First-day road log, from Truth or Consequences to Sierra Cuchillo, Winston graben, Winston, south Fork Cuchillo Negro Creek, Fluorine, and central Black Range

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FIRST-DAY ROAD LOG, FROM TRUTH OR CONSEQUENCES TO SIERRA CUCHILLO, WINSTON GRABEN, WINSTON, SOUTH FORK CUCHILLO NEGRO CREEK, FLUORINE, AND CENTRAL BLACK RANGE

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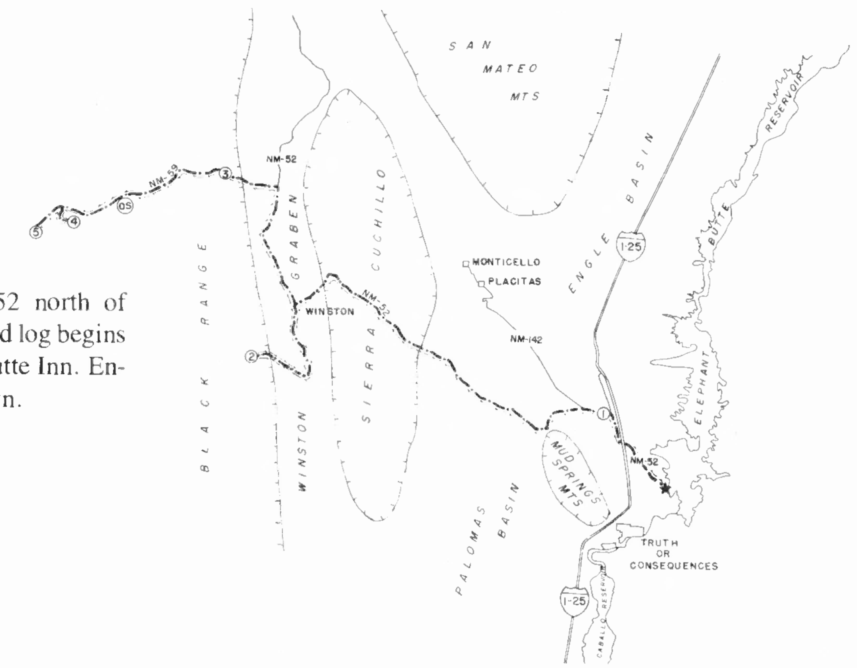

Assembly point:	Junction of NM-85 and NM-52 north of T or C, mile 6.3 of road log. Road log begins on NM-52 opposite Elephant Butte Inn. Entry log provided from downtown.
Departure time:	8:00
Distance:	99.1 mi (one way)
Stops:	7 (2 optional)

SUMMARY

The first-day tour will visit the volcanic areas northwest of Truth or Consequences (T or C) in the Sierra Cuchillo, Winston graben, and Black Range. This tour will emphasize: (1) Miocene to Pleistocene stratigraphy and sedimentology of the Palomas Fm. (Santa Fe Gr.), (2) stratigraphy of the Rubio Peak Fm. including spectacular exotic blocks of Pennsylvanian limestone, (3) Ag, Au, Cu fissure-vein mineralization of the Chloride mining district, and (4) pyroclastic volcanism and tin mineralization associated with the Taylor Creek Rhyolite.

The road log beginning in T or C first traverses the Engle Basin westward to the Sierra Cuchillo. Stop 1 (and assembly point for the caravan) is on the Cuchillo surface just north of the municipal airport (junction of NM-85 and NM-52). From here we have a grand panoramic view of the area that is covered for most of the conference. Closer views of nearby mountain ranges provide the backdrop for discussion of a Pennsylvanian unconformity in the Mud Springs Mtns., volcanic geology of the Sierra Cuchillo and San Mateo Mtns., and stratigraphy of the Palomas Fm. The route to Stop 2 transects the Engle basin and Sierra Cuchillo to the Winston graben. Much of the geology along this route was first described thirty or more years ago by Dick Jahns and his students. Their excellent work is still the best available for much of the geology along this route and this commentary draws heavily on Jahns' previous logs through this area, particularly his coverage of Paleozoic stratigraphy and Laramide intrusives. Newer up-to-date nomenclature and correlation for volcanic rocks have been used throughout the log.

Stop 2 emphasizes the sedimentology and stratigraphic relations of the lower andesitic part of the volcanic pile known as the Rubio Peak Fm. in this area. Overlying and interbedded within this pile are huge limestone blocks (Pennsylvanian) that are up to square kilometers in area and 100 m or more thick. Discussion will include mechanisms for emplacement. These blocks serve as host to some fissure-vein mineralization in the Chloride district at the St. Cloud mine just north of Stop 2 and at several other prospects and mines in the area, including the townsite of Fluorine north of Winston where vein mineralization will be viewed at Stop 3. The route from Winston will pass northward along the Santa Fe-filled Winston graben and westward into the Black Range. From Stop 3, also in rocks of the Rubio Peak Fm., we will climb upward through a gently west-dipping, homoclinal volcanic section several hundred meters thick. Near the top of the volcanic section Stops 4 and 5 will highlight different aspects of the Taylor Creek Rhyolite. At Stop 4, beautifully exposed pyroclastic rocks that are precursors to one or more of the Taylor Creek domes are examined. At Stop 5, a tin occurrence associated with a Taylor Creek dome is

visited. In addition to hematite–cassiterite veinlets, mineralization here includes several vapor-phase minerals typical of topaz rhyolites. These occur as well-formed small crystals usually in lithophysae. An auxillary log is provided to Nugget Gulch, the largest tin producer in the district.

ENTRY LOG FROM DOWNTOWN T OR C

Mileage

0.0 Date Street heading north opposite Ace Lodge. **0.4**
0.4 Shopping center on left. **0.2**
0.6 Road to Hot Springs Landing to right, **stay left. 0.5**
1.1 Turn right (north) on I-25. **1.0**
2.1 Bridge over Cuchillo Creek. Mud Springs Mtns. on left. Apparent folds caused by dissected dip slope. Roadcuts ahead in Palomas Fm. (see Lozinsky & Hawley in this guidebook). **1.5**
3.6 Border Patrol Inspection Station ahead. **0.4**
4.0 Stop for inspection. **1.5**
5.5 Take Cuchillo exit to right. **0.2**
5.7 Stop sign at junction with US-85. Turn left and join main route at mile 3.6.

End of entry log.

MAIN LOG

Mileage

0.0 Elephant Butte Inn. **Drive north on NM-52** through village of Elephant Butte. For next 1.5 mi on low ridge underlain by the axial river facies of the Palomas Fm. (upper Santa Fe Gr.; see Lozinsky & Hawley in this guidebook). These sediments consist mostly of weakly indurated sands with scattered gravel lenses that were deposited by the ancestral Rio Grande between 4.2 and 0.4 my ago. **0.1**
0.1 Junction on left with road to T or C. **Continue straight. 0.9**
1.0 Rock Canyon Road on right provides access to western shore of Elephant Butte reservoir. Popular sandy beaches along the western shore occur in exposures of the sandy, weakly cemented axial river facies. **0.4**
1.4 Cattleguard. Pinkish beds cropping out along ridge to the north for next mile are distal piedmont facies of the Palomas Fm. These sediments consist of sandy silt, clay, and conglomerate interbeds and were deposited by a huge alluvial-fan system that originated in the Black Range and Sierra Cuchillo to the west. The distal piedmont facies intertongues and overlaps the axial river facies. **0.4**
1.8 Drill pad at 9:00 is site of No. 2 West Elephant Butte Federal exploratory well completed in 1983 by Getty Oil Co. The hole penetrated 131 m of axial river facies sands (upper Santa Fe Gr.), 412 m of lower Santa Fe Gr.), 1,732 m of Cretaceous to Cambrian rocks, and bottomed in Precambrian granite at 2,303 m based on preliminary cutting analysis. The hole was reported dry and abandoned. About 0.5 mi northeast of here is the Summit 1 Mims exploratory well drilled between 1950 and 1954. The hole encountered 605 m of Santa Fe Gr., 1,283 m of Cretaceous to Pennsylvanian rocks, and bottomed in the Pennsylvanian at 1,888 m (Foster 1978). **0.4**

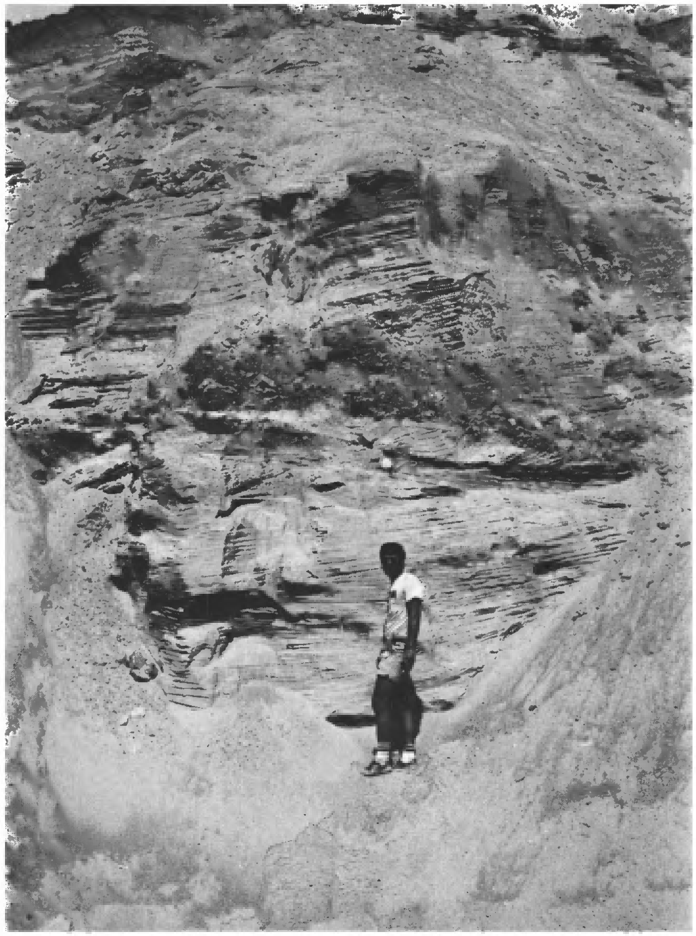

FIGURE 1-1.0—Trough-crossbedded, poorly indurated sand and gravel of Palomas Fm. axial river facies. These sediments were deposited by the ancestral Rio Grande and contain fossils 2–4 my old.

2.2 Cuts in distal piedmont facies. Conglomerate clasts derived chiefly from volcanic terranes in the Black Range and Sierra Cuchillo. **1.4**
3.6 Stop sign. Junction with US-85. **Turn right and continue through I-25 underpass.** NM-52 merges with US-85 for next 2.5 mi. **0.8**
4.4 Traversing the broad Cuchillo surface (Lozinsky & Hawley in this guidebook) that extends from here to the Sierra Cuchillo, a distance of about 22 km. The Cuchillo surface is mainly constructional, marks the end of deposition of the Palomas Fm., and represents the highest aggradation level of the Engle Basin. Near mountain fronts, the surface is erosional. This dissected surface slopes with an average gradient of about 1–2° to the east and southeast from the western mountain fronts and extends into the Palomas Basin. The Cuchillo surface is defined by Lozinsky & Hawley (this guidebook) to include the Palomas surface of Kelley & Silver (1952). Strong calcic soils (Stage III and IV carbonate accumulation) occur in uppermost deposits of the Palomas

Fm. The Cuchillo surface has been interpreted to be 400,000–500,000 yrs old (Lozinksy & Hawley in this guidebook). San Mateo Mtns. at 12:00. Major cliffs consist of Vick's Peak Tuff. **0.7**

5.1 T or C Municipal Airport road to left. **1.1**

6.2 Junction with NM-52. **Turn left, beware oncoming traffic. Prepare to stop.** About 4 km north is the Gartland 1 Brister exploratory well that was drilled in 1951 and 1955. This well reached a total depth of 2,617 m and penetrated 442 m of Santa Fe Gr. basin fill [27 m of McRae(?) Fm., and 2,147 m of Cretaceous to Pennsylvanian rocks with a 225 m thick monzonite sill in the Yeso Fm. (Foster 1978)]. **0.1**

6.3 **STOP 1. Park as directed.** From this perspective we have a spectacular overview of the T or C area. Today's route will take us westward up the Cuchillo surface through the Sierra Cuchillo Mtns. (middle distance to west and northwest), across the Winston graben, and on into the Black Range on the skyline to west. The second-day tour will lead us eastward out of T or C through the northern Caballo Mtns. near Elephant Butte Dam, then northward through the Jornada del Muerto east of the Fra Cristobal Range, and finally into the Fra Cristobals to view spectacular Laramide deformation there. Our third day will visit the very southern end of the Caballo Mtns. and San Diego Mtn. (behind the Caballo Mtns.) where northwest-trending Laramide deformational fronts are well exposed. The northwest trend of these fronts contrasts with the north–south orientation of folds in the Fra Cristobal Range.

This Stop, on the Cuchillo surface, also provides us with an ideal locality to discuss Palomas Fm. deposition

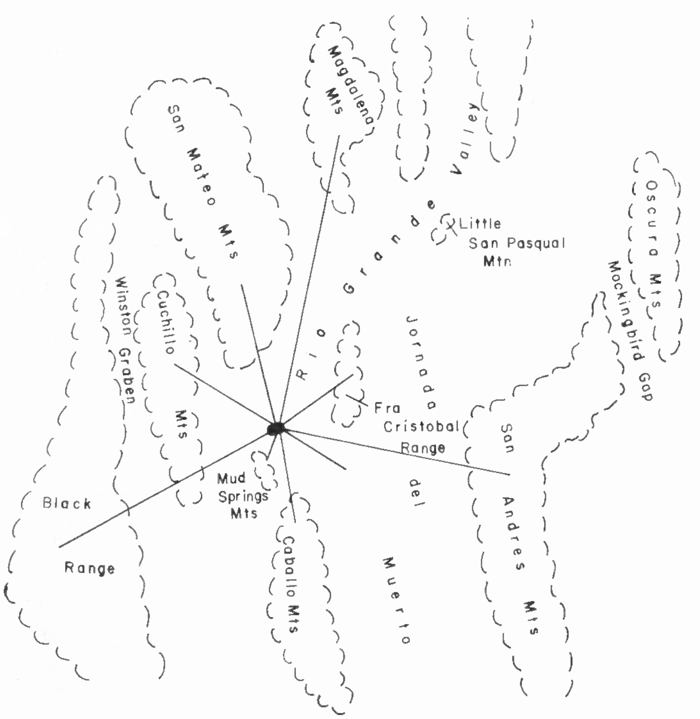

FIGURE 1-6.3a—Ray diagram showing prominent mountain ranges and landmarks from Stop 1.

(see Lozinsky & Hawley in this guidebook). The Cuchillo surface represents the highest aggradational level of the Engle Basin at the end of Palomas Fm. deposition. Sediments here were deposited by a huge alluvial-fan complex that brought volcanic-rich detritus from the western mountains into the Engle Basin. East of here, the piedmont deposits interfinger with well-sorted sands of axial river deposits.

The Mud Springs Mtns. to the south form an east-dipping homocline despite the illusion of folding on the east flank caused by dipping beds crossing complex topography. A major unconformity at the base of the Pennsylvanian documents a period of erosion perhaps related to the ancestral Rocky Mtns. (Maxwell & Oakman in this guidebook). The northeastward dip of the Mud Springs may be a Laramide feature since these gentle dips apparently steepen and become overturned as we trace the Mud Springs eastward through T or C (Bushnell et al. 1955: figs. 3–4). A steeply northeast-dipping section of older(?) Santa Fe beds (Fig. 1-12.0) at the northern tip of the Mud Springs suggests the alternate possibility that part of the dip on the Mud Springs is Tertiary and that the mountain is an intra-rift horst block.

The San Mateo Mtns. to the north–northwest expose a very thick and varied volcanic sequence. The most spectacular exposures are the Vicks Peak Tuff, a major regional ash-flow tuff. Vicks Peak here is within the Nogal Canyon cauldron, its source, and is at least 1,000 m thick as compared to 1–200 m in outflow areas. The Nogal Canyon cauldron was defined to extend from Vicks Peak, the high point above the large cliffs, southeast to near I-25 (Deal & Rhodes 1976). The large hills near I-25 with gently east-dipping strata of outflow Vicks Peak Tuff and older underlying rocks lie just outside the eastern cauldron margin. The western cauldron margin may be several kilometers farther north and west, perhaps near the central pass in the San Mateos (Ferguson 1985, Herman in preparation).

Beneath the Vicks Peak Tuff, the volcanic section closely resembles that in the Black Range and Sierra Cuchillo (Fig. 1-6.3b). The lower rocks comprise andesitic lavas and volcaniclastic sediments with minor shales. These were named the Red Rock Ranch Fm. (Farkas 1969), and they probably correlate with the Rubio Peak Fm. farther west. Several dacitic ash-flow tuffs interfinger with the upper parts of these units. A sequence of andesite and basaltic-andesite lavas follows. These closely resemble, and lie in the same stratigraphic position as, the basaltic andesite of Poverty Creek (Fig. 1-6.3b) exposed farther west. Quartz-rich, phenocryst-rich, ash-flow tuffs, occur as small isolated exposures near the base of these basaltic andesites. The lower of these quartz-rich tuff intervals is perhaps correlative to the Kneeling Nun Tuff. Vicks Peak Tuff overlies the mafic-lava sequence and is in general the youngest unit in the area. Small intrusive bodies of various compositions occur at several stratigraphic levels. **0.4**

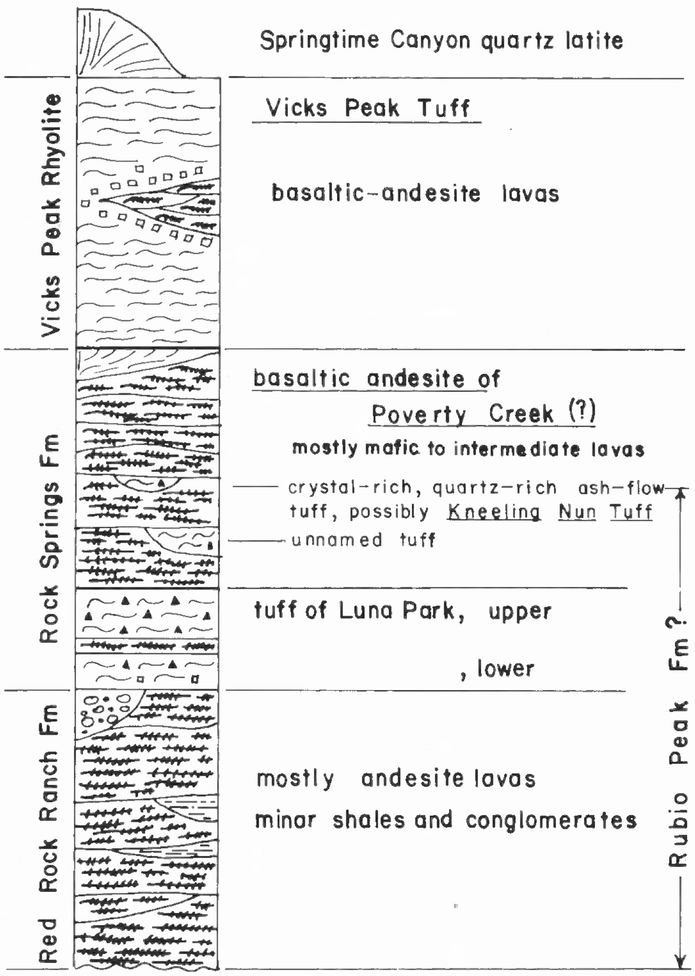

FIGURE 1-6.3b—Generalized stratigraphic section for volcanic rocks in southern San Mateo Mtns. Synthesized from Farkas (1969), Deal & Rhodes (1976), and Herman (in preparation). Possible correlations with Rubio Peak Fm., Kneeling Nun Tuff(?), and basaltic andesite of Poverty Creek are shown. Rubio Peak Fm. interval contains a much higher proportion of lavas and less volcaniclastic detritus compared to sections farther west, indicating position near a vent. The Kneeling Nun Tuff(?) is very thin and sporadic in occurrence. Alternative correlation with Hells Mesa Tuff (Osburn & Chapin 1983) or a local unit possible. Vicks Peak Tuff is within source cauldron here.

CLIMATE OF TRUTH OR CONSEQUENCES

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Truth or Consequences has undergone major growth in the 1970's and 1980's as a result of the influx of permanent retirees and the more mobile snowbirds. Small-town living, coupled with spectacular scenery and access to water sports on Elephant Butte and Caballo reservoirs, provides a lifestyle which many local residents feel is unsurpassed elsewhere in the Desert Southwest. There is little doubt that the local climate is another major attraction to northerners.

The climate of T or C is classified as BWh (hot desert) in the modified Koeppen system of climate classification. However, T or C, located at an elevation of 1,469 m, has a marginal BWh climate, being somewhat cooler and wetter than most desert stations. In fact, T or C is located in the northern extremity of the Chihuahuan Desert which follows the Rio Grande valley northward of El Paso and ends, at least climatically, in the vicinity of Socorro. For comparison, the mean annual temperature of T or C is 10.5°F lower and the mean annual rainfall is 1.72 in. higher than the corresponding figures for Phoenix, Arizona, which is located at approximately the same latitude as T or C, but at an elevation of only 335 m.

TABLE 1—Temperature and precipitation averages, Truth or Consequences, New Mexico.

	Average Temperature(°F)			Total Precipitation(inches)				
	Max	Min	Mean	Mean	High--Yr		Low--Yr	
January	54.1	27.4	40.7	0.30	1.11	78	0.00*	71
February	59.0	30.8	44.9	0.27	1.03	53	0.00*	72
March	65.2	36.1	50.7	0.26	1.33	58	0.00*	80
April	74.4	43.7	59.1	0.22	1.06	57	0.00*	78
May	82.6	52.3	67.5	0.42	2.13	79	0.00*	77
June	92.4	61.9	77.2	0.78	2.89	67	0.00*	74
July	92.6	66.1	79.4	1.51	3.42	62	0.46	54
August	89.8	64.0	76.9	1.64	4.76	57	0.10	62
September	84.4	57.8	71.2	1.57	5.10	75	0.00	56
October	74.8	47.0	60.9	0.97	5.64	72	0.00*	64
November	62.5	35.0	48.8	0.37	3.58	78	0.00*	77
December	54.1	27.5	40.8	0.45	1.67	65	0.00*	81
Annual	73.8	45.8	59.8	8.77	14.64	72	3.36	56
Winter	55.7	28.6	42.2	1.03	2.58	66	0.05	59
Spring	74.0	44.1	59.1	0.90	2.30	79	0.01	67
Summer	91.6	64.0	77.8	3.93	9.43	67	1.62	75
Fall	73.9	46.6	60.3	2.92	8.00	74	0.04	56

Source: Kunkel 1984 * Also earlier years

The following description is based on a climatic record which extends from 1951 to 1982 (Kunkel 1984). The mean annual temperature of T or C is 59.8°F, and temperature extremes include 106°F recorded on 14 July 1979 and −5°F recorded on 11 January 1962 (Tab. 1). Precipitation averages 8.77 in. annually, which includes the water equivalent of 6.0 in. of snow. Seventy-four percent of the annual precipitation falls during June through October, associated with summer thunderstorms and remnants of autumn tropical storms which invade the Rio Grande valley from the Gulf of Mexico and the eastern Pacific. The wettest year on record is 1972 with 14.64 in. and the driest year is 1956 with just 3.36 in. The record rainfall for a 24-hour observation period is 3.16 in. on 14 September 1976.

The following information is based on a climatic record which extends from 1950 to 1978 (State Climatologist unpubl. 1986). Humidity is lowest during the periods April–June (average 26%) and 12:00–6:00 p.m., year around. Humidity is highest during the periods December–January (average 49%) and 3:00–9:00 a.m., year around. Wind speed averages a high of 12.8 mph in the period March–May and a low of 10.0 mph during August–December. An unusual aspect of the wind at T or C is the fact that its direction in the afternoon is predominantly SSW, whereas in the early morning it is predominantly NNW. It appears that afternoon winds are part of the regional southwesterly flow of air, but early morning winds are local gravity winds of cool air which invades the Rio Grande valley from the Black Range to the northwest.

A PENNSYLVANIAN UNCONFORMITY IN THE MUD SPRINGS MOUNTAINS

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The Mud Springs Mountains, just west of Truth or Consequences, are a north–northwest-trending fault block dipping generally 20–25° eastward. The east side of the mountains is mostly a dip slope of Pennsylvanian Magdalena Group limestone and shale. The west face exposes Precambrian, Cambrian, Ordovician, Devonian, and Pennsylvanian rocks, predominantly limestones. Silurian and Mississippian rocks are not present in the area. At the south end and to the southeast of the range, the bedding swings around to a southeastward trend and is vertical or overturned, as revealed in a few discontinuous outcrops near the interstate highway and in T or C. Ordovician Cutter Dolomite of Montoya Group crops out just south of Main Street; Devonian rocks, if they are present, are under the pavement, and Magdalena Group rocks form the prominent hill north of Main Street. Limestone and shale beds at the top of the hill, under the water tank, are overturned and dip 20–40° southward. Other outcrops of overturned Magdalena and Cutter occur to the east, between First and Second Streets and across the river. Precambrian metavolcanic rocks crop out in the bed and banks of the river at the south edge of town.

The southern half of the Mud Springs Mountains has a complete stratigraphic section for the region; the northern half, north of a cross fault near the center of the range (Fig. 1), is missing about 100 m of section. Units not present in the northern half include part of the Ordovician Cutter Dolomite, the Devonian Oñate, Percha, and Sly Gap Formations (Sorauf 1984), and part of the basal Pennsylvanian section—the Sandia Formation (Hill 1956) or the lower part of the Red House Formation (Kelley & Silver 1952). The Sandia Formation is used here because it nearly coincides with that part of the Pennsylvanian section that is missing. A latite sill 0–30 m thick occurs in the middle part of the Sandia.

The boundary between the Ordovician and Pennsylvanian rocks was interpreted to be a normal fault by Kelley & Silver (1952) and a high-angle reverse fault by Hill (1956). Either interpretation is quite reasonable, except that the overlying thin shale and calcarenite beds are

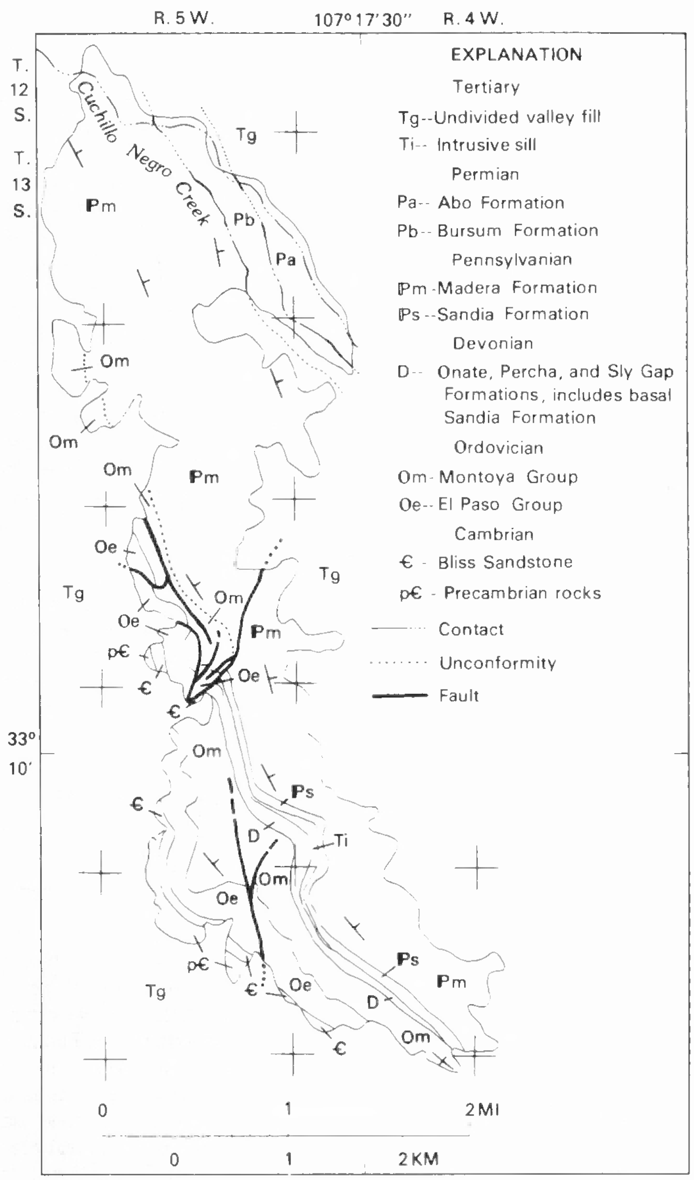

FIGURE 1—Sketch map of the Mud Springs Mountains showing location of Pennsylvanian unconformity. Strike and dip symbols indicate generalized inclination of bedding. Alluvium is not shown but may be indicated by dotted contacts.

parallel to the "fault" along a kilometer of nearly continuous outcrop and are completely undistorted. A fault with a minimum stratigraphic displacement of nearly 100 m would certainly distort adjacent thin shale beds. A little study convinced the authors that it had to be an unconformity (Maxwell & Oakman 1986).

The unconformity is characterized by an overlying 10–100 cm thick zone composed of hard, rounded, irregular or composite nodules of chert and limestone in a soft matrix of very fine-grained calcite and clay, locally covered by a thin caliche layer. The underlying Cutter Dolomite is generally concordant but locally slightly discordant. The lower surface of the chert zone is irregular and the upper surface is even, grading upward into about 40 cm of easily weathered soft green shale containing numerous small, irregular nodules of chert that become smaller and sparser toward the top of the shale. An overlying calcarenite bed about 30 cm thick also contains scattered chert pebbles in its basal centimeter or so. These two beds are overlain by another 7–8 m of interbedded grayish-green shale and light-gray calcarenite, which in turn is overlain by cherty light-gray limestone and dark-gray shale of the Magdalena Group. The 8 m of calcarenite and grayish-green shale are part of the Sandia, but are included with the Magdalena in Fig. 1.

The chert nodules are cryptocrystalline with a few scattered quartz crystallites and have small irregular lenses containing angular, silt-size quartz grains and scattered, rounded, fine grains of detrital quartz and chert, and local contorted lenses of limestone. The chert in the nodules is isotropic with local small areas that show vague aggregate polarization and areas that contain a dusting of microlites that may be concentrated into indistinct concentric or parallel bands. Many of the nodules have cross-cutting dendritic growths of calcite that show optical continuity.

The nearly planar base on which the chert formed appears to have been a wave-base abrasion platform which may have been uplifted to a level that allowed cyclic flooding and subareal exposure, or may have been part of a restricted basin subject to evaporation and influx of ocean or fresh water. The packing and grading of the nodules in a mud matrix indicate enough wave turbation to keep a solid chert bed from forming, but not enough to carry the chert away. The apparent lack of fossils may indicate a restriction of marine life.

6.7 T or C trap club on right. **1.6**

7.9 Junction with NM-142 to Monticello. **Keep left on NM-52.** Two oil exploration wells were drilled a few miles north on NM-142. The Gartland 1 Garner is located about 2.5 km north of this intersection. Drilled in 1950, this well reached a depth of 1,989 m and is reported to bottom in Santa Fe Gr. (Foster 1978). About 1.6 km north from the Garner, the 2,204 m deep West Elephant Butte Federal no. 1, drilled in 1982, penetrated 555 m of Santa Fe Gr., 1,600 m of Cretaceous to Cambrian rocks, and 48 m of Precambrian granite (thicknesses based on preliminary cutting analysis). Gravity data suggest a northwest continuation of the Mud Springs Mtn. block into the area of these holes. Relief on the boundary of this block may account for the thickness variation of the Santa Fe Gr. **2.3**

10.6 Road curves southward and begins descent into canyon of Cuchillo Negro Creek. **1.4**

12.0 Cross Willow Springs Draw. Beware if creek is in flood. Older Santa Fe Gr. exposed 1.3 mi downvalley are faulted, folded, and titled generally eastward 30–50°. These are overlain unconformably and beveled by generally flat-lying Palomas gravels. **0.6**

12.6 Entering Cuchillo, an old farming community that served as a stopover point between the mining areas in the Black Range and the railhead at Engle during the early part of

FIGURE 1-12.0a—Mud Springs Mtns. from north. Note homoclinal dips of beds from this perspective. Caballo Mtns. on skyline.

this century. Although the population has dwindled, the sleepy little village still boasts a bar and a store that has many memorabilia on display from the boom days. Several terrace levels are preserved along the sides of the valley (see Fig. 1-13.9 for elevations). **0.7**

13.3 Begin ascent from Cuchillo Negro Canyon. **0.6**

13.9 Well-preserved inset terrace at 9:00 along opposite side of valley. This terrace is about 150–200 ft above the present floodplain. These terrace levels represent former valley floors that were cut during wetter periods of the Pleistocene. **0.1**

14.1 On terrace level that stands 100–120 ft above the present valley floor. **0.3**

14.4 Traveling on Cuchillo surface for next 8 mi. Fault scarp visible at 3:00. **7.2**

21.6 Cattleguard. Ranch road on right. Thick caldera fill, Vicks Peak Tuff, visible in distance over ranch houses. Roque Ramos hills expose Oligocene volcanic rocks in right foreground. At 11:30, high ridge of Cuchillos exposes Paleozoic rocks intruded by reddish-tan-weathering Laramide quartz-monzonite stock (50.1 ± 2.6 my)

FIGURE 1-12.0b—Palomas Fm. piedmont facies overlying tilted possible lower Santa Fe Gr. deposits. Exposure along Cuchillo Negro Creek at north end of Mud Springs Mtns. Note fault on right side of photo that cuts tilted deposits but not overlying Palomas beds. The fault cuts bedding at about 70°, typical for a normal fault. Apparently the fault formed when bedding was flat and has been rotated with the beds to this relatively low angle.

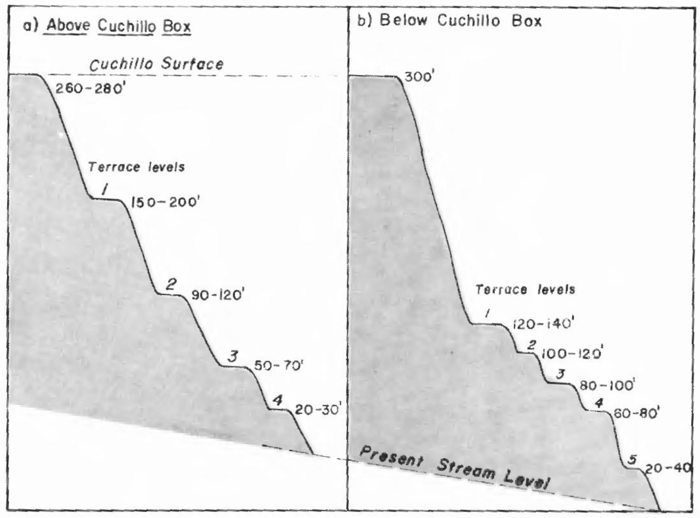

FIGURE 1-13.9a—Terrace levels along Cuchillo Negro Creek: (a) Above (west) Cuchillo box after Maxwell et al. (1986), and (b) Below (east) of Cuchillo box, after Lozinsky (1986).

(Chapin et al. 1975). Numerous Cu, Ag, Mn prospects occur on perimeter including the Dictator Mine which produced minor Pb, Zn, Ag. Gray layered rock on either side is Magdalena Gr. limestones. **0.7**

22.3 East-tilted (25°) Santa Fe Gr. strata of uncertain age exposed in arroyo at 2:00. Eastern part of Sierra Cuchillo ahead underlain by Oligocene volcanic rocks. Contact relationship between Santa Fe volcaniclastics and the volcanics to west are uncertain here. However, about 3 km to north in Roque Ramos Canyon similar older Santa Fe beds clearly overlie the volcanic rocks of the Cuchillos; Cuchillo surface pediments both. Volcanic rocks in the Cuchillos have been described by Jahns (1955), Jahns et al. (1955, 1978), and Heyl et al. (1983). Recently, as part of his dissertation on tin in the Black Range, T.L. Eggleston mapped a small part of the Cuchillos surrounding the known tin prospects. His work suggested correlations with volcanic stratigraphy to the northeast (Osburn & Chapin 1978) and west (Woodard

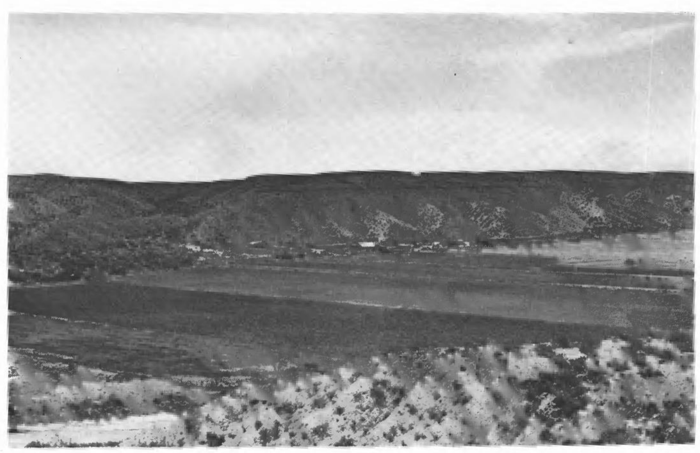

FIGURE 1-13.9b—Floodplain of Cuchillo Negro Creek and high-terrace level on south about 160 ft above creek level.

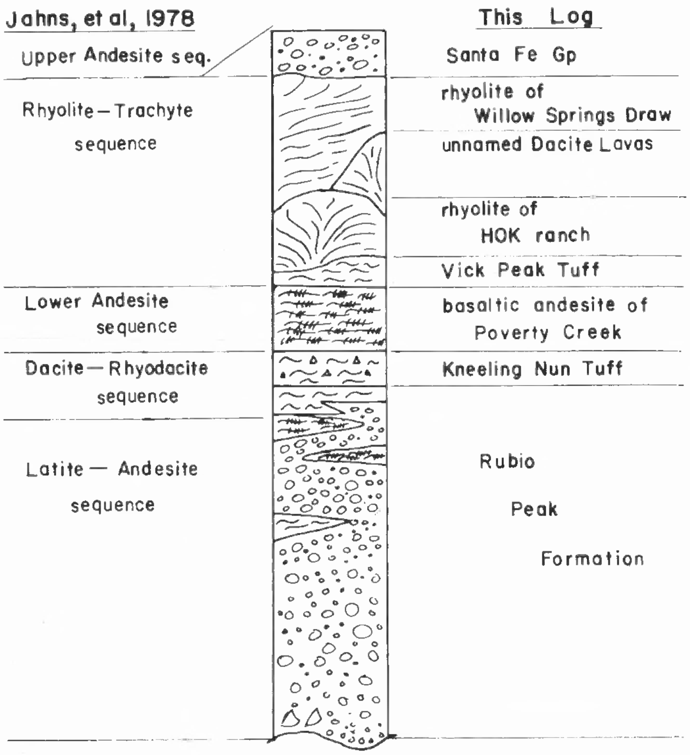

FIGURE 1-22.3—Generalized stratigraphic section for volcanic rocks in Sierra Cuchillo showing stratigraphic nomenclature used in this log and that of Jahns (1955) and Jahns et al. (1978). Correlations with regional units are tentative, but are considered fairly good because of the excellent match with the stratigraphy of the Black Range (Harrison in this guidebook).

1982, Abitz 1984, Harrison in this guidebook). Eggleston's nomenclature is used in this road log. **0.4**

22.7 Leave Cuchillo surface and enter hills of rhyolite lavas, the rhyolite of Willos Springs Draw (Eggleston in press). This rhyolite is petrographically and chemically very similar to the better known Taylor Creek Rhyolite in the Black Range (see Maxwell et al. in this guidebook for analysis). Rhyolite of Willow Springs contains about 30% phenocrysts of subequal quartz and sanidine with traces of plagioclase, biotite, and opaque minerals. White punky areas in the rhyolite are zones of vapor-phase (deuteric) recrystallization. Immediately west of roadcut and north of the road, a number of prospect pits were dug on tin mineralization similar to that found in the Black Range. The occurrences consist of hematite–cassiterite veinlets with minor chalcedony, calcite, fluorite, and zeolites as gangue minerals. **0.7**

23.4 Cattleguard. A small inlier of sedimentary rocks, possibly paleovalley fill, on both sides of road for next 0.3 mi. These rocks are heterolithic, moderately indurated volcaniclastic conglomerates, sandstones, and boulder alluvium with minor fine-grained sediments. They unconformably overlie rhyolite of Willow Springs Draw and underlying latite lavas. The strong induration and red coloration suggest a possible correlation with the older Santa Fe deposits exposed along east side of the range. **0.1**

23.5 Roadcut at left exposes faulted contact of Santa Fe inlier with underlying rhyolite. **0.3**

23.8 Monticello cutoff road across Willow Creek at 3:00. Rhyolite of Willow Spring Draw in cliffs along creek. Adit just to right of road prospects small hematite–cassiterite veinlets which also contain minor amounts of pseudobrookite, titanite, and an unnamed calcium arsenate. **0.2**

24.0 Side road to Monticello on right. **0.1**

24.1 Steep-walled canyon at 2:00 cut in next underlying unit, the rhyolite of HOK Ranch. This distinctive cliff-forming unit, which caps Burro Ridge for several miles to the north, is a high-silica rhyolite with abundant plagioclase phenocrysts in contrast to the overlying Willow Springs. Winding road ahead traverses mainly this rhyolite for next 0.5 mi. **0.5**

24.6 Highest peaks of the Sierra Cuchillo in distance ahead. Monzonite underlies the slopes and main ridges at 1:00 and is capped by east-dipping Pennsylvanian limestone at 12:00. **0.3**

24.9 Turnoff to HOK Ranch. Keep right on NM-52 and climb short hill. A small fault in saddle at top downdrops younger latite lavas (left) against units exposed on Burro Ridge. Vicks Peak Tuff, exposed in small cuts on right at top of rise beneath rhyolite of HOK Ranch, also forms resistant reddish cliffs in midslopes on Burro Ridge head. Grass-covered slopes lower on hill and alluviated valley underlain by basaltic andesite of Poverty Creek. **0.4**

25.3 Cross fault onto basaltic andesite of Poverty Creek. **0.7**

26.0 Cattleguard. Low hills at 10:00 are unnamed ash-flow tuffs at the top of the Rubio Peak Fm. **0.4**

26.4 **Sharp curve!** Intermediate lavas of Rubio Peak Fm. underlie(?) unnamed tuffs just past corner. Tuffs are well exposed in creek bank below road to right. These ash-flow tuffs are densely welded and locally have well-lineated pumice. Such dense welding and stretching of pumice are unusual but not rare in silicic ash-flow tuffs

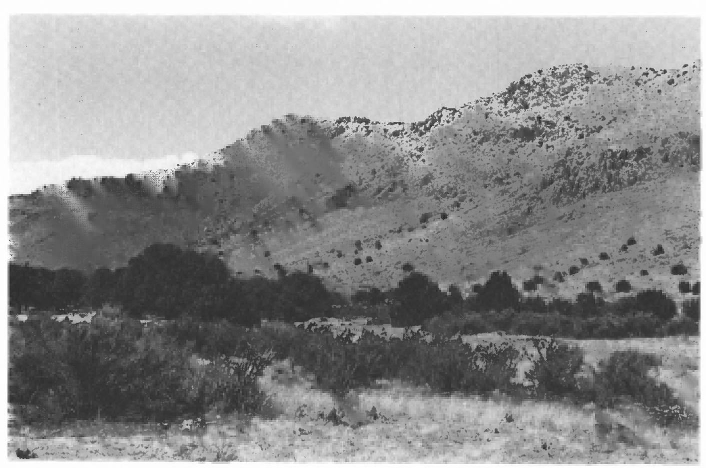

FIGURE 1-24.9—West side of Burro Ridge. Top of ridge is rhyolite of HOK Ranch. Cliffs in mid-slope are the Vicks Peak Tuff, a regional ignimbrite erupted from the Nogal Canyon cauldron in southern San Mateo Mtns. Grassy slope low on hill and alluvial valley floor underlain by basaltic andesite of Poverty Creek. Porphyritic dike forms skyline at left of photo.

and sometimes caused them to be misidentified as rhyolite lavas.

The following segment of log to mi 32.8 is largely after Jahns (1955), with modification to volcanic entries. Junction of Trap Creek and Willow Creek in foreground at 1:00. Broad lowland area ahead lies between Burro Ridge and the Sierra Cuchillo. Low hills are Pennsylvanian Magdalena Gr. and Permian Abo, Yeso, and San Andres Fms. cut by masses of intrusive monzonite and overlain by mainly east-dipping andesitic and latitic volcanic and volcaniclastic rocks of Rubio Peak Fm.

The group of buildings in the nearby valley at 2:00 marks the location of Willow Springs. These seeps are associated with the Willow Springs fault. Crest of northern Sierra Cuchillo is visible on skyline at 2:00.

Reddish-brown hill on right side of highway in near distance is a porphyritic-rhyolite dike that transects monzonite, Rubio Peak, and Pennsylvanian limestone. This dike extends eastward onto Burro Ridge and westward to main ridge of Sierra Cuchillo.

On north side of the reddish-brown hill, out of view, is the site of a small mill built in 1926 for treatment of complex base-metal ores mined from skarn deposits in the Sierra Cuchillo district to the west. With a maximum capacity of about two tons per hour, it was operated intermittently until 1929; the aggregate throughput amounted to approximately 3,000 tons.

Conical hill rising prominently from the lowland at 11:00 owes its existence to a small, irregular intrusive mass of resistant porphyritic rhyolite. **0.4**

26.8 Road traverses flat underlain by monzonite that is intrusive into Rubio Peak volcaniclastic sediments. At 10:00, on the main east face of Sierra Cuchillo, is the hanging-wall contact of a large laccolithic monzonite. Pennsylvanian limestones form the very steep, gray, ribbed slope below the skyline, where pinyon-pine cover is relatively thick; the underlying monzonite forms barer and more brownish lower slopes. Trace of the contact rises from left to right, swings through a saddle in the main ridge, and thence extends back to the left on west face of range; thus, the ridge north of the saddle is composed wholly of monzonite. **0.1**

26.9 Shipping pens for HOK Ranch on left. **0.4**

27.3 Light-colored Pennsylvanian limestone crops out right of road in larger saddle and again 0.1 mi farther along. These limestones overlie intrusive monzonite and are buried by Rubio Peak volcaniclastic rocks. **0.6**

27.9 Road to Red Hill Pass in distance at 11:00. Near base of this grade an east–west cross fault separates the Sierra Cuchillo into two geologically different parts. The northern Cuchillo Range consists mainly of east-dipping Pennsylvanian and Permian strata together with major intrusive masses of white felsite and monzonite, porphyritic rhyolite, aplite, and fine-grained granite (Davis in this guidebook). The southern Cuchillo Range contains a much more varied section that includes rocks as old as Precambrian, but most of it consists of Pennsylvanian limestone and large intrusive masses of gray monzonite.

Very low, subdued hills of reddish-brown Abo sandstones and pinkish and gray Yeso red beds and limestones are visible in the near distance at 10:00. In the distance at 9:00 is the trace of the major bounding fault along the east base of the southern Cuchillo. Northward along this fault, but south of the brownish, cliff-capped knob that rises at the east base of the range, is a gullied, light-colored slope underlain by Pennsylvanian limestone. This limestone lies beneath the main laccolithic monzonite.

Purplish-gray dumps of the Dictator mine, visible only to the discerning eye, are grouped along the monzonite–limestone contact a short distance south of the gullied slope. This mine has yielded about 5,000 tons of galena–sphalerite ore estimated to contain an average of 30% combined lead and zinc together with 2–3 oz/t silver. Substantial quantities of rich oxidized ore were obtained from several near-surface workings. **0.2**

28.1 Twin summit of Jaralosa Mtn. in distance at 12:30. This relatively isolated mass, which dominates the area east of the northern Cuchillos, is composed almost wholly of very coarsely porphyritic rhyolite that is intrusive into the Rubio Peak Fm.(?). Volcanic rocks of the northern Cuchillo form the skyline to left (west) of the peak. To the right are irregularly cliffed peaks that consist of variegated but dominantly light-colored pyroclastic rocks, some of them considerably altered. The alteration is alunitic and a number of coreholes were drilled here in the 1970's testing for aluminum resources.

San Mateo Mtns. in the far distance at 2:00 just to left of the high northern part of Burro Ridge. Carrizo Peak at about 3:00 exposes an excellent section through the upper part of the volcanic section in the Cuchillo Range (Fig. 1-28.1).

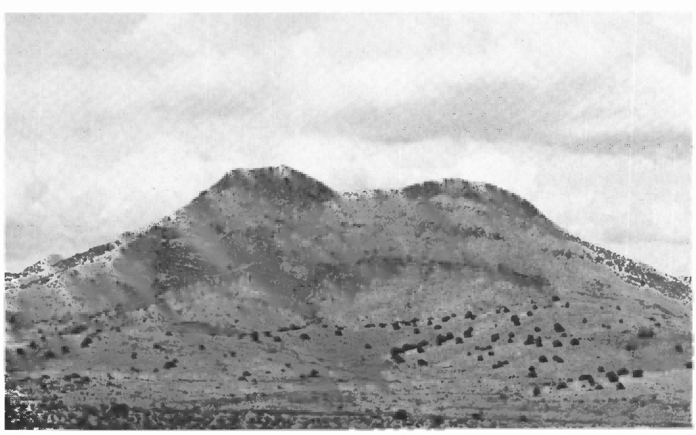

FIGURE 1-28.1—Carrizo Peak viewed from west exposes a beautiful cross section through much of the volcanic section of the Sierra Cuchillo. Rubio Peak lavas and volcaniclastics form flats and lower slopes of hill. Kneeling Nun Tuff(?) forms first dark ledge. Slope between the ledge and caprock is mostly basaltic andesite of Poverty Creek. Peak capped by rhyolite of HOK Ranch. Vicks Peak Tuff, only 1–2 m thick beneath HOK Ranch here, thickens rapidly to about 60 m down slope to east. This change in thickness may indicate tilting and erosion of fault blocks before eruption of the rhyolite of HOK Ranch.

Low ridges and hills in near distance at 1:00 are underlain by northwest-dipping strata of the Abo and Yeso Fms. **0.7**

28.8 Ranch road on right. **0.1**

28.9 In middle distance at 9:00 is the Dictator mine area. The gullied, light-colored slope underlain by Pennsylvanian limestones is recognizable beyond and slightly to the left of a reddish-brown knob. This knob consists of porphyritic rhyolite intruded as a small, elongate plug along the main fault that bounds the southern Cuchillo on the east. Monzonite forms western slopes of hill and Yeso strata form the eastern.

Low ground along road for next mile underlain by volcaniclastic rocks of Rubio Peak Fm. which are well exposed in many arroyo bottoms. **1.3**

30.2 Cattleguard. Road to Red Hill Pass at 12:00. Coarse volcaniclastic, mainly debris-flow deposits well exposed in the nearby stream at 3:00–4:00 and underlying the hill beyond. Hill on right side of road in near distance at 12:30 is composed of northeast-dipping limestones and sandy intervals of Yeso Fm.

Valley on the left extending away from the observer at 7:30 has been developed along the down-to-the-east fault zone that borders the southern Cuchillos on the east. A dip-slope of upper Magdalena strata flanks the valley on the west and lower hills of volcanic rocks flank it on the east. Beneath the valley floor are several elongate fault slices of Abo and Yeso strata. A fault-bounded wedge of Abo red beds is conspicuous in the saddle at 8:00; west of it are Magdalena limestones, east of it Yeso sandstone, siltstone, and limestone. **0.5**

30.7 Road crosses a poorly exposed dike of monzonite that fills a north–northwest-trending fault. About 60 m to the right and on the far side of the creek, the low, rounded ridge that is mantled with yellowish-brown float is another fault-filling dike of monzonite. This fault trends athwart the range and is the boundary between its northern and southern parts. The fault zone that borders the southern Cuchillo on the east appears to terminate northward against this cross break, pre-monzonite movement along which has raised a Magdalena section on the south against an Abo–Yeso section on the north.

The monzonite dike that fills the cross fault extends westward to the crest of the range, whence it bends abruptly southward and expands within the Magdalena section to form a laccolith (stock?) more than 1.6 km long. **0.3**

FIGURE 1-30.2—Unsorted, matrix-supported volcaniclastic conglomerates of Rubio peak Fm. probably deposited by debris flows. C.H. Maxwell is about 6 ft tall.

31.0 Cross fault and monzonite dike here concealed beneath alluvium. Ragged cliffs on the steep slope from 9:30 to 11:00 are brecciated and highly silicified limestone of the Magdalena Gr. Lower part of slope at 12:00 is underlain by intrusive mass of white felsite. **0.2**

31.2 Side road extends up steep canyon at 10:00 to reach prospect and mine workings developed above the upper margin of the monzonite laccolith where its trace lies on the west face of the range.

Contact between reddish-brown siltstone and sandstone of the Abo Fm. and fine-grained, brownish- to yellowish- and greenish-gray clastic strata of the overlying Yeso Fm. is well exposed in the stream bed at right.

Curve at base of final grade to Red Hill Pass. **Drive carefully;** moderately steep grade and several sharp curves. **0.2**

31.4 Tight little syncline exposed in roadcut on left preserves a thin remnant of brownish to greenish beds of the basal Yeso section resting upon typical Abo red beds. **0.1**

31.5 Trace of Abo–Yeso contact passes through right side of the notch traversed by road ahead. It is nicely exposed on the opposite side of the nearby small gulch from 1:00 to 2:00. Light-colored beds, representing lower part of the Yeso Fm., underlie lower slopes on both sides of main canyon from 12:00 to 3:00, and limestone beds that characterize upper part of the Yeso Fm. appear as prominent ribs on middle and upper parts of the opposite canyon wall. **0.6**

32.1 Notch at top of grade. Abo–Yeso contact lies immediately to the right. **0.2**

32.3 Cattleguard at Red Hill Pass. (See figures in Jahns 1955: 38–39). This area provides a thick, well-exposed section of Permian sedimentary rocks together with adjacent parts of Pennsylvanian and Upper Cretaceous sections. Units exposed here include about 10 m of Magdalena limestone, 25 m of "transition beds" tentatively grouped with the Magdalena, 280 m of Abo red beds, 80 m of lower Yeso red beds and greenish- to buff-colored sandstones and siltstones, 143 m of upper Yeso limestones, sandstone, and siltstones, 415 m of San Andres limestone and arenaceous beds, and at least 56 m of Upper Cretaceous conglomerate and finer-grained clastic rocks. No unit identifiable as the Glorieta sandstone has been observed, and the Yeso–San Andres contact is tentatively placed.

The section is distinguished by occurrence of monzonite sills in its lower part; pervasive mild metamorphism of the Magdalena and lower Abo strata; appearance near the base of the Abo Fm. of several thin, lenticular beds of limestone with fossils of Wolfcampian age; scarcity of gypsum and abundance of limestone in the Yeso Fm.; and wide stratigraphic range of red beds in the San Andres Fm.

Less than 60 m west of cattleguard is a roadcut exposure of greenish-gray monzonite. This is part of a sill, approximately 17 m thick, that has been injected along a horizon about 130 m above the Abo Fm. The sill has a known length of nearly 3 km and is flanked by numerous pits and cuts excavated over a long period in attempts to develop small shows of copper and uranium mineralization. To date, the money and effort expended in this work have yielded no more than traces of negotiable materials. **0.2**

32.5 Cross Red Hill branch of Schoolhouse Creek. Basal beds of Abo Fm. are exposed in creek bed at right, and uppermost beds of Magdalena Gr. on downstream side of the crossing at left.

Roadcuts ahead on right exposed mildly metamorphosed limestones, shales, and red beds that represent upper part of the Magdalena section. Several thin sills of monzonite and light-gray felsite also are present. **0.3**

32.8 Crossing eastern boundary fault of Winston graben. Thin, fault-bounded slices of highly deformed shales and limestones lie between Pennsylvanian limestone to east and Winston beds of Santa Fe Gr. to west. Mullions on fault plane plunge about 65° to the north. Fault zone is mineralized with fluorite a few hundred meters to north where several trenches are visible on shoulder of hill. Just over small ridge to north of trenches a fluorite-bearing vein 2 m wide is intergrown upward with travertine containing leaf and twig impressions. **0.2**

33.0 Crossing Schoolhouse Creek. Next several miles traversed through Winston beds. **0.1**

33.1 Table Top Mesa at 12:00 is capped by Pliocene basalt flow dated at 4.8 ± 0.10 my (Seager et al. 1984). This flow overlies Winston beds of Santa Fe Gr. with angular unconformity and crosses boundary fault between Winston graben and Sierra Cuchillo uplift without being offset. (Fault zone is locally occupied by feeder dikes and small bodies of vent breccias.) **0.4**

FIGURE 1-33.1—Table Top Mtn. stands above Winston graben. Basalt cap dated at 4.8 ± 0.10 my (Seager et al. 1984) brackets Winston beds here as Pliocene and older. Black Range in background under clouds.

33.5 Crest of Black Range (continental divide) at 12:00. Black Range opposite Winston consists predominantly of Oligocene volcanics and volcaniclastic rocks. A few small exposures of Abo Fm. are present along the eastern border fault of the Winston graben south of Winston (Stop 2) (Maxwell & Heyl 1976). **0.7**

34.2 Cattleguard and stock watering tank. **0.4**

34.6 Interbedded conglomerates and sandstones of Winston beds exposed in arroyo at 9:00. These deposits contain volcanic clasts from entire local Tertiary stratigraphic section but lack any pre-Tertiary rock types. **1.0**

35.6 Andesitic lavas interbedded in Winston beds exposed in creek bed on left. **0.9**

36.5 Cross Poverty Creek. This crossing subject to flooding during rainy seasons. **0.1**

36.6 Entering Winston (aka Fairview, ca 1881). The town was first settled by respectable folks who preferred its "lower altitude" more than the nearby rambunctious mining town of Chloride. A maximum of about 500 people lived in Fairview in 1883, during the silver "boom" days of the Chloride mining district. The town was officially named Winston in 1930, after its most prominent citizen, Frank H. Winston, became a state senator. **0.1**

36.7 **Turn left onto Sierra County Road (C-6)** and drive south through Winston. Some of the structures standing today are survivors from the early silver boom days. The prominent two-story building to the right at midtown is the former home of Frank H. Winston. The Diamond Bar, one street to the east, is one of the friendlier establishments in this part of the world. **0.6**

37.3 Leaving Winston, low hills to right and ahead are Winston beds. **0.4**

37.7 Road forks. **Turn left on Forest Road 157 toward Chise and Hermosa.** Right fork leads to the "almost" ghost town of Chloride. **0.7**

38.4 Roadcuts are in fine-grained Winston beds containing thin, reworked ash layers, up to 20 cm thick. **0.8**

39.2 Intersection with Chloride cutoff road on right. Entering Chloride Creek drainage. Outcrops to left are intermediate lava flows and related breccias dated at 18.3 ± 0.4 my (Seager et al. 1984). These rocks are interbedded with Winston beds of Santa Fe Gr. and are correlative to upper andesite sequence of Jahns et al. (1978). **0.4**

39.6 Hill to left is capped by intermediate lavas underlain by Winston beds. The basal portion of the lava consists of block-flow material with calcite-lined open spaces. Underlying sediments show 1 m thick reddish baked zone. To the right is a 25–30 m high terrace inset on Winston beds. A northwest-trending, down-to-the-southwest fault is buried beneath Chloride Creek in this area. **0.4**

40.0 Brecciated near-circular plug(?) exposed up right fork of wash to left. May be vent for lava flows at mile 39.6. **0.3**

40.3 Crossing north-trending, down-to-west fault that juxtaposes Winston beds (to right) against basaltic andesite of Poverty Creek (to left). Next 1.5 mi will traverse basaltic andesite of Poverty Creek (Harrison in this guidebook). **0.4**

40.7 Winston beds across valley (and fault) at 1:00 to 3:00 expose light-colored altered-tuff layers rich in clinoptilolite. **1.1**

41.8 Junction of Chloride Creek with Poverty Creek left to form Cuchillo Negro Creek. Winston beds overlie Poverty Creek lavas and are overlain by intermediate lavas at 9:00 to 10:00. **0.1**

41.9 Contact between basaltic andesite of Poverty Creek and underlying phenocryst-rich, quartz-rich ash-flow tuff correlated with Kneeling Nun Tuff by Harrison (this guidebook), but thought by Maxwell & Heyl (1976) to be more local unit with source area to south near mile 42.9. **0.4**

42.3 Petroglyphs on rocks to right. **0.4**

42.7 Contact between Kneeling Nun Tuff and tuffs in top of underlying Rubio Peak Fm. to right. The upper Rubio Peak in this area consists of interbedded ash-flow tuffs and fine-grained volcaniclastic sediments. These ash-flow tuffs occur in the same stratigraphic interval as the Sugarlump Tuff of Jicha (1954) and Seager et al. (1982) (see Harrison in this guidebook). **0.2**

42.9 Petroglyphs to right. Red stone ruins to left are remains of stagecoach relay station that served the run between Winston and Chloride, and Kingston to the south. Exposures to right are of Sugarlump Tuff in upper Rubio Peak Fm. Steep cliffs to southeast (best viewed on return trip) show stratigraphic relationship between Kneeling Nun Tuff (light beds) and overlying basaltic andesite of Poverty Creek (dark beds). Vent area for this sequence of tuffs thought by Maxwell & Heyl (1976) to lie just behind this hill.

Road splits, **turn right and proceed (west) up South Fork of Cuchillo Negro Creek. 0.3**

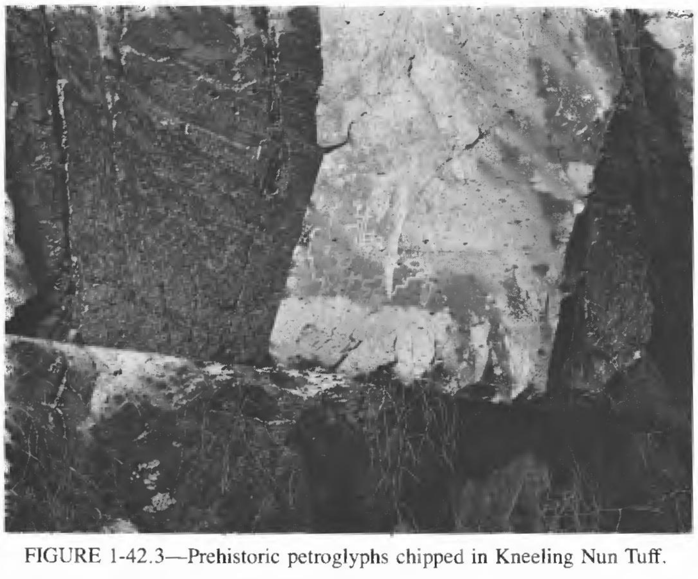

FIGURE 1-42.3—Prehistoric petroglyphs chipped in Kneeling Nun Tuff.

FIGURE 1-42.9—Petroglyphs chipped in Sugarlump Tuff in upper Rubio Peak Fm.

43.2 Crossing north-trending, down-to-west fault (same as at mile 40.3). Buff to white colored zeolitic tuff in hanging wall is tuff of Little Mineral Creek. In this area, tuff of Little Mineral Creek shows strong alteration with up to 50% clinoptilolite which has drawn some exploration activity (Bowie & Barker in this guidebook). Tuff of Little Mineral Creek also caps prominent hills to south at 3:00. **0.4**

43.6 Road to Hermosa on left. **0.1**

43.7 Contact between tuff of Little Mineral Creek and overlying Winston beds. **0.1**

43.8 View to west (12:00) reveals an intriguing geologic relationship. Red beds exposed at base of hills ahead are Permian Abo Fm., mid-slopes are Tertiary Rubio Peak Fm., and gray cliff-forming beds on top of the hill are Pennsylvanian Madera Fm. This relationship is consistently exposed over an area of several square kilometers and is the major object of Stop 2. **0.1**

43.9 Cross north-trending, down-to-the-east fault from Winston beds into tuff of Little Mineral Creek. Good exposures of striated fault surface in bank to right. **0.1**

44.0 Winston beds overlie tuff of Little Mineral Creek to right and are exposed for the next 2 mi in cuts to right. **1.1**

45.1 St. Cloud Project's milling plant ahead. The mill has a

FIGURE 1-43.8—View to west from South Fork of Cuchillo Negro Creek showing Permian Abo Fm. (Pa) overlain by Tertiary Rubio Peak Fm. (Trp) that contains exotic blocks of Pennsylvanian Madera Ls. (₱m), here capping hill (similar relationship is shown in Fig. 1-45.2). Beds in lower left corner are gravels of Winston beds of Santa Fe Gr. (Tsf). A high-angle normal fault with about 1,670 m of stratigraphic displacement places Santa Fe beds against Abo Fm.

450 TPD flotation capacity, producing a single bulk concentrate. Construction of this plant was completed in fall of 1983 and it processed ore from the St. Cloud and U.S. Treasury mines through January 1986, when it shut down for economic reasons. **Follow road around mill, turn left toward mine at junction. 1.1**

46.2 Crossing western boundary fault of Winston graben. This fault has approximately 1,500 m of stratigraphic displacement, juxtaposing Winston beds of Santa Fe Gr. against Permian Abo Fm. **0.2**

46.4 Tertiary Rubio Peak Fm. on both sides of road. The lower Rubio Peak in this area consists of debris-flow (mud-flow) deposits interbedded with volcaniclastic sandstones. Regionally, the Rubio Peak Fm. shows propylitic alteration with an epidote–chlorite–calcite ± pyrite mineral assemblage. Heterolithic clasts of dominantly volcanic rock types with lesser Paleozoic rocks typify the Rubio Peak Fm. mudflows. **0.1**

FIGURE 1-45.1—Aerial view of 450 TPD flotation concentrator operated by St. Cloud Mining Company. Total production through February 1986 is 267,000 tons averaging 1.2% Cu, 0.8% Pb, 1.0% Zn, 7.4 OPT Ag, and 0.04 OPT Au. Photo and data courtesy St. Cloud Mining Company.

FIGURE 1-46.4—Pinnacles eroded in debris-flow deposits of lower Rubio Peak Fm. along South Fork of Cuchillo Negro Creek in Chloride mining district. The debris-flow deposits are matrix-supported and contain heterolithic clasts of dominantly volcanic rocks with lesser Paleozoic sedimentary rocks. This outcrop shows propylitic alteration (calcite, epidote, chlorite, pyrite) typical of lower Rubio Peak rocks throughout the Chloride district.

46.5 Northwest-trending fault displaces Rubio Peak Fm. (right) down against Permian Abo Fm. (left), striated fault surface is visible in Rubio Peak rocks. **0.1**

46.6 Conglomerate beds at base of Rubio Peak Fm. exposed to left. Abundant clasts of Abo Fm. and monzonite, possibly from the Sierra Cuchillo stock, are present in these beds. **0.4**

47.0 Driving through debris-flow deposits of the lower Rubio Peak Fm. Exotic limestone blocks cap hills to both north and south. **0.6**

47.6 **STOP 2** at confluence of Byers Run drainage and South Fork of Cuchillo Negro Creek. **Park as directed.** Excellent exposures of angular unconformity between Permian Abo Fm. and Tertiary Rubio Peak Fm. are seen at the mouth of Byers Run.

Byers Run received its name from an incident occurring on 29 May 1879. On that date detachments of the 9th U.S. Cavalry, under the command of Captain

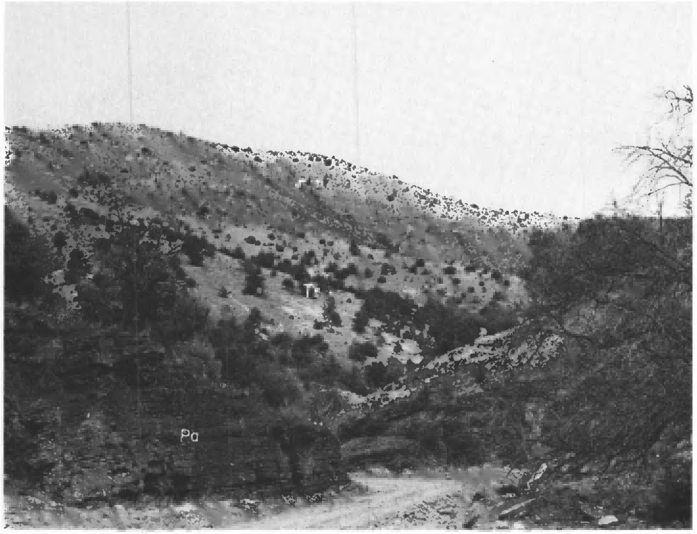

FIGURE 1-47.6—View to north at Stop 2. Thin-bedded Abo Fm. (Pa) in foreground angularly overlain by debris-flow deposits of Tertiary Rubio Peak Fm. (Trp) under light-colored slopes. Large exotic block of Pennsylvanian Madera Ls. (IPm) caps upper third of hill.

Byers, were ambushed by a band of Victorio's Apaches near the stream's headwaters. During a hasty retreat down the drainage, Indian snipers killed one soldier and wounded two others. (New Mexico Recollections by Raymond Schmidt.)

Short traverses up the steep-sided hills on either side of the South Fork of Cuchillo Negro Creek lead to the exotic Pennsylvanian limestone blocks. Best exposures of both underlying Rubio Peak Fm. and exotic blocks are on the north side of South Fork. These particular limestone blocks are the largest of many that occur at one horizon within the Rubio Peak Fm. throughout a 155 km^2 area. The large exotic limestone blocks are interpreted to be of gravity slide origin by Maxwell & Heyl (1976), a position supported by Harrison (this guidebook). Approximately 1.5 mi north of the stop, faulting of this limestone is a major structural control for epithermal Ag–Cu–Pb–Zn mineralization at the St. Cloud mine.

For those not inclined to climb the steep hills, a short 0.5 mi traverse up Byers Run leads to large limestone blocks, some of which are clearly contained within mudflow deposits. Good exposures of Abo and Rubio Peak Fms., as well as examples of high-angle normal faulting and strike–slip faulting, are also present within about 0.5 mi up Byers Run. Excellent exposures of room-sized limestone blocks within debris-flow deposits also occur a short distance up the south-draining White Signal Gulch, a tributary of South Fork whose mouth is just west of this stop.

Return 10.9 mi via same route to Winston. 1.6

49.2 St. Cloud Mill, **bear right** around mill site. **2.4**

51.6 Roads to left and right, **continue straight. 0.7**

52.3 Junction, **turn left** (north) toward Winston. **3.7**

56.0 Chloride road to left, **keep right. 2.5**

FIGURE 1-51.6—View to east on return trip to Winston. Hill in left foreground shows tuff of Little Mineral Creek overlain by gravels of Winston beds of Santa Fe Gr. Distant hill shows Kneeling Nun Tuff (light-colored beds from base to mid-hill) overlain by dark beds of basaltic andesite of Poverty Creek.

58.5 Stop sign at intersection with NM-52 in Winston. **Proceed northward (straight) on NM-52,** up the floodplain of Poverty Creek. Low hills to both right and left along road for next 12.8 mi are Winston beds. Route will cross numerous cattleguards and Poverty Creek and tributaries repeatedly. **1.1**

59.6 Dry Creek turnoff to left. This road is one of the major access routes to the center of Chloride mining district. The old Paymaster, Blackhawk, and Readjuster mines are accessible via this road (if it has not recently washed out). **0.1**

59.7 Jay Cox Ranch headquarters to right. **0.7**

60.4 Turkey Creek road to left. Mining ghost towns of Robinson and Grafton are accessible via this road; a distance of 3 and 6 mi, respectively.

Robinson was founded in 1882 as the projected terminus of a Santa Fe Railroad branch line that was never built. By 1888 the town was deserted and its buildings removed.

Grafton was a relatively active settlement during the late 1800's and early 1900's. It was located near the center of an active portion of the Chloride mining district and served such mines as Ivanhoe–Emporia, Little Granite, Alaska, Montezuma, and Blue Bell. Numerous old foundations are still identifiable as are ruins of an old stamp mill and other mine plants. The last significant operation in the area was pre-WWII mining of the Ivanhoe–Emporia mines by a Japanese company. It is currently operated by local miners on a small scale. **3.1**

63.5 Cattleguard and large, lone ponderosa pine to right. **1.1**

64.6 Sharp bend in road, pavement leaves Poverty Creek and follows unnamed tributary. Riley Peak (2,890 m), the highest peak in Sierra Cuchillo, is visible at 2:00. This mountain mass consists mainly of very fine-grained leucomonzonite, one of the many varieties of Tertiary hypabyssal intrusive rocks in the area. It forms a large discordant body that tapers northward into a thick, 1.5 km long sill enclosed by Pennsylvanian strata. Davis (this guidebook) describes the petrography and chemistry of this intrusion in detail. **2.6**

67.2 Ahead at 2:00 west face of Iron Mtn. is a highly dissected fault scarp with crudely faceted spurs. The following description is after Jahns (1955) and Chapin et al. (1978): Just over the stand of piñon pine is a craggy exposure of pinkish-weathering Tertiary aplite low on the mountain front. Similar cliff-forming outcrops appear on the spurs farther south (right), where the aplite is intrusive into Precambrian metarhyolite. The smooth, grassy slopes above them mark the outcrop belt of metamorphosed sandstone and siltstone of the Cambro-Ordovician Bliss Ss. These strata and an overlying sedimentary section of Ordovician to Pennsylvanian age dip eastward at moderate angles. Together with Permian strata east of the mountain, this sequence is the northwesternmost among all those exposed in southwestern New Mexico that contains a representation of all the Paleozoic systems.

In second gully south of North Peak (2,473 m) just below ridge are dumps from exploratory workings developed during 1942 and 1943 in scheelite-bearing tactite that flanks a dike of porphyritic rhyolite.

The craggy, pinkish-brown outcrops low on the front of North Peak are porphyritic rhyolite and rhyolite breccia, which form an irregular plug-like intrusive mass on the north side of Discovery Gulch. Higher on the relatively bare north side of this gulch is a purplish-gray dump that marks the position of a small fluorspar mine. The site of Brown City, a former mining camp, is in the thickly wooded area at the mouth of Discovery Gulch. **1.1**

68.3 Junction with NM-59 (Beaverhead Road)—**turn left toward Beaverhead.** NM-52 continues through Dusty and on to US-60 near the Very Large Array Radiotelescope west of Magdalena. Dirt road to right leads to ghost town of Brown City and Iron Mtn.

Driving along drainage divide between Poverty Creek–Cuchillo Negro drainage to south and Alamosa Creek drainage to north. Sawmill Peak is visible at 11:45, Wahoo Peak at 2:00, and Lookout Mtn. at 10:00. This surface is a small remnant of a high alluvial surface, possibly the surface marking highest aggradational level of Winston graben, and hence may be equivalent to the Cuchillo surface to the east. **2.4**

70.7 Cattleguard. Entering Gila National Forest. Information display to right. **1.0**

71.7 Cattleguard. **0.4**

72.1 Crossing buried western boundary fault of Winston graben. At least 1,525 m of stratigraphic displacement exists across this section of the fault. **0.3**

72.4 Driving through outcrops of rhyolite of Sawmill Peak [informal name of Eggleston (in press), same as red lataite lava of Coney (1976)]. **0.2**

72.6 Descending from Little Red Hill. Occidental mine dumps visible at 11:00, Minnehaha at 10:00, and Great Republic at 9:45. These mines are on north end of the Great Master Lode, 13 km + epithermal vein structure that contains "shoots" of precious-metal mineralization. Vein mineralization similar to that of the Great Master Lode can be inspected at Stop 3. **0.2**

72.8 Outcrop of basaltic andesite of Poverty Creek in roadcut to right. **0.2**

73.0 Dirt road to left leads to Occidental, Minnehaha, and Great Republic mines along the Great Master Lode. Intensely altered volcanic rocks on hill at 2:00. **0.1**

73.1 Crossing buried Great Master Lode fault zone, down to east. Rocks of lower Rubio Peak Fm. (similar to those viewed at Stop 2) occur in the footwall. **0.2**

73.3 Crossing Wildhorse Creek, road to Wildhorse fuel wood area to right. **0.7**

74.0 Old townsite of Fluorine and outcrops of Fluorine vein to right. A 30 m thick exotic Paleozoic limestone block crops out in hillsides to both right and left. As was the case with limestone blocks at Stop 2 (19 km to south), the fluorine area exotic blocks occur within debris-flow deposits of the lower Rubio Peak Fm. **0.1**

74.1 **STOP 3. Park as directed.** An example of precious-metal epithermal mineralization, typical of the northern Chloride mining district (Harrison in this guidebook),

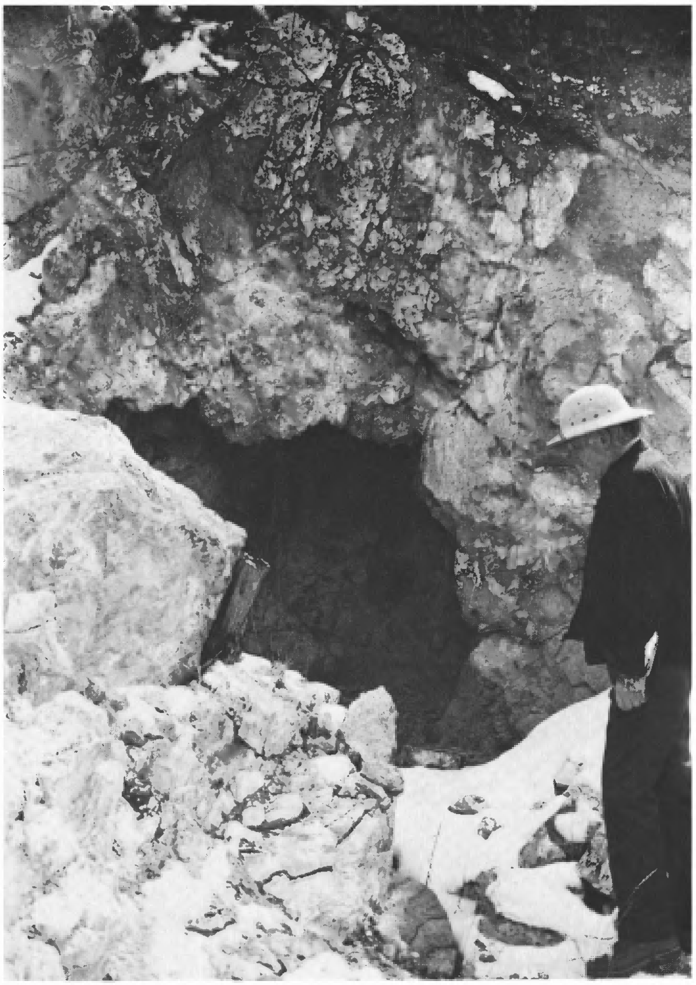

FIGURE 1-74.1—Small adit at Fluorine townsite exposed fissure vein cutting Pennsylvanian limestone block. Vein which dips slightly to left is composed mostly of quartz, with lesser calcite, barite, and fluorite. Small dark streaks contain the copper and silver values. Free gold is occasionally found in reddish hematite-stained rocks on dumps.

is exposed in prospect pits south of road. **Beware of open, 15 m deep shaft.** Vein mineralization occurs as fissure filling of fault zones that cuts the Rubio Peak and exotic limestone blocks. Gangue mineralization consists of quartz, calcite, fluorite, and minor barite. Precious-metal mineralization occurs as dark, very fine-grained bands and pods of argentite and tetraherite, with common $CuCO_3$ and occasional native gold. Assays across the mineralized portion of this vein run about 0.2% Cu, 4.5 oz/t Ag, and 0.1 oz/t Au. This vein structure has in excess of 30 m of vertical fault displacement at this locality. It is also a miniature duplicate of the structural control responsible for localizing mineralization at the St. Cloud mine (about 18 km to the south). That structural control is defined by a limestone hanging wall and debris-flow breccia footwall, with an overlying limestone–limestone situation. This vein system is but one of many similar vein systems that occur in the northern Chloride mining district (Harrison in this guidebook).

Also of interest at this stop are the exotic Paleozoic limestone blocks, smaller than those at Stop 2, but still quite impressive. The limestone blocks at this stop and those at Stop 2 occur at about the same stratigraphic horizon, approximately 150–180 m above the base of the Rubio Peak Fm., and perhaps represent a single, catastrophic emplacement event. **0.2**

74.3 Exotic blocks of Paleozoic limestone crop out to both sides of road. **0.2**

74.5 End of limestone block, andesites for next 3 mi. Cross Wildhorse Creek, and cattleguard. **0.1**

74.6 Aphanitic basaltic andesite of upper Rubio Peak Fm. crops out on both sides of road. **0.6**

75.2 "Turkey Track" andesite of upper Rubio Peak Fm. along road. **0.9**

76.1 Drainage divide between Poverty Creek to south and Wildhorse Creek to north. Sawmill Peak visible at 9:00–10:00. **0.6**

76.7 Driving through exposures of "Turkey Track" andesite, aphanitic basaltic andesite and ash-flow tuffs of upper Rubio Peak Fm. **0.4**

77.1 Poverty Creek Store, cross Poverty Creek. **0.4**

77.5 Rocks on either side of road are andesite and basaltic andesite of Rubio Peak Fm. **0.1**

77.6 Cliffs ahead at 9:00 across Poverty Creek are a crystal-rich, quartz-rich, ash-flow tuff. The tuff from this locality has been dated at $35.6 \pm .1$ my by $^{40}Ar/^{39}Ar$ method (McIntosh et al. in this guidebook) and tentatively correlated with the Kneeling Nun Tuff of Elston et al. (1976). An exact correlation with the type section of the Kneeling Nun is presently uncertain. Regardless, this unit is lithologically similar to, and in the same stratigraphic position as, the "Kneeling Nun" seen earlier south of Winston and in the Sierra Cuchillo. This unit is mapped as the first stratigraphic unit above the Rubio Peak Fm. throughout this area (Harrison in this guidebook). Dips are low and Kneeling Nun comprises outcrops on both sides of road for next 0.7 mi. **0.7**

78.3 Koko Well on left. Steep bank at 9:00 across Poverty Creek consists of the Kneeling Nun Tuff overlain by 5–10 m of ledgy volcaniclastic rocks and a fairly thick, unwelded, rhyolitic ash-flow tuff. The volcaniclastic interval and ash-flow tuff are mapped together and informally named the tuff of Koko Well (Eggleston in press, Harrison in this guidebook). Regionally, this unit may be as much as 100 m thick, although erosion of the top beneath the basaltic andesite of Poverty Creek makes the thickness variable. The base locally contains volcaniclastic rocks, as it does here. In some areas, the ash-flow tuff has a thin lower rhyodacitic interval. Intermediate lavas of the basaltic andesite of Poverty Creek overlie the Koko Well under alluvial valley ahead. **1.7**

80.0 Cattleguard at Mud Hole. The park-like, rolling topography along Poverty Creek is underlain by the basaltic andesite of Poverty Creek. The strata from here to our last stop (mile 99.1) are flat lying or dip a few degrees west and are structurally relatively simple. We will gradually pass up section as we drive west. We are presently driving through intermediate lavas of the basaltic andesite of Poverty Creek. Several grossly similar, poorly welded ash-flow tuffs overlie the Poverty Creek in this area and are in turn overlain by rhyolitic lavas and associated pyroclastic rocks. The rhyolite lavas comprise the Taylor Creek Rhyolite (Elston 1968) and the rhyolite of Dolan Peak (Coney 1976). Detailed stratigraphic relations of these units are given by Eggleston (in press). These exact correlations are not universally accepted, but are followed in this road log. For the purposes of this log, details of the stratigraphy are de-emphasized in favor of a broader stratigraphic and structural viewpoint. For a stratigraphic column of these units see Eggleston & Norman (this guidebook).

High ridge to right (north) capped by tuff of Stiver Canyon (Woodard 1982) and the rhyolite of Sawmill Peak (Eggleston in press; formerly red latite of Coney 1976). The tuff of Stiver Canyon crops out extensively both north and south along the eastern edge of the Black Range. The Stiver Canyon usually underlies all of the Sawmill Peak; however, on this hill a thin flow of Sawmill Peak lava also underlies the tuff (Eggleston in press). Apparently, the geologically instantaneous ash-flow tuff was emplaced between two lava flows from the same center. **0.6**

80.6 Road to gravel pit on right in tuff of Stiver Canyon. Stiver Canyon here is pink and altered due to an alteration halo around the rhyolite porphyry of Kline Mtn. (Eggleston 1982) or to argillic alteration localized along approximately north–south fractures. **0.7**

81.3 Kline Mtn. at 9:00. The north edge of the rhyolite porphyry intrusion (Eggleston 1982) is just past crest of mountain. **0.3**

81.6 Road crosses from basaltic andesite of Poverty Creek onto tuff of Stiver Canyon and then approximately 0.2 mi ahead onto the tuff of Kline Mtn. (Eggleston 1982). The rhyolite of Sawmill Peak which separated these two units at mile 76.0 has pinched out. The tuff of Kline Mtn. is the unit which is altered at the Continental Divide clay pits 0.6 mi ahead. The Kline Mtn. consists of a sequence of thin pumiceous layers with somewhat variable phenocryst content and may be as thick as 200 m at the clay pits where advanced argillic alteration has obscured nearly all of the primary features of the rock. **0.6**

82.3 Continental Divide. A shallow shaft just left of road and numerous bulldozer cuts both north and south of road prospect altered tuff of Kline Mtn. for kaolinite and/or alunite resources. Some samples from the shaft here are nearly pure kaolinite (Ericson et al. 1970, T.L. Eggleston unpubl. data), whereas others contain appreciable alunite (C.H. Maxwell unpubl. data). **0.2**

82.5 **OPTIONAL STOP.** Park in flat area left of road (OK when wet). Pit is about 150 m south of road behind stockpiles. Pit was opened to produce kaolinite for the paper industry apparently without adequate testing. Some of the kaolinite in the area is reported to be high quality except for minor quartz and chalcedony impurities which make it unsuitable for commercial use (Ericson et al. 1970). The material here, however, uniformly contains abundant alunite in addition to kaolinite and smaller amounts of chalcedony and cristobalite. Chalcedony, in addition to being disseminated throughout the tuff, occurs as large discrete blobs (replacement bodies?). One is exposed in this pit and another on the ridge to the south. Still others are found in the numerous undeveloped cuts in this vicinity. Eggleston & Norman (this guidebook) relate this alteration to the Kline Mtn. intrusive. Nearer the intrusion alunite content increases to as much as 70%. Alunite from that area has been dated at 27.6 ± 1.2 my (conventional K/Ar technique, AR40* = 0.007682 ppm, K40 = 4.723 ppm, average values for two analyses) (T.L. Eggleston unpubl. data). **0.2**

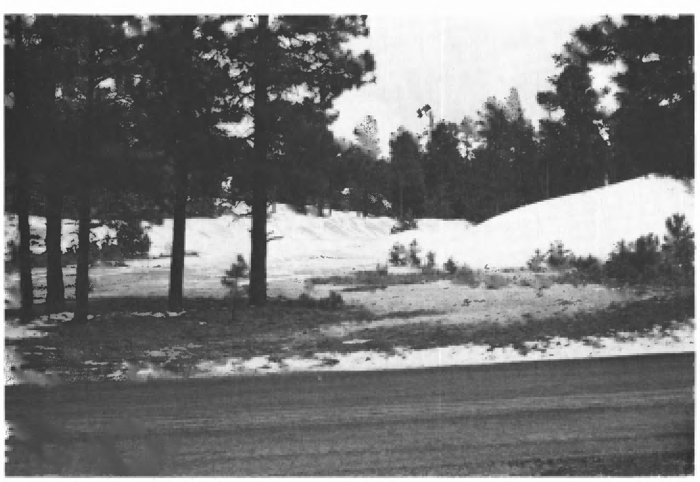

FIGURE 1-82.5—Stockpiled clay minerals at the Kaolin Pits near the continental divide. The main excavations are visible through the trees behind the stockpiles.

ALTERATION ASSOCIATED WITH THE RHYOLITE PORPHYRY OF KLINE MOUNTAIN, BLACK RANGE, NEW MEXICO

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The rhyolite porphyry of Kline Mountain intrudes a thick sequence of Tertiary volcanic rocks (Fig. 1) that include, in ascending order, basaltic andesite of Poverty Creek, tuff of Stiver Canyon, rhyolite of Sawmill Peak, rhyolite of Dolan Peak, tuff of Kline Mountain, and La Jencia Tuff (Eggleston in preparation). This subvolcanic intrusive is an irregularly shaped mass of high-silica, vertically flow-banded rhyolite porphyry consisting of about 3% quartz, 5–7% sanidine, and traces of plagioclase and biotite phenocrysts in a lithoidal groundmass.

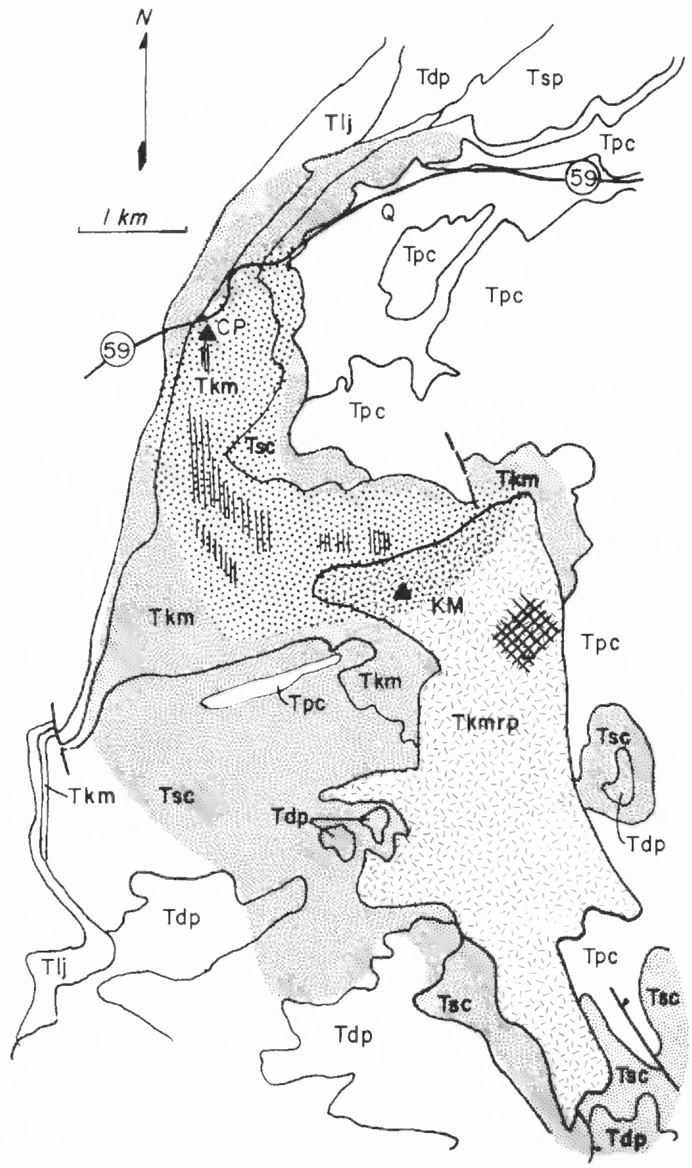

FIGURE 1—Alteration surrounding rhyolite porphyry of Kline Mountain. Tpc = basaltic andesite of Poverty Creek; Tsc = tuff of Stiver Canyon; Tsp = rhyolite of Sawmill Peak; Tdp = rhyolite of Dolan Peak; Tkm = tuff of Kline Mountain; Tlj = La Jencia Tuff; Tkmrp = rhyolite porphyry of Kline Mountain. Blank area on west side of map is covered by volcanic rocks younger than the Le Jencia Tuff and Quaternary deposits. KM = Kline Mountain; CP = kaolin pits. Random hachure pattern is the area of the intrusive. Vertical ruling indicates zones of intense silicification (replacement bodies) and cross-ruled pattern indicates area of quartz stockworks within the intrusive. Coarse-sand pattern indicates advanced argillic alteration; fine-sand pattern indicates argillic alteration.

Alteration surrounding the intrusive includes propylitic alteration of the basaltic andesite of Poverty Creek, with argillic and advanced argillic alteration of the rhyolite lavas and ash-flow tuffs overlying Poverty Creek. The propylitic alteration consists of epidote, calcite, and possibly chlorite coatings on fractures, and is nowhere pervasive. Within the area of Fig. 1, all basaltic andesite of Poverty Creek is altered and the alteration dies out immediately to the northeast. The argillic-alteration assemblage is restricted to felsic rocks and consists of clay minerals which have replaced the groundmass and plagioclase feldspars. Sanidine is little affected by this alteration. Pumice fragments are progressively replaced by clay minerals with increasing alteration intensity. Relict pumice textures are frequently observed on weathered surfaces. Silica veining increases as the boundary of the advanced argillic assemblage, which is gradational over as much as 1 km, is approached.

The advanced argillic assemblage consists of kaolinite, alunite, and chalcedony and is exposed in a north-trending zone which parallels the continental divide north of Kline Mountain for a few kilometers. Large silica replacement bodies with relict quartz phenocrysts are common in this assemblage. X-ray-diffraction analyses of argillically altered tuff from a shallow shaft where NM-59 crosses the continental divide indicate that the tuff is nearly pure kaolinite with only minor quartz contamination. On the north flank of Kline Mountain, the tuff of Kline Mountain has been converted to about 70% alunite, 20% kaolinite, and 10% silica species. Alunite generally decreases away from the intrusive, although a distinct zonation has not been defined. This pattern of alteration suggests that the heat source for the alteration was the intrusive and that the fluid flow was controlled by north-trending structures. Such structures have not yet been identified.

Near the north boundary of the intrusive, advanced argillic alteration has obscured the contact with surrounding rocks. Immediately south of the advanced argillic alteration, quartz–pyrite stockworks are hosted by intensely silicified intrusive. The entire intrusive is silicified to some degree. Chemical analyses from the relatively fresh southeastern part of the intrusive indicate that the intrusive is a high-silica rhyolite similar to known molybdenum-porphyry systems, although no economic mineralization is known.

The alteration has been dated by K–Ar techniques at 27.6 ± 1.2 my (see road log for analysis). This date can be applied to the intrusive if one assumes that the intrusive is the heat source for the alteration and thus indicates that it is the youngest igneous rock in the area.

South of the Kline Mountain area, Woodard (1982) described a number of intrusives with similar alteration, which form a 10–20 km long, roughly north–south trend, with the Kline Mountain intrusive at the north end. Woodard's descriptions suggest that these intrusives are chemically and mineralogically similar to the Kline Mountain. These similarities and the spatial association suggest that the age of the intrusives may likewise be similar.

82.7 Welded ash-flow tuff correlated by Eggleston (1982) with the La Jencia Tuff (Osburn & Chapin 1983) from the Magdalena Mtns. is exposed above tuff of Kline Mtn. to north of alluvial area along highway. **0.3**

83.0 Road to Adobe Ranch to right also leads to Nugget Gulch, the major tin producer of the district (access log provided). About 74,000 lbs of tin concentrate were reported (unverified) from placers here in 1960's and 1970's. Maxwell et al. (this guidebook) divide the deposits in this district into several types depending on the complexity of their paragensis. Stop 5 will examine the simplest type which is related to degassing and vapor-phase recrystallization of the rhyolites. We will not stop at examples of their more complex types; however, an access log is provided here to Nugget Gulch which Maxwell et al. (this guidebook) describe as complexly mineralized and favorable for exploration. The reader should consult Maxwell et al. (this guidebook) for details of the other types of deposits. **0.2**

ALTERNATE ROAD LOG TO NUGGET GULCH TIN DEPOSITS

Do not take this trip if roads are wet and puddles are full of water, the wet tuff has no bottom!

0.0 Adobe Ranch road at mile 78.8 of first-day log. Turn right (north). **1.7**

1.7 Road forks. Take left road. **0.3**

2.0 Cliffs at 2:00–3:00 are lithic tuff, apparently from Tin Mtn. dome at 1:00. Crossing broad, flat area on local tuff units associated with the rhyolite domes. **0.8**

2.8 Road intersection; go straight ahead up hill, across narrow cattleguard and turn right down ridge. **0.6**

3.4 Intersection, road downhill to left goes to Squaw Creek. Go straight ahead through gate. **0.8**

4.2 Indian Peaks at 10:00, South Water Canyon dome and flows from 10:00 to 2:00, Tin Mtn. dome at 2:00–5:00. **0.2**

4.4 Road forks, keep right down hill, bear right across creek and past log cabin. Four-wheel drive from here on or a short walk. Many trenches, shafts, and adits to right of road. For details see Fries (1940).

End of alternate log.

MAIN LOG cont'd

83.2 Bedrock here is a non-welded, crystal-rich, rhyolitic ash-flow tuff correlated by Eggleston (in press) with the tuff of Garcia Camp (Lawrence & Richter in press). The Garcia Camp is extremely phenocryst-rich (quartz and sanidine) and is interpreted to have erupted as a precursor to the Indian Peak domes of the Taylor Creek Rhyolite. Contact ahead (before hill crest) with underlying local pyroclastic unit. This tuff interval is petrographically similar to Taylor Creek Rhyolite near here; poor exposures conceal exact relationship. A portion of this deposit will be examined at Stop 4 where it is well exposed in Scales Canyon. There, excellent exposures allow use of modern classification schemes based on sorting and grain-size characteristics of individual beds (Fisher & Schminke 1984) to distinguish air-fall, surge, and ash-flow deposits. **0.2**

83.4 Crest of hill, Burned Cabin Flat ahead. **0.6**

84.0 Road on left to Lookout Mtn. **Turn left for Stop 4,** 9.8 mi round trip. If roads are extremely wet, especially during spring thaw, access to this stop may be impossible. Valley-bottom roads sometimes cannot be traversed and even this "all-weather" road can be treacherous. Access via 0.5 mi hike is possible from cattleguard 1.9 mi ahead if this road is passable and the valley road is not.

Rocks across arroyo from NM-52 at turn are a carapace breccia on one of the Taylor Creek domes. See Eggleston & Norman (this guidebook) for description and names of individual domes that compose the Taylor Creek Rhyolite. All of the Taylor Creek is at least moderately phenocryst-rich and contains subequal quartz and sanidine phenocrysts with traces of plagioclase, biotite, and opaque oxides. Total phenocryst content varies from dome to dome. Vapor-phase recrystallization is common. **1.9**

85.9 Cattleguard. If road is muddy, valley road will be impassable. Park here and walk about 0.5 mi southeast into Scales Canyon to reach the stop. **0.6**

86.5 Begin the descent into Scales Canyon. **0.6**

87.1 Sandstone of Inman Ranch (Eggleston in press) exposed along road. Deposits are dominantly fluvial sandstones and conglomerate with minor eolian intervals. Also present are a number of massive, structureless sandstone layers as much as 2 m thick, which are believed to be deposited from hyperconcentrated flood flows (Smith 1986). Much of the sandstone and conglomerate detritus consists of tuffaceous material and clasts of Taylor Creek Rhyolite. La Jencia Tuff(?) fragments are common near the top of the unit, suggesting a source to the east where the La Jencia is exposed. **0.1**

87.2 Thin tuff interval exposed in roadcuts. This material is fine-grained but poorly sorted, and is probably an ash-flow tuff, perhaps the distal end of a regional ash-flow-tuff sheet. Paleomagnetic-pole position and phenocryst mineralogy suggest a correlation with the South Canyon Tuff of Osburn & Chapin (1983) (W.M. McIntosh unpubl. data). **0.4**

87.6 **Turn hard left** up Scales Canyon. Road is rough and narrow; **high clearance required!** Timber-covered hills from 11:00–3:00 before turn are Taylor Creek Rhyolite mantled by thinly bedded pyroclastic material and underlain by a thin, poorly welded ash-flow. Crossbedded volcaniclastic sedimentary rocks (Inman Ranch of Eggleston & Norman in this guidebook) sporadically exposed along canyon walls for next 1 mi. **1.0**

88.6 Base of sandstone of Inman Ranch overlying a 30 m thick coarse breccia consisting of mildly vesiculated angular to rounded Taylor Creek Rhyolite clasts. Breccia is paleomagnetically homogeneous and, therefore, was hot when emplaced. It is thought to be a coarse block-and-ash-flow that formed when a growing dome or spine collapsed. Breccia overlies a thinly layered pyroclastic sequence which overall is mineralogically similar to, and probably related to emplacement of, the Taylor Creek Rhyolite domes. **0.3**

88.9 **STOP 4. Parking tight, park as directed in meadow to right of road.** The object of this stop is to examine the sequence of thinly layered pyroclastic rocks and overlying breccias. These excellent exposures contain a number of beautifully developed ash-flow-tuff units showing normal grading of lithics and reverse grading of pumice fragments. Many other less easily classified layers are present to test your observational skills. Most of the pyroclastic section consists of 0.5–1 m thick ash-flow tuffs. Packages of thin ash-flow-tuff intervals are locally separated by unconformities. Pyroclastic fall deposits frequently mantle paleotopography along these unconformities and eolian beds also occur. Key to distinguishing between ignimbrites and air-fall deposits is the concept that ignimbrites are poorly sorted, whereas air-fall deposits are better sorted ash or pumice.

Three major pyroclastic episodes are recognized here (Kyle et al. in this guidebook). The first is characterized by numerous thin ash-flow tuffs totaling as much as 35 m in thickness. This interval is overlain by 5 m of fine to coarse, subaerial ash-fall deposits. At least 10 m of coarse breccia caps the sequence composing the third interval. The first two intervals represent numerous pyroclastic eruptive events, whereas the third probably formed from collapse of a growing lava dome.

Retrace route 4.9 mi to NM-59. 1.3

90.2 **Turn hard right from valley road to gravel. 3.6**

93.8 NM-59. **Turn left. 0.1**

93.9 **Sharp corner, drive carefully.** Just beyond this corner, pumiceous tuffs associated with Taylor Creek Rhyolite crop out. The contact with the Taylor Creek lava is under valley immediately ahead. The exposures on the hillside to the right (north) are a dome carapace breccia (Boiler Peak–Paramount Canyon dome of Eggleston & Norman in this guidebook). **0.2**

94.1 Cattleguard. **Caution,** winding road the next several miles, drive carefully. **0.1**

94.2 Road to the south, though now closed, accesses the "Clearing," one of many local tin occurrences. A small amount of tin was produced from veins and colluvial placers at this site (Maxwell et al. in this guidebook). Driving on Taylor Creek Rhyolite for next several miles. **0.2**

94.4 Forest road to right. **0.3**

94.7 Boiler Peak at 12:00. **0.3**

95.0 Small, localized gravel deposits exposed in roadcuts to left. **0.3**

95.3 Excellent exposures of Taylor Creek Rhyolite in arroyo at 2:00 and along road ahead for 0.3 mi. **1.5**

96.8 Forest roads 677 and 665 to the right. We have just

FIGURE 1-96.8—West flank of Black Range from near Boiler Peak is a gently sloping plateau with deeply incised canyons and a few isolated hills. Plateau topography is possibly due to pedimentation.

crossed the contact between two Taylor Creek Rhyolite domes. The poorly exposed contact is perpendicular to the road and in the saddle behind you. Farther down arroyo to the south, the contact is marked by a thick accumulation of pyroclastic rocks and by carapace breccias on top of, and conformable with, the underlying Boiler Peak–Paramount Canyon dome. Good exposures of nearly horizontal, thin flowbanding in the Taylor Creek Rhyolite on right of road. **1.2**

98.0 Minor road to right leads to prospects in Adams Canyon. **0.6**

98.6 Taylor Creek Rhyolite exposed in low, rounded outcrops on both sides of road for next 0.3 miles. **0.5**

99.1 **STOP 5. Park on left side of NM-59 as directed.** Follow track through gate to rim of canyon (~400 m). Parking allows only two to three vehicles to drive to the overlook. This stop provides a view of tin mineralization related to vapor-phase activity during cooling of the Taylor Creek Rhyolite. In this area 50 m of relatively unaltered, flow-banded, and locally lithophysal rhyolite overlie a zone of light-colored (bleached), intensely vapor-phase recrystallized rhyolite (Fig. 1-99.1). Tin mineralization occurs as thin stringers and veins of hematite and cassiterite along discrete zones in the lithophysal rhyolite, best seen in outcrops along the canyon rim. Drusy linings of vapor-phase minerals are present in lithophysal cavities (vesicles) within this rhyolite. These have been described by numerous workers including Fries (1940), Fries et al. (1942), Lufkin (1972), Lufkin (1976), and Kimbler & Haynes (1980). In addition, Eggleston & Norman (this guidebook) and Maxwell et al. (this guidebook) describe this and other similar occurrences in their discussion of the genesis of tin mineralization in the Black Range. Minerals present in these zones in relative order of abundance include quartz, specular hematite, topaz (hard to tell from quartz), bixbyite, pseudobrookite, and red beryl (rare) first discovered here in 1979 and reported by Kimbler & Haynes (1980). This assemblage is similar to that reported from other topaz rhyolites in the western U.S. (Burt et al. 1982).

Within the white, intensely vapor-phase recrystallized zone below the lithophysal zone, the Taylor Creek Rhyolite has been converted to a granular aggregate of quartz and sanidine. Groundmass crystallite size has been much enlarged and quartz and sanidine phenocrysts are strongly overgrown. Often the rock is granular and can be dug out with a hammer. Minor clay minerals, possibly of weathering origin, are found in this zone (Eggleston in press). Despite this extensive recrystallization, major-element chemistry of the rock is essentially unchanged, as are most trace elements. Strontium and the rare-earth elements are somewhat enriched. The model proposed for the origin of this and numerous similar occurrences in the district is that high-temperature (650°; Eggleston & Norman in this guidebook) magmatic fluids evolved and migrated out of the rhyolite as it was emplaced and began to cool. There fluids recrystallized the host rhyolite. Near the surface metals precipitated on the walls of open cavities in response to very large thermal gradients. Some recrystallization of lithophysae walls is present and was described by Kimbler & Haynes (1980): "The crystals are weakly attached to the rhyolite matrix due to the small amount of quartz sand occurring in the vugs." The gases were soon exhausted and consequently the amount of mineralization is small. Short-lived, meteoric-water-dominated hydrothermal systems formed as the rhyolite cooled and deposited variable amounts of quartz, calcite, fluorite (Eggleston & Norman in this guidebook), and locally complex fluoroarsenates (Foord et al. 1985). This scenario is presented as a general model for Black Range tin occurrences by Eggleston & Norman (this guidebook). Maxwell et al. (this guidebook) report more complex occurrences, for which they envision a cooler hydrothermal component and greater resource potential.

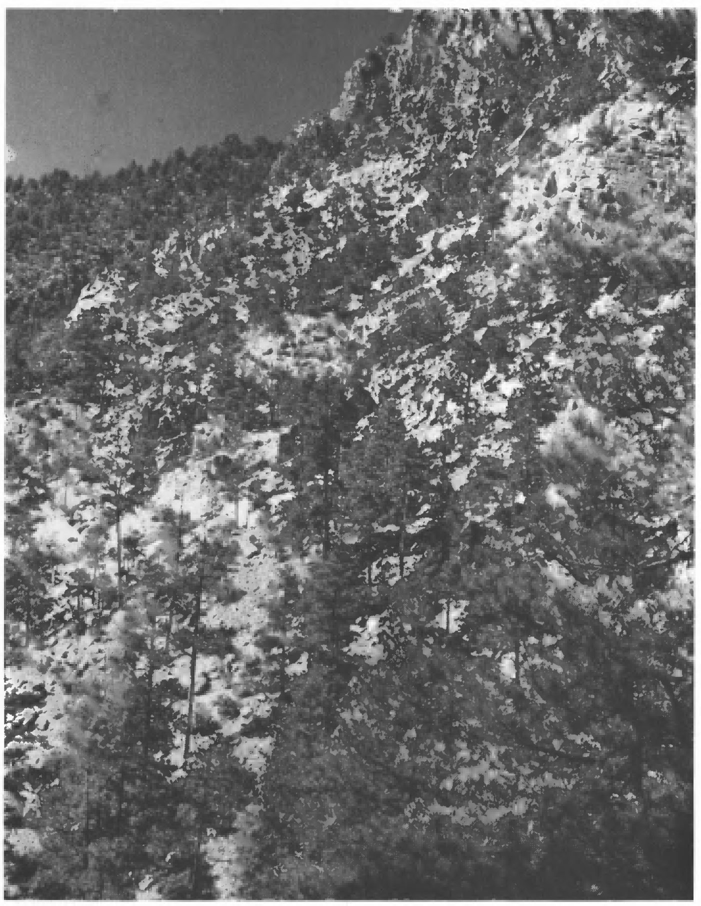

FIGURE 1-99.1—Intense vapor-phase recrystallization in Paramount Canyon. The white rocks in foreground are intensely vapor-phase recrystallized Taylor Creek Rhyolite. The rhyolite in cliff above is mildly vapor-phase recrystallized and lithophysal. This cliffy, mildly recrystallized rock hosts tin veinlets a few hundred meters to the right of the field of view. View to north from near the bottom of Paramount Canyon.

Return to T or C via NM-59 to NM-52 (21.1 mi), NM-52 to Winston (9.8 mi), to US-85 (30.4 mi) and south to T or C (~6.0 mi), a total of 67 miles.

End of trip.