Circular 153 1976

Guidebook to Albuquerque Basin of the Rio Grande Rift, New Mexico

by

V.C. Kelley,
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and J.F. Callender

New Mexico Bureau of Mines & Mineral Resources

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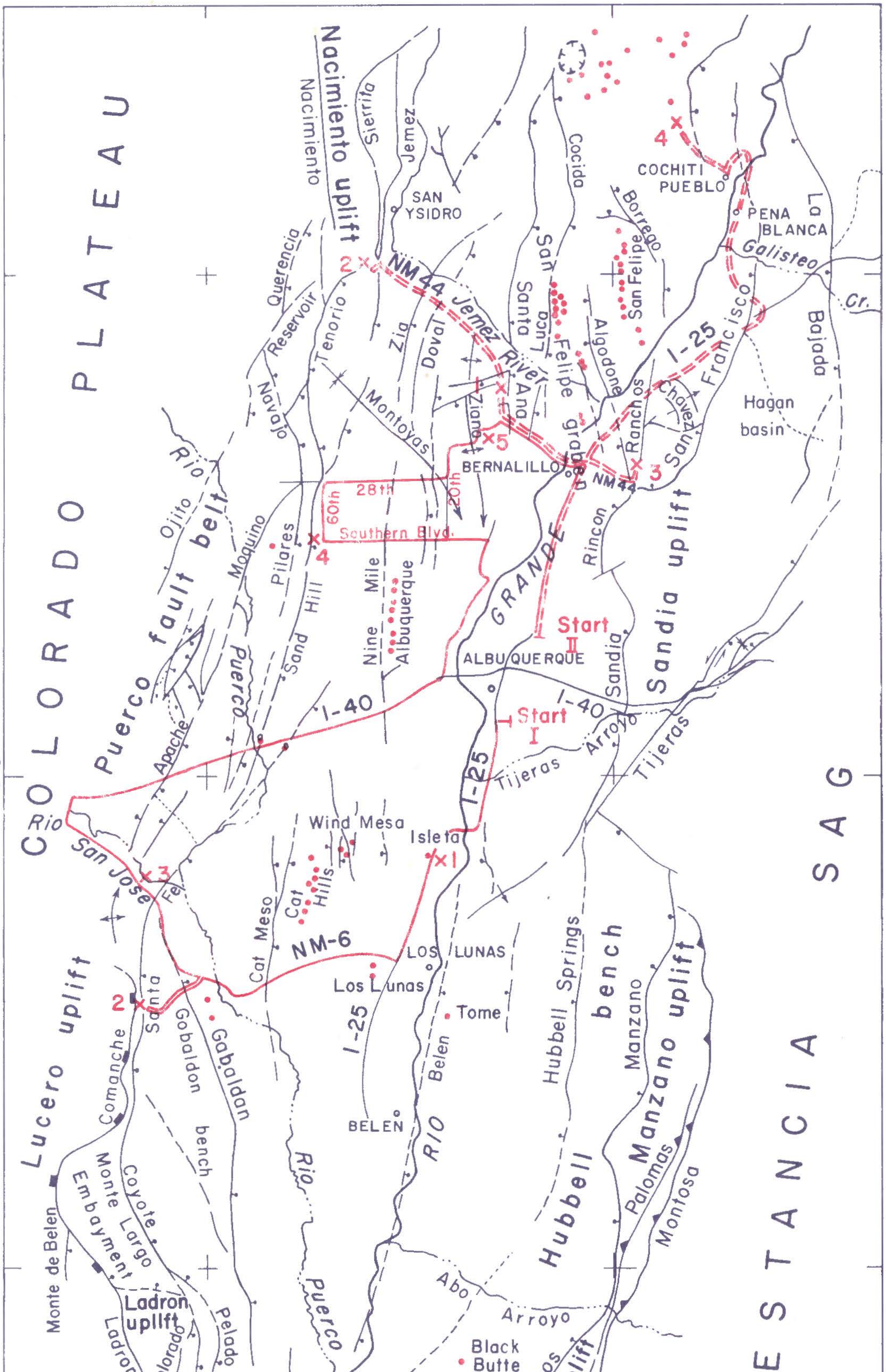

TRIP ROUTES (IN RED) PLOTTED ON TECTONIC MAP OF ALBUQUERQUE BASIN.
Fault symbols: ball on down side normal fault; barb on up side thrust fault; block on up side reverse fault.

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by Vincent C. Kelley, Lee A. Woodward,
Albert M. Kudo, and Jonathan F. Callender

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Contents

FIGURES

Nos 1-21, First Day; Nos. 22-32, Second Day

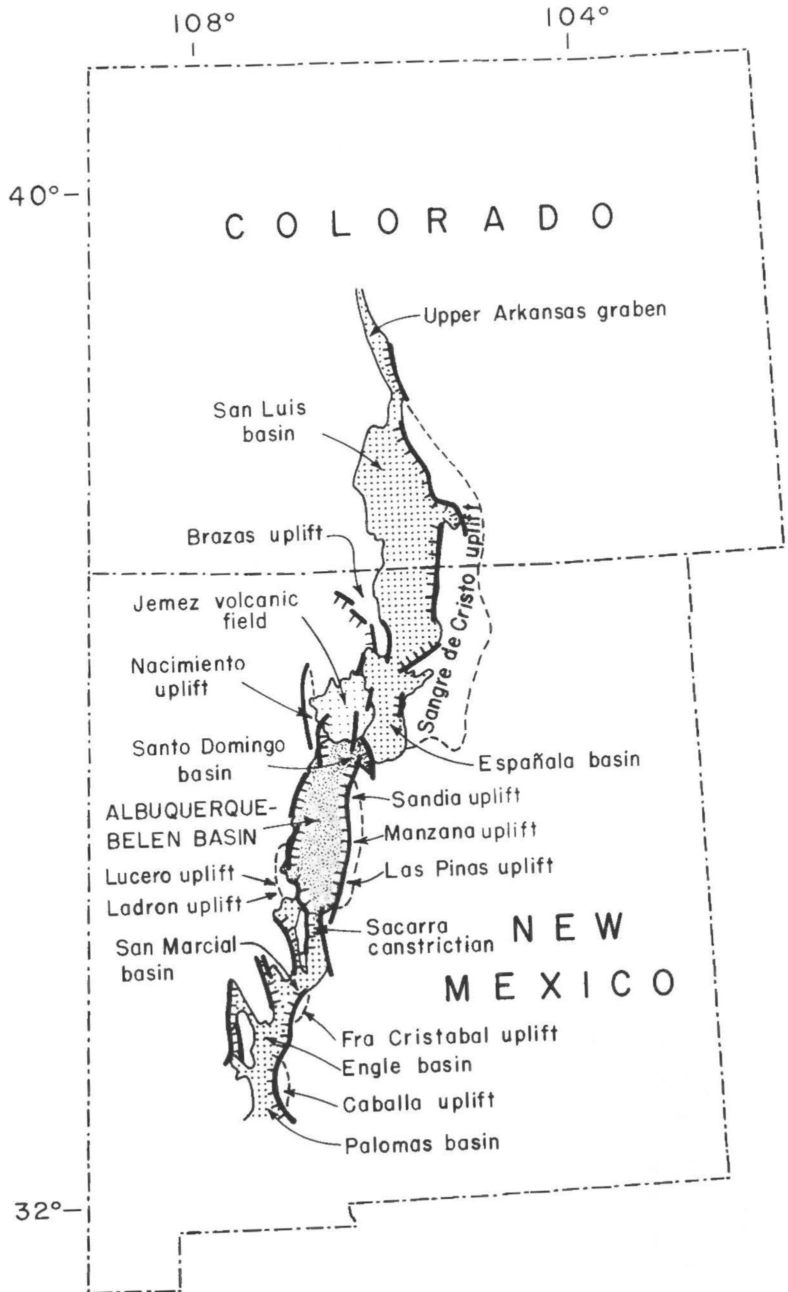


FIGURE 1—Index map of Rio Grande rift (stippled area).

Introduction

The Rio Grande rift is comprised of a series of north-trending grabens (arranged en echelon north-northeasterly) occurring for a distance of at least 450 miles in New Mexico and Colorado (Kelley, 1952). Antithetic and synthetic faults occur within the major grabens, forming step faults as well as second-order grabens and horsts. The major grabens, usually referred to as basins, are described from north to south (fig. 1).

The Upper Arkansas Valley in Colorado may be the northernmost graben of the Rio Grande rift (Chapin, 1971). This basin probably extends to the Continental Divide north of Leadville and is linked with the San Luis Valley to the south by a structural constriction containing late Cenozoic sediments. The basin narrows to a point at its north end where the graben dies out.

The San Luis basin is about 150 miles long and 55 miles wide. This basin is tilted eastward, with possibly 35,000 ft of structural relief on the east side adjacent to the Sangre de Cristo uplift. In addition to late Cenozoic sediments, volcanic rocks also occur within the basin.

The Española basin, 40 to 50 miles long and 18 to 40 miles wide, is connected with the San Luis basin by the Embudo constriction. To the west, near Abiquiu, the Española basin is bounded by high-angle faults downthrown mostly to the east. These faults are covered by extrusive rocks of the Jemez volcanic field to the south, but reappear in the vicinity of Battleship Rock along Jemez Creek. Other high-angle faults offset the volcanic rocks at many localities, indicating continued development of the graben during and after volcanism. The Española basin is tilted westward and is linked with the Albuquerque basin to the southwest by the La Bajada constriction.

The Santo Domingo basin and Albuquerque-Belen basin (Kelley, 1952) are considered as one tectonic feature in the present report. This feature, about 90 miles long and 30 miles wide, is hereafter called the Albuquerque basin. The depth to Precambrian rocks in the Albuquerque basin may be about 18,000 ft below sea level (Black and Hiss, 1974), with total structural relief of approximately 28,000 ft between the deepest part of the Albuquerque basin and the Sandia uplift. Several basaltic and andesitic volcanic centers occur within the Albuquerque basin. The west side of the basin is bounded by the Nacimiento uplift, the Puerco fault belt, the Lucero uplift, and the Ladron uplift.

The Jemez volcanic field straddles the western margin of the Rio Grande rift and consists of a thick pile of Pliocene and Quaternary extrusive rocks. Present elevation of the Jemez Mountains is due to accumulation of volcanic rocks rather than to structural uplift. Some of the sedimentary strata filling the Albuquerque basin grade into volcanic rocks of the Jemez field. To the south, east, and northeast the sediments filling the Rio Grande rift are also unconformably overlain by the Jemez volcanics.

Volcanism began after initial development of the Rio Grande rift and continued contemporaneously with later stages of rifting. Early eruptions of basalt were followed by extrusion of andesite, dacite, quartz latite, rhyolite, and rhyolitic ash flows (Ross and others, 1961). In the southern and eastern parts of the Jemez field, high-angle faults related to rifting were active during and after volcanism resulting in eastward thickening of the volcanic pile (Ross and others, 1961).

The rift narrows just south of Socorro, but a gravity survey by Sanford (1968) suggests that basement may be nearly 10,000 ft below sea level there. South of Socorro the rift consists of three small basins, the San Marcial, Engle, and Palomas, with lengths ranging from 15 to 30 miles, and widths from 12 to 20 miles. These basins have north-northwesterly trending extensions that die out to the northwest.

The southern extent of the Rio Grande rift is in question. Some workers believe it merges with the Basin and Range province in the vicinity of Hatch, New Mexico at the south end of the Palomas basin; others would extend the rift to El Paso, or even further south into Mexico (fig. 1).

This guidebook was prepared specifically for one of the field trips in connection with Geological Society of America Rocky Mountain Section meeting held in Albuquerque, May 19-23, 1976. For more details on the area the following recent publications are recommended. They are available from the New Mexico Bureau of Mines and Mineral Resources, in Socorro, and from the Geological Society of America in Boulder, Colorado. Also, during the meeting, copies may be purchased in the Geology Building on the University of New Mexico campus.

Albuquerque—its mountains, valley, water, and volcanoes. By V. C. Kelley, 1974. New Mexico Bureau of Mines and Mineral Resources, Scenic Trips, No. 9, 2nd ed., 106 p. ($2.50). A guide for professional geologists as well as the layman; provides an overview of the geology of the Albuquerque area, including the adjacent Sandia Mountains, Rio Grande valley, and the mesa west of town.

Geology of Sandia Mountains and vicinity, New Mexico. By V. C. Kelley and S. A. Northrop, 1975. New Mexico Bureau of Mines and Mineral Resources, Memoir 29, 136 p. ($12.50). Provides in-depth discussion of stratigraphy and structure of the Sandia uplift, including a detailed geologic map in color (scale 1:48,000) of areas seen at Stop 3 of Second Day.

Geologic map of the Jemez Mountains, New Mexico. By R. L. Smith, R. A. Bailey, and C. S. Ross, 1970. U.S. Geological Survey, Map I-571, scale 1:125,000 ($1.00). Includes the area of volcanic rocks in Jemez Mountains and sedimentary strata of northern part of Albuquerque basin seen at Stop 4 of Second Day.

Tectonic map of the Rio Grande rift, New Mexico. By L. A. Woodward, J. F. Callender, and R. E. Zilinski, 1975. Geological Society of America, Map and Chart Series #MC-11, scale 1:500,000 ($5.00 folded, $6.00 rolled). Shows all the structural features of the rift from Hatch, New Mexico to the Colorado-New Mexico border, including the features seen on the field trip. Adjacent uplifted borders of the rift are also shown.

Geologic map and sections of the San Ysidro quadrangle, New Mexico. By L. A. Woodward and R. L. Ruetschilling, 1976. New Mexico Bureau of Mines and Mineral Resources, Geologic Map 37, scale 1:24,000 ($2.00). Shows in detail the geology of boundary of Rio Grande rift at Stop 2 of Second Day.

Central Part of Albuquerque Basin

RÉSUMÉ (FIRST DAY)

This trip covers a distance of 167 miles. The first stop is at Isleta volcano, a short distance south of Albuquerque. The special features and problems of this volcanic field are seen and described. The eastern border uplifts are in full view from this stop. The route then crosses the Albuquerque basin to its western border at the Lucero uplift. Along the way several other volcanic centers and fields are passed, especially on Ceja Mesa the surface of which is thought to be a remnant of the Ortiz pediment (early Pleistocene). From the western edge of the mesa the long, low Lucero uplift is seen to merge into the prominent and most unusual Ladron uplift at the southwestern corner of the basin. Santa Fe beds, the basin-bounding Santa Fe fault, and possible Laramide deformation are seen at Carrizo Arroyo in the Lucero uplift.

After Stop 2, the route doubles through the Rio Puerco fault zone and passes back into the Albuquerque basin along I-40 and again across the high Ceja Mesa divide. From its eastern rim is seen the grand view across the inner valley of the Rio Grande at Albuquerque with the great Sandia backdrop along the basin's eastern border. The route then goes north along the western edge of the Rio Grande valley to Rio Rancho, thence west again across the dissected northern end of Ceja Mesa to the Rio Puerco rim (Stop 4). Here, the type area of the Bryan and McCann subdivisions of the Santa Fe Group appear as spectacular badlands.

The final leg of the trip is across a dissected portion of Ceja Mesa to an overlook of the Jemez Valley at Stop 5. At this point more of the Santa Fe strata is seen, including the relationship of the Bryan and McCann members to Galusha's Zia Sand Formation.

GEOLOGIC ROAD LOG

Mileage

000.0 STARTING POINT on east side of Girard Ave. (in southeast Albuquerque) 0.3 miles south of Gibson Ave. Proceed north to Gibson Ave.
0.3

0.3 Gibson Ave. *Turn left.* Ceja Mesa, forming the western skyline, is 70 miles long and up to 8 miles wide. It is the divide between the Rio Grande valley and the Rio Puerco valley, west of the mesa. The surface is thought to be a pediment (Ortiz pediment), but a distinct capping of gravel is not easily defined. There is, however, a distinct, well-developed caliche, and much wind-blown sand in sheets, long obscure longitudinal dunes, and dune piles, especially along the western windward edge. Scattered lag gravel in the sand indicates much scalping by the winds (Kelley, in preparation).
0.5

0.8 Stop signal at Yale Ave. *Straight ahead.*
0.5

1.3 Stop signal at University Ave. *Straight ahead.*
0.2

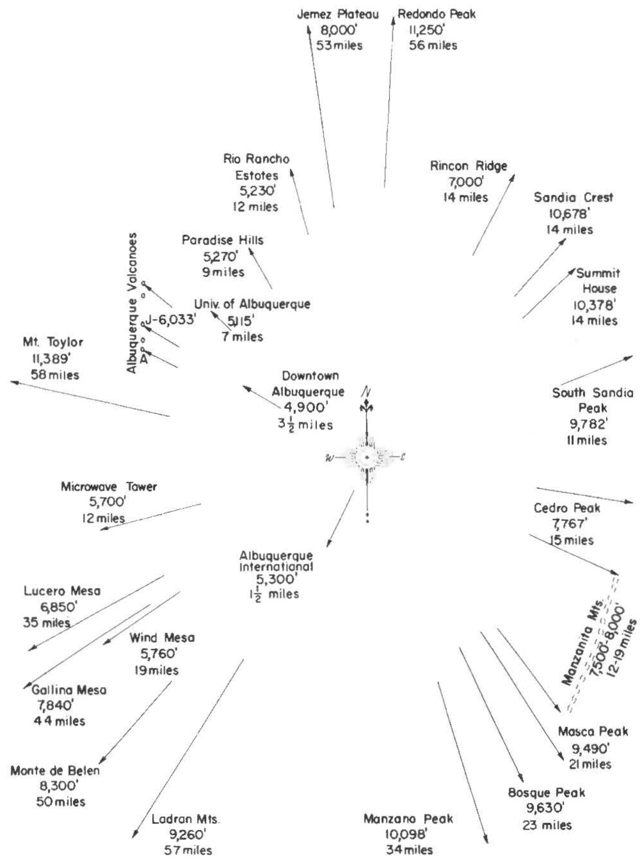


FIGURE 2—PANORAMIC INDEX OF FEATURES SEEN FROM STARTING POINT (FIRST DAY).

1.5 I-25 ahead, use left lane for turn to onramp beyond overpass.
0.3

1.8 *Turn left* to I-25 South; at 2.0 merge onto I-25.
0.5

2.3 Road crosses Albuquerque Heights south diversion ditch (Kelley, 1974, p. 23); exposures of sand and gravel of the Santa Fe Formation in cuts ahead.
0.9

3.2 Bridge over railroad spur to Sandia Base. University of New Mexico south golf course on hills on left.
0.3

3.5 New Mexico Public Service Company power plant (Person Station) at 1:00. Capacity is 114,000 KW. It is fueled by natural gas with standby oil installations. Source of fuel is the San Juan Basin of northwestern New Mexico. The plant also houses the statewide Transmission Systems Control Center for all plants. (Early on the Second Day trip, a similar facility will be seen north of Albuquerque, the Reeves plant with 175,000 KW capacity.)

Rio Grande flood plain on right; Wind Mesa basaltic hills on Ceja Mesa of western horizon at 2:30.
0.7

4.2 Exit 220, Rio Bravo Blvd. *Straight ahead* on I-25. Note gray gravel in roadcut on right; this is axial gravel (Bryan, 1938) of the Santa Fe Formation.
1.3
5.5 Bridge over railroad spur. Large valley ahead is Tijeras Arroyo which drains into the Rio Grande from tributaries through and east of the Sandia uplift.
0.7
6.2 Overpass.
1.2
7.4 Magdalena Mountains, far distance at 12:30; at 1:00 Los Lunas volcano in middle distance across Rio Grande valley, with Ladron Peak (Precambrian) on line in far distance. At 1:30 Isleta volcano and location of Stop 1. High flat ridges on far skyline, from Isleta volcano to 2:00, are part of Lucero uplift west of trough. At 2:30 on Ceja Mesa are the Wind Mesa basaltic hills.
1.6
9.0 Exit 214, Broadway (NM-47). *Straight ahead* on I-25 and curve west to cross the valley.
0.8
9.8 Overpass; bridges across Rio Grande ahead.
0.5
10.3 Bridge over main line of A.T. & S.F. railroad. Isleta volcano at 11:00.
0.5
10.8 Rio Grande.
0.5
11.3 Exit 213. *Continue straight ahead.* Basalt above big roadcut ahead has no outcrop connection with the Isleta volcano at 11:00. It thins out away from the view. A buried vent is suspected in the flood plain somewhere between here and the flow.
0.7
12.0 Begin big roadcut; Santa Fe river gravel capped by the beheaded basalt flow. In cuts ahead may be seen a gradual increase in fingers of basaltic tuff blown out of the early Isleta maar.
0.6
12.6 Bridge over Coors Rd.
0.4
13.0 Note pinch-out of lava flow on right and prevalence of basalt tuff in bluffs on right.
0.3
13.3 At 3:00 unconformity; inward-dipping basalt tuff and breccia of maar on truncated, flat-lying similar beds outside the crater. No. 1 flow, a lava lake eruption of the Isleta cone, lies just above. This feature will be seen ahead; it extends about 100 degrees of arc around the east side of the old buried maar, at Stop 1.
1.2
14.5 **STOP 1.** Park right of road. Features of the eastern margin of the Albuquerque basin and some of the nearby basaltic and andesitic eruptions can be seen (figs. 4 & 5).

From top of small mesa east of road, walk 100 yds down gulley east of road for excellent exposure of maar contact. Isleta volcano is a compound volcano with a cone buildup of five flows 1 to 1.25 miles in diameter and rising about 300 ft above its base on an earlier maar of basalt tuff-breccia (Kelley and Kudo, 1976). In addition, there are several outlying basalt flows with no exposed connection to the volcano. The lowermost flows of the volcano may have been part of a lava lake that erupted in the maar (fig. 6).

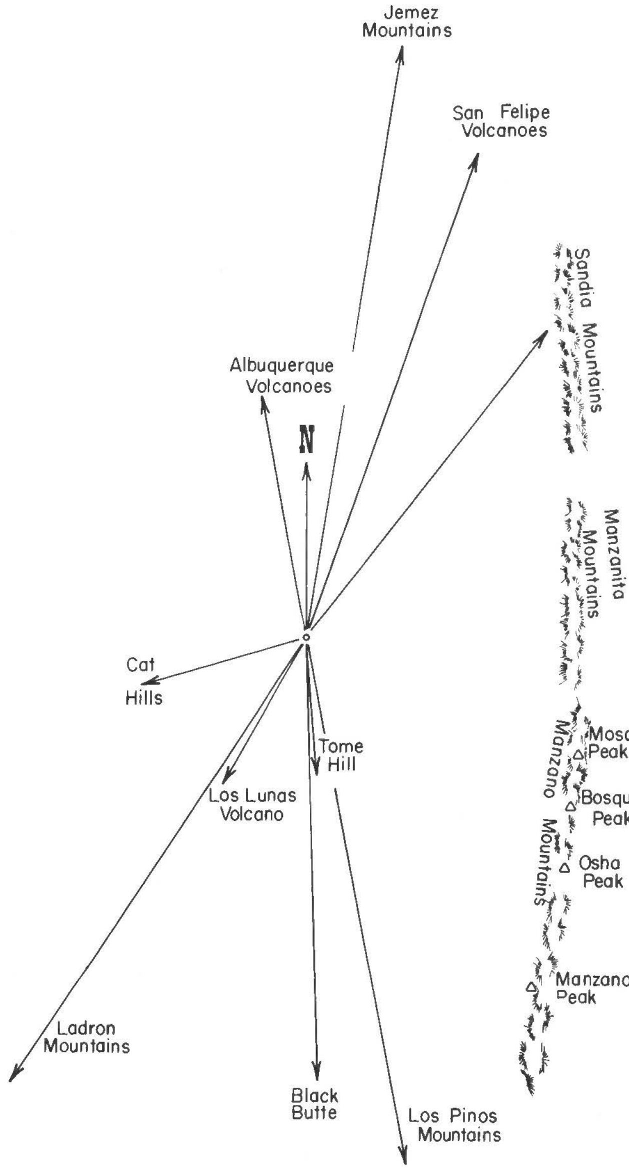


FIGURE 3—PANORAMIC INDEX OF FEATURES SEEN FROM STOP 1.

Of the six flow units delineated in the main cone, flow 1 and flow 2 are medium- to dark-gray, finely vesicular olivine basalt. Flow 3 and flow 5 are likewise olivine basalt, but slightly coarser and with less olivine. Flow 4 is pyroclastic scoria breccia. Plagioclase phenocrysts of flow 1 and flow 2 are An_{65}; phenocrysts of plagioclase from flow 3 range from An_{63} to An_{52}; and plagioclase from flow 5 is An_{52}.

The Isleta flows have affinities with alkali olivine basalts as evidenced from petrography, chemistry, and differentiation trends. Some of the flows contain green augite phenocrysts and inclusions of wehrlite.

0.6

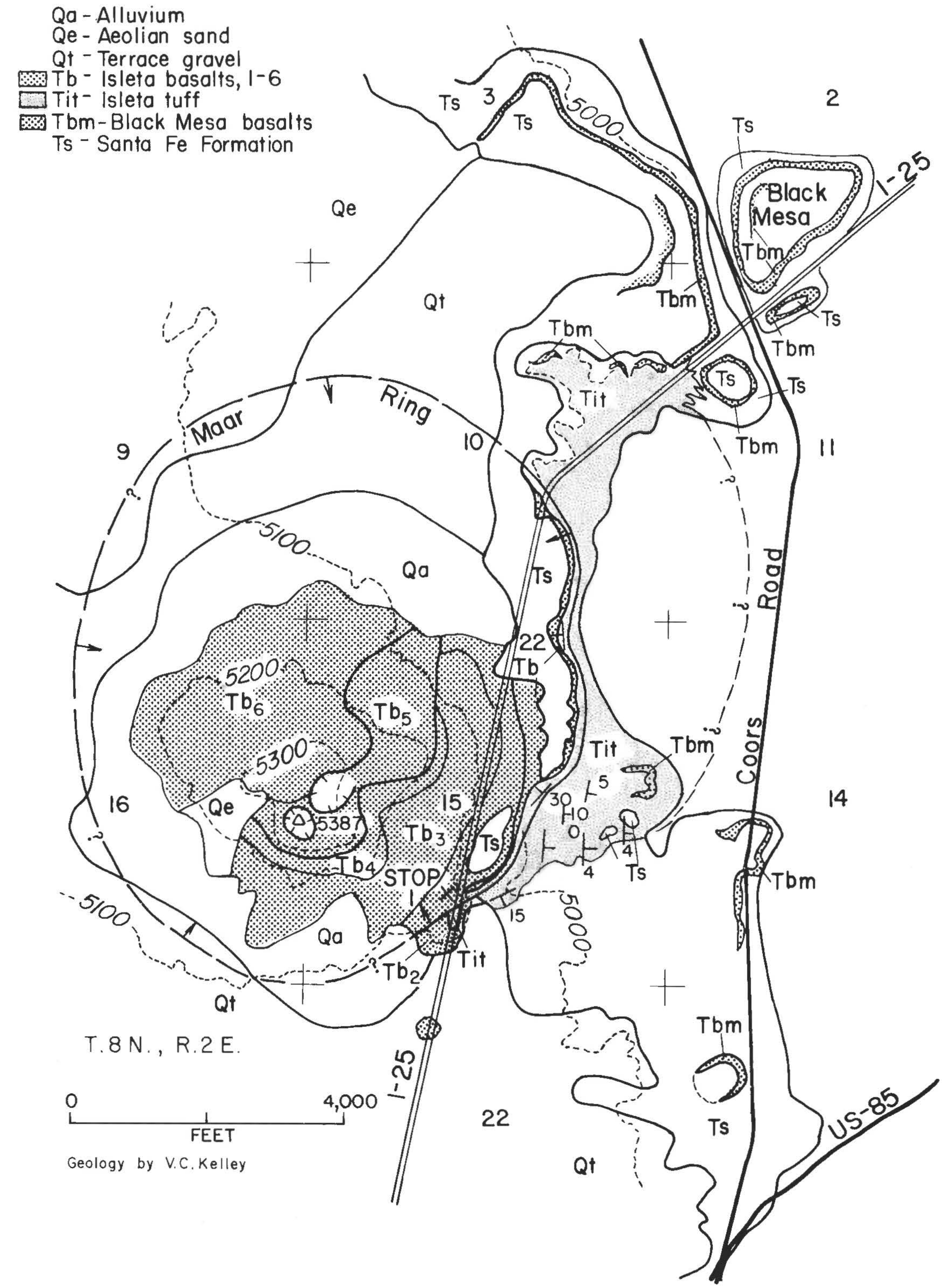


FIGURE 4—Geologic map of Isleta volcano. (Stop 1)

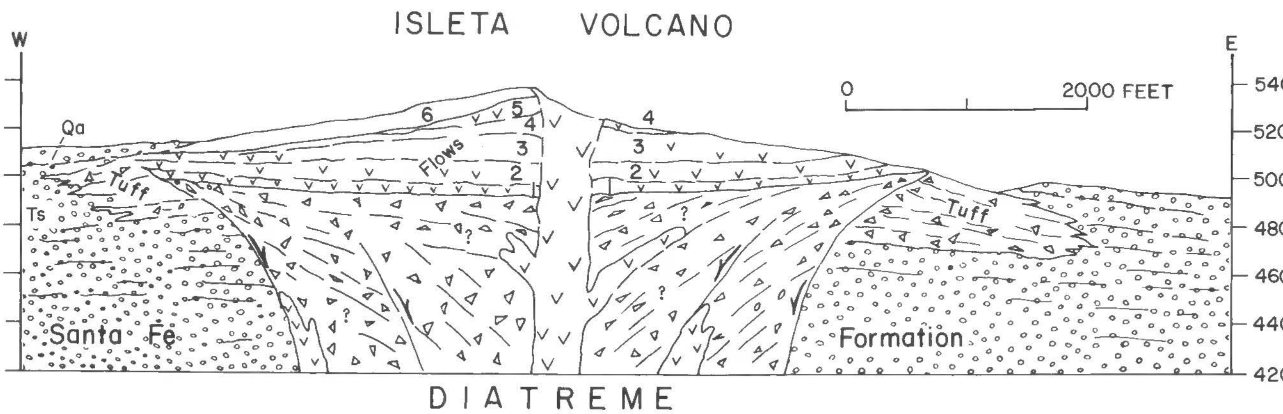


FIGURE 5—STRUCTURE SECTION OF ISLETA VOLCANO. (STOP 1)

FIGURE 6—CONTACT OF EDGE OF ISLETA MAAR. BEDS ARE TUFF BRECCIAS; BEDS TO LEFT ARE IN THE MAAR COLLAPSE AND ARE CAPPED BY BASALT, POSSIBLY A LAVA LAKE IN THE MAAR. BEDS ON RIGHT WERE DEPOSITED OUTSIDE THE VENT BEFORE COLLAPSE. (STOP 1)

15.1 Exit 209 to Isleta Pueblo. *Continue straight ahead.* Wind Mesa basalt flows, 3:00; Cat Hills flows and cinder cones, 2:30. Road ahead traverses a terrace of the Rio Grande. Road is about 110 ft above the river here but descends southward to about 70 ft above river near Los Lunas. Road is lower than the mesa surface across the valley. That mesa surface is correlated with the Ceja Mesa surface beneath the lava flows on the western skyline (Kelley, in preparation).

1.4

16.5 Bridge over A.T. & S.F. railroad; Los Lunas volcano at 1:00 is andesite.

1.6

FIGURE 7—VIEW SOUTHWEST OF LOS LUNAS VOLCANO. NOTE TILTED STRATA OF SANTA FE FORMATION ON EXTREME RIGHT. (REFERENCE MILEAGE 16.5)

18.1 Basalt flow on low bench west of road erupted from Cat Hills fissures aligned with the cones on the western skyline.

1.6

19.7 At 3:00 about 1 mile west, on line with second cone from south, Shell Oil Company drilled its Isleta Central well in early 1975 to a total depth of 16,346 ft. The base of the Santa Fe and top of Cretaceous is reported at 12,110 ft.

2.3

22.0 SLOW. *Take Exit 203* to NM-6. Stop sign at 22.3, *turn right.*

0.5

22.5 Los Lunas volcano at 10:30 (see figs. 8 & 9).

Los Lunas volcano consists of 5 flows and 2 vents, all andesite, containing phenocrysts of hypersthene, augite, basaltic hornblende, biotite, and plagioclase ($An_{55\text{-}52}$) (Kelley and Kudo, 1976). Because the flows appear to have cascaded down slopes from the mesa edge, the center of eruption appears to have occurred along the eastern edge of Ceja Mesa after erosion of much of the inner valley. Possibly they flowed over fault scarps. The volcano has been displaced by several faults, the principal ones being an east-west fault between the main vent and the north plug, and a north-south fault that dropped most of the field down on the east with respect to an elevated small patch on the west.

To the west of the volcano an anticline appears to be in the Santa Fe beds, but the crest is marked by a fault downthrown on the west. East of the fault the Santa Fe beds dip east beneath the flat andesite flows. Thus, the volcanic eruption occurred after early faulting and erosional truncation. The truncation surface beneath the andesite along the western edge may be the Ortiz surface; if so, it has been elevated by the fault on the west. The top of the Santa Fe on the upthrown side along the west face is nearly 200 ft higher than any other Santa Fe strata for tens of miles in all directions.

Considerable andesite occurs southwest of the main hill, but mostly in landslide terrain.

0.9

23.4 At 9:30 the large landslide out of the northern feeder of Los Lunas volcano has uncovered a

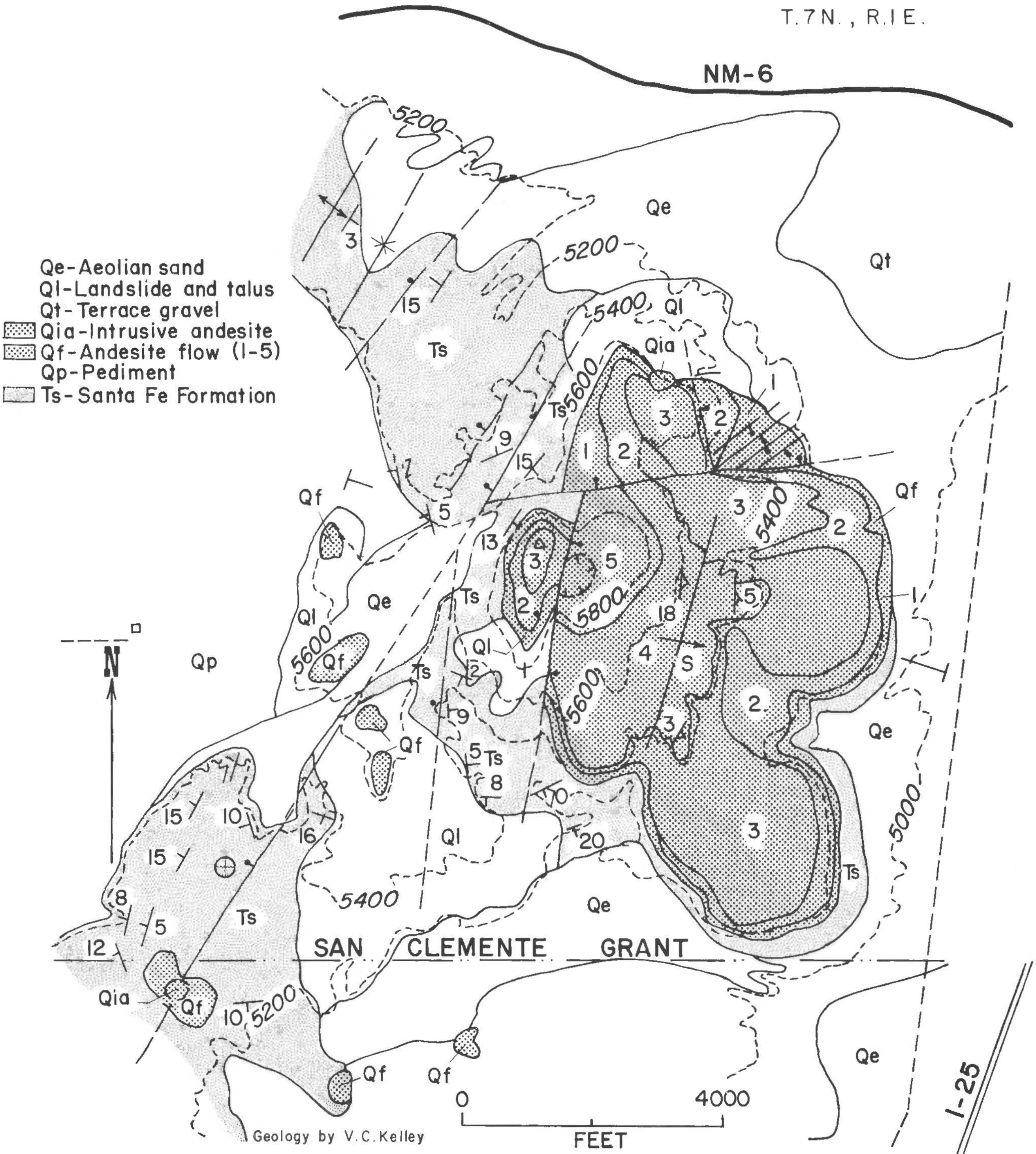


FIGURE 8—GEOLOGIC MAP OF LOS LUNAS VOLCANO. (REFERENCE MILEAGE 22.5)

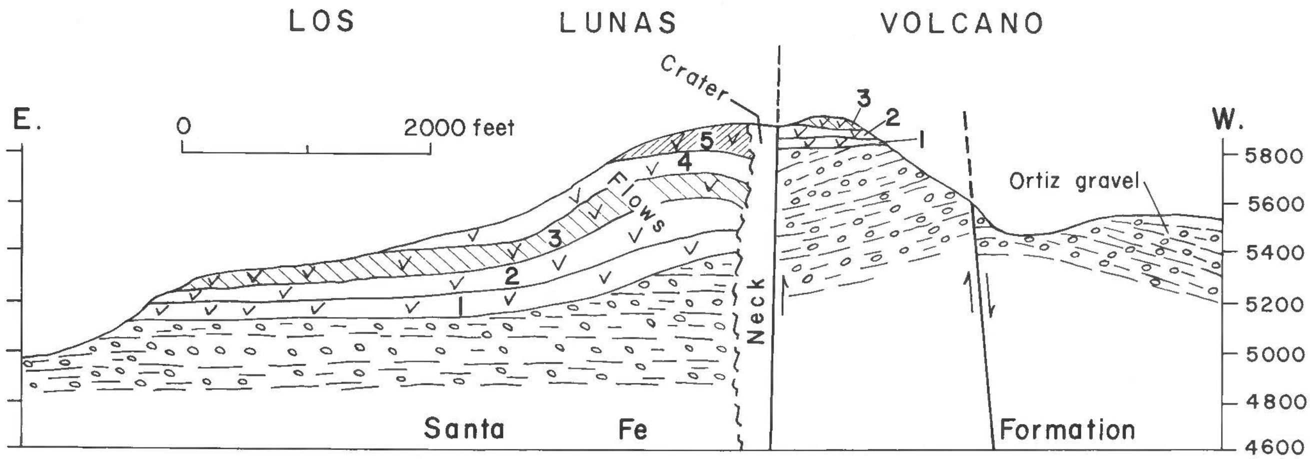


FIGURE 9—STRUCTURE SECTION OF LOS LUNAS VOLCANO. (REFERENCE MILEAGE 22.5)

section of the neck. Note the strong vertical ribbing in the plug transecting thick flows on either side. Some breccia is present along the plug contracts. Ahead note the Santa Fe beds dipping west in the flank of a faulted anticline. The Ortiz surface (early Pleistocene) of Ceja Mesa truncates the beds. Eruption of the andesite cone appears to have taken place on the edge of the mesa and the Ortiz surface, with flows descending the slopes of the mesa.

2.4

25.8 Ortiz erosion surface ahead. Note thin, white caliche bands at rim. Wind Mesa at 3:00; Cat Hills flows and cinder cones from 1:00 to 3:00.

Wind Mesa stands as a low shield volcano near the eastern edge of Ceja Mesa about 6 miles west of Isleta volcano (Kelley and Kudo, 1976). The eruptions crop out in an area of only about 4 square miles; they are nearly 200 ft thick (base not exposed) and consist of several flows of rather uniform character. The field is considerably disrupted by several north-trending faults. The breakup resulted in a central graben adjoined by a horst on the west and two eastward-tilted blocks on the east (see figs. 10 & 11).

All the flows consist of dark-gray to black, irregularly vesicular basalt. The groundmass is fine grained with scattered, anhedral, green olivine phenocrysts to 3 mm in diameter, along with smaller pyroxene and plagioclase phenocrysts.

Nearly a dozen separated and coalesced small cinder cones have broken through the flows in the east-central part of the main horst. The cinder eruptions generally form depressions because they erode more readily than the surrounding flows.

A chemical analysis of one of the lower flows has silica content of 52.35 percent by weight and normative quartz with more normative hypersthene than diopside. Modal abundance of phenocrystic olivine decreases systematically upward in the flow pile, and the ratio of phenocrystic augite to plagioclase and olivine increases. The plagioclase phenocrysts become more sodic in the younger flows, changing from An_{59} in the oldest flow to $An_{55\text{-}43}$ in the youngest flow.

The Cat Hills eruptions consist of extensive flows and cones from a northerly trending fissure zone. About 26 square miles of flows remain. Seven flow units which erupted from the fissures and vents have been mapped. Twenty-three cinder cones are aligned slightly east of north indicating control on fissures, although none is evident at the surface. The first flow units, 1 and 2, have wide distribution north and south, therefore probably came from fissures. Younger flow units have more restricted distribution along the fissure trend, therefore came from either central vents or shorter stretches of fissures. The latest event was cinder cone buildup. The largest and southernmost cone is 500 ft in diameter and 70 ft high with a crater 150 ft in diameter.

The flows are all olivine basalts with alkaline affinities. Chemical analyses (in percent) show following:

Flow no.	Silica	NaO_2	K_2O
2		3.18	1.10
3	48.40-49.66	3.98	0.83
5		3.43	1.30

Petrographically, the basalts contain olivine and plagioclase phenocrysts to 3 mm in an intersertal granular groundmass of brown titaniferous augite, plagioclase, olivine, and opaques. Modally, the phenocrystic olivine to plagioclase ratio decreases upward from 3+ in flow 1 to 0.3 in flow 4. This decrease is reflected in modal plagioclase phenocrysts becoming more sodic from An_{67} in flow 1 to An_{54} in flow 4. The differentiation trend in the eruptions was toward a more undersaturated magma. In the younger flows the decrease in normative hypersthene which becomes slightly nepheline-normative is significant.

0.4

26.2 Road tops Ceja Mesa with view of Lucero uplift ahead on skyline. From 11:30 to 12:00 basalt flows cap gently westward-tilted Triassic and Permian beds of the high, distant Sierra Lucero (Kelley and Wood, 1946). The lower and nearer part of the facade is capped by a younger basalt erupted also on the Ortiz surface, inferred to have been continuous with the surface traversed here by NM-6. The obviously higher position of the Lucero Mesa surface is probably due partly

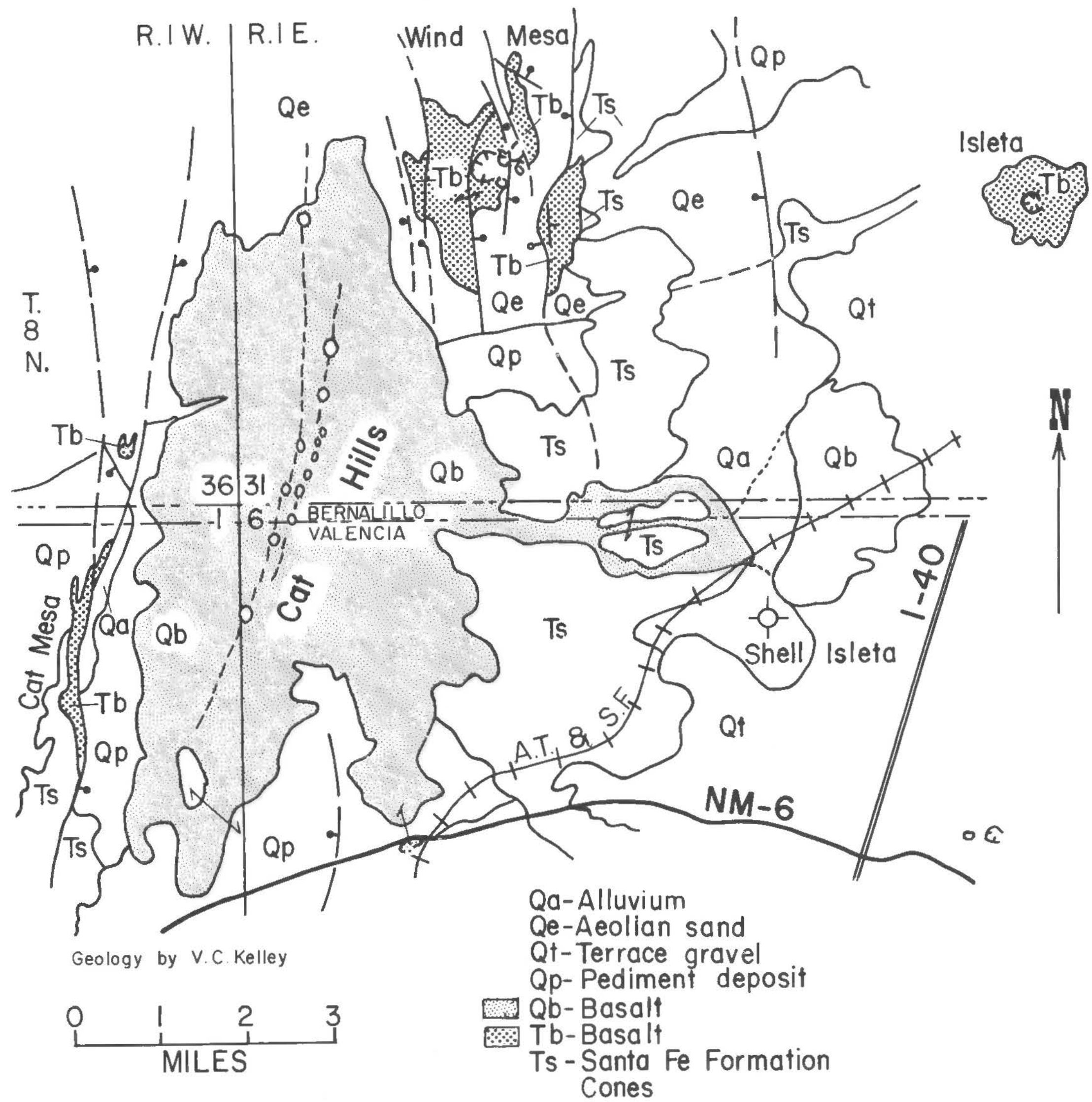


FIGURE 10—GEOLOGIC MAP OF CAT HILLS AND WIND MESA VOLCANIC FIELDS. (REFERENCE MILEAGE 25.8)

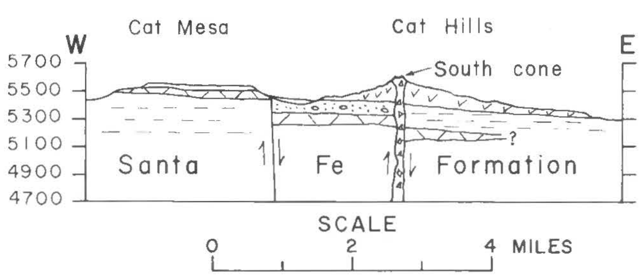


FIGURE 11—STRUCTURE SECTION THROUGH CAT MESA AND CAT HILLS. (REFERENCE MILEAGE 25.8)

to minor late Cenozoic uplift along the basin-margin fault at the base of the Lucero and partly by low doming around the low Lucero cone surmounting the whitish Permian cliffs at 12:30.

Ceja Mesa surface (latest Pliocene or early Pleistocene) is correlated with the Ortiz pediment along the northeastern margin of Albuquerque basin (Bryan, 1938). Identification of early Pleistocene (?) vertebrates in the underlying Upper buff member of the Santa Fe conflicts with radiometric dates of 2+ m.y. for basalt on correlated remnants of the surface.

1.2

27.4 Bridge over A.T. & S.F. railroad.

1.0

28.4 Cattle guard on left. Ladron Peak at 10:00; Mount Taylor at 2:00; and Cat Hills basalt cinder cones at 3:00.

3.5

31.9 Road begins descent into the valley of the Rio Puerco. Mohinas Mountain across valley at 12:10 is a cone sheet of thick basalt and diabase apparently having formed in the base of a volcano that may have erupted a hundred ft or so higher on an exhumed Ortiz surface. The thick, inward-dipping basalt ring has a core of steeply dipping, chaotic blocks of Santa Fe sandstone and mudstone. A similar (but flatter) cone sheet eruption, Hidden Mountain, is situated behind the gravel ridge at 1:00. This cone comes out of hiding at mileage 33.9!

3.7

35.6 Hidden Mountain cone sheet with its landslide aprons of former flanking flows at 9:30. Low Lucero cone on Lucero Mesa at 10:00. Distant Mount Taylor and mid-distant, basalt-capped

FIGURE 12—View southwest of Hidden Mountain. Flanks of hill are tilted Santa Fe beds covered with landslides and colluvium of basalt from vent and perhaps former flows around the center that have since been eroded. The thick basalt cap dips centripetally and was probably emplaced in the base of a former cone. (Reference mileage 31.9)

Mesa Redondo at 11:30 are on the Colorado Plateau west of the Rio Grande trough. The northern end of Lucero uplift seen here and ahead is an asymmetrical anticline plunging northward. Dip slopes of the steep limb incline toward the viewer in rather obscure low hogbacks. Downfaulted, steeply dipping Santa Fe beds are exposed against Permian to Jurassic beds along this part of the basin margin on the Santa Fe fault. The anticline of this part of the uplift gives way southward to the high-angle, reverse Comanche fault. Both features are probably Laramide, prior to late Oligocene.

White patches seen here and farther along near the base of the uplift are active spring deposits of travertine. Older travertine deposits, some the Ortiz surface, are found in and along the Lucero uplift. Preliminary studies of water geochemistry indicate a relatively deep source for the spring waters.

0.5

36.1 Small narrow bridge. Hills on right are flat-lying Santa Fe gravel.

0.9

37.0 Bridge over Rio Puerco ahead. The Rio Puerco rises in the Nacimiento uplift some 90 miles to the north. The gulley which is 20 to 40 ft deep along most of its length began forming out of the flat valley floor about 100 years ago.

0.2

37.2 Bridge on the Rio Puerco.

0.3

37.5 *Turn left* on side road to Lucero uplift.

0.1

37.6 A.T. & S.F. railroad, double track. *Caution,* road curves through fence and across deep Carrizo Arroyo gulley.

0.5

38.1 Fork, take right fork.

0.3

38.4 Hidden Mountain basalt center to left.

0.3

38.7 Cattle guard.

0.4

39.1 Road crosses El Paso Natural Gas Company pipeline.

0.9

40.0 Cattle guard. Santa Fe gravel beds in hill to right.

0.2

40.2 Transwestern Pipeline Company gas line. Gravel beds here dip into the Gabaldon fault situated just over the steep rise in the road. DANGER. KEEP TO RIGHT while crossing ridge. The fault is upthrown on the west. Upthrow on this

FIGURE 13—Oblique airview northwesterly of Gabaldon badlands which are eroded in a thick, westerly dipping section of sandstone and mudstone of the Santa Fe Formation. Lucero uplift front and basalt-capped Lucero Mesa in background. (Reference mileage 40.2)

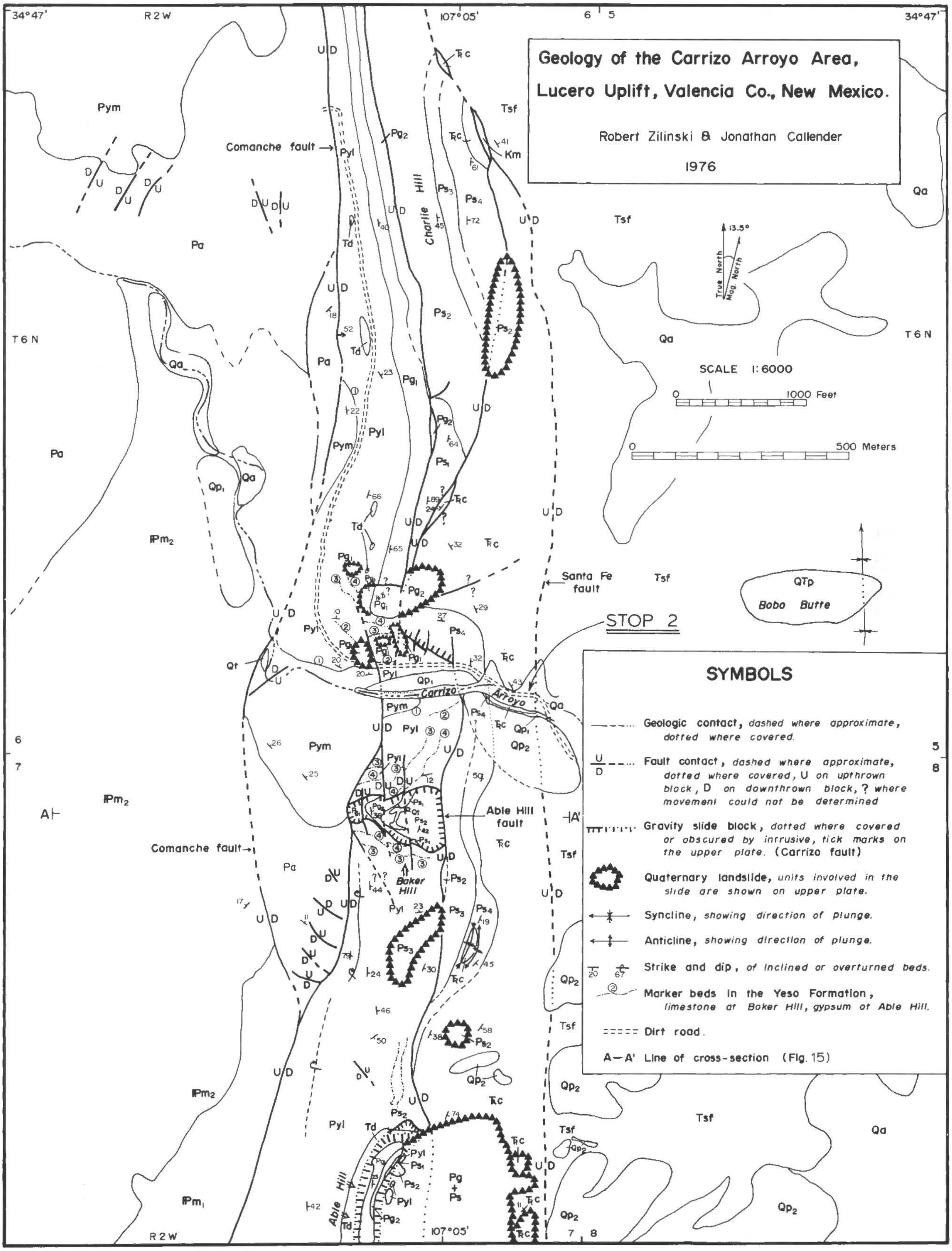


FIGURE 14—GEOLOGIC MAP OF THE CARRIZO ARROYO AREA AT STOP 2, FIRST DAY (AFTER CALLENDER AND ZILINSKI, IN PRESS). IPm$_{1,2}$—Madera Limestone; Pa—Abo Formation; Pym—Yeso Formation (Meseta Blanca Member); Pyl—Yeso Formation (Los Vallos Member); Pg$_{1,2}$—Glorieta Sandstone; Ps$_{1,2,3,4}$—San Andres Limestone; TRc—Chinle Formation; Km—Mancos Shale; Td—microdiorite intrusive; Tsf—Santa Fe Formation; QTp—travertine-cemented pediment gravels; Qp$_{1,2}$—pediment gravels; Qt—travertine and tufa; Qa—alluvium and colluvium.

fault 3 to 6 miles to the south tilts up a beautifully exposed 3,000-ft-plus section of Santa Fe (Wright, 1946; Kelley and Wood, 1946).

1.9

42.1 *Turn right* on side road.

0.6

42.7 Flat-topped hill at 12:00 is Bobo Butte. Note the syncline running through the hill in Santa Fe mudstones and sandstones with local pebbly conglomerate beds. The flat cap is gravel and travertine, probably deposited on a remnant of the Ortiz pediment. Inasmuch as the basalt capping the skyline in the Lucero uplift is on the Ortiz surface (Wright, 1946), apparently some downthrow on the basin-bounding Santa Fe fault (just west of the butte) occurred in Pleistocene time.

0.2

42.9 Note west-dipping Santa Fe sandstone beneath terrace on left.

0.1

43.0 Carrizo Arroyo.

1.1

44.0 **STOP 2.** Stop is practically on the trace of the Santa Fe fault. Laramide faulting and folding and gravity sliding are likely here (figs. 14 & 15). Walk a short way up the west face of Bobo Butte for an excellent view of the Santa Fe fault and examination of the Santa Fe lithology.

Drive another 0.25 miles up the road.

0.25

44.25 Excellent view of the Lucero anticline exposed in Permian beds. The road was built in 1974 for an oil test of the anticline.

Retrace route to NM-6.

6.25

50.5 NM-6, *turn left.*

4.6

55.1 Road rises onto a basalt flow that erupted from Cerro Verde volcano west of the Lucero uplift. The basalt flowed to this point in the basin following a horseshoe path of 27 miles. The road traverses this flow for many miles across the basin margin into the Colorado Plateau. To the east may be seen the western edge of Ceja Mesa remnant of the Ortiz surface which forms the divide between the Rio Puerco and Rio Grande valleys. Note Manzano and Sandia uplifts on far eastern skyline.

3.5

58.6 Curve left in road. Somewhere along here beneath the lava flow is the margin of the Albuquerque basin and Rio Grande rift. Basalt-capped Mesa Redonda around the curve consists of gently tilted and faulted Jurassic and Cretaceous beds of the southern end of the Puerco fault zone. The Lucero uplift terminates in the low ridges just west of the two railroad beds. To the right and north of the curve are more Jurassic and Cretaceous beds that form the low western margin of the basin.

1.4

60.0 **STOP 3.** View overlooks the Rio San Jose which drains into the Rio Puerco about 2 miles to the east of here. The Rio San Jose rises along the Continental Divide some 80 miles to the west. The big sandstone cliff across the canyon is Entrada Sandstone (Jurassic), capped by thin Morrison shale (Jurassic) overlain disconformably by thin Dakota Sandstone (Cretaceous). The prevailing dip across the Puerco fault zone is low to the east and into the Albuquerque basin (Hunt, 1936).

3.0

63.0 Suwanee Peak at 10:30 consists of, in ascending order: Entrada Sandstone, Morrison shale, Dakota Sandstone, Mancos Shale, and a capping knob of travertine.

4.1

67.1 Crossing of old US-66 and new NM-6. *Continue ahead.* Road on left over A.T. & S.F. railroad was US-66 until new divided I-40 was built about 2 miles north of here. The old Correo stop (motel and store) is at trees just across the tracks. Vin Kelley stayed there while mapping most of the Lucero country in 1944!

The prominent exposures in Mesa Gigante to the north consist of, in descending order:

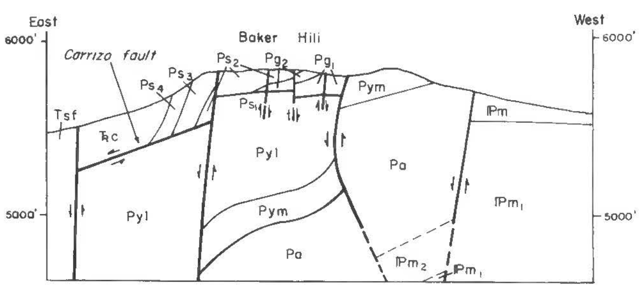


FIGURE 15—STRUCTURE SECTION THROUGH BAKER HILL, CARRIZO ARROYO AREA (AFTER CALLENDER AND ZILINSKI, IN PRESS). QUATERNARY UNITS NOT SHOWN. NO VERTICAL EXAGGERATION. (STOP 2)

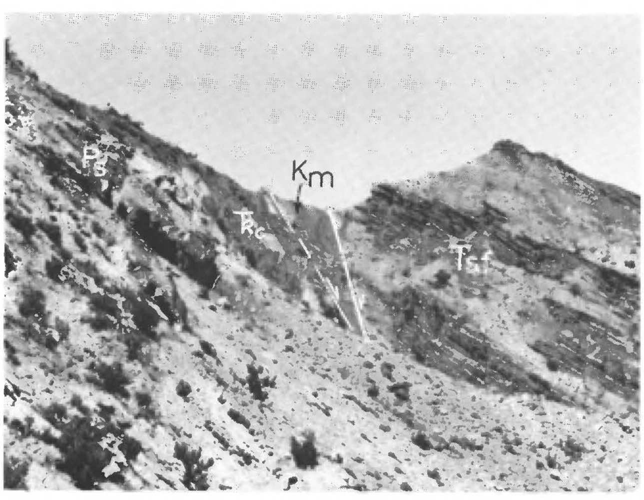


FIGURE 16—VIEW NORTH OF SANTA FE FAULT NORTH OF BOBO BUTTE. Ps—San Andres Limestone; ℞c—Chinle Formation; Km—Mancos Shale; Tsf—Santa Fe Formation. (STOP 2)

Dakota Sandstone Brushy Basin Shale Westwater Canyon Sandstone Recapture Shale	Cretaceous
Bluff Sandstone (brown cliff) Todilto gypsum and limestone Entrada Sandstone (white and pink)	Jurassic
Correo Formation (low brown ledge) Chinle Shale	Triassic

0.9
68.0 Bridge over Rio San Jose.
0.9
68.9 *Bear right* on access road to I-40 East.
1.1
70.0 Chinle Shale and capping Correo sandstone in cliff on left; note landslide blocks along road.
1.5
71.5 Enter Puerco fault zone.
1.1
72.6 Gallup Sandstone (Cretaceous), in roadcut on left; Mancos Shale in gulley on right. Road ahead for about 5 miles crosses poorly exposed Cretaceous beds, overlain by pediment alluvium and windblown sand.
1.6
74.2 Sandia uplift at 12:00 with Manzanita and Manzano at 2:00 are the east border of rift. Ceja Mesa in middle distance.
4.0
78.2 West Apache fault (Wright, 1946), contact between Cretaceous shale and downfaulted Santa Fe beds, is shown in west end of the cuts. Note much disturbance of Santa Fe in the cuts.
2.1
80.3 Disturbed Santa Fe gravel in cut on right.
1.4
81.7 Site of Shell's Santa Fe #2 well at right 600 ft south of road. Well was spudded in Cretaceous and bottomed out at 11,115 ft in Precambrian.
2.1
83.8 Bridge over Rio Puerco.
0.4
84.2 La Mesita Negra at 9:00 is amygdaloidal basalt flow. Center or feeder may be at south edge of outcrop. Cerro Colorado at 1:00 is a complex latite plug dome in Santa Fe beds (Wright, 1943).
3.6
87.8 Base of Upper buff member of Santa Fe Formation about here. The Santa Fe in this area consists of the following informal members, in ascending order: Lower gray, Middle red, and Upper buff.
0.6
88.4 Caliche and top of Ceja Mesa.
1.9
90.3 Carpenter well site just north of highway. This hole was drilled to 6,600 ft without bottoming the Santa Fe.

Dick Meleski photo

FIGURE 17—Airview north of Albuquerque volcanoes. Late cones surmounting lava flows are aligned along faults. Jemez Plateau and Mountains on northern skyline (from Kelley, 1974). (Reference mileage 95.2)

2.4
92.7 Central Ave. exit. Continue on I-40; Albuquerque volcanoes at 10:00.
1.0
93.7 East edge of Ceja Mesa; note caliche cap and Santa Fe gravel of Upper buff member. Albuquerque in Rio Grande valley ahead.
1.5
95.2 Albuquerque volcanoes and related flows on slope to north.
0.8
96.0 Overpass.
1.5
97.5 Road descends onto Segundo Alto river terrace 100 to 130 ft above Rio Grande (Bryan, 1938).
1.2
98.7 Bear right onto Coors Rd. exit.
0.3
99.0 Stop Sign. *Turn left* on Coors Rd. *Stay north. Do not take* right onramp back to I-40!
0.5
99.5 Albuquerque volcanoes and flows capping mesa on left. The field covers 23 square miles and consists of 6 mappable flow units that erupted from two, nearly aligned fissures of north trend (Kelley, 1974). Five large cones and 11 small nubbins occur along the line. The first three flow units appear to have issued widely from along the fissure zone, whereas the later flows came

largely from central vents or short lengths of fissures. Flows 1 and 2 are relatively thin (6 to 20 ft) and relatively smooth on their upper surfaces compared to the thicker and more hummocky later flows. Late cones along the fissures are generally low in cinder compared to Cat Hills, Wind Mesa, and San Felipe. Instead, cones consist more of coarse scoriaceous blocks and large spatter, or short lava flows, and domes. Special features are the radial dikes and driblet flows on cone flanks.

The flows are olivine tholeiite with olivine and plagioclase 0.5 to 2.0 mm in a groundmass of plagioclase, olivine, green augite, and opaques. Plagioclase phenocrysts increase relative to olivine in progressively younger flows. Also, anorthite content of plagioclase decreases from An_{69} to An_{65} from oldest to youngest flows.

1.3

100.8 Road descends from Segundo Alto terrace. Road ahead runs mostly on Holocene alluvial material spread eastward from dissected Santa Fe sand and mud facies of the Upper buff member. The facies is axial river flood-plain material.

3.3

104.1 On left is northeastern edge of the Albuquerque basalt flow—the number 2 flow here. One small lobe extends down onto the Segundo Alto terrace level.

0.6

104.7 Stop signal. *Continue straight ahead.* Road to left leads to Paradise Hills community.

2.0

106.7 Stop signal. *Turn left* on NM-528 to Rio Rancho.

0.4

107.1 Road ahead ascends to Segundo Alto terrace.

1.5

108.6 Rio Rancho headquarters, *straight ahead.* Jemez Mountains at 12:00; Santa Fe Range at 1:30, northeast of Sandias.

0.8

109.4 Panorama Inn on left.

0.6

110.0 Stop signal. *Turn left* on Southern Blvd. at Rio Rancho Shopping Center. Follow Southern Blvd. due west for 12.7 miles to 60th St. and rim of the Ceja Mesa.

0.3

110.3 Rio Rancho Country Club on hill at 1:30.

1.0

111.3 End of pavement.

1.2

112.5 20th St. *Continue straight ahead.* Road to north leads to Star Heights community.

1.6

114.1 Road tops hill; note that Southern Blvd. "zeros in" on Mount Taylor, a large Miocene-Pliocene volcano 50 miles to the west!

1.6

115.7 Calabacillas Arroyo. Diagonal crossing is Idalia Rd. Albuquerque volcanoes at 9:00.

1.7

117.4 Diagonal crossing is Encino Rd. following Southern Union Gas Co. gas line from San Juan Basin. Try it sometime; it goes a long way! Along Southern Blvd. ahead, note gravel bladed out from the Upper buff member of the Santa Fe Formation.

2.0

119.4 Road tops out on remnant of Ortiz surface. Most of the surface that is traversed along Southern Blvd. consists of Holocene dissected slopes and alluvium. Note ahead cliff sand dunes that surmount the western rim of Ceja Mesa. Next stop is near rim just north of the microwave tower.

2.5

121.9 60th St. *Turn right.*

0.2

122.1 *Turn left* past microwave tower to leeward base of sand dune for Stop 4.

0.4

122.5 Fork, bear right.

0.2

122.7 **STOP 4.** The hill is a large sand dune built at the top of the erosion escarpment that descends in badlands to the Rio Puerco valley. Walk a short distance down the abandoned road west of the hill to see the Sand Hill fault (Bryan and McCann, 1937). Where the fault crosses the road is a good place to look back at Ceja Mesa. Sand blanket and caliche beneath the sand dune is the Ortiz surface. Beneath the Ortiz is Upper buff member gravel—about 50 ft thick. The light olive drab beds below are part of the Middle red member (fig. 19).

Retrace road to 60th St.

0.5

123.2 60th St. *Turn left.* Notice that 60th St. is "zeroed in" on the crest of the Nacimiento uplift which bounds the San Juan Basin on its eastern side and the Rio Grande trough to the south. Follow 60th St. north (4.5 miles) paralleling New Mexico Public Service Company power line from its coal-fired generating plant west of Farmington, New Mexico.

3.4

126.6 Jemez Mountains 12:30 to 1:30. Redondo Peak (11,252 ft) is a round resurgent dome in the Jemez caldera. The lower ridges and peaks are part of the southern rim of the caldera. The low eastward slope of the immediate terrain is a somewhat tilted and stripped modification of the Ortiz surface.

1.1

127.7 Gate and fence. *Turn right* on 28th St. Fence line is north boundary of old Town of Alameda grant. Follow 28th St. 11.4 miles to 20th St. 28th St. is "zeroed in" on the village of Placitas at the northern base of the Sandias. The far mountains, and the slightly left-inclined surface at their base, is the type locality of the Ortiz surface. The road traverses a surface correlated with the Ortiz.

1.9

129.6 Encino Rd. and Southern Union Gas Co. gas line. *Continue straight ahead.*

1.5

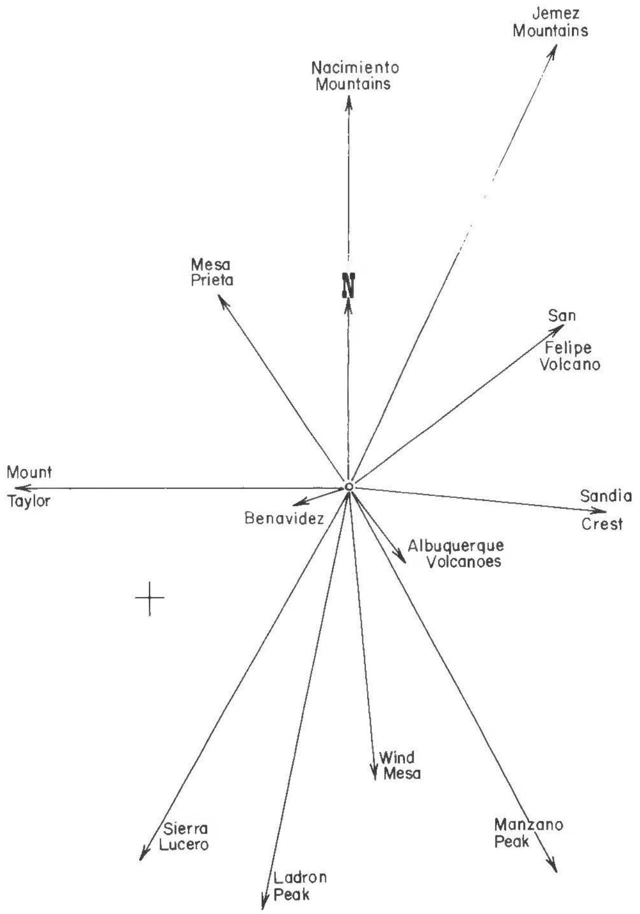


FIGURE 18—PANORAMIC INDEX OF FEATURES SEEN FROM STOP 4.

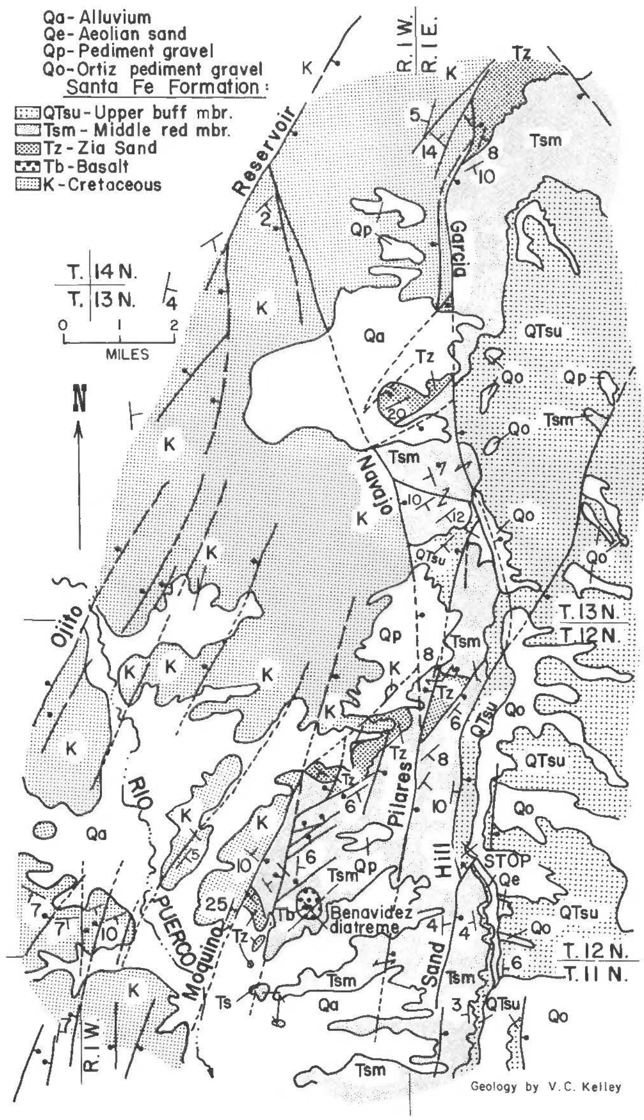


FIGURE 19—GEOLOGIC MAP OF SAND HILL AREA. (STOP 4)

131.1 Calabacillas Arroyo.
2.4

133.5 Road ahead slopes into Montoyas Arroyo drainage area, descending stratigraphically from the Upper buff gravel member into Middle red sandstone member of the Santa Fe Formation.
0.3

133.8 Montoyas Arroyo (west).
1.6

135.4 Rainbow Blvd. *Continue straight ahead.* The base of the Upper buff member is along the base of the mesa to the south. The road here is in the Middle red member, although covered by much wind-blown sand and alluvium. Try Rainbow north sometime; it leads nearly to the spectacular rim which overlooks the Santa Fe badlands south of the Jemez Valley.
0.9

136.3 Montoyas Arroyo (east).
0.8

137.1 20th St. *Turn left.*
0.9

138.0 Corner of 35th St. and 20th St. *Continue straight ahead.* Hills north across Barranca Arroyo valley are sandstone and mudstone of Middle red member, the main body of the Santa Fe. The small butte is Picuda Peak; on left of road the hill is Loma Duran.
0.5

FIGURE 20—OBLIQUE AIRVIEW NORTH OF MOQUINO FAULT WHICH DROPS CURVING SANTA FE HOGBACKS AGAINST EAST-DIPPING CRETACEOUS BEDS. BASALT-CAPPED MESA PRIETA, UPPER LEFT AND NACIMIENTO UPLIFT, UPPER RIGHT. SEE FIG. 19 FOR LOCATION.

138.5 Progress Blvd. We could have come on Progress via Encino or Rainbow. Progress is fun too!
0.9

139.4 20th St. Curves right, and at 140.2 curves right again.
1.0

140.4 Hill at 10:30 is Loma Machete (cane knife); white clearing along its side is site of Shell's #1 Santa Fe well drilled to 11,045 ft, with Santa Fe Formation on Eocene at 2,970 ft.
0.7

141.1 20th St. Curves left and crosses Venada Arroyo.
0.5

141.6 Cross road. Left 0.3 miles leads to Shell well.
0.2

141.8 View left of well site and well plug.
0.1

141.9 *Turn right* on Jennifer Ave. over top of Loma Machete. View northwest from this intersection is toward Nacimiento uplift. In foreground along side of dissected mesa can be seen the contact between the Middle red member and the Lower gray member or Zia Sand (Galusha, 1966) of the Santa Fe Formation. Beds dip west in western limb of Ziana anticline (Black and Hiss, 1974) drilled by Shell. The location is in the Lower gray member and slightly east of the anticline crest in east-dipping beds well exposed along the next side road left off 20th St.; but we go with Jennifer Ave.
0.1

142.0 **STOP 5.** Ziana anticline and contact of Lower gray member and Middle red member may be seen in the badland ridges about 1 mile to the west from this stop. The contact seen in the ridge is traceable to the type section of the Zia Sand Formation 10 miles to the west.

Features of the geology and geography to the north of Jemez Valley in the southern margin of the Jemez Mountains are observed beautifully from this point.
1.1

FIGURE 21—View north of Santa Fe beds along the crest and west flank of Ziana anticline (from Black and Hiss, 1974). (Reference mileage 141.9)

143.1 Westphalia St. *Turn left.*
0.4

143.5 *Turn right* on Majesty Ave. to NM-44. Hill ahead is Loma Barbon (Billy Goat Hill).
1.1

144.6 Old NM-44. *Turn right.*
0.4

145.0 NM-44. *Turn right.*
4.7

149.7 Bridge over Rio Grande.
0.8

150.5 Stop sign. US-85 *Straight ahead.*
0.5

151.0 Take Albuquerque onramp to I-25.

END OF ROAD LOG. Return to Albuquerque, about 16 miles.

Northern Part of Albuquerque Basin

RÉSUMÉ (SECOND DAY)

This trip, covering 156 miles, includes the area called the Santo Domingo sub-basin. The route goes north to Bernalillo and then west into lower Jemez Valley to the western margin of the Albuquerque basin, south of San Ysidro. At Stop 1 is a typical exposure of Zia Sand Formation. Stop 2 is a vantage point overlooking the margin of the Albuquerque basin and the plunging southern end of the Nacimiento uplift.

The trip then retraces its route and crosses the Albuquerque basin to the complex border at the northern end of the Sandia uplift. At Stop 3 near Placitas a view of Santa Fe fanglomerate beds is seen. This is the best spot to see the margin and border structures related to basin formation.

The final leg of the trip goes into and across the Santo Domingo sub-basin to Stop 4 along the southern edge of the Jemez Mountains. The principal feature here is the volcanic nature of basin stratigraphy. In this segment of the trip the Ortiz pediment is seen at and near its type area, and its modification by warping and faulting is also seen.

Other notable features in this area are the San Felipe and Cerros del Rio basaltic fields and the La Bajada escarpment and Cerrillos uplift bordering the Albuquerque basin at the northern part of its eastern boundary.

GEOLOGIC ROAD LOG

Mileage

000.0 STARTING POINT is 4 miles north of Albuquerque on I-25 at Osuna and San Mateo intersection. North on I-25.

1.5

1.5 Overpass.

1.1

2.6 *Exit 234* to Tramway Rd. and Alameda. *Continue straight ahead.* Low dissected ridges in next 4 miles are granite wash alluvium from the Sandia uplift to east. This alluvium overlies Middle red member axial gravels of the Santa Fe Formation in low bluffs west of the road and ahead.

3.0

5.6 Precipitous, frontal Rincon Ridge of the Sandia uplift is directly east. This ridge consists principally of Precambrian micaceous quartzite, quartz-mica schist, and gneiss, cut by numerous, prominent pegmatite dikes. The main escarpment east of Rincon Ridge consists of the Sandia Granite (Precambrian), veneered along the Sandia rim by the Sandia Formation (Pennsylvanian) in the basal slope and Madera Limestone (Pennsylvanian) to the crest.

A small Holocene fan scarp 5 to 15 ft high occurs at the base of the ridge along its southern part (Kelley and Northrop, 1975).

1.7

7.3 Roadcuts show axial gravel of the Santa Fe Formation. The gravel beds are intercalated with reddish sandstone and mudstones of the Middle red member as may be seen below and above the road ahead. Pleistocene pediment alluvium overlies the Santa Fe on the dissected ridges.

2.4

9.7 *Exit 240* to Bernalillo. *Continue straight ahead.*

0.6

10.3 Exits ahead. *Take Cuba exit* (10.5) just beyond overpass and circle around and over overpass on NM-44 to Cuba and Farmington.

0.6

10.9 Bridge over A.T. & S.F. railroad.

0.4

11.3 Stop sign US-85. *Continue straight ahead.*

0.8

12.1 Bridge over Rio Grande.

1.0

13.1 Junction NM-526. *Continue straight ahead.*

0.9

14.0 Alluvial slope wash in roadcut on right.

1.2

15.2 Note fault in roadcut on right. This is one of the faults in the basalt flows capping Santa Ana Mesa 6 miles to the north (Kelley, in press). The fault dips and is downthrown east, displacing east-dipping sand and gravel of Middle red member of Santa Fe Formation. Typical exposures are seen in the hills north of the road ahead.

2.0

17.2 Road tops Loma Barbon (Billy Goat Hill) through roadcuts in east-dipping typical Middle red member sediments. Note excellent badland exposures to right of road just ahead. Reversal of bed attitude to westerly dip on west side of canyon is largely due to a north-trending fault just beyond the knob to right of road.

2.6

19.8 **STOP 1.** Roadcut in Zia Sand (Lower gray member of Santa Fe). Examine sandstone. Note calcite-cemented concretionary aggregates and "curb and gutter" cementation of sand high in cut; both are typical of Zia. Scattered pink sand grains are also typical. Outcrops in the valley ahead are typical Zia Sandstone (Galusha, 1966) of the Santa Fe Formation. At bridge over arroyo at bottom of hill note bentonite bed in arroyo bank to right of road.

1.2

21.0 Side road right leads to Santa Ana Pueblo on north side of Jemez River; gates are usually locked. *Continue straight ahead.*

3.6

24.6 Roadcut on left is in Zia Sand. Most of the outcrops north of the Jemez River are also Zia Sand, but are poorly exposed and cut by faults. The prominent butte at 1:30 is Chamisa Mesa. Some geologists have suggested both Zia Sand and Middle red members occur in the mesa below the basalt cap. Volcanic samples above the basalt cap have been dated at 9.1 m.y.

Regardless of age or fossils, no rigorous separation of the Santa Fe in the area around Chamisa Mesa is tenable. Note tilted Sandia uplift at 6:00!

1.8

26.4 Zia Sand in roadcuts.

2.7

29.1 Road right leads to Zia Pueblo. *Continue straight ahead.*

3.3

32.4 *Turn left* on dirt road leading up White Mesa.

0.8

33.2 **STOP 2.** White Mesa. We are on the trace of the San Ysidro fault (fig. 24 and Woodward and Ruetschilling, 1976) that forms the western margin of the Rio Grande rift here. The fault is downthrown to the east with Dakota Formation (Cretaceous) against Jurassic strata to the west (fig. 23). Stratigraphic separation across this fault is about 900 ft.

A minor syncline is seen in the Dakota strata east of the San Ysidro fault; the west limb is steeply dipping and appears to have formed by drag along the fault, whereas the east limb is gently dipping and represents regional westward dip toward the fault. West of the fault is an anticline (structure section *A-A'*, fig. 23) that grades northward into a monocline.

About 2 miles south of here another north-trending fault has Zia Sand Formation on the east and Mancos Shale (Cretaceous) on the west; this fault is covered by alluvium to the north, but may continue in the subsurface and occur east of Stop 2 in the alluvial valley.

South of here these faults die out; the western margin of the Albuquerque-Belen basin swings to the west with the basin margin defined by the unconformable sedimentary contact of the Zia Sand Formation on Cretaceous and early Tertiary strata.

To the north the western margin of the rift

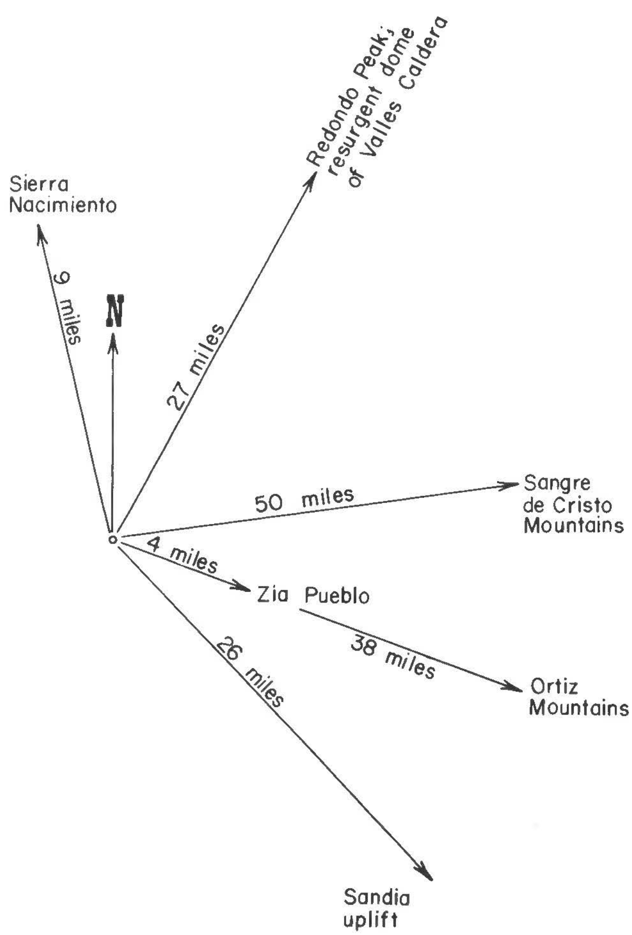


FIGURE 22—PANORAMIC INDEX OF FEATURES SEEN FROM WHITE MESA, STOP 2.

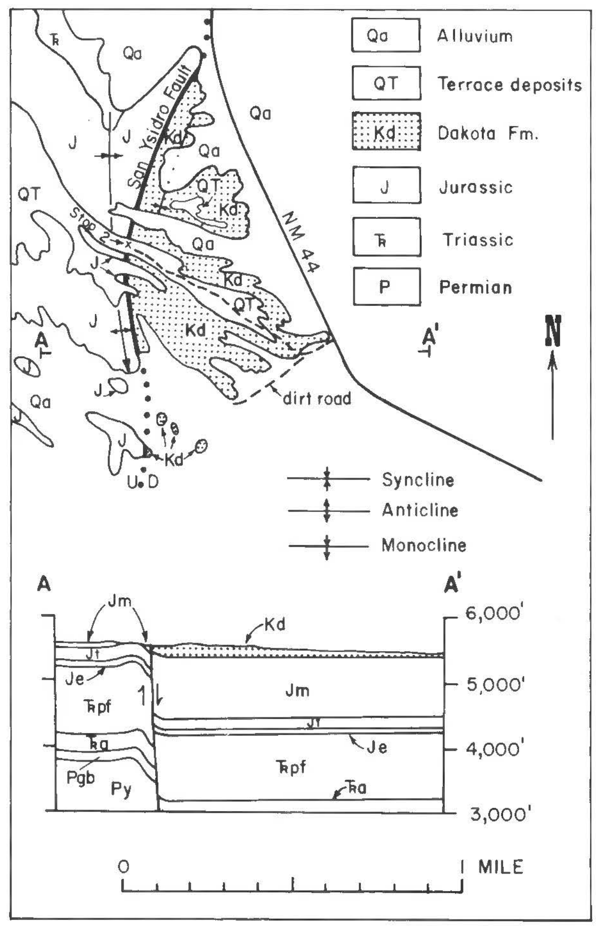


FIGURE 23—GEOLOGIC MAP AND STRUCTURE SECTION OF WESTERN EDGE OF ALBUQUERQUE BASIN AT WHITE MESA. (STOP 2)

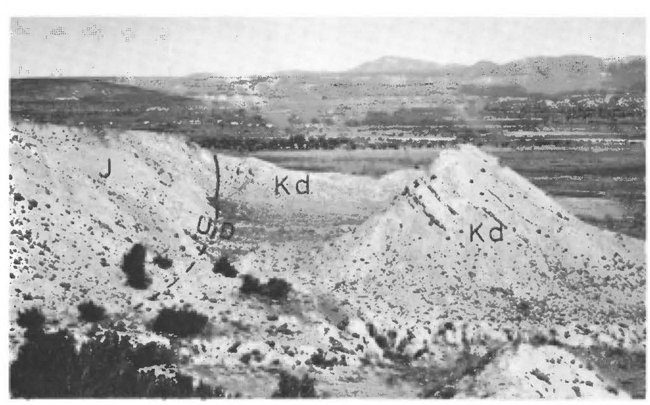


FIGURE 24—VIEW NORTH OF SAN YSIDRO FAULT FROM STOP 2 OF SECOND DAY. CRETACEOUS DAKOTA FORMATION (Kd) DOWNTHROWN TO RIGHT AND JURASSIC TODILTO AND MORRISON FORMATIONS (J) TO LEFT.

becomes more complex and is marked by several north-trending faults that are downthrown to the east and are connected by several northeast-trending en echelon faults.

The total amount of structural relief across the western margin of the rift in this vicinity is much less than on the east side of the rift at Stop 3. This relief results in an asymmetrical graben with the deepest part on the east side. Also, Black and Hiss (1974) suggest an intragraben horst in the subsurface beneath the Shell #1 Santa Fe well near Stop 5 of the first day. The Ziana anticline may be the surface expression of this horst, possibly formed by passive draping of the graben-fill over faults at depth.

Gypsum is quarried from Todilto Formation (Jurassic) about three quarters of a mile north-west of here. We are on the haulage road leading to the quarry.

Retrace road to NM-44.

0.8

34.0 Stop sign. NM-44. *Turn right.*

20.2

54.2 Bridge over Rio Grande.

0.8

55.0 Stop sign US-85. *Straight ahead.*

0.4

55.4 I-25 offramp. *Straight ahead* on NM-44 across I-25 overpass to Placitas. Note typical Middle red member beds inclined northeasterly in road-cut on left.

0.7

56.1 Road tops surface of dissected alluvial fan. Excellent views of the plunging northern end of eastward-tilted Sandia uplift for next 2 miles ahead.

1.8

57.9 At 12:00 knob near base of uplift is part of downthrown, north-dipping Pennsylvanian and Permian beds in a ramp structure occurring between the northward-running Rincon fault, along base of uplift from 12:00 to 2:30, and the San Francisco fault which is 3 miles to the east beginning near the northern end of the sloping skyline of the Sandias (Kelley and Northrop, 1975).

The low hills from 9:00 to 12:00 beyond the surface of the road are an eroded fault scarp.

0.9

58.8 Fanglomerate of Santa Fe in gulley to left of road. These beds dip about 9 degrees easterly toward the basin-bounding fault exposed in the roadcut around curves ahead. The dipping fan-glomerates are part of the limb of a northerly plunging syncline in the Santa Fe and also a part of the Sandia structural ramp.

0.4

59.2 Basin bounding fault in roadcut is between Santa Fe fanglomerates and Mancos Shale (Cretaceous). The fault here is a middle member of a splay of faults from the northern end of the Rincon fault and is termed Ranchos fault to the north of here, seen at Stop 3.

0.3

59.5 Knob at 9:00 has Ranchos fault near its top with olive drab Mancos on this side and fanglomerate on top and west side. Ranchos fault passes just below tan and white house on slope across valley at 2:00. Note also steeply north-dipping Mancos in roadcut to right of road. SLOW for left turn at Ranchos de Placitas road ahead.

0.4

59.9 Turn left on paved road into Ranchos de Placitas subdivision.

0.1

60.0 Ridge to right, north of road, is basal fanglomer-ate of Santa Fe. This fanglomerate lies beneath the limestone- and Precambrian-bearing fan-glomerates seen above. The basal fanglomerate of the ridge to the north has no limestone fragments and is made up mostly of red Permian sandstone boulders. It dips 30° to 45° N. and unconformably overlies Eocene Galisteo beds that dip 60° to 70° N. along the base of the ridge. Note step-faulted basalt flows of the San Felipe volcanic field across the Rio Grande valley from 11:30 to 1:30.

0.3

60.3 Road forks. *Take right fork.*

0.1

60.4 Fork, stay right on paved road.

0.2

60.6 **STOP 3.** Intersection of Juniper Rd. and Cholla Ln. Walk to top of hill west of stop for outstanding view. Structure of the northern end of the Sandia uplift and especially the ramp descent into the Rio Grande trough can be seen (figs. 26 and 27). Walk to the arroyo to the north

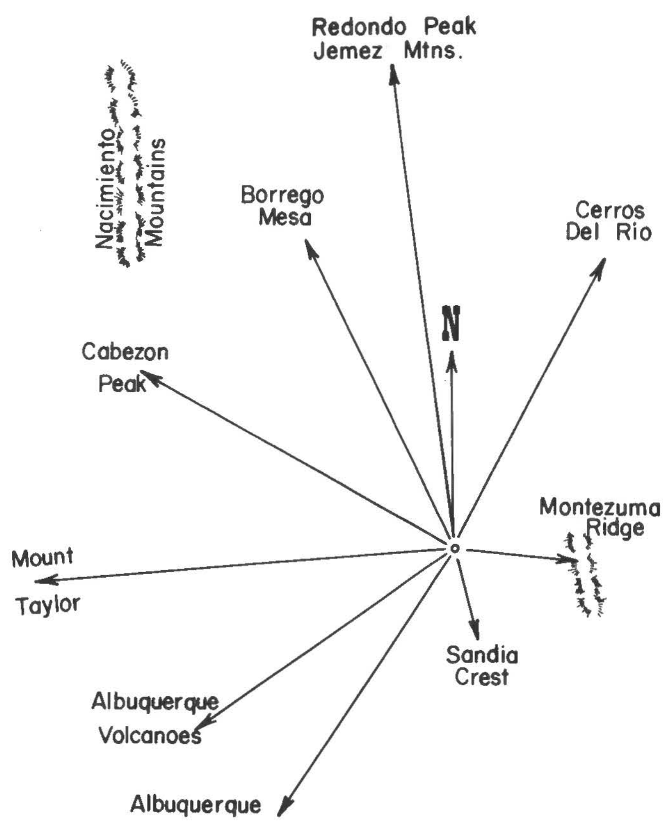


FIGURE 25—PANORAMIC INDEX OF FEATURES SEEN FROM STOP 3.

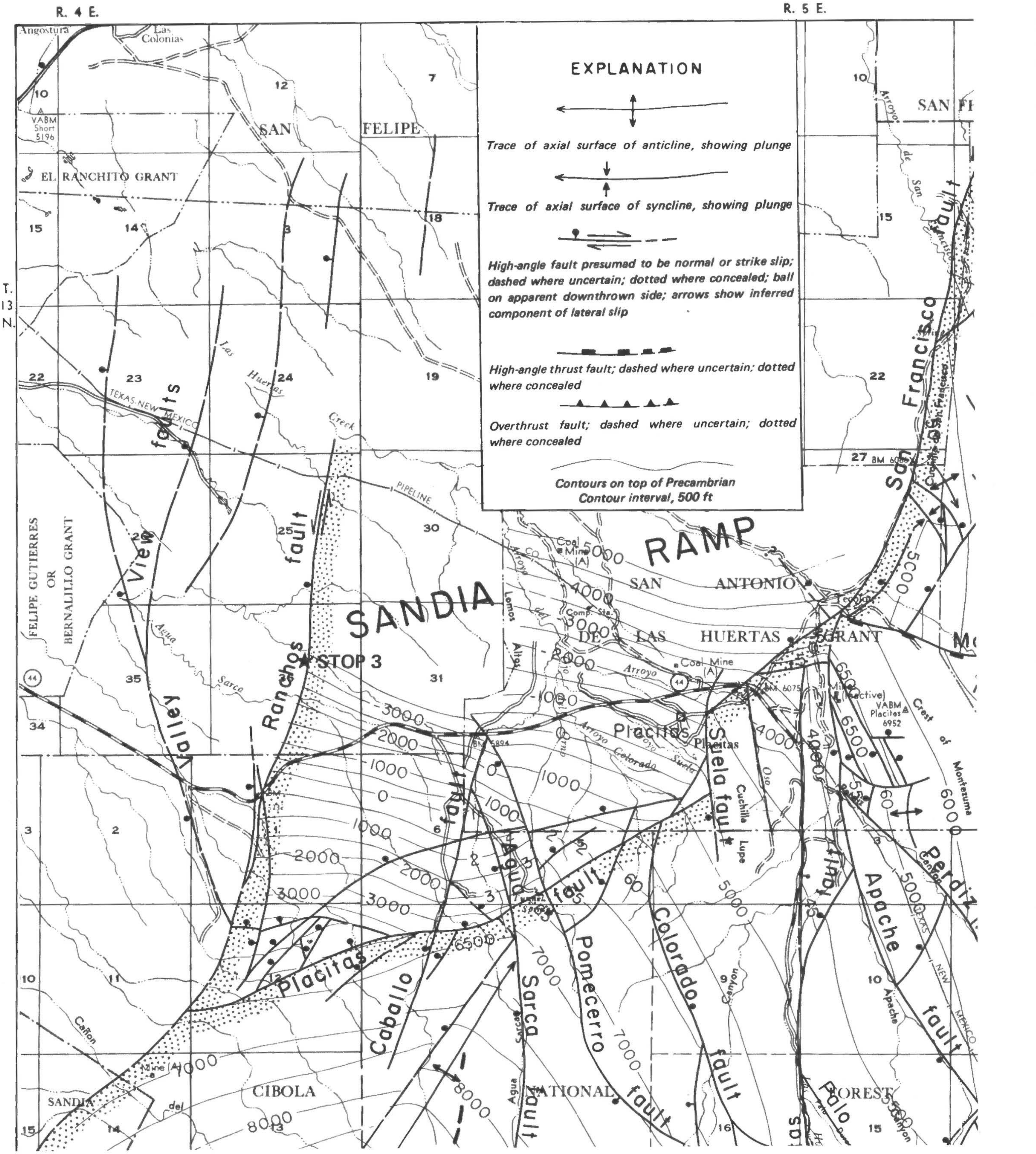


FIGURE 26—STRUCTURE CONTOUR MAP OF SANDIA RAMP AT PLACITAS (FROM KELLEY AND NORTHROP, 1975). NOTE LOCATION OF STOP 3 IN SECTION 26.

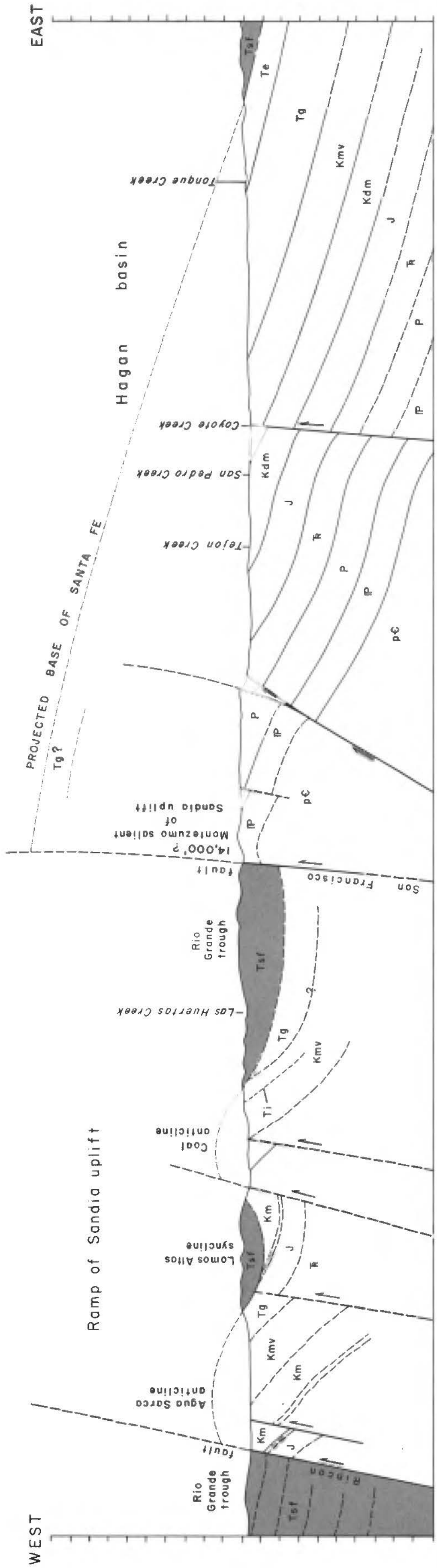


FIGURE 27—STRUCTURE SECTION NEAR PLACITAS ACROSS SANDIA RAMP AND NORTHERN END OF UPLIFT (FROM KELLEY AND NORTHROP, 1975). SANTA FE FORMATION IS SHADED.

FIGURE 28—VIEW OF RANCHOS NORMAL FAULT AT STOP 3. EAST-DIPPING SANTA FE FANGLOMERATE, LEFT; STEEP, NORTH-DIPPING EOCENE GALISTEO STRATA (BARE SURFACE) AND MODERATELY NORTH-DIPPING SANTA FE FANGLOMERATE, RIGHT OF FAULT. LEFT DRAG EXISTS IN STEEP GALISTEO BEDS.

to see the Ranchos fault, the downthrown younger fanglomerate of limestone fragments, the older reddish fanglomerate containing chiefly reddish sandstone fragments, and the underlying steep Galisteo Formation.

Retrace route to I-25.

0.7

61.3 Stop sign NM-44. *Turn right.*

4.2

65.5 Slow for curve right to I-25 and north toward Santa Fe.

0.3

65.8 Merge onto I-25 North.

0.8

66.6 San Felipe volcano at 11:00, the field of basalt flows caps high mesas from 9:30 to 12:00. Canjilon diatreme in bluffs across Rio Grande at 10:00 (see fig. 29).

The San Felipe basaltic volcanic field is eroded nearly all around its edges; however, the remaining, considerably faulted part covers about 38 square miles, easily the largest in the basin (Kelley and Kudo, 1976). San Felipe Peak, the main center of eruption, stands nearly 800 ft above its projected base beneath the field and is part of a northerly 7-mile trend of about 20 cones. In addition, there are lesser, low subfields: one of about 3 square miles in the southeast, another of about 2 square miles in the south, and another of about 9 square miles in the southwest. A 7-mile northerly trend of tiny cinder cones runs through the southwestern subfield. The first eruption was a stratified basalt tuff that spread mostly east from the main fissure zone. This early flow is 20 ft thick. In the northeast it extends beyond the later overlying flow and into beds of the Middle red member of the Santa Fe. The first flow of the field is the most expansive and occurs nearly everywhere, is relatively thin, and generally 20 to 50 ft thick, as exposed along the mesa edges. The second flow is considerably less expansive, but apparently considerably thicker in the area of the main ridge, judging solely on topographic rise. However, some of the central height may be due to buried buildup by early tuff rings. The third delineated flow is mostly along the main volcanic ridge. The last event was cinder cone eruption. Sixty-six cones have been identified in the entire field, mostly fissure aligned. A special feature common in the cones is the presence of small plugs and dikes, many of which are ring intrusives that dip inwardly within the cone. All these are nonvesicular. The San Felipe field is inter-Santa Fe; it probably was largely if not completely covered by continuing Santa Fe deposition after the eruption.

The San Felipe flows are olivine basalt. No systematic change in An content, which ranges from An_{65-60}, has been recognized in the sequence of flows. Olivine and plagioclase phenocrysts are dominant in the flows, some of which are quartz normative. All are vesicular.

Canjilon diatreme is probably an early phase outlier of the once more expansive San Felipe field, consisting dominantly of inward-dipping tuff breccia. Internally, this diatreme consists of 1) a low small basin in the northern end, 2) a local collapsed vent with basalt plugs and radial dikes in the eastern corner, 3) a central sag-and-collapse basin with a peripheral cone sheet of basalt, and 4) a large southern collapse basin filled with lava flows. The basalt is generally uniform, being vesicular and locally amygdaloidal. Phenocrysts consist of olivine, pale-brown augite, and plagioclase in a similar intergranular groundmass. On the basis of both modal and chemical characteristics, the basalts have been classified by Kudo (Kelley and Kudo, 1976) as hypersthene-normative, alkali olivine basalt.

0.4

67.0 Bluffs to right of road are Middle red member consisting of reddish sandstone and mudstones with intercalations or tongues of axial river gravel and fanglomerates. Local river terraces or graded alluvial slopes cap the ridge.

2.4

69.4 Road tops old alluvial slope graded to a higher level of the Rio Grande; Montezuma Ridge of Sandia uplift at 2:45; Ortiz porphyry laccolith mountains on far skyline at 1:45. Sangre de Cristo Range on distant skyline, 12:00 to 1:00, is eastern border of Rio Grande trough in the Española basin, next basin north of Albuquerque basin. The low skyline from 11:30 to 12:00 is Cerros del Rio; its escarpment facing the viewer is La Bajada fault scarp, the eastern structural border at the northern end of the Santo Domingo sub-basin of the Albuquerque basin.

2.5

71.9 R.E.A. power plant on left.

1.2

73.1 Locked gate on side road up Maria Chavez Arroyo. The land belongs to the San Felipe Pueblo situated along the Rio Grande at the narrows between the two mesas at 10:30. Two basalt flows (faulted apart) can be seen in the east side mesa, 10:30 to 11:00. This flow in the Santa Fe Formation is an outlier of the basal flow on San Felipe Mesa west of the Rio Grande. Remnants of the Santa Fe beds capping the basalt east of the river occur locally on the basalts west of the river, especially at the northeastern corner of the field north of the Pueblo. The field may have been largely buried in late Santa Fe time.

East of the low hills up Maria Chavez Arroyo is a wide, northeast-dipping monocline that exposes nearly 3,000 ft of upturned (up to 37 degrees) Middle red member of the Santa Fe. The upper 40 percent of the section along the skyline ridge left of the arroyo is made up of fanglomerate with fragments including most of the rocks now exposed in the Sandia uplift. The fragments decrease in size northwestward along the monocline.

1.0

74.1 Side road left to San Felipe Pueblo. *Continue straight ahead.*

1.1

75.2 Note axial gravels of Middle red member of Santa Fe in big roadcut on left. They are impregnated by iron oxides probably deposited by former warm springs. About 0.5 miles southeast of here similar Santa Fe beds are impregnated by manganese oxides. As with most outcrops near here, dips are a few degrees northeastward.

0.5

75.7 Excellent view of Sange de Cristo uplift 11:30 to 12:30. Santa Fe, the State capital, is located near the base of the Sangre de Cristo Range at about 12:00. Road descends into Tonque Arroyo ahead. Tonque (San Pedro Creek) rises far to the southeast and drains much of the eastern slope of the Sandia Mountains.

0.5

76.2 Cross road along Tonque Arroyo; San Felipe Pueblo is downstream on the Rio Grande. Three miles up the arroyo Santa Fe beds are abruptly downfaulted against Jurassic beds on the San Francisco fault.

1.2

77.4 Low ridge of near skyline from 1:00 to 2:30 is Espinaso Ridge. The ridge is held up by coarse latitic to andesitic fanglomerate and local flows of the Espinaso Formation (Oligocene?). Along the southwestern base the Espinaso overlies the Galisteo Formation of Eocene age (Stearns, 1953); northeast of the ridge the Espinaso is overlain by basal beds of the Santa Fe (probably Zia Sand Formation) of Miocene age. Dips along the ridge section are all northeasterly 10 to 25 degrees. Termination of the ridge at 1:00 is at downfaulted Middle red beds of the Santa Fe along the San Francisco fault. Much diagonal crossfaulting and left-curving of the ridge beds toward the fault suggest some left shift along the San Francisco boundary fault of the trough.

Three laccolithic intermediate porphyry mountains are seen on the eastern skyline from about 2:00 to 3:30, from left to right: Ortiz, San Pedro, and South Mountains. The Jemez Mountains form the skyline from 9:00 to 10:30. The

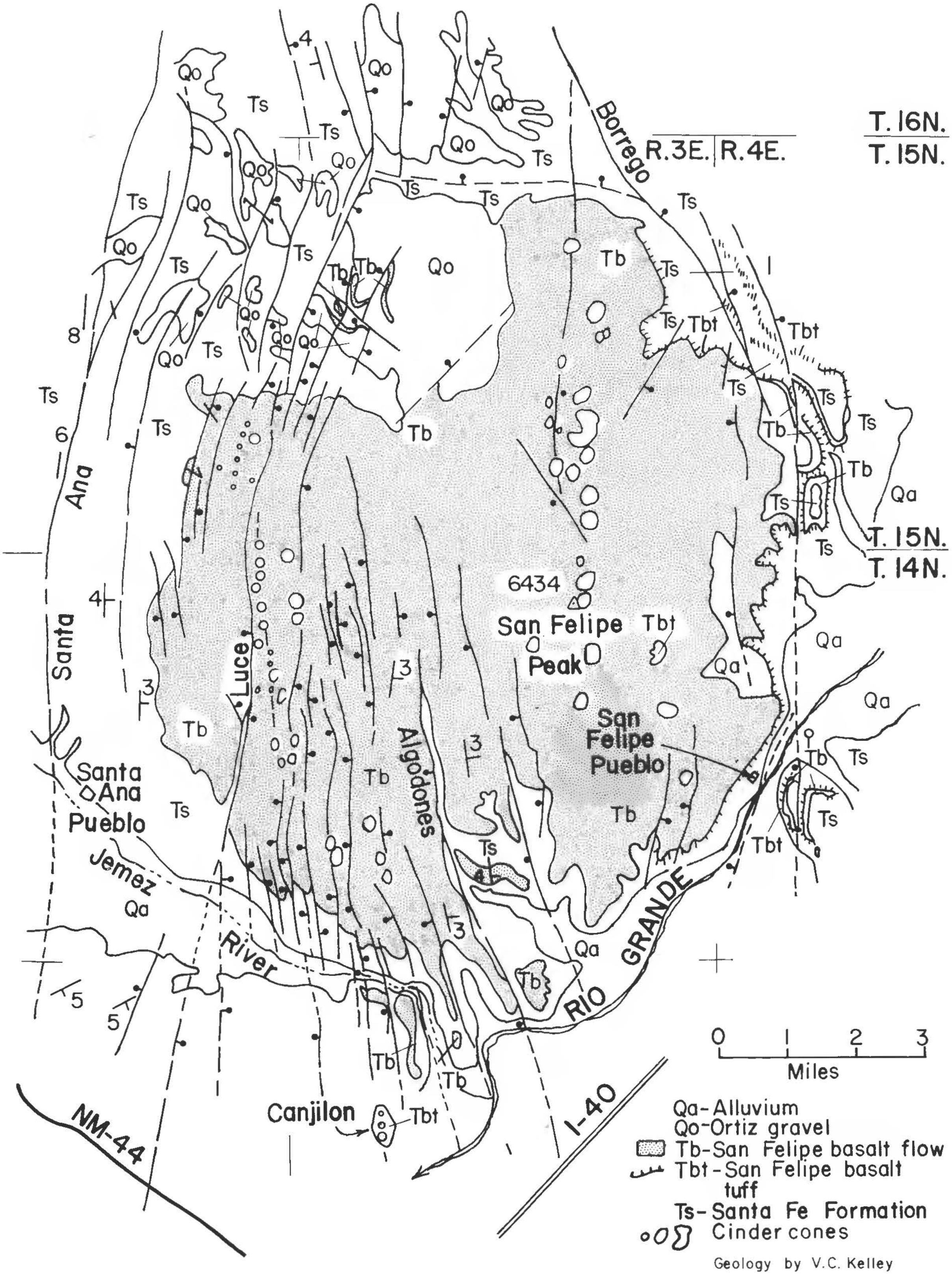
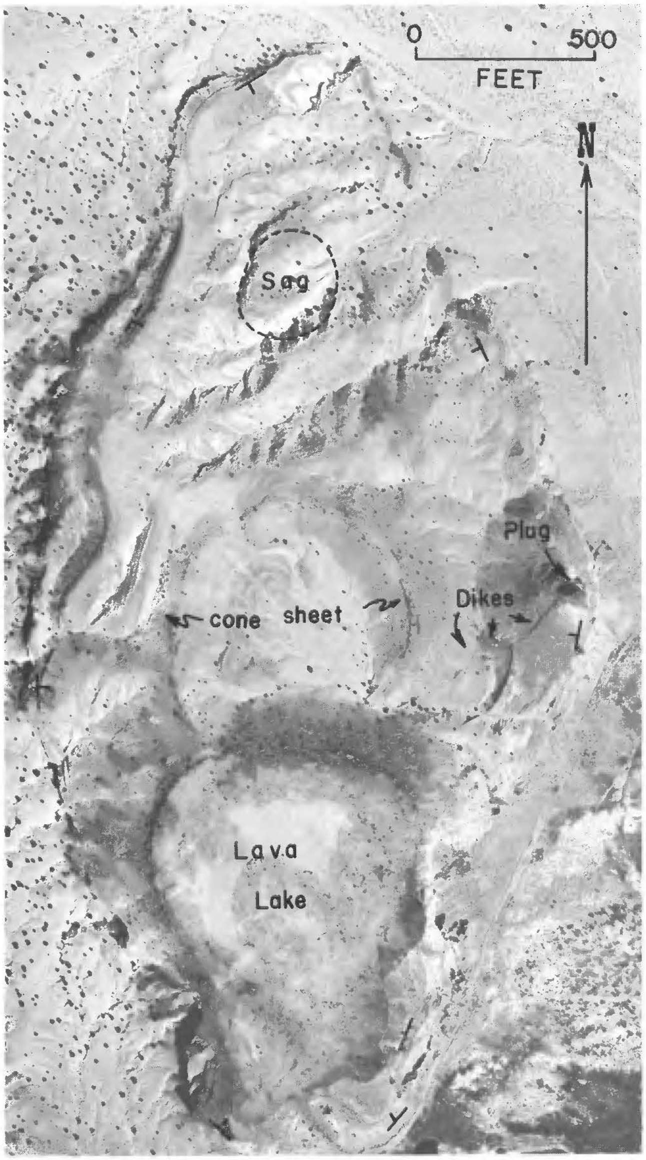


FIGURE 29—Geologic map of San Felipe volcanic field. (Reference mileage 66.6)



Limbaugh Engineers, Inc.

FIGURE 30—VERTICAL AIRPHOTO OF CANJILON DIATREME. (REFERENCE MILEAGE 66.6)

route heads for exposures along their southeastern base.

0.9

78.3 Bridge over Vega de los Tano Arroyo; it heads northeast of Espinaso Ridge.

1.6

79.9 Road ascends onto small outlier of the Ortiz surface with the type area around the Ortiz Mountains at 2:00. Rise in the road a mile or so ahead is over a scarp on the San Francisco fault, where older Santa Fe is upthrown against younger downthrown Santa Fe. The surface at the top of the hill is Ortiz also, so that at least some of the movement on the San Francisco is post-Ortiz, early Pleistocene.

0.4

80.3 End view of Espinaso Ridge; area to left is Santa Fe strata nearly to the Ortiz Mountains and this area is what Kelley (1952) termed the Hagan embayment. The embayment is a half-graben against the La Bajada fault to the east. The whole area including the Tertiary and older beds down to the Paleozoic beds along the northeastern base of the Sandia uplift, 4:00 to 5:00, is part of what is termed the Hagan basin, also a half-graben. The long homoclinal succession extending nearly 15 miles from the crest of the Sandia to the Cerrillos uplift along the La Bajada border fault of the trough is the grandest condensed stratigraphic (Mississippian to Pliocene) section in the state. In one sense, it is all a part of the Sandia uplift which Kelley and Northrop (1975) have suggested may have risen out of the early Santa Fe basin in Pliocene time.

1.2

81.5 Road ascends San Francisco fault scarp. The fault dies out 6 to 10 miles north of here in the basin beds. The light-colored outcrops across the valley at about 9:00 are the site of the next and last stop of the trip.

1.1

82.6 Good view on Ortiz surface. The surface descends to this level here from the Ortiz Mountains base partly by original slope, some northward tilting, and small east-northeast-trending faults downthrown on the north. Bryan early designated the surface here and especially off to the northwest the La Bajada surface. It formed lower and later than the Ortiz. The surface beneath and in the basalt flows at the top of La Bajada fault scarp is traceable southeastward up Galisteo Creek to a conforming level with the type Ortiz south of the Galisteo. With the new interpretation (mentioned by Kelley 1952), there is no La Bajada surface that is different or younger than the Ortiz.

Use left lane in preparation for left turn onto NM-22 across south moving traffic of divided I-25.

0.5

83.1 NM-22. *Turn left. STOP SIGN.* CROSS WITH CAUTION.

1.6

84.7 Road begins descent from Ortiz surface down dissected slopes of the north valley of the Rio Grande. The vague tree-covered surfaces across the valley along the base of the Jemez Mountains at about eye level from here are also

FIGURE 31—VIEW SOUTH OF LA BAJADA FAULT SCARP FROM OBSERVATION POINT AT COCHITI DAM.

correlated as Ortiz. The surface of the San Felipe flow-field, 11:00 to 12:00, was designated erroneously by Bryan (1938) as Ortiz. This surface is an inter-Santa Fe surface. However, the Ortiz surface does truncate a small northwest corner of the tilted basalt field.

0.4

85.1 Note eastward-tilted and truncated (by Ortiz surface) Santa Fe beds across Galisteo Arroyo at 2:00 to 3:00. The Santa Fe beds here are the high Middle red member.

2.2

86.3 Bridge over A.T. & S.F. railroad. Continue on NM-22.

0.4

86.7 Mesa segments at 12:00 across valley above the tilted whitish outcrops are formed of Pleistocene Bandelier ash-flow tuff. They are post-Ortiz. The La Bajada fault, after crossing the Rio Grande Canyon, dies out beneath the Bandelier. However, the Bandelier has a monoclinal drape across the trend of the fault by either flowing over a scarp or being downwarped by later movement. The drape can be seen after crossing the hills ahead, showing up back of the water tower at the west end of Cochiti Dam.

From 8:30 to 9:30 the fissure alignment of cones of the San Felipe basalt field may be seen on the skyline; the northernmost cone is at about 9:30.

3.3

90.0 Entering Peña Blanca (white rock).

2.2

92.2 Bridge over Santa Fe River arroyo. This drainage cuts through the La Bajada escarpment and heads through the city of Santa Fe. Note "heavy" ancestral Rio Grande axial gravel in roadcut ahead.

1.3

93.5 Long earthfill Cochiti dam on the Rio Grande ahead.

0.4

93.9 Bridge over the Rio Grande. Note Santa Fe gravel beds on right strongly tilted by local faulting.

0.9

94.8 *Turn left* with NM-22 to Cochiti Pueblo.

1.8

96.6 Cochiti Pueblo on left. *Turn right* on Bear Springs dirt road up Peralta Canyon.

1.3

97.9 Note Santa Fe beds with low southwesterly dips high on hills at 11:30.

0.4

98.3 Fanglomerate in roadcut is probably late Pleistocene terrace material.

0.7

99.0 Bandelier tuff on ridge to right unconformably overlies tilted Santa Fe fanglomerate.

0.4

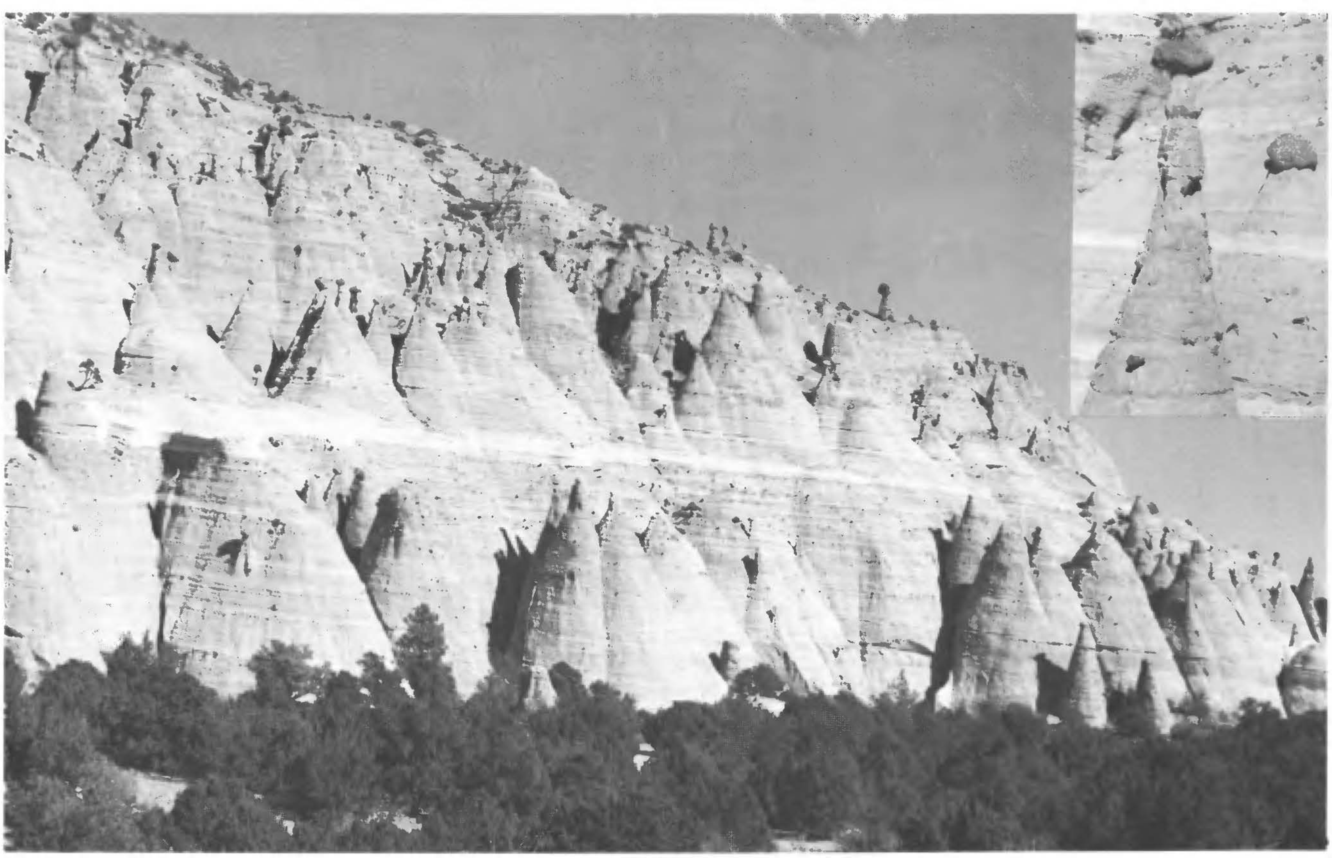


FIGURE 32—View of Tent Rocks in Peralta Canyon (Stop 4). Peralta Tuff Member of Bearhead Rhyolite of Keres Group. This tuff is a facies of Santa Fe Formation.

99.4 Slumped Santa Fe and hillside alluvium in roadcut.
0.2
99.6 Windmill.
0.3
99.9 Santa Fe fanglomerate in roadcut.
0.6
100.5 East-dipping Santa Fe fanglomerate in roadcut.
0.2
100.7 Peralta tuff of Smith, Bailey, and Ross (1970) in big cliff up canyon at 12:00.
1.2
101.9 **STOP 4.** Take right loop turn around trees just before road crosses Peralta Creek.

Tent rock exposures are rhyolitic tuff breccia. Smith, Bailey, and Ross (1970) designated the Peralta tuff as the basal member of the Bearhead Rhyolite Formation of their volcanic Keres Group of roughly middle Pliocene age. As mapped in Peralta Canyon, the Peralta tuff underlies the Cochiti Formation which they put above their Santa Fe Formation (see fig. 32).

Retrace route to I-25

106.2 Small flat-topped mesa at 12:30 is capped by a basalt flow. Note extension of the thin flow in the Santa Fe along the mesa northward to about 11:45. Near the end of this flow is a wing dam of Cochiti reservoir.
1.1
107.3 *Turn left* on paved NM-22. Cochiti Pueblo.
8.7
116.0 Santo Domingo Pueblo at 12:30. High, tilted Sandia fault-block mountain on skyline at 12:00.
1.2
116.2 Galisteo Creek bridge.
3.3
119.5 Cerrillos Hills porphyry intrusions at 10:00, Ortiz Mountain 12:15.
1.1
120.6 I-25. *Turn right.*
17.3
137.9 NM-44 *Continue straight ahead* through overpass.

END OF ROAD LOG. About 17 miles to Albuquerque.

Type faces: Text–10pt. Times Roman, leaded one-point
References–8pt. Times Roman, leaded one-point
Display heads–24pt. Times Roman, letterspaced

Presswork: Text–38" Miehle Offset
Cover–20" Harris Offset

Binding: Saddlestitched

Stock: Text–70 lb. White Matte
Cover–65 lb. White Hopsack

Inks: Text–Cal Mira-jet Black
Cover–Cal PMS 534

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STRATIGRAPHIC NOMENCLATURE

Era	System	Series	Group, formation member	Thickness (ft)	Lithology
CENOZOIC	Quaternary	Holocene and Pleistocene		0 to 300	Terrace, valley, and slope alluvium; eolian sand; basalt flows of Cat Hills, Albuquerque, and Cerros del Rio
	Tertiary	Pliocene	Santa Fe Formation: Upper buff member	0 to 200	Sandstone (reddish, buff, purplish, gray, and white); mudstone (reddish, gray, and brownish); gravel. Contains lateral alluvial-fan facies of sedimentary, crystalline, and volcanic rocks; also eolian, playa, and fluvial facies. Group status is also applied and may include equivalents of Zia, Abiquiu, and Espinaso in local and adjoining areas. Also contains flows of basalt and andesite
		and	Santa Fe Formation: Middle red member	500 to 10,000	
		Miocene	Santa Fe Formation: Lower gray member	100 to 3,000	
		Oligocene	Volcanics, undivided	0 to 3,000	Rhyolite and basalt
		Eocene	Galisteo, San Jose, and Baca Formations	0 to 3,000	Sandstone, mudstone, and conglomerate
MESOZOIC	Cretaceous	Upper	Mesaverde Group	3,000	Sandstone, shale, coal
		Upper / Lower	Mancos Shale	1,500	Shale (black, olive drab)
		Lower	Dakota Sandstone	20 to 200	Sandstone (buff)
	Jurassic	Upper	Morrison Formation	0 to 800	Mudstone, sandstone, conglomerate (variegated)
			Todilto Formation	0 to 200	Gypsum, limestone
			Entrada Sandstone	0 to 150	Sandstone
	Triassic	Upper	Chinle Formation	1,500	Mudstone, sandstone, conglomerate (reddish brown)
			Santa Rosa Formation	70 to 400	Sandstone, conglomerate, mudstone
PALEOZOIC	Permian	Guadalupian	Bernal Formation	0 to 50	Sandstone, limestone
		Guadalupian / Leonardian	San Andres Formation	0 to 150	Limestone, sandstone (Glorieta Ss)
		Leonardian	Yeso Formation	400 to 700	Sandstone, gypsum, limestone (tan brown)
		Wolfcampian	Abo Formation	800	Mudstone, sandstone, conglomerate (red brown)
	Pennsylvanian	Upper / Middle	Madera Formation	0 to 1,400	Limestone, shale, sandstone
		Middle	Sandia Formation	50 to 200	Sandstone, shale, limestone, conglomerate
		Lower	Osha Canyon formation	0 to 60	Limestone
			Log Springs Formation	0 to 30	Hematitic shale and sandstone
	Mississippian	Osagean	Arroyo Peñasco Formation	0 to 100	Limestone
PRECAMBRIAN					Gneiss, schist, quartzite, greenstone, granite, and metavolcanics