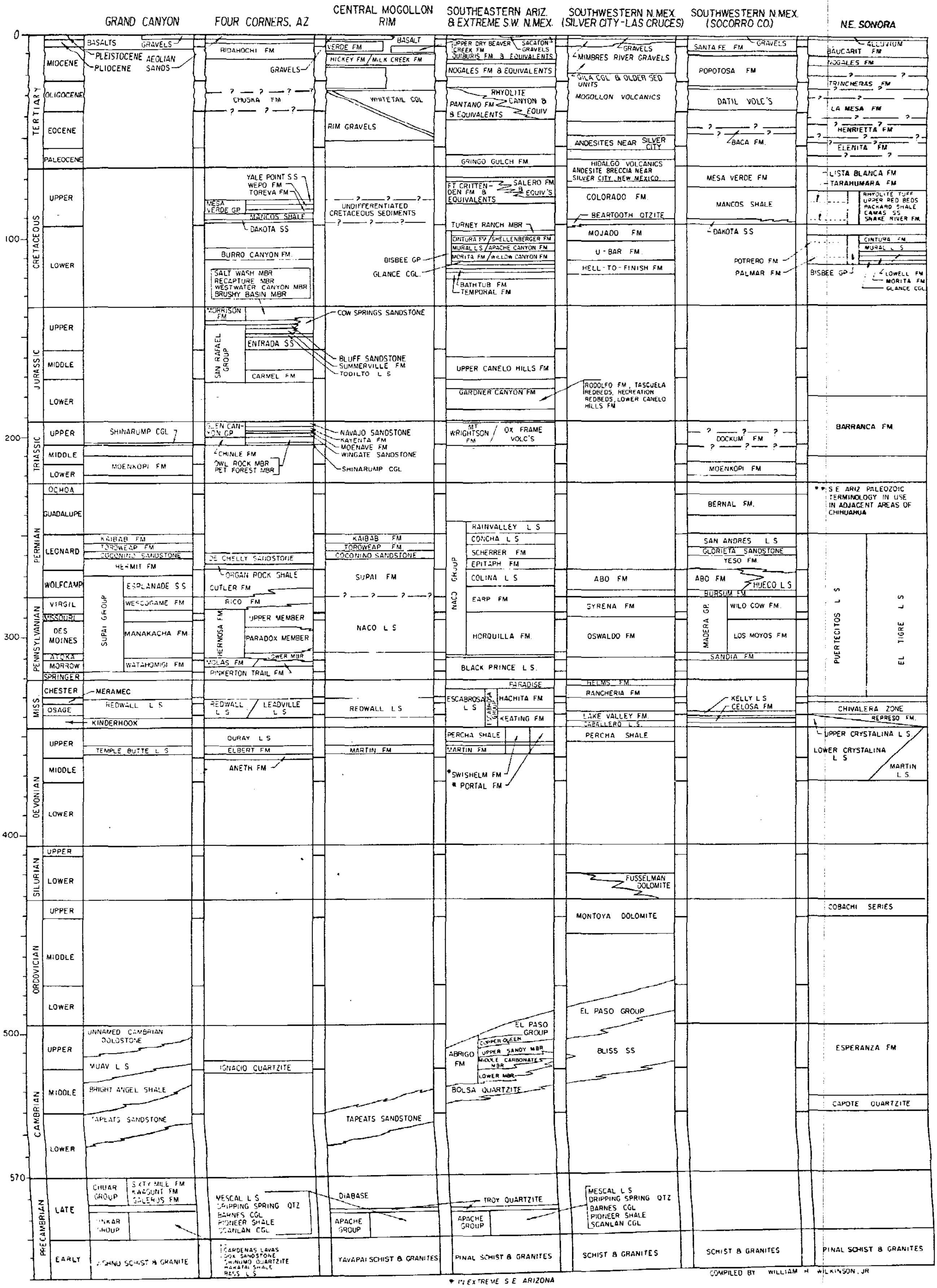
Today's route in southwestern New Mexico and southeastern Arizona will traverse basins containing Pleistocene playas and Plio-Pleistocene valley fill and volcanics, and intervening ranges of pre-Pliocene rocks. The route leads west along Interstate 10 from Lordsburg across the playa remaining from Pleistocene Lake Animas, with a good view of the Peloncillo Mountains and Steins Pass, which separates Cretaceous andesites to the south from Tertiary rhyolites and latites to the north.

The trip turns south along U.S. 80, following the Animas Valley, a closed basin east of the central Peloncillo Mountains. The first stop is adjacent to Paleozoic strata intruded by mid-Tertiary granite near Granite Gap and gives a panoramic view of Late Cretaceous through mid-Tertiary volcanic rocks in the Pyramid Mountains.

After Stop 1 the trip crosses a pediment cut on mid-Tertiary and Precambrian granite and passes through mid-Tertiary granite with associated lead-zinc-silver mines at Granite Gap. The route descends into the lower, two-fault graben of San Simon Valley, with a view of mid-Tertiary volcanic rocks in the Chiricahua Mountains, where some investigators have postulated the existence of a volcanic cauldron, and of Blue Mountain in the Portal area with its well-exposed Paleozoic section. At the southern end of San Simon Valley are agglutinate cones and basalt flows of the San Bernardino volcanic field, the only young volcanic field in southeastern Arizona (Stop 2). The Pedregosa Mountains, with their complex thrust faults, are visible from this stop.

The field trip then crosses a pass between the Pedregosa and Perilla mountains, traveling through mid-Tertiary(?) rhyolites which cap deformed Bisbee Group and Late Cretaceous volcanic and sedimentary rocks. Douglas, in Sulphur Springs Valley, is the site of Phelps Dodge copper smelter. The route extends into the southern Mule Mountains (Stop 3) to view Bisbee Group stratigraphy and structural complications on the Gold Hill reverse fault.

STRATIGRAPHIC NOMENCLATURE CHART



Note: Historic art work used in the log is from Wallace (1971), courtesy: University of New Mexico Press.

0.0 Assembly point (elev. 4,225 ft). Lordsburg was established in 1881 during the building of the Southern Pacific Railroad from California to Texas and was sustained as a cattle shipping point.

Beyond the tracks is Lordsburg Draw, which drains northwestward into the northern, lower part of Animas Valley. Northeast of Lordsburg Draw, an aggradational alluvial surface ascends to the southern end of the Big Burro Mountains, which are mostly Precambrian granite, gneiss, schist, quartzite and amphibolite (Hewitt, 1959).

Just south of Lordsburg are the northern foothills of the Pyramid Mountains, composed of Late Cretaceous to Paleocene andesite and basalt equivalents of the Hidalgo Volcanics, whose type locality is in the Little Hatchet Mountains, 25 mi southeast of Lordsburg. Recent dating by Marvin and

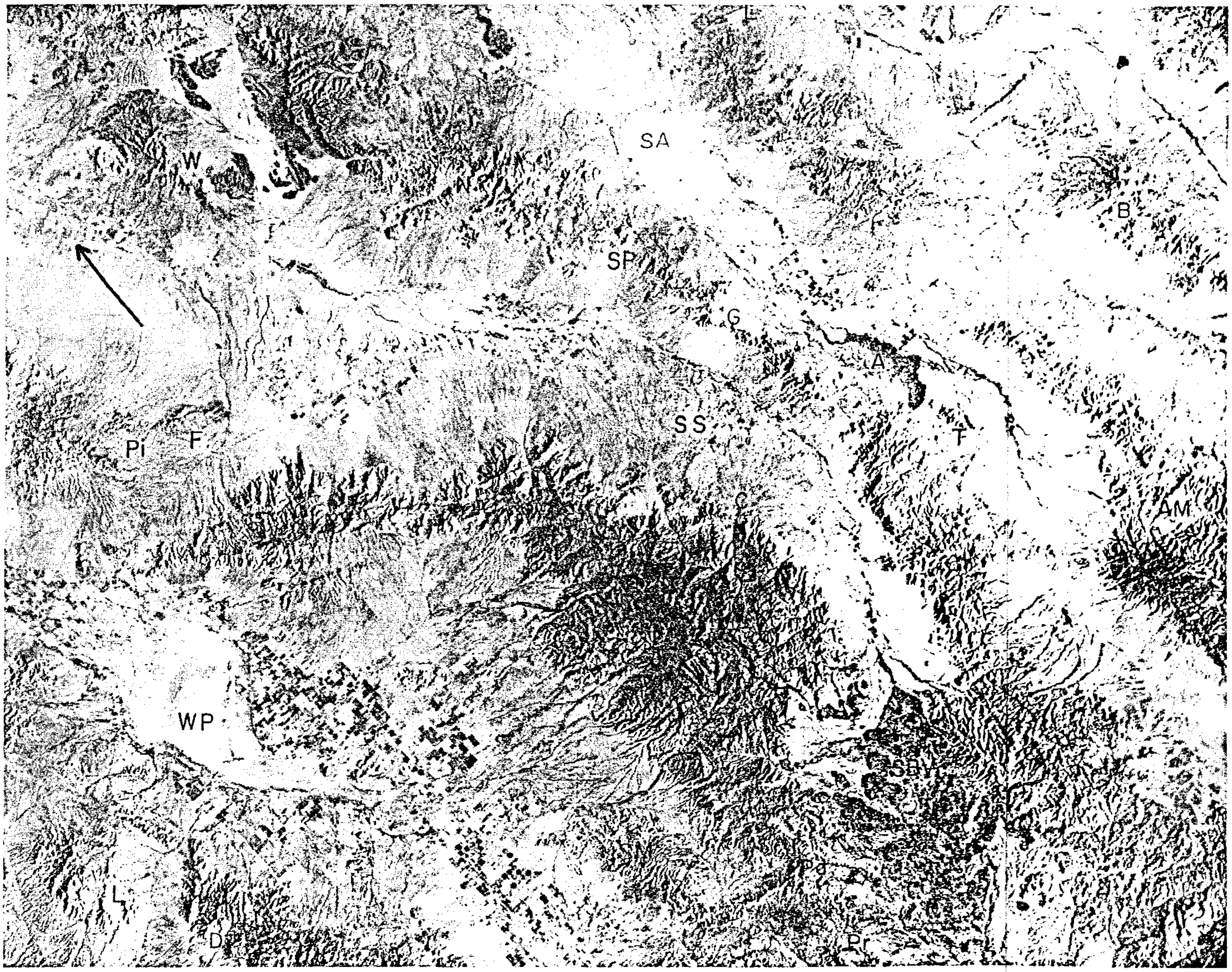


Figure 0.0. Skylab 1 photo of parts of southwestern New Mexico and southeastern Arizona. Today's route will proceed from Lordsburg (L) at the north end of the Pyramid Mountains across the southern edge of South Alkali Flat (SA), then south along the east flank of the central Peloncillo Mountains, through Granite Gap (G) into San Simon Valley (SS) and southwestward to San Bernardino Valley across the northwestern edge of San Bernardino volcanic field (SBV). The trip then proceeds through the gap between the Perilla Mountains (Pr) and Pedregosa Mountains (Pd) and off the southwestern edge of the photo to Douglas. Other features shown on the photo (clockwise) include: Big Hatchet Mountains (B), Animas Mountains (AM), Tank Mountain (T) south of the Animas basalt field (A), alluvial fan at northeastern entrance to Cave Creek Canyon (C), Turkey Creek cauldron (TC), Swisshelm Mountains (SM), northern Dragoon Mountains (D), Texas Canyon in the Little Dragoon Mountains (L), Willcox Playa (WP), Pinaleno Mountains (Pi), Fisher Hills (F), Whitlock Mountains (W), northern Peloncillos (N) and Steins Pass (SP). Arrow points north (photo courtesy of NASA).

others (this guidebook) reveals a considerable spread in ages for the Hidalgo Volcanics. In the northern Pyramid Mountains the Hidalgo Volcanics are 67.3 to 54.9 m.y. old. The older volcanic rocks are intruded by a granodiorite pluton (Lordsburg stock) which has yielded ages of 58.8 m.y. and 56.5 m.y. (see Deal and others, this guidebook). The volcanics and stock are cut by felsic dikes and closely allied quartz veins. The 52.7 m.y. age of the dikes may equate with the age of mineralization. To the south Hidalgo Volcanics are overlain by a thick series of Tertiary rhyolitic volcanic rocks.

The Lordsburg mining district, encompassing about 35 mi^2, lies in the foothills of the Pyramid Mountains. Initial production in the district was from high-grade silver ores, but copper has been the principal product (Clark, 1970). Associated quartz veins have been mined to depths in excess of 2,200 ft. Most of the chalcopyrite vein material was shipped as flux to El Paso.

Hills at 11:30 are interlayered glassy andesite and rhyolite tuffs. Basalt flows crop out at 10:00 on Lee Peak. The 85 mine (copper) is at the base of 85 Hill at 9:30. The workings along the Emerald vein strike northeast on the hillside.

Vein structures in the Lordsburg district form a distinctive east-trending zone of en echelon, east-northeast striking veins. These are bounded on their north and south sides by left-slip, transcurrent faults (see Thorman and Drewes, this guidebook). The overall pattern suggests mineralization was emplaced along a 3 mi en echelon set of deep-seated tension fractures which were formed adjacent to an east-trending shear zone. Left slip along this zone took place in response to east-northeast compression in Laramide time. The age of associated felsic dikes places this movement at 52.7 m.y. This tectonic style may be a clue to Laramide movements (68-50 m.y. ago) on west to west-northwest striking fractures thought by some to be elements of the controversial Texas lineament.

0.4

0.4 Bear right onto Interstate 10.

0.4

0.8 Merge with westbound I-10 traffic. Ghost town of Shakespeare, which is not visible from here, is in the low hills at 9:00. It was originally called Ralston (after W. C. Ralston, a California banker), but was renamed Shakespeare in 1872 to attract capital from English investors. William Tatembaum, a Russian nobleman who emigrated to the United States to become an outlaw, met frontier justice in Shakespeare. He was hung for horse-stealing in 1881, after a fair trial, along with one Sandy King, who was accused of being a "damned nuisance."

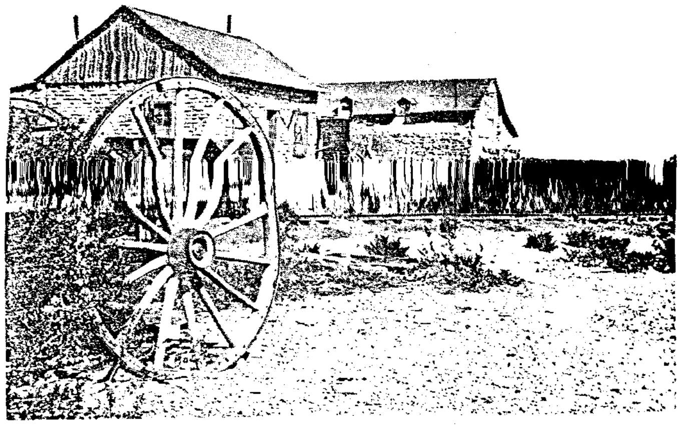


Figure 0.8. Ghost town of Shakespeare (H. L. James photo).

0.6

1.4 Low hills at 2:00 are Tertiary rhyolitic tuffs underlain by andesite.

2.0

3.4 Peloncillo (Spanish meaning "sugarlump") Mountains from 11:00 to 2:00; Chiricahua Mountains on distant skyline from 11:00 to 12:20.

1.6

5.0 Roadcuts in altered, manganese-stained rhyolite and basaltic-andesite. Alteration along north-trending structures was probably caused by hydrothermal activity associated with the granodiorite stock in the Pyramid Mountains. The steep hills on both sides of the highway are rhyolite intrusives into andesite flows and breccia.

0.5

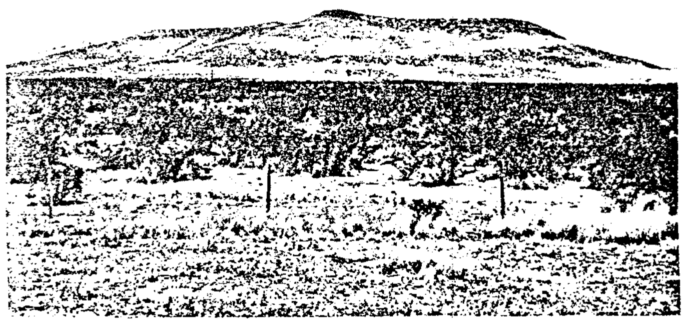


Figure 1.4. View northwest from Milepost 20. Tertiary tuffs cap hills of andesite (Jan Wilt photo).

Figure 5.5. Westward panorama from Exit 15 of northern Peloncillo Mountains beyond South (left) and North (right) Alkali flats (Jan Wilt sketch).

5.5 Exit 15. Hill at 2:00, composed of tuffs and basalt-andesite, marks the west edge of the Pyramid Mountain fault block. The area to the west is down-faulted along a north-trending Basin and Range fault. Buffalo Oil Company No. 1 well was drilled 3.5 mi to the right and bottomed at 700 ft in valley fill (Hawley and Kottlowski, 1965).

0.9

6.4 Granite Gap in central Peloncillo Mountains at 10:30. Steins Pass in northern Peloncillo Mountains at 12:15. First hill to the right of pass is Quarry Peak; conical peak farther to right is Steins Mountain.

There is considerable freedom (and confusion) with the Steins place name in this area. You will note at 1:30 a conical-shaped peak; this is called Steins Peak, not to be confused with Steins Mountain. Steins Peak landmarks the Butterfield Overland Mail route through the Peloncillos in Doubtful Canyon, which at times is erroneously referred to as Steins Pass. The Butterfield established a relay point in the canyon, appropriately called Steins Peak station. Then, of course, there is the old town of Steins; even a dry arroyo called Steins Creek; and finally (as you read on) you will be informed that basaltic andesite forms the lower slopes of Steins Mountain (not Steins Peak), while the Steins Mountain Quartz Latite constitutes the upper part of Steins Mountain. Had enough of Steins? If not, there is still more in **Supplemental Road Log No. 3** (H. L. James, written comm.).

0.7

7.1 Descend across the lowest beach ridge of Pleistocene Lake Animas (elev. about 4,175 ft). The highest shoreline at 4,190 ft is only patchily preserved. Outcrops of lacustrine gravel and silt are about 0.1 mi wide along this east shoreline. The beach ridge is an asymmetric ridge of sand and gravel with steep landward slopes, flat to convex crests and concave foreshore slopes. At high stage, Lake Animas had a surface area of about 150 mi^2 and a depth of nearly 50 ft (see **Fleischhauer, this guidebook**).

The playas of South Alkali Flat (12:00) and North Alkali Flat (2:00) are remnants of Lake Animas, which was 17 mi long and 4 to 8 mi wide. Aerial photos show spectacular mudcracks, up to 0.25 mi across. An arm of the lake extended up Lordsburg Draw to the small playas east and southeast of Lordsburg (Schwennesen, 1918). Later, a river system developed and meandering channels, complete with oxbows, are easily spotted on air photos.

The lake bed is bordered on the north and northeast by a sand dune area of about 30 mi^2. The nearest dunes are at 4:00, about 3 mi to the north across Tobosa Flats, where Lordsburg Draw merges with North Alkali Flat. The dunes reach a height of 60 ft and were blown from the lake bed by southwesterly winds. At present, most of the dunes are stationary, being held by mesquite and creosote bush (Hawley and Kottlowski, 1965).

0.3

7.4 Milepost 14. East edge of South Alkali Flat. This is the lowest part of the Animas Valley, which extends from a divide 58 mi to the south near the Mexican border to a low divide near Summit, New Mexico (14 mi north). The valley is bordered by the Peloncillo Mountains on the west and the Animas and Pyramid mountains on the east.

Schwennesen (1918) divided the valley fill into four kinds of deposits: (1) Stream deposits, including materials spread on alluvial fans by sheet wash, (2) lake deposits, (3) wind deposits and (4) basalt interbedded with and on top of unconsolidated valley fill. The valley fill is correlated with Gila Conglomerate of Pliocene to Pleistocene age. A section about 330 ft thick is exposed north of

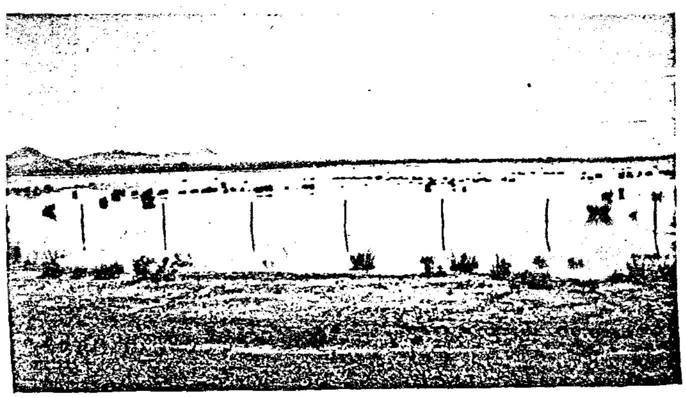


Figure 7.4. Playa of South Alkali Flat. Pyramid Mountains on the horizon to the southeast (H. L. James photo).

Summit, New Mexico, along a drainage to the Gila River (Hawley and Kottlowski, 1965).

1.7

9.1 South Alkali Flat playa. Animas (Spanish meaning "departed souls") Range (9:00) in far distance is composed chiefly of a thick series of volcanic rocks except near the north end, where upper Paleozoic beds are thrust over Lower Cretaceous strata (Hawley and Kottlowski, 1965). At 10:00 Table Top Mountain in distance; Peloncillo Mountains from 10:00 to 3:00; Chiricahua Mountains on horizon from 11:00 to 12:30; Steins Pass at 1:00.

1.0

10.1 Exit 11; N.M. 338 to Animas. About 12,000 ac of farmland, mainly cotton, are irrigated from deep wells near Animas.

Schwennesen (1918) believed that if conditions promoting downcutting continue, gullies which head on the north side of the divide between the Animas and Gila basins will cut headward, drain the Animas basin into the Gila River, and cause extensive dissection of the Animas basin. This will allow the integration of not only the Animas Valley, but also the areas from Lordsburg to the Cedar Mountains, or an area of some 2,300 mi^2.

0.9

11.0 Sign: Road Forks 4 mi, Tucson 145 mi. Steins Pass at 1:00; to right are middle Tertiary rhyolitic volcanic rocks overlying lower Tertiary andesites. Probable rhyolitic cauldron complex at 3:00.

2.3

13.3 Spectacular cliffs carved from rhyolitic volcanics are at 3:00. At 10:30 on the eastern slopes of the Peloncillo Mountains are small mines and prospects.

1.1

14.4 Big Hatchet Mountains at 9:00; Animas Mountains at 9:30; southern Peloncillo Mountains at 10:00.

Directly ahead (west) the road and railroad cross the Peloncillo Mountains through Steins Pass.

Volcanic rocks are the surficial rocks in the Steins Pass area, but farther south Cretaceous and Paleozoic sediments and Precambrian granite are exposed in parallel, northwest-trending fault blocks. These can be seen forming the range from a point about 3 mi south of Road Forks and extending southward for about 13 mi. The Tertiary Weatherby Canyon Ignimbrite extends southward from Granite Gap for many miles.

In the area west of Road Forks near Steins Pass the volcanic rocks have been divided into an early Tertiary sequence and a middle Tertiary sequence. The older sequence makes up the low hills and higher peaks west and southwest of Road Forks and consists of over 5,000 ft of northward-dipping, dark gray, red and purple andesitic flow rock and breccia, with some dacite and basalt included in the sequence. The gray to purple color of the rock imparts a characteristic hue to the terrain occupied by the andesite. These rocks crop out west of Road Forks along Interstate 10 (Gillerman, 1968).

Recently (see Marvin and others, this guidebook) ages have been obtained on the older volcanics. Fission tracks in zircon provide a 44.7 m.y. age for andesite in the upper part of the sequence. These upper andesites are underlain by the Bobcat Hill Conglomerate, which in turn overlies a quartz latite unit considered extrusive by Gillerman (1958). Fission tracks in zircon and apatite extracted from the quartz latite unit give 32.7 and 27.5 m.y. ages, respectively. Perhaps this anamously young age reflects resetting by 32.2 to 31.0 m.y. old granite porphyry dikes which constitute a northwest-trending, extensive dike swarm throughout the central Peloncillo Mountains.

The middle Tertiary sequence crops out north of the railroad west and northwest of Road Forks. Three separate units can be seen. Quarry Peak Rhyolite forms prominent Quarry Peak just north of Steins, and Steins Mountain Quartz Latite forms Steins Mountain (the higher conical peak just north of Quarry Peak) and the hills to the north. Fifty feet of basaltic andesite separate the two.

Quarry Peak Rhyolite consists of over 2,000 ft of rhyolite flows, lithic tuffs and breccias, which dip 15-30 degrees north. The tuff and breccia are postulated to represent violent volcanic eruptions which fragmented solidified vent-filling lava. Fine volcanic ash mixed with the breccia fragments fell on land and in shallow lakes. The interbedding of the lithic tuffs and the lavas indicate more than one eruptive cycle of explosion, lava flow and solidification of the plug.

Figure 14.4. Quarry Peak (left) and Steins Mountain (right) just north of Steins Pass as viewed from Milepost 7 (Jan Wilt sketch).

The basaltic andesite occupies the lower slopes of Steins Mountain. Porphyritic Steins Mountain Quartz Latite constitutes most of Steins Mountain and contrasts sharply in color and topographic expression with Quarry Peak Rhyolite. Steins Mountain Quartz Latite and underlying basaltic andesite dip northward at low angle and were laid down across previously tilted and beveled Quarry Peak Rhyolite, from which they are separated by an angular unconformity. Age relationships of Steins Mountain Quartz Latite and Weatherby Canyon Ignimbrite farther south are indeterminate, but both are mid-Tertiary, consist largely of pyroclastic fragments and are products of explosive volcanism. They may be different phases of one period of violent volcanic activity (Gillerman, 1968).

Quarry Peak Rhyolite is intruded by a northwest-striking quartz latite porphyry dike dated at 27.0 and 26.1 m.y. (Hoggatt and others, 1977). Mid-Tertiary volcanic rocks north of Steins Pass have recently been dated by **Marvin and others (this guidebook)**; the rhyodacite of Doubtful Canyon has yielded a K-Ar biotite age of 33.0 m.y. and a fission track zircon age of 28.7 m.y. A vitrophyre from the rhyodacite of Braidfoot Ranch yielded a fission track age of 31.4 m.y.

1.1

15.5 **Bear right for Exit 5**; U.S. 80 to Rodeo and Douglas. Low roadcuts are in lacustrine beach sand and gravel on west edge of Lake Animas **(see Fleischhauer, this guidebook)**. The lake is probably of late Wisconsin age, correlative with Lake Estancia and Lake San Agustin in central and west-central New Mexico. To the north in the Virden-Duncan valley of the Gila River, Morrison (1965) mapped gravel deposits which he believed were related to a large lake or lakes of mid-Pleistocene age. He found stream gravels of probable late Pleistocene age covering two strath terraces along the Gila and unconsolidated alluvial gravel, sand and silt that underlie a still lower, younger terrace of Recent age.

Other ancient lake beds in this part of the Basin and Range province are: Lake Cochise (Willcox Playa) in Sulphur Springs Valley **(see Schreiber, this guidebook)**, Lake Cloverdale in San Luis Valley (south of Animas Valley), Playas Lake in Playas Valley (30 mi south of Lordsburg), a lake in the Mexican part of Hachita Valley and many lake beds in Mexico in northwestern Chihuahua (Hawle and Kottlowski, 1965).

0.5

16.0 I-10 overpass.

0.3

16.3 Shady Grove restaurant on left, Road Forl saloon on right. Pyramid Mountains are fro 7:30 to 9:30. Coyotero Hills are at 10:(about 15 mi south of Lordsburg. The large cache of prehistorically worked turquois was found there in Bobcat Cave in the earl 1960's. The find consisted of thousands c beads and pendants of turquoise probabl obtained from the Santa Rita region ne Silver City, which is about 100 mi northea of here (Naylor, pers. comm.).

1.0

17.3 Brown ridges at 1:30 are in Bobcat Hill Cor glomerate which is conformable with ove lying Eocene (44 m.y.) andesite. The andesit is cut by light-colored, Oligocene, granit porphyry dikes and quartz latite porphyr dikes which cut eastern slopes of Attorne Mountain at 1:45 and Robinson Mountain a 2:30.

1.0

18.3 Pyramid Peak (8:45) and Leitendorf Hills below it are composed of rhyolite flows. Rimrock Mountain (9:00) contains a sequence of 7 ash-flow tuffs and interlayered, basaltic andesite; dark hills below Rimrock Mountain are latite flows and domes. Lightning Dock Mountain (10:30) is composed of rhyolitic ash-flow tuffs of the Muir cauldron **(see Deal and others, this guidebook)**. Low hills (10:00) between Rimrock Mountain and Lightning Dock Mountain are rhyolite domes and flows that rest on basal andesite; high knobs just north of Lightning Dock are basal andesite; low hills south of Lightning Dock are a complex of basal andesite and rhyolite tuffs. The low hills at the extreme south end of the range are composed of Rimrock Mountain tuffs **(see Deal and others, this guidebook)**. Table Top Mountain, the isolated butte in Animas Valley at 11:00, is composed of breccias shed off of the Pyramid Mountains.

The light-colored buildings in the valley west of Lightning Dock Mountain are greenhouses near McCants Hot Wells. These wells are the principal reason for designating the Lightning Dock KGRA (Known Geothermal Resource Area) **(see Smith, this guidebook)**. The wells were reported to have originally produced water with a temperature of 115.5°C at a depth of 87 ft.

1.6

19.9 Road on right to Carbonate Hill mine. The mine is in Bisbee Group of Early Cretaceous age. It was located in 1894 but not actively mined until 1906; main activity was during 1924-1930. It has yielded lead-zinc-silver ore consisting of silver-bearing galena and sphalerite in a gangue of calcite and quartz. The main ore body was along an andesite-latite dike, intruded along a north- to northwest-trending fault zone with replacement of Lower Cretaceous limestones adjacent to the dike. Internal molds and shells of pelecypods and cephalopods replaced by galena are striking features of the ore.

Bobcat Hill, north of the mine road in the foreground, is Cretaceous-Tertiary andesite. Northeast-dipping Bisbee Group, which forms the hills south of the mine (Gillerman, 1958) unconformably overlies Permian Concha Limestone. Bisbee Group here consists of, in ascending order: (1) basal McGhee Peak Formation, 370-666 ft, of mainly limestone conglomerate; (2) Carbonate Hill Limestone, 200 ft; (3) Still Ridge Formation, 600 ft of impure limestone, limy sandstone and limestone conglomerate; and (4) Johnny Bull Sandstone, 1,050 ft of orthoquartzite and subgraywacke. Unconformably overlying the Bisbee Group in the Peloncillo Mountains is either quartz latite or the next younger unit, Bobcat Hill Conglomerate.

Big Hatchet Mountains in distance at 10:00; Animas Mountains from 10:30 to 11:30.

1.4

21.3 Limestone ledges dipping northeast at 3:00 are part of Wolfcampian Earp Formation overlying Pennsylvanian-Wolfcampian Horquilla Limestone in a fault-bounded block between Lower Cretaceous strata to the north and south. Blue Mountain at 1:15 in the Peloncillos is capped by southwest-dipping, folded Horquilla Limestone. Granite porphyry dikes cut Horquilla Limestone in the northeast slopes of Blue Mountain at 1:15 to 1:45.

Figure 19.9. Carbonate Hill mine (CH) on east slope of Peloncillo Mountains (J. D. Forrester photo).

2.0

23.3 Milepost 25. Low hills next to the road on the right are lower Bisbee Group strata of the McGhee Peak Formation and overlying Carbonate Hill Limestone.

0.4

23.7 Road to left intersects N.M. 338 north of Cotton City. The large isolated hill of Tertiary volcanics in the valley at 11:00 is Tank Mountain. These rhyolite flows and tuffs, and breccias containing blocks up to 100 ft long of Paleozoic (?) limestone are capped by porphyritic quartz latite flows.

Animas Peak is on distant skyline at 11:15. Grey Mountain, in the southern Peloncillos, at 12:00 on skyline, is composed of rhyolitic flows and domes. At 12:15 is 1117 Mountain comprised of Weatherby Canyon Ignimbrite of Gillerman (1958), determined to be 26 m.y. old by Marjaniemi (1969). Rhyolitic tuffs of the Weatherby Canyon include at least two cooling units that probably total over 1,000 ft.

0.7

24.4 Road on right to Crystal mine. Crystal mine was one of the last active mines in the Peloncillos. Gillerman (1958) noted that the vein strikes N. 20° E., is almost vertical and occurs along a fracture in the Escabrosa

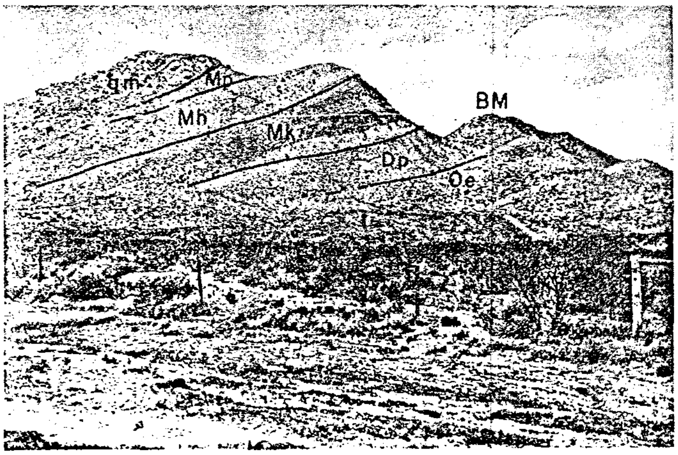


Figure 24.4. Tertiary quartz monzonite sill (qm) overlying thin slices of Paradise Formation (Mp), light-colored Hachita Formation (Mh) and dark-colored Keating Formation (Mk) of the Escabrosa Group; Percha Shale (Dp) and El Paso Formation (Oe) form lower slopes. Blue Mountain (BM) is mostly Horquilla Limestone (J. D. Forrester photo).

Limestone near a faulted dike of Oligocene (32.2 to 31.0 m.y.) granite porphyry (Hoggatt and others, 1977). Sphalerite, galena, chalcopyrite and pyrite are in a calcite and quartz gangue. Some bodies of sphalerite-rich tactite have been reported.

Hill at 1:30 is capped by a southwest-dipping quartz monzonite porphyry sill overlying a thin sliver of Paradise Formation, which rests on Escabrosa Group forming the light and dark ledges below. Hachita Formation of the Escabrosa Group (Armstrong, 1962) rests on dark-colored ledges of Keating Formation of Escabrosa Group, which overlies Percha Shale in the slopes immediately below the Keating. Percha Shale is marked at its upper contact by a vegetation line. El Paso Limestone comprises the remainder of the lower slopes. Blue Mountain in the background to the right is composed of Horquilla Limestone. Foothills at 3:00 to 4:00 are in Cretaceous strata.

0.9

25.3 **STOP 1. Pull off onto right shoulder of highway.**

Orientation: Clockwise from 6:00, using the highway as a reference line with 6:00 towards Lordsburg, principal landmarks are as follows: Pyramid Mountains are from 6:00 to 8:00; Burro Mountains are in the far distance at 6:00; Big Hatchet Mountains are in far distance at 9:00; the Animas Valley intervenes between our stop and the Pyramid and Big Hatchet mountains. The Animas Mountains are from 9:00 to 10:00 with the southern Peloncillo Mountains from 10:00 to 12:00. Granite Gap (12:00), Preacher Mountain (1:00), Cienega Peak or Granite Peak (1:30) and unnamed divide at 3:00 with Blue Mountain at 3:00 to 4:00.

Geology: On the southwest flank of the Peloncillo Mountains, south of Granite Gap Mountain (11:30), is a complex of Tertiary rhyolite-latite intrusions and rhyolitic ash-flow tuffs exposed for a distance of about 2 mi to Cowboy Pass (11:00). Farther south these Tertiary rocks and Paleozoic rocks are covered by the 26.3 m.y. old (Marjamemi, 1969) Weatherby Canyon Ignimbrite of Gillerman (1958).

Granite Gap Mountain at 11:50 southeast of the gap is capped by Escabrosa Limestone. Low hills at 11:30 east of Granite Gap Mountain and south of the road, are composed of fault slivers of Bliss Sandstone and El Paso Limestone resting on granite. In the area south of the road the Precambrian granite porphyry, which is overlain unconformably by the Bliss Sandstone (Cambrian), yielded a muscovite age of 34.4 m.y. and a microcline age of 58 m.y. Enough middle Tertiary igneous activity occurred in that area to explain these anomalously young ages by differential loss of argon during heating (Hoggatt and others, 1977).

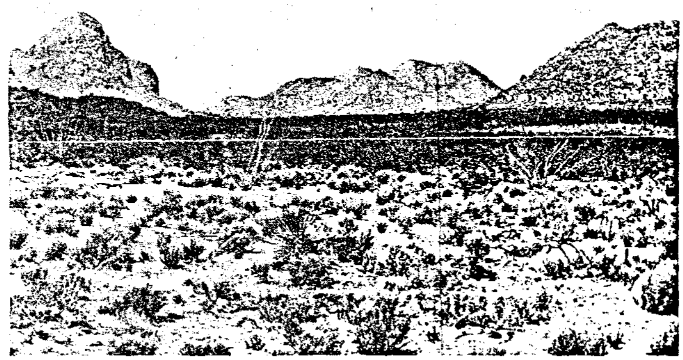


Figure 25.3a. View northwest toward Cienega Peak (upper left) showing faulted, southwest-dipping, Paleozoic section down through Bliss Sandstone overlying granite to far right (J. D. Forrester photo).

The area north of Granite Gap from the gap to Preacher Mountain to the intrusive cap on Cienega Peak is occupied by Oligocene granite of Granite Gap which has five K-Ar determinations ranging from 32.5 m.y. to 29.8 m.y. (Hoggatt and others, 1977). The Granite Gap stock (originally mapped as Precambrian by Gillerman, 1958) is intruded by an extensive, nearly contemporaneous, northwest-striking dike swarm (32.2 to 31.0 m.y.) composed of granite porphyry. These are intruded by a slightly later set of 27.7 to 25.8 m.y. old quartz latite porphyry dikes (Hoggatt and others, 1977).

Lead-zinc-silver mineralization at the Granite Gap and Crystal Hill mines is probably synchronous with these intrusions. Small-scale underground mines at Granite Gap have pursued copper-lead-zinc-silver ores that were enriched during oxidation of the sulfide mineralization. Metallization occurs in the Horquilla and Escabrosa limestones and is related to the quartz monzonite porphyry dikes genetically linked to the Granite Gap Granite (see Williams, this guidebook).

The somewhat metamorphosed section in the hills on the skyline to the right of Cienega Peak (Granite Peak), in descending order includes: Permian Colina Limestone

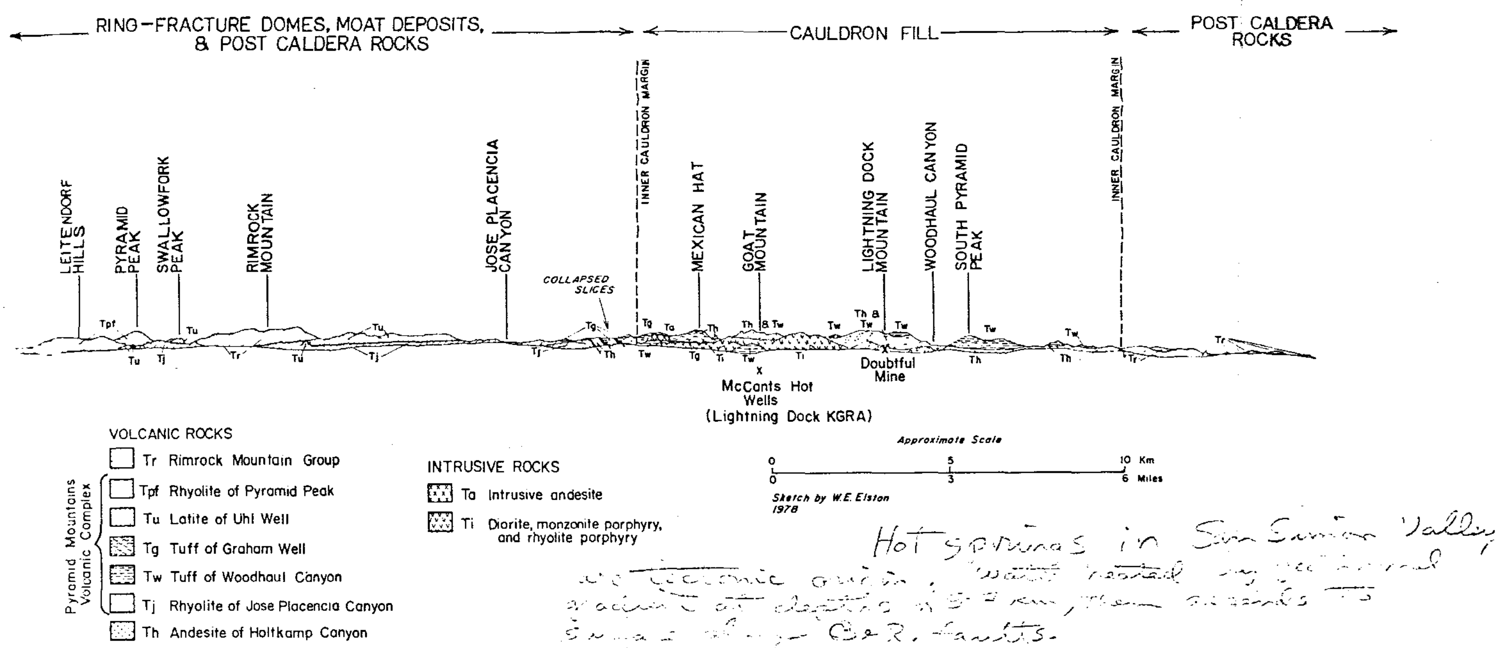


Figure 25.3b. Pyramid Mountains and Muir cauldron (W. E. Elston sketch).

(bluish-gray, ledgy band), Permian Earp Formation in the lower slopes of Granite Peak and the next hill, Pennsylvanian Horquilla Limestone, Mississippian Paradise Formation and Escabrosa Group (Hachita Formation underlain by Keating Formation) in the ridge and northern slopes of the ridge, as well as underlying Devonian Percha Shale, Ordovician El Paso Limestone, Cambrian Bliss Sandstone, and Precambrian granite in the pass at 2:30 (Armstrong and others, 1978).

The Wood Canyon fault, a large, northwest-trending, high-angle reverse fault, strikes through the unnamed divide at 3:00, placing Precambrian granite on the west in contact with southwest-dipping Earp Formation in the lower slopes of Blue Mountain, with Horquilla Limestone making up most of Blue Mountain. Light brown areas in the southern slopes of Blue Mountain are northwest-trending dikes of quartz latite and granite porphyry.

The hill at 4:00 is composed of Tertiary granite porphyry with Precambrian granite exposed in the southern slopes in a slice of the east to east-northeast trending, Preacher Mountain fault. From the Tertiary granite porphyry down the hill to the east in northwest-striking bands are the Paradise, Hachita, Keating, Percha and El Paso formations with a Tertiary rhyolite dike intruding the northwest-trending Goat Camp fault at the base of the hill (Armstrong and others, 1978). The Goat Camp fault separates the Paleozoic section from Cretaceous Bisbee Group strata in low hills at 5:00 to 5:30.

Precambrian granite in the pass at 2:30, which is nonconformably overlain by Bliss Sandstone, was correlated by Gillerman (1958) with the Granite Gap Granite at Granite Gap on the basis of petrographic similarity. However, he noted that the Granite Gap Granite at Granite Gap was harder, more resistant to weathering and more jointed than the granite in the pass at 2:30 which underlies the Bliss. Hoggatt and others (1977) presented numerous Tertiary dates for the Granite Gap Granite which they call the granite of Granite Gap. (Moral: Don't take granite for granite!)

Paleozoic strata measured by Gillerman (1958) in the central Peloncillo Mountains are Bolsa Quartzite (Bliss Sandstone) 60-395 ft, El Paso Limestone 50-150 ft, Percha Shale 230 ft, Escabrosa Limestone 450 ft, Paradise Formation 140-215 ft, Horquilla Limestone 1,500 ft, Earp Formation 830+ ft, Colina Limestone 500 ft, Scherrer Formation 50 ft and Concha Limestone 0-800 ft.

Most of the units are much thicker in the Big Hatchet Mountains to the southeast, where Zeller (1965) measured: Bliss 190-325 ft, El Paso 915-1,070 ft, Montoya 385 ft, Percha 280 ft, Escabrosa 1,260 ft, Paradise 320 ft, Horquilla 3,245-3,530 ft, Earp 995 ft, Colina 355-505 ft, Epitaph Dolomote 1,480-1,520 ft, Scherrer 5-20 ft and Concha Limestone 1,375 ft.

Faults within this part of the Peloncillo Mountains are steep, normal faults trending northwest (diagonally across the range), except for the east-northeast-striking faults which separate the upthrown Granite Gap Granite from the downthrown monocline of Cienega Peak and the Paleozoic section just south of Granite Gap (Gillerman, 1958). The diagonal faulting and associated tilting and folding, probably occurred in early Tertiary time.

Most of the range-bounding faults in this part of New Mexico, of probable late Teritary age, are covered by alluvial fans, but some recent fault scarps are preserved and have sinuous northward strike. There may be 2 to 3 mi of structural relief between the Peloncillo horst and the bordering San Simon and Animas Valley grabens (Hawley and Kottlowski, 1965).

Reeder (1957) reported that development of groundwater for irrigation in the Animas Valley reached its height in 1948 when the State Engineer designated the area a closed ground-water basin, 100 permits being issued to irrigate 14,200 ac. Water levels in wells have declined each year throughout almost all of the irrigated area, with a maximum lowering of 70 ft estimated for the period of 1948-1968. Most of the irrigated fields are along the center of the Animas Valley in a 10-mi stretch 5 to 15 mi north of Animas. Depths to water are 40 to 100 ft, although some wells are 500 ft deep. The chief crop is cotton, with some corn, beans, various livestock feeds and some garden crops.

The water-bearing gravel and sand are partly in the upper Gila Conglomerate fill of the Animas graben and partly in lenses within late Pleistocene lacustrine beds. Some wells penetrate as many as 6 water-bearing beds that range from 5 to 45 ft in thickness, averaging about 20 ft. Recharge is only from precipitation on drainage areas of the Animas Valley; Reeder (1957) estimated that less than 0.1 in of the normal annual precipitation of about 10 in contributes to the ground-water body.

The view of the Pyramid Mountains (6:00-8:00) is dominated by an Oligocene (~ 33 m.y.) cauldron complex, the Muir cauldron (fig. 25.3b) (see Deal and others, this guidebook). The rocks of the cauldron are collectively included in the Pyramid Mountain volcanic complex. They rest on an early Tertiary andesite, the andesite of Holtkamp Canyon. Only a central fragment of the Muir cauldron remains exposed to view. Basin an Range faults on both sides of the Anima Valley control hot-spring deposits and low temperature veins of fluorspar (including th Doubtful or Animas mine) and manganes oxides. The hot wells of the Lightning Docl KGRA seem to be controlled by the intersec tion of the ring-fracture zone of the Mui cauldron and a Basin and Range fault tha displaces Quaternary deposits.

0.7

26.0 Side roads to left and right. At 12:0C through Granite Gap loom the Chiricahua Mountains in Arizona.

0.8

26.8 Side road to right; hills to left are fault slivers of Bliss Sandstone nonconformably overlying Precambrian granite. Note excellent pediment cut on Oligocene granite of Granite Gap north and south of the road just before the gap. Cienega Peak at 2:30.

0.4

27.2 Crest of Granite Gap with roadcuts in Oligocene granite of Granite Gap. Beautiful knob and boulder landscape formed by weathering of granite. Note prominent west-northwest striking joints in the hill at 1:00. Descend into San Simon Valley, which has a considerably lower base level (some 300 ft) than that in the Animas Valley to the east.

0.7

27.9 Road on left to Granite Gap mines. Large-scale operations from 1897 to 1908 and sporadic activity until 1950 mined more than $1 million of lead-silver ore. The deposits

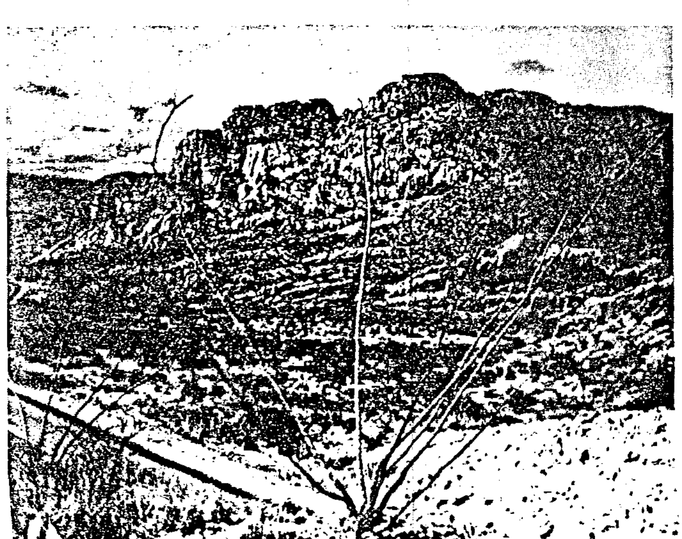


Figure 27.2a. U.S. Highway 80 passing through Granite Gap San Simon Valley in left distance, backdropped by cloud cov ered Chiricahuas (H. L. James photo).

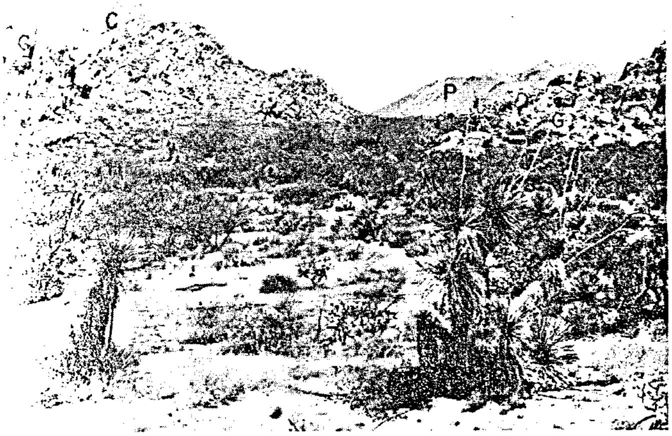


Figure 27.2b. View north showing exfoliated Granite Gap granite (G) in foreground. Cienega Peak granite (C) and faulted Paleozoic section (P) in background (R. E. Clemons photo).

formed in highly fractured Escabrosa and Horquilla limestones, near northwest-striking quartz latite porphyry dikes, and consisted mainly of cerussite with some unoxidized cores of galena and tetrahedrite. Dumps in view are arranged along prominent, northwest-striking quartz latite porphyry dikes (see **Williams, this guidebook**).

0.2

28.1 Low hill on left at 9:00 is Horquilla Limestone. Southern Peloncillos on skyline at 10:00 in distance are Weatherby Canyon Ignimbrite and similar rhyolite ash flows (Wrucke and Bromfield, 1961). The nearby low ridge at 9:30 is composed of late (?) Tertiary dikes ranging from rhyolite to latite in composition.

0.2

28.3 Milepost 20. Ranch road to right. Peloncillo Mountains from 4:00 to 10:00; Guadalupe Mountains in far distance at 10:30. Chiricahua Mountains from 11:00 to 2:00 with Cave Creek Canyon and Portal at 12:00; Blue Mountain in Chiricahuas at 1:00 is a low double hill below the skyline on the west edge of San Simon Valley. Dos Cabezas Peaks are at 2:00; Mount Graham in the Penaleno Mountains is at 3:00.

San Simon Cienega at 1:00 is the green patch near the east edge of the valley.

San Simon Valley was named for San Simon Creek, which at one time was a perennial stream. It was known as Rio San Domingo in the 1840's, as the Cienega de Sauz ("willow swamp") or Rio de Suaz on the Boundary Survey map of 1853, and as San Simon Cienega and "underground passage of Rio de Suaz" on the 1879 map. Obviously in the years since 1849, the perennial stream had dried up (Barnes, 1960).

Road now descends a pediment and valley-fill surface. Caliche-cemented fan gravels are exposed on both sides of highway ahead.

1.0

29.3 Cave Creek-Portal area is at 12:00 in the Chiricahua Mountains. V-shaped Cave Creek is in Cave Creek rhyolite dated at 25.1 and 25.7 m.y. (Marjaniemi, 1969; **see Shafiqullah and others, this guidebook**).

Note the symmetrical, low-relief alluvial fan headed in Cave Creek. Cave Creek was named for Crystal Cave which is developed in Bisbee Group limestones. The cave is near a siliceous dike-like body, and as a result both quartz crystals and calcite and aragonite speleothems occur in the cave.

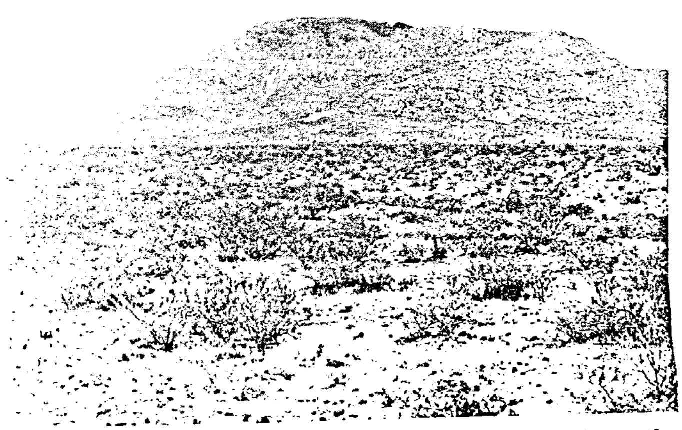


Figure 27.9. View southeast of Granite Gap mines (J. D. Forrester photo).

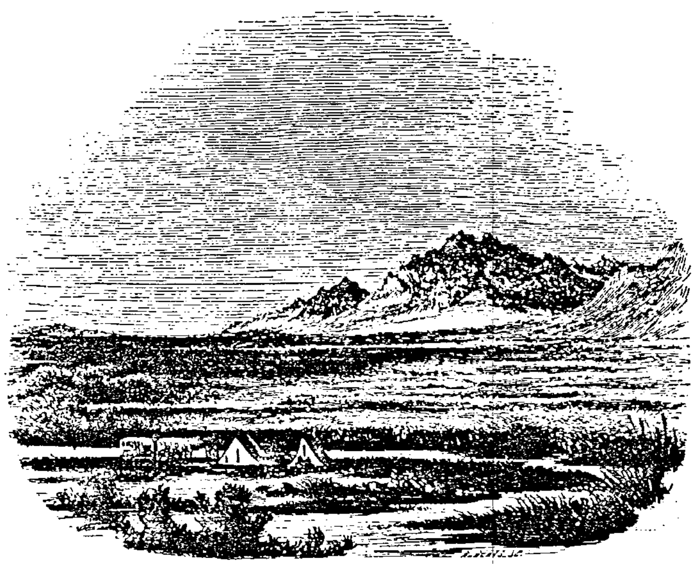


Figure 28.3. U.S. Boundary Commission camp at Cienega de Sauz (Bartlett, 1854).

Figure 29.3. View northward from Sentinel Peak (8,999 ft) overlooking headwaters of Cave Creek. Summit ridge line of Chiricahua Mountains (middleground) and Dos Cabezas Mountains (center distance). Willcox Playa in upper left corner; San Simon Valley in upper right corner (W. F. Heald photo, courtesy: U.S. Forest Service).

Foothills on south side of mouth of Cave Creek Canyon are composed of Horquilla Limestone, Earp Formation and Colina Limestone. AVA Ridge, the high northwest-trending foothills ridge north of Cave Creek, contains a complete southwest-dipping, Paleozoic section from Bolsa Quartzite resting on Precambrian granite through Colina Limestone (Sabins, 1965).

1.0

30.3 Near Blue Mountain at 1:00 below skyline are type sections of several formations which represent a transition from southern Arizona nomenclature to southwestern New Mexico nomenclature. Sabins (1957a) named Devonian exposures in the steeply southwest-dipping Paleozoic section on AVA Ridge the Portal Formation. Armstrong (1962) identified the Keating and overlying Hachita formations within Escabrosa Limestone at Blue Mountain and raised the term "Escabrosa" to group status. He extended this nomenclature eastward into New Mexico. The Mississippian section in the northeastern Chiricahua Mountains also contains upper Mississippian strata not found farther west. These were named Paradise Formation, for the abandoned mining camp of Paradise a few miles southeast of Blue Mountain. Paradise equivalent rocks of late Mississippian age also extend eastward into southwestern New Mexico.

1.2

31.5 Road to right to Cienega Lake of the San Simon Cienega, a Bureau of Land Management-administered Mexican duck habitat. The large cottonwood trees mark the course of San Simon River. North of the line of trees and on projection with this reach of the San Simon River, Gillerman (1958) mapped a 1-mi long fault swarm which cuts Quaternary alluvium. This north-trending swarm may mark the structural boundary of the Peloncillo Mountain horst block in this area. This fault swarm is about 2.5 mi from the alluvium-mountain front boundary.

1.0

32.5 Cross bridge over San Simon Creek. Quarry cut to left is in older alluvium or Gila Conglomerate.

Chiricahua Mountains now loom impres-

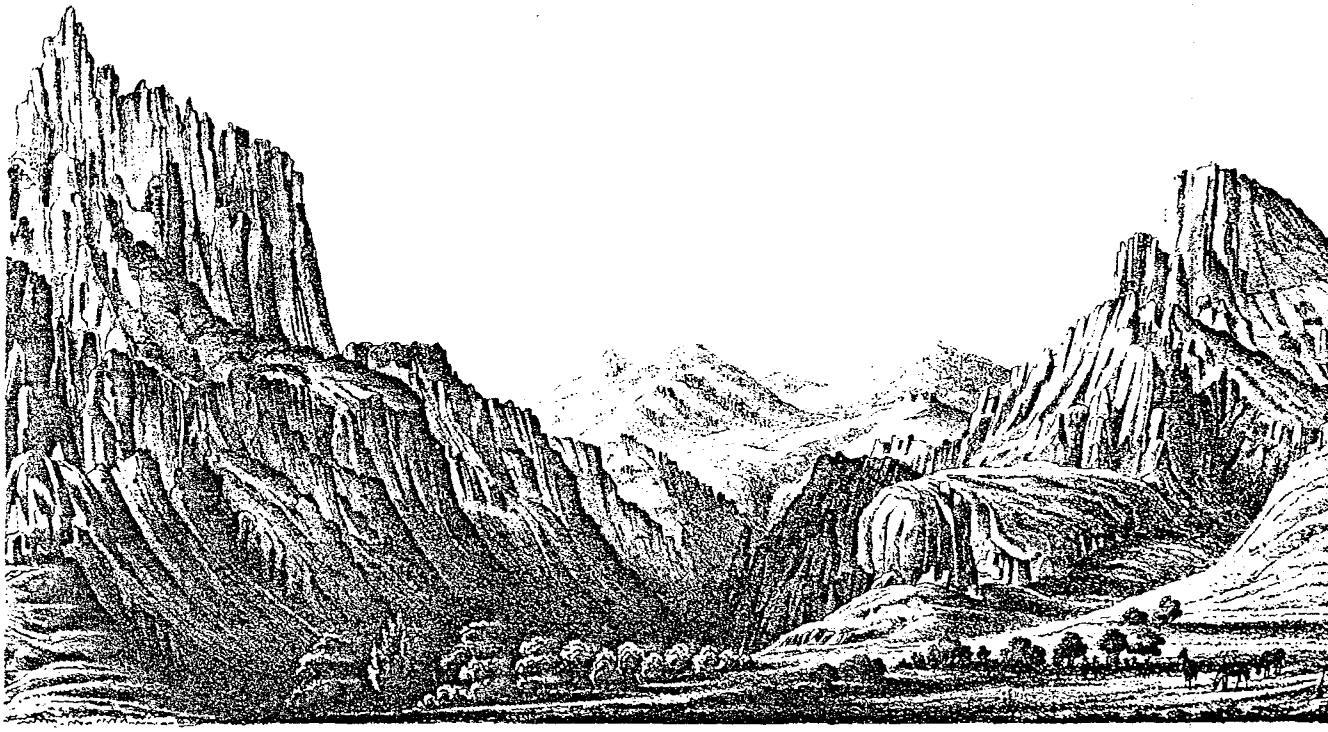


Figure 32.5a. Dramatized sketch by Gray (1856) of Portal area in the Chiricahua Mountains.

sively on the west side of San Simon Valley. Darnell Peak at 11:00; Portal Peak (8,544 ft) at 11:30; Cave Creek Canyon at 12:00; AVA Ridge in the foothills at 12:30; Davis Mountains are the low foothills at 2:00; Blue Mountain at 2:30.

The geology of the central and southern Chiricahua Mountains is dominated by an Oligocene ignimbrite sequence **(see Shafiqullah and others, this guidebook).** North of Cave Creek the east flank of the Chiricahua Mountains was mapped by Cooper (1959) as predominantly pre-Tertiary rocks including Precambrian, Paleozoic and Cretaceous sedimentary rocks and Late Cretaceous(?) volcanic rocks. The volcanic rocks include andesite flows and breccias, and lenses of clastic sedimentary rocks and rhyolite. These rocks correlate with the Blacktail Formation of Raydon (1952) in the Cave Creek area and the Nipper Formation of Sabins (1957a) in the Vanar quadrangle. Drewes and Williams (1973) observed that the Nipper Formation resembled the Salero Formation of Late Cretaceous age in the Santa Rita Mountains. They also noted that the less altered dacitic lava may be Tertiary and as such, would be more related to the overlying Tertiary rhyolitic volcanic pile rather than the Late Cretaceous(?) rocks in the lower Nipper Formation. The 32.4 m.y. age date of the Nipper Formation reported by **Shafiqullah and others (this guidebook)** substantiates such an interpretation.

Resting on Nipper Formation and correlatives is a sequence of interbedded rhyolite flows, ash-flow tuffs, air-fall tuffs and volcaniclastic beds that Raydon (1952) named Cave Creek Formation. Marjaniemi (1969) obtained a 25.7 m.y. age on a sample from the Eagle Cliffs member in the upper part of the Cave Creek Formation. Cave Creek Formation correlates with the lower rhyolite unit as mapped by Drewes and Williams (1973) farther west in the Chiricahua Wilderness Area, and with "lower rhyolites" mapped throughout the Chiricahua Mountains by Marjaniemi (1969). Cave Creek Formation makes up Portal Peak and dips southward into Sulphur Draw at the northeast side of Darnell Peak.

To the west the Rhyolite Canyon Formation of Enlows (1955), as correlated southward into the central Chiricahuas by Marjaniemi (1969) and Drewes and Williams (1973), overlies Cave Creek Formation. Spectacular columns in Chiricahua National Monument are made of ash-flow tuffs within the Rhyolite Canyon Formation. According to Marjaniemi, (1969) the Rhyolite Canyon Formation is a widespread series of ash-flow tuffs ranging from 1 to 7 cooling units and 300 to 3,000 ft in thickness. Marjaniemi proposed the Turkey Creek cauldron as the

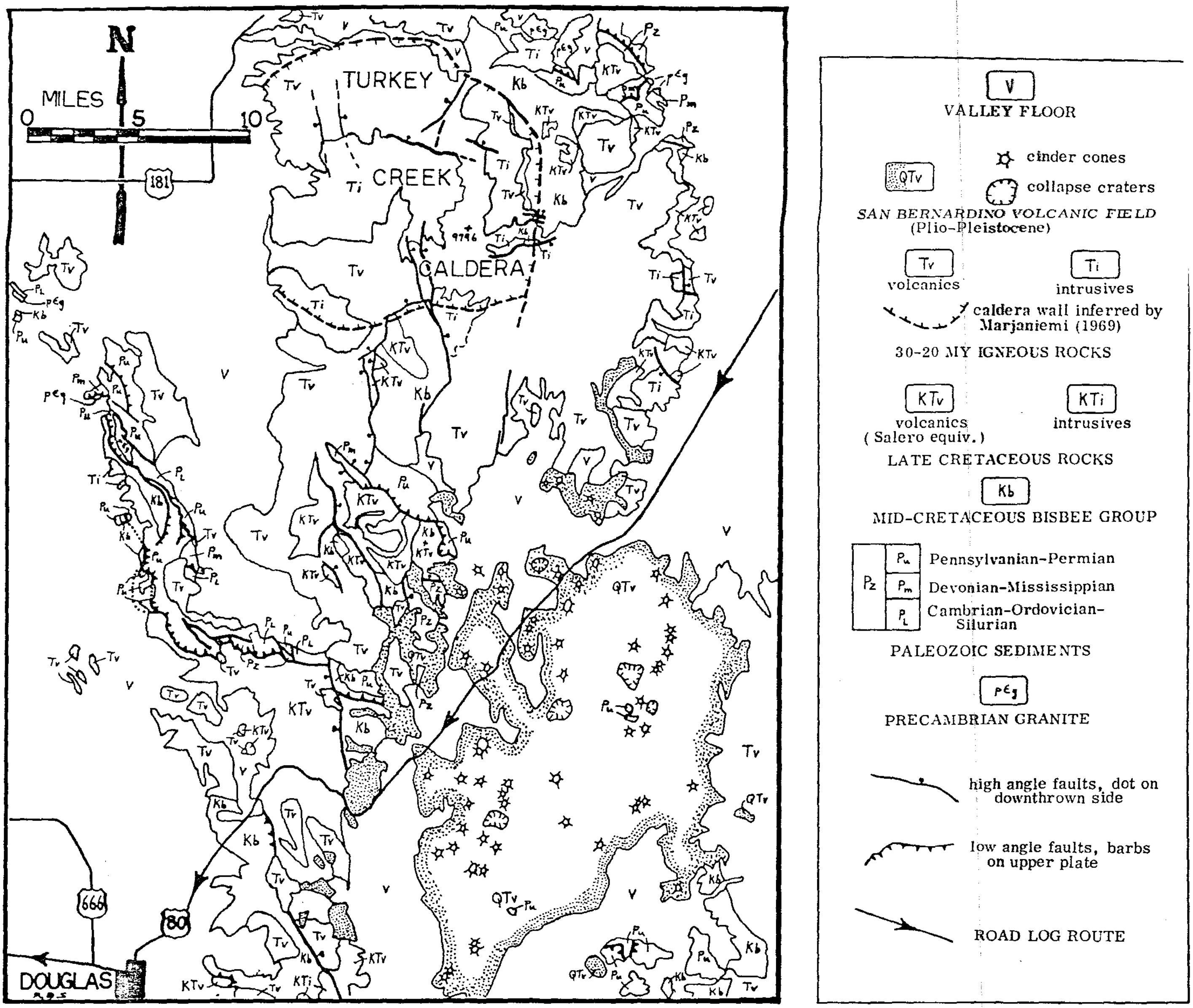


Figure 32.5b. Generalized geologic map of southern Chiricahua, Swisshelm and Pedregosa mountains and San Bernardino Valley (by R. Scarborough).

source cauldron for the thicker sections of Rhyolite Canyon tuff on the west side of the Chiricahua Mountains. He estimated the total volume of the Rhyolite Canyon ash-flow sheet(s) at 110 mi^3 or 450 km^3, which exceeds presumed analogs in the classic Valles caldera in New Mexico (Smith, 1960).

Rhyolite Canyon tuff is intruded by a flat-roofed monzonite and latite laccolith. The age of this intrusion is bracketed by the 24.2 to 25.0 m.y. date on the Rhyolite Canyon Formation, which the monzonite-latite intrudes, and by 24.8 m.y. old rhyolite and andesite dikes which intrude the monzonite-latite intrusive body. Marjaniemi (1969) regarded the monzonite-latite intrusion as a resurgence phenomenon.

Rhyolite Canyon Formation is overlain by a series of rhyolite flows, tuffs, tuff-breccia and tuffaceous sandstone at least 1,200 ft thick, designated by Marjaniemi (1969) and Drewes and Williams (1973) as the upper rhyolite unit. The basal contact is a disconformity on a surface of moderate relief, according to Drewes and Williams. The upper rhyolite unit is also intruded by the 24.8 m.y. old rhyolite and andesite dikes.

0.4

32.9 Road on right to Cienega ranch. Low hills at 10:00 are Gila Conglomerate. Peaks at 9:00 in the Peloncillo Mountains are comprised of Weatherby Canyon Ignimbrite. Gillerman (1968) believed the duplication of major features warranted a correlation between

Rhyolite Canyon Formation and Weatherby Canyon Ignimbrite. They are undoubtedly closely related in time, genesis, and method of formation (Gillerman, 1968). Marjaniemi (1968) suggested a general thickening (of the Faraway Ranch Formation) reaching thousands of feet in the southern Peloncillo Mountains and indicated that the source of these rocks is in southwest New Mexico. (Perhaps in the Rodeo cauldron as proposed by **Deal and others, this guidebook.)**

1.4

34.3 **Note:** Most of the stratigraphic names used in this part of the road log for rocks in the southern Peloncillo Mountains are new, informal field terms of E. G. Deal and are subject to change **(see Deal and others, this guidebook).** Cowboy Pass at 8:30; North Antelope Pass is at 10:00. Antelope Pass marks an important break in the Tertiary volcanic stratigraphy of the Peloncillos. On the north side of North Antelope Pass and south of Cowboy Pass, the Weatherby Canyon Ignimbrite forms northward-dipping dark-brown ledges from which Marjaniemi (1969) obtained a 26.9 m.y. K-Ar date. The Weatherby Canyon Ignimbrite overlies a buff-colored sequence of pumiceous, lithic-rich, ash-flow and air-fall tuffs and volcaniclastic sedimentary beds (unit of Antelope Pass), which here has an aggregate thickness of about 1,000 ft. South of the pass, the unit of Antelope Pass is composed chiefly of rhyolite flows and minor interbedded tuffs that are exposed on Grey Mountain (the high peak south of the pass) and the ridges for several miles to the south. The dip changes to generally southward south of Antelope Pass. The low hills within the pass are a complex sequence of older rhyolite tuffs, megabreccias containing exotic blocks (up to 0.3 mi long) of pre-Tertiary sedimentary rocks, and flows of intermediate composition. This zone of older rocks continues southeastward along the east margin of the Peloncillo Mountains to Tank Mountain before being covered by valley fill. North Antelope Pass and the rocks within it are thought to represent the northern rim of the Rodeo cauldron, which probably extends across San Simon Valley and into the eastern side of the Chiricahua Mountains south of Portal. Weatherby Canyon tuffs have not been recognized south of Antelope Pass, although rocks are present there in their apparent stratigraphic position.

1.0

35.3 Squaw Peak at 12:30; Horseshoe Canyon at 1:30. Horseshoe Canyon was named for its arc shape and was one of several Apache strongholds in the Chiricahuas. The impenetrable nature of the country made it next to impossible for the calvary to catch up with the Indians.

1.0

36.3 Milepost 12. Low hills in foreground at 9:30 are composed of rhyolite flows.

3.0

39.3 Dark, ledgy ridges from Grey Mountain to South Antelope Pass (10:30) are dominantly rhyolite flows in the unit of Antelope Pass. Lower slopes of the Chiricahua Mountains between Sulphur Draw (1:30) and Cave Creek (2:30) are mapped as "pre-Tertiary" (Marjaniemi, 1969) and as Cretaceous volcanics by Cooper (1959). The low hills at the mouth of Sulphur Draw are welded ash-flow tuff (tuff of Black Mountain), overlain by rhyolite flows of "lower rhyolites." The tuff

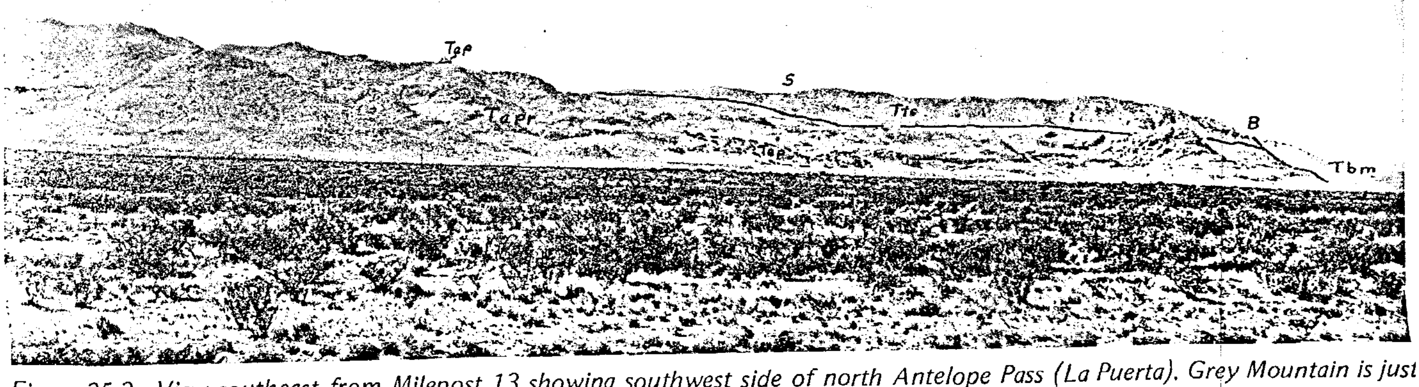


Figure 35.3. View southeast from Milepost 13 showing southwest side of north Antelope Pass (La Puerta). Grey Mountain is just off left edge of photo. Tuff of Trail Creek (Ttc) overlies the unit of Antelope Pass, which is predominantly rhyolite flow rock (Tapr) with minor tuff (Tap), to just north of south Antelope Pass (S). A fault at Burro Pass (B) separates these rocks from the older tuff of Black Mountain (Tbm) at the extreme right (H. L. James photo).

of Black Mountain is thought by Deal and others to be the main filling unit of the Rodeo cauldron, indicating a general location for the northwestern margin of the cauldron.

0.9

40.2 N.M. 9 on left leads eastward to north Antelope Pass through the southern Peloncillo Mountains, at a place formerly called La Puerta (Spanish: "the door") in the 1854 survey by A. G. Gray for the Texas Western Railroad (Bailey, 1963). The abandoned southern route of the Southern Pacific Railroad came through this pass. Valley fill in this area is about 7,000 ft thick.

2.1

42.3 South Antelope Pass at 9:30. Several ridges here on either side of the pass are capped by a dark, crystal-rich, rhyolite ash-flow tuff that locally fills east-trending canyons that are cut up to several hundred feet into the unit of Antelope Pass. Hand-specimen similarities suggest this rock may correlate with the Rhyolite Canyon Formation of the Chiricahua Mountains.

1.3

43.6 Road on right to Portal. See Sabins (1965) for road log from here to the Paleozoic section that is well-exposed at Blue Mountain in the Chiricahua Mountains.

0.1

43.7 Ahead are fine-grained sands on both sides of highway. These represent small, discontinuous, playa-like evaporative pans.

0.6

44.3 Milepost 4. Roadcuts expose fine-grained, lacustrine clays and silts overlain by coarse-grained sand, which contains well-rounded, pebble-sized rhyolite clasts (80 to 85%) and scoriaceous basalt clasts (15 to 20%). The basalt clasts are possibly outwash from the San Bernardino volcanic field, 15 mi to the south.

Low dark hills at base of Peloncillo Mountains (11:30) are Post Office Canyon basalt cones which have been completely dissected. This is the northernmost basalt of the San Bernardino volcanic field, although similar basalts are found farther north on the east side of the Peloncillos.

The hill just north of the cone and also the first spur of the ridge directly east of it are composed of down-faulted tuff of Black Mountain. The second spur and the remaining lower slopes of the scarp next to the next large canyon to the south (Owl Canyon at 12:30) are composed of a younger, coarsely porphyritic quartz latite (quartz latite of Owl Canyon). The contact between the two rocks is either intrusive or faulted. The quartz latite of Owl Canyon overlies tuff of Black Mountain in the Peloncillo Mountains. The same relationship exists in the southeastern foothills of the Chiricahua Mountains, where both rocks were previously mapped as "pre-Tertiary," and underlie rhyolite flows of the "lower rhyolite." These rocks would intervene between the lower rhyolites and other rocks also mapped as pre-Tertiary. Stratified rocks at the crest of the Peloncillos just north of Owl Canyon include tuffs in the unit of Antelope Pass and an interlayered "moonstone"-bearing ash-flow tuff.

1.0

45.3 Overpass over abandoned grade of El Paso and Southwestern Railroad. This railroad was built in 1902 by Phelps Dodge after the Southern Pacific refused to extend its lines south of Fairbank or to allow another line to connect to Bisbee. After an eventful construction interval, Phelps Dodge ran out of building material. The AT&SF had 400 cars of material for the Phelps Dodge line, but armed guards from Southern Pacific prevented any transfer of building material from

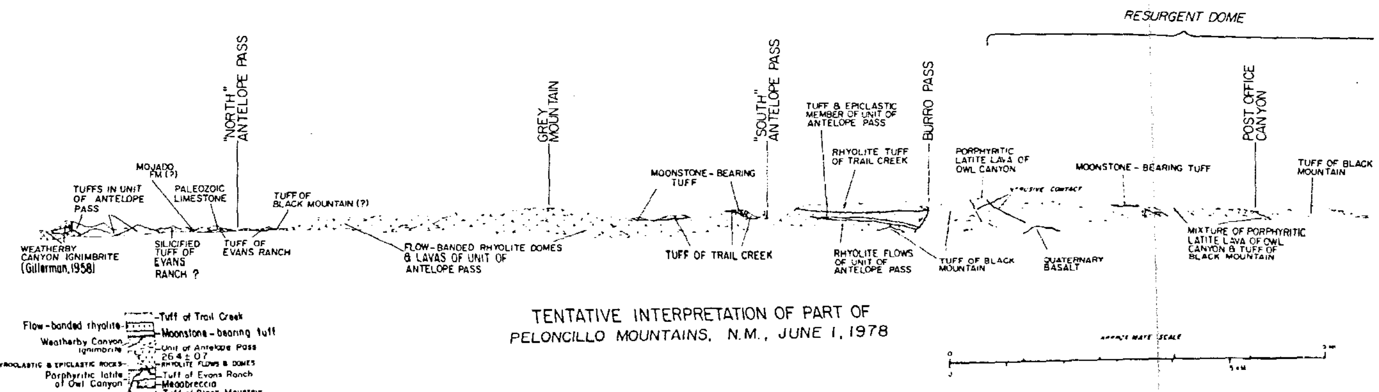


Figure 43.6. Geologic sketch of Peloncillo Mountains near Rodeo, New Mexico (by E. G. Deal and W. E. Elston).

Phelps Dodge across Southern Pacific rails. During the dark of night, the guards disappeared, a temporary crossing was constructed, and the 400 cars of material were transferred. Upon realizing the implications of Phelps Dodge completing their line and connecting to the AT&SF, the Southern Pacific purchased the nearly completed line on Phelps Dodge's terms. The line was used until abandoned in the early 1960's.

The top of the bridge offers excellent views of the Peloncillos and a large cone in the northern San Bernardino volcanic field.

0.7

46.0 Entering Rodeo, New Mexico. Settlement established in 1902 as a cattle shipping point on the railroad.

2.3

48.3 New Mexico-Arizona state line. Dirt road to Portal intersects diagonally from the right. Owl Canyon at 9:00; Post Office Canyon with completely dissected basalt cone at its mouth at 9:30; Skull Canyon at 10:00; Skeleton Canyon at 10:30; Horseshoe Canyon at 1:00; Sulphur Draw at 2:45 with Portal Peak at 3:00.

The rocks from Owl Canyon to the high mountains south of Skull Canyon are dominantly tuff of Black Mountain, overlain by flows in the quartz latite of Owl Canyon. The same rocks form the walls of Horseshoe Canyon in the Chiricahua Mountains, where the coarsely porphyritic quartz latite of Owl Canyon may equate with a coarsely porphyritic, subconcordant pluton mapped by Cooper (1959) (Tpi unit) and recognized by Marjaneimi (1969). Little detail is known of the tuff of Black Mountain at this time, except that in this area it must have a minimum thickness of several thousand feet. It contains 20 to 30 percent phenocrysts and appears to be a compositionally zoned rhyolitic ash-flow tuff. In the area of Skull Canyon, light-tan to white zones mark a cooling break within the tuff. Reconnaissance mapping suggests the southern margin of the Rodeo cauldron probably crosses the Peloncillo Mountains slightly north of Skeleton Canyon.

3.5

51.8 Horseshoe Canyon at 2:30, Squaw Mountain at 12:30 and foothills at 1:30 are all composed of presumed Rhyolite Canyon Formation tuffs which overlie "pre-Tertiary" of Marjaniemi, 1969). In the Horseshoe Canyon area Cooper (1959) mapped fine-grained porphyritic monzonite in relatively large subconcordant bodies which intruded Late Cretaceous (?) propylitized andesite flows and pyroclastic rocks.

3.0

54.8 At 10:30 east-dipping basalt flows of the northern San Bernardino volcanic field overlie beveled, east-dipping Tertiary rhyolites.

2.0

56.8 Squaw Peak at 1:00 is mostly east-dipping rhyolite tuffs punctured by basalt vents and small alkali-olivine basalt flows which issued from these vents.

0.8

57.6 Geronimo Surrender Monument on left. Historical Commemorative reads: *Near here Geronimo, last Apache chieftain, and Nachite with their followers surrendered on September 6, 1886, to General Nelson A. Miles. U.S. Army Lt. Charles B. Gatewood with Kieta and Martine, Apache scouts, risked their lives to enter the camp of the hostiles to present terms of surrender offered to them by General Miles. After two days Gatewood received the consent of Geronimo and Nachite to surrender. The surrender of Geronimo in Skeleton Canyon on that historic day forever ended Indian warfare in the U.S.* Nachite (sometimes spelled Natchez) was the youngest son of Cochise.

0.3

57.9 Enter and leave "metropolitan" Apache, Arizona Post Office 1908-1943.

0.1

58.0 Road on left to Skeleton Canyon.

Skeleton Canyon received its name after a group of about 20 cowboys (outlaws led by Curly Bill and Old Man Clanton) ambushed a pack train of Mexicans smuggling silver to Tucson in 1881. The 16 bodies they left behind produced the gruesome scene resulting in the name. Mexicans who escaped from this slaughter vowed vengence. Twenty miles northeast of Skeleton Canyon they found it in Guadalupe Canyon. Here, in retaliation, Old Man Clanton was ambushed and murdered with four other members of his party (Barnes, 1960).

The Peloncillos south of Skeleton Canyon are currently being mapped (**see Deal and others, this guidebook**). The proposed Geronimo Trail cauldron, source of the rhyolitic tuff of Guadalupe Canyon, makes up the bulk of the Peloncillo Mountains south of Skeleton Canyon. From Skeleton Canyon southward approximately 6 mi to the Geronimo Pass area, the rocks on the skyline are mostly crystal-poor rhyolite flows and domes emplaced along the north, northeast and east

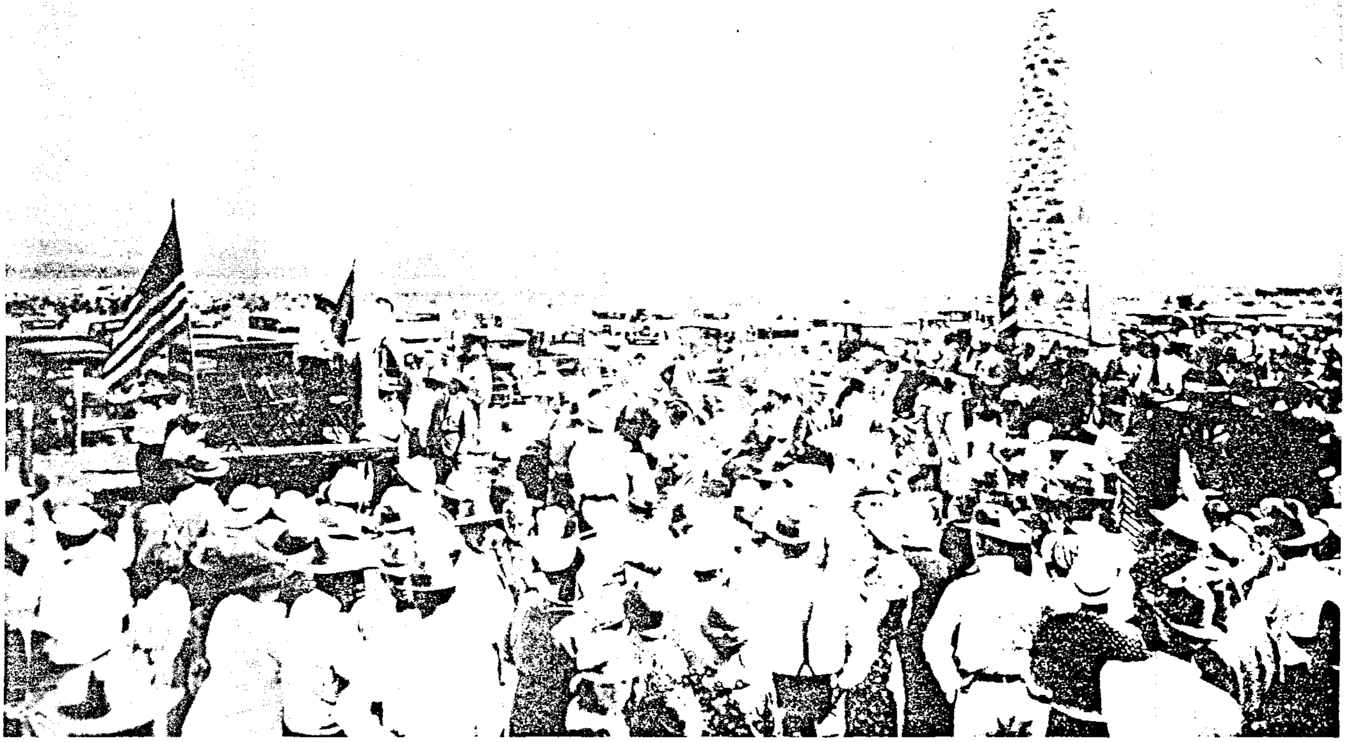


Figure 57.6. Dedication ceremonies of Geronimo Surrender Monument, presided over by Arizona Governor Moeur—April, 1934 (Courtesy: Arizona Pioneer's Historical Society).

margins of the cauldron. Between the rhyolite domes on the high ridge and the young alkali basalts of the San Bernardino Valley are domes and flows of the latite of Outlaw Mountain, a distinctive porphyritic rock with plagioclase phenocrysts up to an inch long. These rocks were also deposited along the same margins of the cauldron, forming the inner and older part of a double arc of domes and flows in the cauldron's ring-fracture zone.

The tuff of Skeleton Canyon, a light-gray moonstone tuff with about 15 percent phenocrysts, forms the upper cliffs on the east side of San Bernardino Valley at the mouth of Skeleton Canyon. This tuff is best exposed near the center of the Peloncillo Mountains in Skeleton Canyon, but can be traced discontinuously along the west side of the range from just north of Skeleton Canyon southward for about 19 mi almost to the Mexican border. Stratigraphically, the tuff of Skelton Canyon lies beneath the rhyolites on the skyline and above the latite of Outlaw Mountain. It does not, at this time, appear to be genetically related to the Geronimo Trail cauldron.

South of Geronimo Pass, the geology becomes more complex but is dominated by 1,400 ft (with the base not exposed) of tuff of Guadalupe Canyon, interpreted as the ash-flow tuff fill of the Geronimo Trail cauldron.

Young alkali basalts, which cover large parts of the San Bernardino Valley can also be found as minor dikes and flows intruding and capping the mid-Tertiary silicic rocks of the Peloncillos all the way to the crest of the range (E. E. Erb, written comm., 1978).

0.8

58.8 From 10:30 to 1:00 are major cones within the northern part of the main San Bernardino volcanic field. The San Bernardino field has been mapped and analyzed by Lynch (1972).

San Bernardino Valley has considerable geothermal energy potential. Preliminary investigations indicate thermal gradients are in excess of 100°C per kilometer and chemically determined reservoir temperatures are in excess of 200°C (Dick Hahman, pers. comm.). **(See also Swanberg, this guidebook.)**

2.0

60.8 We are now passing the southern structural terminus of the San Simon graben. As determined from gravity data, the trend of this terminus bears about N. 70° W. To the south the San Bernardino graben is a single-fault, asymmetric graben tilted to the west. At 10:00 the western margin of the Peloncillo

Mountains steps 3 mi to the west. This westward stepping is on the projection of the west-northwest-striking structural terminus of San Simon graben. To the west this structural terminus projects into a complex series of west- to west-northwest-trending reverse faults which cut pre-Tertiary rocks. At 2:00 several basalt cones are perched on ridges of rhyolite, extending south from the Chiricahua Mountains. These cones also lie along the west-northwest trend and are more visible a short distance ahead at 3:00.

2.0

62.8 At 10:00 and 11:00 are two partially dissected agglutinate cones. Agglutinate cones are built by layers of welded, basalt spatter ("gooey cinder").

0.5

63.3 Bridge crossing. Price Canyon road on right. More ridge-top cones at 3:00.

0.5

63.8 Bridge crossing. Black material on abandoned railroad bed to the right is not cinder; it is smelter slag from the Douglas smelter.

1.0

64.8 Directly ahead is the northern margin of the Krentz Ranch basalt flow which the highway ascends. Low hill at 1:00 is another dissected basalt cone.

0.7

65.5 Ranch road on left. Highway ahead descends onto another level of the Krentz Ranch basalt flow. Notice the total absence of flow-top features, such as spines and ridges, which would have indicated geomorphic youthfulness.

0.3

65.8 Cones at 1:30 will be Stop 2. Just beyond milepost 398, road descends from Krentz Ranch basalt flow. Limestone Mountain in the northern Pedregosa Mountains is prominent peak at 3:00. Five more unnamed cones now appear on the left and ahead (9:30 to 12:00).

1.0

66.8 Milepost 397. **Slow for turnoff to right** on Tex Canyon road.

Tex Canyon road continues through the Chiricahua Mountains, where it merges with Rucker Canyon Road and emerges from the mountains along Whitewater Draw. Rucker Canyon was named for Lt. John Rucker, who was killed in a flash flood in the canyon on July 11, 1878. According to the story told by the Apache Indian scout John Rope, who was with Rucker's party when the officers were drowned, Rucker and Henely met two citizens at a saloon "on the left fork" where all four remained until the hard rain abated. The two citizens then mounted their mules and swam across the flooded river. The officers followed on horseback but made the mortal error of riding side by side. The swift current knocked one horse against the other and the officers fell off. Safely ashore the men threw ropes to the officers, but in vain. During the 1880's Camp Rucker was one of the most important military stations in the campaign against the Apaches (Barnes, 1960).

0.6

67.4 Intersection with Tex Canyon road. **Turn right** onto Tex Canyon road. Cross cattleguard. Note red soil horizon on the flat surface we are traversing. Tex Canyon at 12:00 marks the divide between Limestone Mountain of the northern Pedregosa Mountains and the flat-topped, rhyolite-capped mesas of the southern Chiricahua Mountains.

1.3

68.7 Cattleguard.

0.7

69.4 **STOP 2. Pull off road and park** near cattle sign. Group will ascend low, agglutinate cone at 9:00 to collect lherzolite nodules (chunks of the mantle containing olivine) and to obtain a panoramic view of the San Bernardino volcanic field and surrounding geology in Limestone Mountain and the northern Pedregosa Mountains.

Walk to the top of the small cone approximately 0.3 mi from the road. The flanks of this cone are composed of basalt agglutinate (welded spatter) and agglomerate (angular fragments of basalt, scoria and ultramafic debris in a soft, yellow-brown matrix). Nodules of lherzolite (olivine and chrome diop-

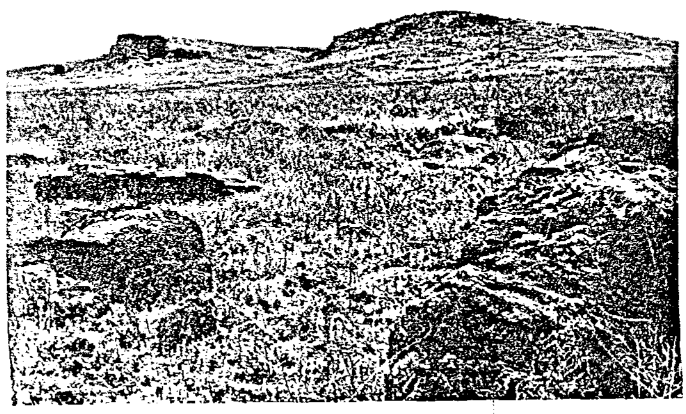


Figure 69.4a. Low agglutinate cone at Stop 2. Basalt in foreground contains lherzolite nodules (Jan Wilt photo).

Figure 69.4. Speaker at Stop 2.

side) are abundant, while megacrysts (1 in) of clear labradorite and glassy, black, aluminous clinopyroxene are much less common. A few euhedral octahedra of spinel may be found by diligent search.

While the high cone nearby hides the south and east parts of the volcanic field, the view from its summit is also similarly blocked so the extra climb isn't worth the effort. The Krentz ranch buildings can be clearly seen against the mountains at the head of the broad alluvial fan (N. 40° W.); for scale, they are 3 mi distant. Behind them are the 3 vents of the Krentz Ranch cone group. To the right (clockwise) cliffs developed in the Rhyolite Canyon Formation form the flanks of the Chiricahua Mountains. These thick rhyolite flows erupted from the Turkey Creek caldera (Marjaniemi, 1969), which is beyond the cliffs 22 mi away.

Due north is Price Canyon alluvial fan which coalesces with the Tex Canyon fan. Both drainage systems connect with the discontinuous, poorly developed San Simon Valley system, thence to the Gila River, Colorado River and Gulf of California.

From N. 25° to N. 50° E. are ridge-crest cones. Vertically ascending basalt magma ignored the structural weaknesses of the near-by valley-margin faults and erupted onto the crests of rhyolite ridges that extend southward from the main mass of the Chiricahua Mountains. Four cones and two small accessory vents constitute this group.

On the surface of the fan from N. 60° E. is the Krentz tuff ring (see **Lynch, this guidebook**). The lava flow noted in the road log prior to this stop extends southeastward from this structure and was erupted as normal, fluid basalt during the first phase of the eruption. The last phase consisted of steam blast explosions caused when the magma encountered ground water in the fan sediments. These explosions fragmented the magma and built the tuff ring. Sediment has been swept around the west horn of this partial ring and has filled the interior.

Nearly horizontal flow remnants can be seen at S. 60° E. far across the valley on the flanks of the Peloncillo Mountains. Flow surfaces step southward from an elevation of 5,200 ft to 5,600 ft.

Paramore Crater, a major maar crater and tuff ring can be seen at S. 60° E. with some difficulty. Only the inner face of the far tuff ring is visible.

Eroded lava flow margins are visible in the hills due west. These flat-lying flows are similar to the eastern flows in their nearly horizontal attitudes and association with the mountain flank. They are at an elevation of 5,600 ft, remarkably coincident with those to the east. They are thought to be lava flows erupted onto a pediment which has since been uplifted and dissected.

Limestone Mountain at N. 70° W. dominates much of the geology and geography of the northern Pedregosa Mountains. Paleozoic limestones are in the upper plate of a large overthrust above Cretaceous rocks to the south (Epis, 1956; Cooper, 1959). This thrust fault was named the Limestone Mountain thrust fault by Epis. The trace of the thrust generally strikes northwest to west-northwest across the southern slopes of Limestone Mountain just below the prominent limestone cliff of Colina Limestone. The thick Colina Limestone overlies Earp and Horquilla formations in the lower slopes. Farther southeast the upper plate contains rocks as old as Bolsa Quartzite.

Paleozoic strata in the upper plate of the Limestone Mountain thrust are flexed into a broad, anticlinal arch with a gently dipping northeastern limb. The southwest-facing asymmetry and gentle, northeasterly dip of the thrust fault suggest transport of the upper plate toward the southwest (Epis, 1956). The Paleozoic is thrust over southwest-dipping, moderately inclined, Upper Cretaceous volcanic rocks (Hunt Canyon Andesite) and Bisbee Group rocks. Stratigraphic throw reaches 19,500 ft at the northwest end of the Limestone Mountain thrust. The throw decreases southeastward to 13,500 ft at the southeast exposed end of the Limestone Mountain thrust in the low ridges to the south of Limestone Mountain.

Structure in lower plate rocks consists of broad, northwest-trending folds in the northwestern end of the Limestone Mountain thrust. These folds progressively tighten southeastward and are truncated by the Limestone Mountain thrust. In the central Pedregosa Mountains, Epis (1956) shows a large, overturned section with steep northeastward dips in the inferred lower plate rocks.

The age of the thrusting and folding postdates the Hunt Canyon andesite and predates numerous rhyolite dikes and plugs which locally intrude the thrust faults. This deformed terrane is, in turn, unconformably truncated by a thick section of rhyolite ash-flow tuffs as much as 4,500 ft thick in the southern Chiricahua Mountains.

Turn around and return to U.S. 80 via Tex Canyon road.

2.0

71.4 Intersection of Tex Canyon road with U.S. 80. **Turn right** on U.S. 80 toward Douglas.

0.4

71.8 Low ridges at 2:00 are the eastern terminus of a major west-northwest-striking, thrust fault zone in the south-central Pedregosa Mountains. To the west of these ridges Cambrian through Permian strata are indicated by Cooper (1959) to be thrust southward over Late Cretaceous volcanics and sediments.

Flat-topped, mesa-like ridges at 2:00 are underlain by perched flows at the edge of the San Bernardino volcanic field. One of these flows yielded a K-Ar age of 3.2 m.y. (Lynch, 1972). Their elevation and perched nature suggests about 500 ft of subsidence, presumably related to Basin and Range faulting.

1.0

72.8 Still more cinder cones are seen to the southeast. Lynch (1972) identified some 135 individual cones in the San Bernardino volcanic field.

0.3

73.1 Bridge. The stream we just crossed is interiorly drained to a local pond in the Bowen tuff ring (Lynch, 1972). Large cone at 9:00 is another dissected, agglutinate cone. The step-like features on the southwest side of the cone are resistant layers of welded spatter.

1.7

74.8 Milepost 393. Abandoned cinder quarries on right in a dissected cone. These quarries originally tried to exploit cinders for road material, but mining has long since stopped because of the poor quality of the cinders.

1.0

75.8 Perilla Mountains (Spanish: "saddle horn") at 12:00 to 1:00. North College Peak and South College Peak at 1:00 to 2:00 are capped by mid-Tertiary(?) rhyolite ash-flow tuffs.

College Peak (6,385 ft) was locally called the Nipple as late as 1880 by the cavalry unit camped at White Springs. On the 1883 map, however, the name had been changed to College Peak (Barnes, 1960).

0.7

76.5 Roadcuts on right and left provide a section through the gently-sloping, low-relief, agglutinate cone. Note the oxidized agglutinate lapilli tuffs and interwelding of the fragmentals. In roadcut on left note the concentric exfoliation and lobate, massive alkali-olivine basalt which may be part of a vent neck.

0.3

76.8 At 11:00 in far distance is Cinder Hill, which contains a larger cinder pit named Scoria in the northern slopes. This was the largest operation for cinders in the San Bernardino volcanic field. This operation was also doomed to failure because of the poor quality of the cinders.

1.0

77.8 Milepost 390. Saddle Gap at 1:00 separates

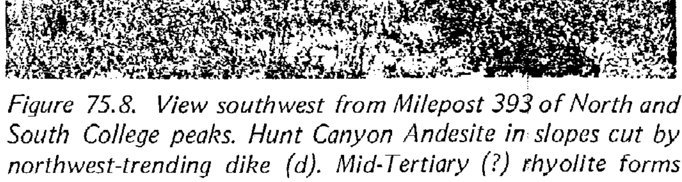


Figure 75.8. View southwest from Milepost 393 of North and South College peaks. Hunt Canyon Andesite in slopes cut by northwest-trending dike (d). Mid-Tertiary (?) rhyolite forms upper cliffs (Jan Wilt photo).

the Perilla Mountains to the south from the Pedregosa Mountains to the north. The Guadalupe Mountains on the left are composed principally of Tertiary rhyolite. South and North College peaks, in the Perilla Mountains, are at 12:30 and 1:00.

1.0

78.8 San Bernardino siding to right. The San Bernardino Valley and volcanic field were named for the San Bernardino Land Grant which is partially in Mexico and partially in the U.S. *As early as 1697 Spanish and citizen soldiers of Sonora used the spring. By 1846 when the Morman Battalion passed here, the San Bernardino Hacienda was in ruins, but "Texas" John Slaughter purchased the land in 1884 for a ranch* (Post office 1906-1918) (Barnes, 1960).

0.5

79.3 Road now crosses the Half Moon Canyon basalt flow which issued from Half Moon Canyon to the west in the southern Pedregosa Mountains.

1.5

80.8 Milepost 387. Cinder Hill cone group at 9:00 to 10:00. These cones are the youngest geomorphic features in the field. A lava flow which originated at the northernmost (9:00) cone is the only flow to retain flow-top geomorphic features such as festoon flow banding and rounded lava spines that are characteristic of uneroded flows. A K-Ar whole rock age of 280,000 years was obtained for this flow **(see Lynch, this guidebook).** Entrenched, San Bernardino alkali-olivine basalt flows may be seen at 11:00 on the flanks of the Perilla Mountains.

2.0

82.8 Milepost 385. Low roadcut ahead and rocks exposed nearby are in gently east-tilted, San Bernardino basalt flows.

0.9

83.7 Road on left. Good view of rhyolite ash-flow stratigraphy in the Perilla Mountains. A large, northwest-striking, dark-colored dike cuts Hunt Canyon Andesite (the slope-former), which is unconformably overlain by mid-Tertiary (?) rhyolites. Cliffs in the southern part of the skyline ridge (9:00 to 10:00) are stepped down from ridges to the west by normal faults.

0.6

84.3 Roadcuts ahead for next half mile are in valley-fill alluvium capped by San Bernardino basalt. Alluvium contains large subangular clasts of rhyolite and angular clasts of basalt.

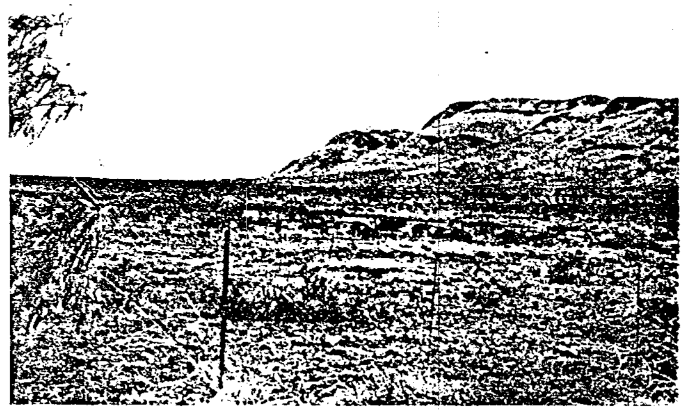


Figure 83.7. View southwest of Perilla Mountains south of College Peaks. Rhyolitic ash-flow tuffs form upper cliffs overlying Hunt Canyon Andesite slope-former. Mountains in distance on left are in Mexico (Jan Wilt photo).

Note WPA bridge relict to left without connecting road.

0.8

85.1 Roadcuts ahead and nearby low-relief topography are Hunt Canyon Andesite of Epis (1956). The Hunt Canyon Andesite is 2,500 ft of purple, maroon and green weathering, propylitized flows and agglomerates with scattered lenses of limestone conglomerate and coarse sandstone. The Hunt Canyon Andesite interfingers downward into the Javelina Formation, locally 4,000 ft thick. The Javelina Formation is gray-weathering limestone, sandstone, dolomite and chert conglomerate with some thin, coarse sandstone composed of debris derived from Bisbee Group and Paleozoic formations. According to Epis (1956) the Javelina Formation rests disconformably on Bisbee Group strata.

Hayes (1970b) suggested that the uppermost strata assigned to the Cintura Formation by Epis are also more properly included in his Javelina Formation. The pyroclastic volcanics of the Hunt Canyon Andesite were correlated by Hayes (1970b) with the Salero Formation farther west in the Santa Rita Mountains. Farther east the Hunt Canyon Andesite closely resembles the Hidalgo Volcanics of Lasky (1947) in the Little Hatchet Mountains of southwest New Mexico. The Javelina Formation would correlate with the Fort Crittenden Formation to the west and the Ringbone Shale-Skunk Ranch Conglomerate sequence in the Little Hatchet Mountains. The "lower" Hidalgo Volcanics have recently been dated as 57.9 to 69.6 m.y. (**see Marvin and others, this guidebook**), which suggests the "lower" Hidalgo Volcanics are about 5 to 10 m.y. younger than the equivalent 80 to 70 m.y. Salero Volcanics of southeastern Arizona. The Hunt Canyon Andesite would presumably be intermediate in age with respect to the Salero and the Hidalgo Volcanics. That is, it would have a predicted age of about 72 to 68 m.y.

We have also just crossed a large, north-striking fault at 2:00 named the Foster tear fault by Epis (1956). According to Epis the Foster tear fault displaces the Castle Dome thrust about one mile to the south on the east side of the tear fault. Epis considered that displacement was right-lateral. The Foster tear fault is shown on the map of Cooper (1959) to be unconformably overlain by thin Pliocene alkali-olivine basalts (3.2 m.y. old) at the west edge of the San Bernardino volcanic field.

Bisbee Group strata in the block east of the Foster tear fault at 3:00, over which the Pliocene basalts rest in pronounced angular unconformity, are overturned and dip steeply northeast. This overturned section is truncated by the eastern continuation of the north-dipping Castle Dome thrust. Erosion of soft Hunt Canyon Andesite has left the younger basalts to the east relatively high.

1.0

86.1 Cross bridge over Silver Creek. The route along Silver Creek was once popular with people smuggling liquor into Arizona. This particular confined stretch led to the arrest of many such enterprising businessmen.

Silver Creek is part of the Rio San Bernardino drainage system. This well-integrated system flows south into Mexico and into the Gulf of California via Rio Yaqui. Silver Creek is actively cutting headward through Saddle Gap towards Sulphur Springs Valley.

0.7

86.8 Castle Dome, a Tertiary rhyolite plug, at 1:00. Mud Springs, once a popular watering spot for Indians, outlaws, smugglers and soldiers, is 3 mi south of Castle Dome.

0.1

86.9 Cazador siding on right.

0.9

87.8 A light-colored, northwest-trending rhyolite dike cutting Hunt Canyon Andesite holds up the ridge line on Pedregosa Peak at 3:30. At 2:00 a prominent cliff of Escabrosa Limestone is visible. Not so visible at the base of this cliff is Natural Cave, a small black spot (like a tree) right at the base of the cliff about midway between the prominent notch at the west end of the cliff and the broad saddle along the top of the cliff to the east.

This cave is developed on the west-northwest striking, north-dipping, Castle Dome thrust(?) fault. This fault separates Escabrosa Limestone in the cliff face from Hunt Canyon Andesite in the lower slopes. Epis (1956) suggested transport from the north-northeast along this thrust. The Castle Dome fault is about 9 mi long, dips steeply (about 65°) to the north and has a stratigraphic throw of 22,000 ft. Castle Dome intrudes the Escabrosa Limestone in the hanging wall at the current erosional edge of the fault. Drewes (1976a) has reinterpreted the Castle Dome thrust to be a strike-slip fault offset by several high-angle faults. According to Drewes, this strike-slip fault has had questionable left-slip movement.

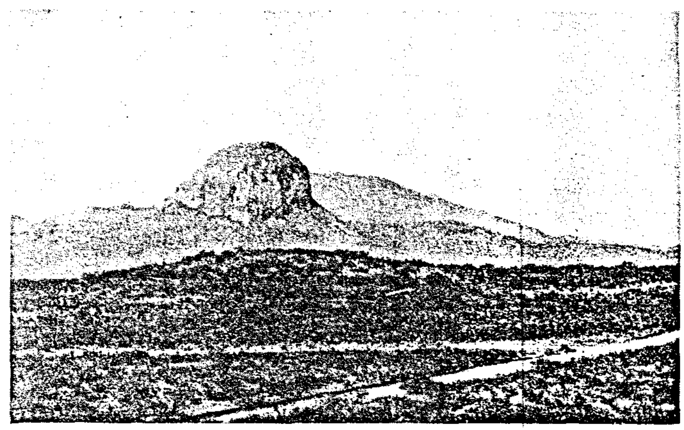


Figure 86.8. View to northwest of Castle Dome, a rhyolite plug southwest of Escabrosa Limestone ridge connecting the Pedregosa and Swisshelm mountains (N. Colburn photo).

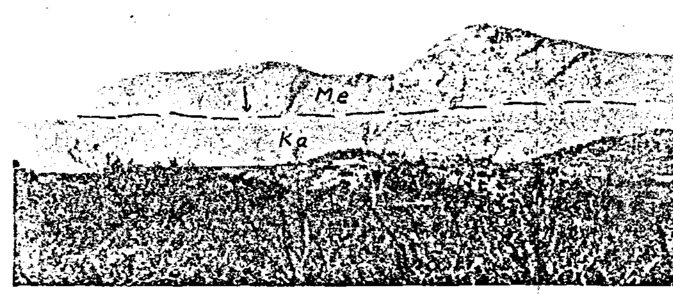


Figure 87.8. "Natural Cave" (arrow) developed at base of Escabrosa Limestone (Me) thrust over Hunt Canyon Andesite (Ka) (N. Colburn photo).

The Castle Dome fault is nearly on strike with a major east-west structural zone in the northern Mule Mountains, southern Tombstone Hills and northern Huachuca Mountains. According to Gilluly (1956), much of the deformation related to this east-west structural zone is truncated by Salero-equivalent, Late Cretaceous Bronco Volcanics in the Bronco Hills part of the southern Tombstone Hills blocks. In contrast, in the Pedregosa Mountains, the correlative Hunt Canyon Andesite is cut by the west-northwest striking Castle Dome fault. Thus, to the west, east-west tectonized zones predate Salero Volcanics and equivalents, while to the east, in the Pedregosa Mountains and Brockman Hills in southwestern New Mexico, west- to west-northwest-striking zones with similar geometries cut Salero-like volcanic rocks. One interpretation is that magmatism and deformation were moving east but at different rates, with the magmatic sweep the faster of the two (S. Keith, pers. comm.).

The pedimented area between the highway and the Castle Dome fault zone is underlain by Hunt Canyon Andesite intruded by north-northeast to northeast-striking rhyolite dikes.

2.0

89.8 Poverty Flat area northwest of road is between us and an unnamed ridge to the west. Rhyolite ash-flow tuffs of presumed Tertiary age comprise the upper slopes of this ridge and unconformably overlie Hunt Canyon Andesite at the eastern base of the ridge. At the southern tip of the ridge another southwest-dipping thrust fault mapped by Cooper (1959) places Bisbee Group rocks over the Hunt Canyon Andesite. This whole sequence is unconformably truncated by Tertiary(?) rhyolite tuffs. Low hills to the south are also in Bisbee Group, which has questionably been thrust over Hunt Canyon Andesite. Again this structural sequence is unconformably truncated by Tertiary(?) rhyolite ash-flow tuffs in the Perilla Mountains.

2.0

91.8 Milepost 376. In this area to the left and right of the road southwest- and west-dipping Mural Limestone rests on Morita Formation of the Bisbee Group. To the northeast and eastward into New Mexico the proportion of carbonate rocks in the Bisbee Group becomes increasingly greater. The Mural equivalent in the Pedregosa Mountains was named the Tex Canyon Formation by Epis (1956). Epis further divided the Tex Canyon Formation into 4 members with an aggregate thickness of 3,300 ft. This is much thicker than the type Mural Limestone in the Mule Mountains (far distance at 12:00 to 1:00), where the Mural is 500 to 700 ft thick.

0.2

92.0 Rest stop on left.

1.8

93.8 Milepost 374. Douglas and Agua Prieta at 12:00; stacks of Phelps Dodge's Douglas smelter at 12:30.

1.0

94.8 Cerro Gallardo at 9:30 is a rhyolitic dome in northern Sonora, Mexico. The Sierra de los Ajos, also in Sonora, are composed mainly of Bisbee Group. Dip slopes in view are a southern continuation of the east-dipping Mural Limestone in the southern Mule Mountains at 2:00 to 3:00. San Jose Peak on skyline at 1:30, also in Sonora, is composed of Cretaceous Mural-equivalent limestones as well. Scar visible at 2:00 is the Paul Spur lime plant, a limestone quarry in Mural Limestone.

Taylor Butte (about 10 mi distant at 3:30), is the largest of a number of inselbergs on an extensive pediment at the west edge of the Pedregosa Mountain structural block. Two miles west-northwest of Taylor Butte is the site of the Waddell-Duncan #1 Murray oil test. The hole penetrated pre-basin fill bedrock at 540 ft, drilled through Bisbee Group and encountered the top of the Naco Group at 1,608 ft. The hole then penetrated the entire Paleozoic section and entered Precambrian granite at 4,000 ft and bottomed in Precambrian granite at 4,400 ft (Peirce and others, 1970). The thin alluvial veneer in this area emphasizes the extent of pedimentation processes which followed termination of active Basin and Range faulting.

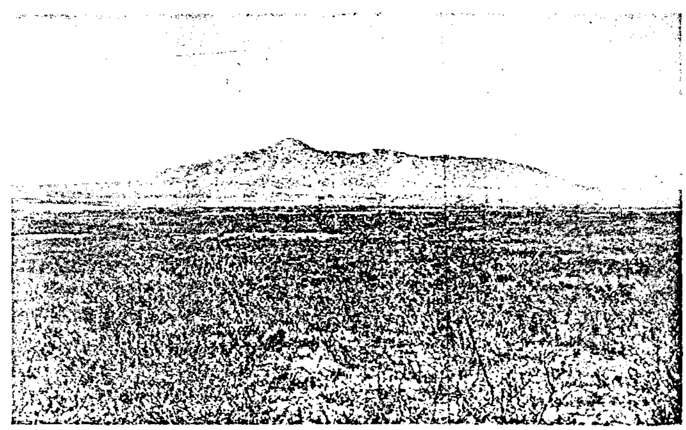


Figure 94.8. San Jose Peak in Sonora, Mexico. Mural equivalent limestones thicken rapidly southward to form this and similar ranges "south of the border" (J. D. Forrester photo).

Valley in middleground at 2:00 to 3:30 is the southern end of Sulphur Springs Valley. Sulphur Springs Valley is internally drained to a base level at an elevation of 4,135 ft at Willcox Playa, 40 mi northwest.

1.0

95.8 Sulphur Springs Valley was named for springs which are potable, in spite of the name. Wherever water stagnated, a trace of hydrogen sulphide developed from decaying vegetation and the chemical action on gypsum in the water.

In 1868 two Americans named Rogers and Spence homesteaded Sulphur Springs. When the Chiricahua Reservation was established in 1872, the two were allowed to keep a trading post, where the Apaches were sold as much "vile" whiskey as they wanted. A fight developed here on April 6, 1876, between some of the Indians, and the trading post keepers were killed. The Indians fled to Mexico and began six more years of Apache depredations (Barnes, 1960).

1.5

97.3 Agriculture Inspection Station. **Prepare to stop.**

2.3

99.6 Junction with Leslie Canyon road on right. **Bear left** on U.S. 80.

Leslie Canyon was named after Frank Leslie, an army scout under Gen. Crook and Gen. Miles, and later a bartender in Tombstone. Leslie is known to have killed at least three people, the last in 1889 being his supposed wife at his ranch following a drinking spree in which they were joined by James Neal. He shot her twice while she was talking to Neal; he then shot Neal, making the curious comment, "Now don't get excited; they are just blanks." Neal struggled to Tombstone and reported the matter. So certain was Leslie that he had killed Neal that when the deputy sheriff came to get him, Leslie said that Neal had killed Mollie and that Leslie shot Neal in self-defense. Leslie was sent to prison in Yuma, but a romance via mail developed between Leslie and a Mrs. Belle Stowell, a wealthy woman in San Francisco who was instrumental in having him released from prison. They were married in 1897 (Barnes, 1960).

0.2

99.8 Douglas city limits (elev. 3,990 ft). **Turn right on 22nd Street; follow "trucks" sign.**

0.4

100.2 **Bear left onto Pan American at stop sign. Follow U.S. 80 west signs.** After turning onto Pan American, **continue straight ahead to stop sign.**

0.5

100.7 **Turn right** under underpass at stop sign.

1.2

101.9 Milepost 365. Phelps Dodge Corporation's Douglas smelter at 11:00. Douglas was founded in 1901 and named for the mining engineer, Dr. James Douglas, who established a smelter here for the Bisbee ores. This smelter was actually blown in by the Calumet and Arizona Company in November, 1902. The Copper Queen smelter of Phelps Dodge was located at 9:00 where the old power house and general offices are visible. Although construction was begun before the C & A, the Copper Queen smelter was blown in during March, 1904. By 1906, its new 250-ft smokestack was the tallest in the world. The C & A rebuilt and enlarged their smelter in 1913. It is the one now operating. The two companies merged in 1931. The red and white tower to the right and others scattered around Douglas are air quality monitoring stations.

In 1915, Agua Prieta, just across the Mexican border from Douglas was the scene of a major battle of the Mexican Revolution. 12,000 troops under the command of Pancho Villa attacked a 6,000 strong force of Federales. Villa was repulsed after two days of heavy fighting and aerial bombardment (Barnes, 1960).

0.4

102.3 U.S. 666 to Willcox on right. **Continue straight ahead on U.S. 80.** Sierra de los Ajos at 11:00; Mule Mountains at 12:00; Dragoon Mountains at 1:30; Swisshelm Mountains at 3:00; and Pedregosa Mountains at 4:00.

0.3

102.6 Bridge over Whitewater Draw, which drains south to Rio San Bernardino and the Gulf of

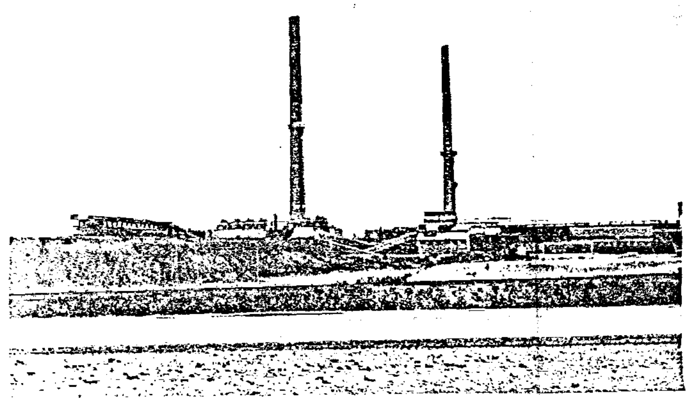


Figure 101.9. Phelps Dodge copper smelter at Douglas (J. D. Forrester photo).

California via the Rio Yaqui. Because of its ample supply of water in 1900, it was selected as the site for the Douglas smelter.

About 8 mi up Whitewater Draw are important Cochise culture sites dated at about 5,000 years B.P. (before present). The Cochise culture (nothing to do with the Apache chief) has been dated by Carbon^{14} methods from 2,000 to 6,000 years B.P. The people were pre-ceramic and subsisted by hunting and gathering. They are intermediate between the Early Man big-game hunters of the Pleistocene and the much more recent pueblo pottery makers of the southwest. Sites are characterized by dart points and stone grinding implements (Naylor, pers. comm.).

2.3

104.9 Prominent inclined hogback cliffs (9:00) in Sierra de los Ajos are of Mural Limestone which thickens southward in Mexico.

3.0

107.9 San Jose Peak at 10:30, Mule Mountains at 1:00, southern Dragoons at 2:00, Dos Cabezas in distance at 3:00, and Swisshelms at 3:30.

0.9

108.8 Cochise College on right. **(This is the assembly point for tomorrow's breakfast and trip.)**

1.7

110.5 Paul Spur road on left. Paul Spur cement plant and quarry at 10:00. The quarry for metallurgical grade limestone is in Mural Limestone of the Bisbee Group.

A cement plant and small community are located at this place on the railroad where there is also a section house. It was so named for Alfred Paul, Sr. (b. Germany, 1878), who came to Arizona in 1885. Paul helped lay out the site of Douglas. The fact that the Calumet and Arizona Mining Company was using the flotation process to extract copper led to Paul's putting in a lime kiln at this place after 1914 because lime was needed to neutralize acid in the ore. Currently this place is producing cement.

P.O. est. July 24, 1930. Bert Whitehead, p.m. Discont. May 2, 1958 (Barnes, 1960).

About 13 mi due north of here an oil test (Allen #1 Davis well) was drilled in Sulphur Springs Valley. The hole penetrated 2,710 ft of fine-grained, gypsiferous, lacustrine sediments and interbedded coarser alluvium of Plio-Pleistocene age. The hole continued through Miocene(?) volcanics consisting mostly of rhyolite and bottomed in andesite porphyry at 5,400 ft (Peirce and Scurlock, 1972).

1.4

111.9 Milepost 355. **Slow down for left turn onto** Gold Hill road at the truck crossing sign ahead.

0.2

112.1 **Turn left** on Gold Hill road and cross cattleguard. This road becomes a line road for the Phelps Dodge power line. Mural Limestone caps spurs to the right and left.

0.6

112.7 Curve to right under power line.

2.8

115.5 Road on right to sand and gravel operation in wash.

0.2

115.7 Ridge on right is capped by an allochthonous block of Horquilla Limestone and Glance Conglomerate resting on Mural Limestone. The fault surface separating upper and lower plate rocks dips gently east and is marked by a vegetation line which runs diagonally down

Figure 110.5. Paul Spur lime plant. Cuesta capped by Mural Limestone (J. D. Forrester photo).

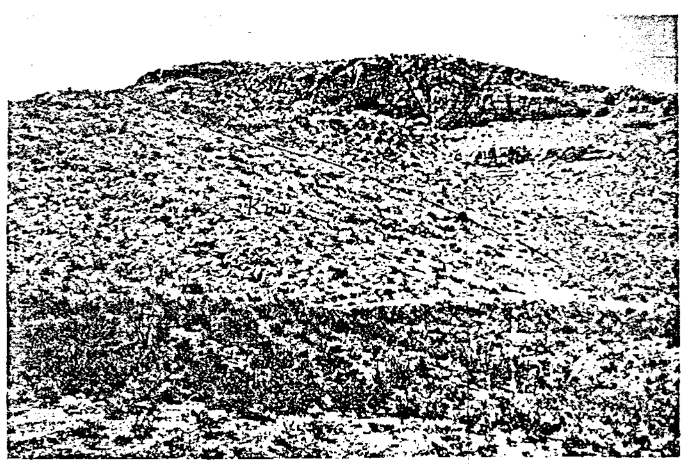


Figure 115.7. View to North of allochthonous block of Horquilla Limestone (Ph) resting on Mural Limestone (Kmu). Note V-shaped grabens in cliff (Jan Wilt photo).

the hill from the left to the right. Observe the highly fractured nature of Horquilla Limestone and V-shaped graben structures in the upper plate.

0.3

116.0 Clastic section below Mural Limestone in hills to right and left is Morita Formation of Bisbee Group. Road bears left around the hill ahead and services a flux quarry in a quartzite unit of the Morita Formation.

0.3

116.3 A rather obscure turnoff on the right leads through a gully and is the continuation of the Gold Hill service road for the Phelps Dodge power line. This road (for field vehicles) continues west for about 5 mi to a junction with the paved Warren road, which connects northward to U.S. 80.

0.3

116.6 **STOP 3. Follow flagmen's directions for parking.** After parking climb low hill to southeast.

Figure 116.6a. View to northwest of east-dipping Mural Limestone (Kmu) resting conformably on the Morita Formation (Km) at southeast end of the Mule Mountains (H. L. James photo).

GEOLOGY OF SOUTHEASTERN MULE MOUNTAINS

William L. Bilodeau and Stanley B. Keith

Introduction. Objectives of this stop include: (1) observation of rocks in the Lower Cretaceous (Aptian) Morita Formation of the Bisbee Group, (2) discussion of tectonic significance of Glance Conglomerate in its type locality, and (3) development of structural evolution of Gold Hill reverse fault and the allochthon to the northeast.

Orientation. From top of the ridge south of the parking area the Mule Mountains extend 15 to 20 mi northwest. To the south, the Mexican border is 3.5 mi away, just beyond the Southern Pacific Railroad tracks. San Jose Peak is 15 mi southwest in northern Sonora, Mexico. Ten miles west-northwest are the Naco Hills, and 5 mi west are the leveed tailing ponds from the Phelps Dodge Lavender Pit copper mine. The pit is located 3 mi north of the tailings pond. Bisbee is one mile northwest of the pit or 7 mi northwest of Stop 3.

Geology. This hill is composed chiefly of quartzite, sandstone, shale and siltstone in the Morita Formation. The quartzite here was of sufficient metallurgical grade to be used as flux at the Douglas smelter. Surface talus was screened and the plus 8-inch size contained mostly pure quartzite with most of the alumina removed by weathering. This surface silica "en-

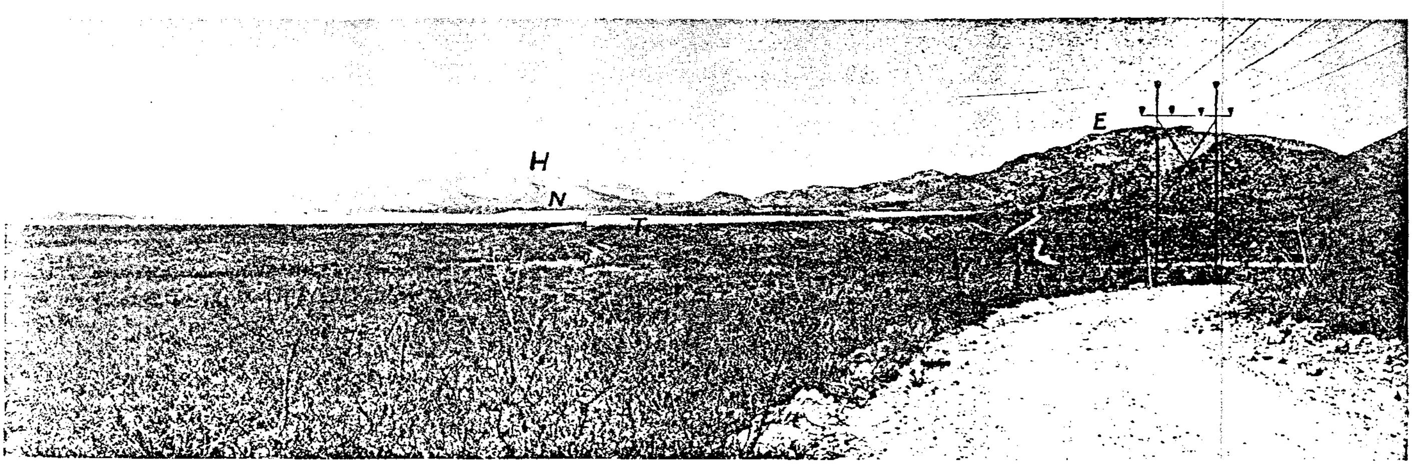


Figure 116.6b. View west along Gold Hill road. Escabrosa Ridge (E) on right skyline; Naco Hills (N) on left below Huachuca Mountains (H) on distant skyline; Abrigo and Escabrosa fault zones in notches near center above Lavender Pit tailings (T) (J. D. Forrester photo).