Walter J. Arabasz

ROAD LOG TO THE QUATERNARY TECTONICS OF THE INTERMOUNTAIN SEISMIC BELT BETWEEN PROVO AND CEDAR CITY, UTAH

By

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Field Trip #8, April 30-May 1, 1978

FIELD TRIP #8

Anderson Larry W	Long Beach, CA
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Bryant Bruce	Denver, CO
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Carrara Paul E	Denver, CO
Carter Lorna M	Denver, CO
Clark, Eugene	Houston, TX
Cook Robert Annan	Dallas, TX
Crosby Paul M	St. George, UT
Currey Donald R	Salt Lake City, UT
Darby Dave	Kaysville, UT
Denault Kenneth J	Cedar Falls, IA
Dresser Hugh	Butte, MT
Edmiston R C (Bob)	San Francisco, CA
Everitt Benjamin L	Salt Lake City, UT
Hait Mortimer Hall	Denver, CO
Hamel Deborah	
Hanson Kathryn Lee	San Francisco, CA
Hinrichs Edgar Neal	Denver, CO
Kaliser Bruce	Salt Lake City, UT
Kneupfer Peter L	San Francisco, UT
Miller Darryl G	Long Beach, CA
Miller Robert D	Golden, CO
Olsen Kenneth H	Los Alamos, NM
Petersen James F	Salt Lake City, UT
Quinlivan William D	Lakewood, CO
Ritzma Howard R	Salt Lake City, UT
Rowley Peter Dewitt	Denver, CO
Sargent Kenneth A	Denver, CO
Schwartz David P	San Francisco, CA
Scott William E	Denver, CO

FIELD TRIP #8

Shroba Ralph R	Denver, CO
Staes Edward	Ogden, UT
Swan ~~Frank H~~ Bert	San Francisco, CA
Villaneuva Louis F	Bakersfield, CA
Weschler, Debra	Salt Lake City, UT
Williams Van Slyck	Lakewood, CO
Young John C	Arcata, CA

INTRODUCTION

The formal introduction to this field trip is included as a chapter in the guidebook that has been distributed to the field trip participants. In that report an attempt is made to outline the regional geologic and geophysical settings of seismicity in southwest Utah, to summarize current understanding of the Quaternary tectonics of the area, and to outline the trend of recent and current earthquake hazard research in the area.

The field trip leaders are engaged in geologic, geomorphic, and, to a limited extent, geodetic studies related to earthquake hazards in Utah. The studies are continuing, and the field trip participants will have an opportunity to view some aspects of our progress. No aspects of the studies are complete.

An important part of earthquake hazards studies in Utah is devoted to evaluating regional structural relationships such as the distribution in time and space of late Quaternary faulting. Such studies are essential to the understanding of earthquake hazards in more restricted areas, such as the urban corridor along the Wasatch front, because they provide a regional tectonic framework within which interpretations of more localized fault studies can be made. The field trip provides an opportunity to view some of the regional aspects of our studies. These statements are offered to those who might wonder "why the trip heads to the southwest away from the Wasatch fault and from the main urban area in Utah."

On the first day our route will take us south southwest along the western edge of some of the uplifted blocks of the western High Plateaus such as the San Pitch and Valley Mountains, the Pavant Range, the Tushar Mountains, and the Markagunt Plateau (fig. 1). To the west will be the valleys and ranges of the Basin and Range province. We will view examples of late Quaternary offsets at the margins of uplifted blocks as well as some that are far out in the alluviated valleys. We will stay in Cedar City overnight. On the second day, after visiting an exposure on the northern part of the Hurricane fault, we will head east across the boundary between the Basin and Range and Colorado Plateaus provinces and up onto the picturesque High Plateaus to the valley of the Sevier River. After visiting some exposures of a faulted late Quaternary uplift near Panguitch we will follow the Sevier River north for about 175 km through the mountainous High Plateaus. We will then retrace our route from Levan to Provo where the trip will terminate.

In the road log that follows distance intervals and cumulates are given in miles whereas metric units are used in the descriptive part of the log. This cumbersome inconsistency is necessitated by the general shortage of metric odometers in automobiles and buses.

Several of the entries in the road log are modified from or borrowed verbatim from road logs of previous field trips, especially from a log by Rowley and Anderson (1975).

The field trip route can be followed by reference to figures 2 through 6 in the following order: 2, 3, 4, 5, 6, 5, 4, 3. The trip consists of 13 planned and a few optional stops. Their locations are indicated on figures 2 through 6. Fault scarps in those figures are indicated by light-weight lines and the approximate position of the Bonneville shoreline is indicated by heavy dotted lines on figures 2, 3, and 4. The patterned areas on figure 4 mark the locations of microseismic activity as determined in the summer of 1975 (Olson and Smith, 1976).

Interval	Cumula-tive	Observations
		1)Itinerary for first day, Sunday, April 30, covers route from Provo, Utah, to Cedar City via route I-15 and its temporary segments. The log begins at the parking lot, Rodeway Inn, 1292 S. University, Provo, where if you face east, you will see Buckley Mtn., which forms the abrupt west edge of the Wasatch Range here composed mostly of highly deformed Paleozoic rocks. The conspicuous scars at the base of the range result from quarrying operations in Lake Bonneville deposits. Shorelines of ancient Lake Bonneville are not conspicuous on the bed-rock front to east (12:00) but are clearly visible at about 1:00.
0	0	2)Leave parking lot and turn right (south) onto University Ave. and follow signs to St. George.
		REFER TO FIGURE 2.
0.5	0.5	3)Overpass, Utah Lake visible on right.
0.7	1.2	4)Merge onto I-15 which heads S30W toward Springville and Spanish Fork--two municipalities situated in the bed of Lake Bonneville. The south-trending Wasatch fault zone takes a large easterly swing in this area forming a conspicuous reentrant into the edge of the Colorado Plateaus.
0.8	2.0	5)On right, exit ramp to Springville. Spanish Fork Peak is at 11:00 and its lower slopes display outstanding examples of a series of 2-stage faceted spurs above the highest Bonneville shoreline. This is one of the classic examples that led Davis (1903) to recognize that faceted spurs found at the base of block-faulted mountain fronts on the Basin and Range and along the Wasatch front reflect long-continued displacements on the frontal faults. Recently Hamblin (1976) suggested that the size and spacing of pediment remnants preserved at the apices of successive generations of faceted spurs can be used as a guide to understanding the displacement history on a frontal fault.
1.8	3.8	6)Turn right onto offramp to highway 89 and Springville and at top of ramp turn east over I-15 toward Springville.
1.1	4.9	7)Single track of UPRR.

Interval	Cumula-tive	Observations
1.0	5.9	8)Overpass for D&RGW RR tracks.
0.4	6.3	9)Cross highway 89, continue east through Springville and note Springville Art Museum on right; it's a treasure house worth visiting.
0.4	6.7	10)Hobble Creek.
0.5	7.2	11)Hill marks rise of roadway onto alluvial terrace.
0.4	7.6	12)Follow main road through curves (first to right and then to left) toward mouth of canyon of Hobble Creek.
0.9	8.5	13)Roadway on planar surface that may be underlain by a thin veneer of alluvium deposited as part of the floodplain of Hobble Creek when the creek was graded to the Provo I shoreline. The alluvium is believed to rest on Alpine sediments. To right (south) at lower topographic level are Draper Formation fluvial gravels graded to early Utah Lake level of Bissell (1963). These suggested stratigraphic assignments are based on a recent preliminary investigation of this area by Woodward Clyde Consultants (1975). The basic stratigraphic framework established by Bissell (1963) for southern Utah Valley was used in the preliminary study. The map compiled by Woodward Clyde Consultants (1975) is shown in fig. 7 and the generalized stratigraphy of the eastern Bonneville basin is shown in fig. 8.
0.3	8.8	14)Good view at 9:00 of fault scarp that rises 15 m from cultivated field at maximum angle of 35°. Scarp is formed on fluviolacustrine gravel deposits of the Alpine Formation and on post-lake fanglomerate. Ahead, roadway crosses low fan composed of post-Draper--pre-Holocene alluvium and approaches the fault scarp. The fan gravels tend to bury the fault scarp. They are offset less by the frontal fault than are the beds of the Alpine Formation.
0.6	9.4	15)On left, steep road embankment is cut into upthrown block exposing fluvial gravels believed to have been deposited when Hobble Creek was graded to the Provo I level.
0.1	9.5	16)Intersection with Mapleton Drive, stay to left.
0.1	9.6	17)Turn out to left into gravel area at edge of road--STOP.

Interval	Cumulative	Observations
		Silty sand and gravel deposits of probable upper member of the Bonneville Formation are veneered by coarse terrace gravels in artificial cut at turnout. Walk NW up gravel road to gate which is at edge of gravel-veneered terrace.
		The frequency of earthquake recurrence based on the geologic record of faulting has not been determined for the Wasatch fault. The purpose of this stop is to point out some of the Quaternary features that led to designation of the section of the Hobble Creek site as one of the target areas for detailed study of fault recurrence along the Wasatch fault. The fault here displaces a sequence of undated alluvial and lacustrine deposits, and some of its activity may be recorded in a series of undated terraces along Hobble Creek. Continued investigations by Woodward-Clyde Consultants call for detailed surface mapping and soils studies augmented by numerous shallowly dug pits and followed by the sinking of boreholes and the digging of trenches. Suitable materials will be analyzed for their paleomagnetic properties and age estimates. The hope is that a record of the greatest number of displacements can be acquired either by correlation of units to other areas of known stratigraphy and chronology or by age determinations on materials involved in the faulting at this site.
		Return through Springville to junction with I-15.
5.7	15.3	18) Turn left onto I-15 onramp toward Santaquin. Most of the remainder of the field trip is focused on the preliminary results of efforts by Bucknam and Anderson to map and conduct morphometric studies of late Quaternary fault scarps that are formed on unconsolidated alluvial deposits. Those studies have led to the recognition that scarps of similar age have maximum slope angles that are strongly dependent on scarp height. The relationship is so strong that it could probably be used to establish the approximate age of scarps if ages could be established for several control data sets. On the field trip we will give careful consideration to the kinds of data that are available, and that future studies may provide, to aid in establishing the ages of scarps.
1.8	17.1	19) On right, exit ramp to Spanish Fork and Price.

Interval	Cumula-tive	Observations
3.5	20.6	20)On right, exit ramp to U-164 and Spanish Fork.
3.7	24.3	21)On right, exit ramp to U-115, Benjamin and Payson. On left (east) good views of alluvial fans and Bonneville shorelines at base of Wasatch Range. On right shorelines are well developed at base of West Mountains. Bissell (1963) found no evidence to indicate a large normal fault at the base of West Mountain.
3.4	27.7	22)On right, gravel pit in Bonneville Formation at base of West Mountain.
2.1	29.8	23)On left, gravel pit in Bonneville Formation and overlying colluvium and fanglomerate. Well-developed faceted spurs above highest shoreline. Fan surfaces at base of range show no conspicuous offset.
0.8	30.6	24)On right, exit ramp to US-6. On left (east) a scarp about 15 m high is formed on old alluvial fill that is deeply dissected in small valley; surface of active fan that is graded to present stream level shows no offset.
1.5	32.1	25)Leave valley of Provo and Utah Lake.
1.0	33.1	26)On right, exit ramp to south Santaquin.
1.2	34.3	27)Leave Utah County; enter Juab County. Good view ahead of fan surface unbroken by faulting. Enter Juab Valley.
1.1	35.4	28)On left debris flow in red and yellow rocks of the Upper Cretaceous and Paleocene North Horn Formation.
1.4	36.8	29)On right, two small but conspicuous benches probably mark shorelines formed by Lake Bonneville.
1.9	38.7	30)On left, sage-covered fan surface is unfaulted.
0.9	39.6	31)Mona Reservoir on right.
2.0	41.6	32)Mount Nebo at 10:00.
0.6	42.2	33)At 9:00 steep-walled Bear Canyon that drains Mount Nebo contains alluvial deposits that are incised by modern stream. Incision into old fan deposits probably related to fault offset but surfaces of large active fans at base of mountain as at 10:30 show no evidence of fault offset.

Interval	Cumula-tive	Observations
0.2	42.4	34)On right, exit ramp to U-54, Mona.
0.6	43.0	35)Landslide at 10:00. Long Ridge, from 1:00 to 6:00, consists of Tertiary lava flows, tuffs, and breccias of intermediate composition and Oligocene age. Bissell (1963) reported that surficial evidence of faulting along the east side of Long Ridge is lacking, but a fault or faults could be concealed under the valley-fill deposits.
0.8	43.8	36)Underpass.
0.2	44.0	37)At 9:00 fault scarps formed on Quaternary alluvium in Willow Creek and at range front north of creek.
1.0	45.0	38)At 10:00, beautiful display of offset fan surfaces.
0.9	45.9	39)End, 4-lane I-15. Start 2-lane temporary I-15. Well-exposed discontinuous young fault scarps on left (east) for next three kilometers. These scarps have slope angles ranging from 25° to 40°. They extend south to the north limits of Nephi.
3.6	49.5	40)Enter town limits of Nephi.
1.3	50.8	41)Junction with U-132.
1.0	51.8	42)Leave town limits of Nephi. Wasatch Range from 6:00 to 9:00; San Pitch Mountains from 9:00 to 12:00. San Pitch Mountains define an uplifted block of High Plateaus. The mountains consist mostly of subhorizontal Paleocene and Eocene sedimentary rocks unconformably overlying Mesozoic rocks.
0.9	52.7	43)Though not marked by any conspicuous geomorphic feature, the low point of roadway coincides with the Bonneville shoreline. No fault scarps are recognized in alluvium at base of San Pitch Mountains to east or West Hills to west for next 11 kilometers.
		REFER TO FIGURE 3.
6.8	59.5	44)At 11:00 canyon of Chicken Creek. Fault scarps on unconsolidated alluvium are present north and south of canyon mouth but are not visible from highway.

Interval	Cumula-tive	Observations
1.5	61.0	45)Enter town limits of Levan.
0.3	61.3	46)Junction with U-28.
0.4	61.7	47)Leave town limits of Levan.
1.7	63.4	48)Relay tower at 3:00.
2.0	65.4	49)Enter bed of Lake Bonneville; UPRR tracks on right.
2.1	67.5	50)Low scarps at 3:00 are probably wave-cut embankments.
1.9	69.4	51)Chicken Creek Reservoir on left.
1.5	70.9	52)Summit of hill. Road cuts in yellow and gray rock of middle Eocene age (Green River Formation) on both sides of road. Mountains ahead and to the right (west) are the Canyon Mountains which are capped by Precambrian metasedimentary rocks thrust over Paleozoic and Mesozoic sedimentary rocks. Red sedimentary rocks on low hills near the base of the range are of Upper Cretaceous and Paleocene age (North Horn Formation).
0.9	71.8	53)Valley Mountains at 10:00. They, like the San Pitch Mountains, are an upfaulted block of the High Plateaus composed mostly of sedimentary rocks (North Horn Formation overlain by Paleocene and Eocene Flag-staff Limestone). Several fault scarps as much as 4 m high are present in the alluvial fill of a graben at the crest of the Valley Mountains.
2.2	74.0	54)On left, road to Yuba State Park. On right, at distance, are exposures of clastic sediments possibly deposited in Lake Bonneville.
0.5	74.5	55)Red and gray cliffs on left (east) probably belong to the Upper Cretaceous and Paleocene North Horn Formation.
0.4	74.9	56)Gray scarps between 3:00 and 4:00 are probably composed of lacustrine sediments, but topographic maps indicate that they attain elevations slightly in excess of 5200 feet, considerably higher than the 5110 feet that one would expect for the highest stand of Lake Bonneville in that area.

Interval	Cumula-tive	Observations
0.6	75.5	57)To right, large meander loop of Sevier River. Gray embankments to left consist of unconsolidated gravel containing abundant well-rounded to moderately rounded pebbles in a poorly sorted sand matrix. These deposits, and those in middle distance to right (west) are below the level of the high stand of Lake Bonneville, but their relationship to the lake is not known.
0.7	76.2	58)Cross Sevier River. Valley Mountains at 10:00.
5.2	81.4	59)Flagstaff Limestone and North Horn Formation on both sides of road.
0.8	82.2	60)Leave Juab County; enter Millard County. Enter Scipio Valley where recent studies have revealed a series of fault scarps of probable Holocene age formed on unconsolidated alluvium. Lake Bonneville did not occupy Scipio Valley.
2.2	84.4	61)At base of the southeast flank of the Low Hills from 3:00 to 4:00 the trace of a low fault scarp can be seen above the zone of dense sage cover. It shows as a light-colored band a couple of meters high and reflects movement of Holocene (?) age that offsets alluvial fill in the small valleys that drain from the Low Hills.
2.3	86.7	62)On right, scarps to west of bottom of Scipio Valley between 2:00 and 3:00 are formed on alluvial fan gravels extending from the Canyon Mountains. Our second stop will be at this scarp.
2.3	89.0	63)On left, junction U-26 to Scipio. The town is visible at 11:00. On right are the Canyon Mountains. Prepare to turn right.
0.9	89.9	64)Turn right onto gravel road that leaves highway toward 2:00.
0.2	90.1	65)Turn right (north) and follow main gravel road for 1.8 miles through series of left (west) and right (north) turns. On north-trending segments fault scarps are visible to west.
1.6	91.7	66)Road turns left (west) toward conspicuous fault scarp visible at 10:00 to 11:00.
0.2	91.9	67)Road turns right (north) with Canyon Mountains to left and Valley Mountains to right.
0.5	92.4	68)On left, track goes to gravel pit cut in low fault scarp. Scarp is conspicuous for next kilometer or so and its height increases.

Interval	Cumulative	Observations
1.3	93.7	69)Go through gate and STOP. The prominent scarp at this stop is the result of 2 distinct periods of movement. The older period produced a scarp as much as about 12 m high, probably as a result of several events. That scarp was modified and eventually breached by large washes. A relatively recent event resulted in about 2.5 m of additional offset which is particularly conspicuous at the mouths of the washes. In comparison with other fault scarps in alluvium in western Utah the appearance of this scarp is that of extreme youthfulness. The slopes of the scarp are steep, the crest of the scarp is angular rather than rounded, and the scarp is developed on all deposits except those of currently active washes. Several sizeable washes have a nickpoint only a few meters above the scarp. Measurements of profiles along the scarp show a relationship between scarp height and slope angle (Bucknam and Anderson, 1978) that indicates that the scarp is Holocene in age--probably on the order of several thousand years old. Return to temporary I-15 (after closing gate).
3.7	97.4	70)Turn right on temporary I-15.
0.9	98.3	71)On left, U-26 to Scipio. Valley Mountains at 8:00. At 10:00, north edge of the Pavant Range, an upthrown block of the High Plateaus. The Pavant Range consists of Paleozoic rocks thrust over Paleozoic and Mesozoic rocks that are unconformably overlain by gently east dipping Upper Cretaceous and Tertiary sedimentary rocks. Tertiary volcanic rocks of the Marysvale volcanic pile overlie the Tertiary sedimentary strata (Callaghan and Parker, 1962) in the southern part of the range.
3.4	101.7	72)Scipio Pass, leave Scipio Valley.
3.2	104.9	73)Pavant Range at left. No fault scarps have been found on alluvial fans on this flank of the Pavant Range, but at the base of the other (east) side of the range impressive scarps of probable Holocene age are found (fig. 3).
1.8	106.7	74)Divided 4-lane highway of I-15 resumes.

Interval	Cumula-tive	Observations
0.3	107.0	75)On right, exit 173 to Holden. Enter broad alluvial basin of the Sevier Desert.
1.4	108.4	76)Pavant Butte at 2:00. This basalt cone has a K-Ar age of 30,000-70,000 years (Hoover, 1974). Basalt flows near it and south of it belong to the Pavant field, dated at 30,000-22,000 years by Condie and Barsky (1972) and Hoover (1974). Pavant Butte is near the north edge of an extensive province of upper Cenozoic bimodal basalt-rhyolite.
3.4	111.8	77)On right, Exit 174 to Holden.
3.7	115.5	78)Low hill at 3:00 underlain by Sevier River Formation of late Tertiary and Quaternary age.
2.6	118.1	79)Highway crosses arcuate bar that probably marks the Bonneville high stand. The bar has been partially destroyed by borrow pit excavations. Good exposures of the bar-forming sediments are found in some excavations to north at about 4:30.
		REFER TO FIGURE 4.
0.6	118.7	80)On right, exit ramp to Fillmore.
1.5	120.2	81)The southern part of the Sevier Desert between 12:00 and 4:00 embraces the northern part of an extensive area of Quaternary volcanism that is characterized by a bimodal basalt-rhyolite petrologic association. Much of the volcanic area is located in a graben, and eruptions took place from northerly trending fault-controlled fissures within the graben. Successively older eruptive products record progressively greater amounts of fault displacement. K-Ar data indicate that volcanism began in the area about 2 million years ago and continued into the period of Lake Bonneville occupation. Our route will first pass through the northern part of the volcanic area which has been mapped by Hoover (1974), as shown in fig. 9. Because the terrain is so open, several of the volcanic source centers are visible from the highway as conspicuous topographic features. Most faults, however, are not visible from the highway because they have formed west-facing scarps. Hoover (1974) reported displacements ranging from 67 m in

Interval	Cumula-tive	Observations
		1-million-year old lavas to about 6 m in lavas that are inferred to be a few thousand years old. The youngest basalts in the area crop out directly west of Fillmore at 3:00 in what Hoover (1974) called the Ice Springs field. The lavas are fresh and nearly devoid of soil cover or plant growth. Their age is estimated to be 1,000 to 4,000 years on the basis of their geomorphic expression, stratigraphic position, and comparison with other young lavas of known age in the Great Basin and Idaho (Hoover, 1974).
1.9	122.1	82)On right, exit ramp to Fillmore, the first capital of the Territory of Utah. The old statehouse has been preserved as an historical museum and park.
1.5	123.6	83)Several volcanic features are visible; at 11:45 is the Black Rock volcano; at 1:15 is White Mountain, a low light-colored hill composed of the only rhyolitic deposit in this area; beyond White Mountain is Tabernacle Hill. At about 3:30 is Pavant Butte, a cone composed of palagonite. The volcanic rocks have chemical affinities that are transitional between alkali olivine basalt and tholeiite (Hoover, 1974).
3.7	127.3	84)On right, exit ramp to Meadow. On left, beyond town, a faint trace of the Bonneville shoreline is visible on the alluvial fan. From 7:00 to 10:00 is the Pavant Range, brownish-red Triassic(?) and Jurassic sandstone (Navajo Sandstone) is overlain in thrust contact by Paleozoic rocks.
2.2	129.5	85)Overpass.
0.4	129.9	86)Basaltic cone of Tabernacle field at 3:00. In contrast to lavas in the Ice Springs field, lavas in the Tabernacle field are slightly veneered with eolian sand and support moderate plant growth. Early eruptions were subaqueous into Lake Bonneville and are estimated to be 12,000 to 24,000 years old, and later ones were subaerial (Hoover, 1974). Low white hill about 3 km east (right) of Tabernacle Hill is White Mountain, consisting of partly devitrified crystal-poor rhyolite lava flows that have an age of less than 1/2 m.y. according to K-Ar dating by H. H. Mehnert (Lipman and others, 1978, table 3).

Interval	Cumula-tive	Observations
2.4	132.3	87)At 3:00, low white ridge consists of tufa mounds of Meadow Hot Springs and Hatton Hot Springs; they formerly were the sites of baths.
1.2	133.5	88)Exit to right to view area and STOP for overview of Black Rock Desert volcanic field. Black Rock volcano itself is to the southeast of highway and the Bonneville shoreline is clearly visible on its north flank. Lavas have a K-Ar age of 670,000 years (Hoover, 1974). To left (north) of volcano is floodplain of Corn Creek which drains from the Pavant Range and flows past the town of Kanosh. Areas of Quaternary volcanic rock such as the one visible from here provide relative or absolute time-stratigraphic markers that can be valuable in deciphering structural history. The most recent episode of faulting in this area was inferred by Hoover (1974) to be Holocene in age, and he estimated vertical displacement rates on the main fault zone to be 1.4 to 2 mm/yr and the horizontal extension rate to be about 1 mm/yr. Leave view area and continue south on I-15.
1.7	135.2	89)At 9:00 lavas of Black Rock volcano; between 9:00 and 11:00 is Pavant Range.
3.3	138.5	90)Between 1:00 and 2:00, distant exposures of undeformed lacustrine sediments deposited in Lake Bonneville.
0.8	139.3	91)On right, exit 145 to Kanosh; on left (southeast) highly deformed lower Paleozoic rocks are part of upper plate of thrust produced during Sevier orogeny. Two white rhyolite cones at 2:00 in distance. The northern cone, which is deeply breached by erosion, contains magnetite veins and consists of porphyritic (sanidine and quartz) rhyolite. The southern cone is petrologically similar to the northern one; it has a K-Ar age of about 2 m.y. (H. H. Mehnert, unpub. data, 1975). Just west of these cones, but not visible from here, are crystal-poor rhyolite flows near the Cudahy Mine; these consist in large part of perlite and mostly devitrified rhyolite about 2 m.y. old (Lipman and others, 1978, table 3). Basalts having ages of about 1 m.y. (Condie and Barsky, 1972) surround all the rhyolite flows and plugs on the west, south, and east. Basalt lava flows

Interval	Cumula-tive	Observations
		near the horizon at 3:00 are part of the 1-m.y.-old basalts. Basalts at 4:00 have K-Ar ages of 540,000 and 920,000 years (Hoover, 1974).
0.2	139.5	92)Optional stop where highway crosses conspicuous dry wash. A traverse westward down the wash reveals quartzite bedrock overlain by alluvial and lacustrine deposits that form the steep walls of the wash. A northerly trending west-facing fault scarp is formed on the alluvial and lacustrine deposits about 1 km from the highway. The scarp is in the basin of Lake Bonneville. It predates the Bonneville high stand because it has been obliterated by a conspicuous wave-cut bench at that level. It probably postdates some earlier lake occupation (Alpine?) because lacustrine gravels appear to be offset. Thus, the fault scarp in the area to the west of the optional stop has survived at least one major transgression and regression of ancient Lake Bonneville.
2.5	142.0	93)On right, conspicuous shorelines at 3:00; large borrow pit at 2:00, is cut into lacustrine sediments.
2.0	144.0	94)Enter Baker Canyon; high embankments on both sides of road are formed on Quaternary(?) alluvium by stream dissection.
1.0	145.0	95)Discontinuous exposures of shattered Paleozoic carbonate rocks on both sides of highway for next 1.5 miles are in the upper plate of a thrust plate that moved eastward over Mesozoic and upper Paleozoic rocks during the Sevier orogeny.
1.6	146.6	96)Pass; leaving Pavant Valley and Baker Canyon; entering small closed basin called Dog Valley.
0.4	147.0	97)Dark ridge at 11:00 consists of lavas and breccias of the Marysvale volcanic pile.
1.0	148.0	98)On right, ranch exit.
1.4	149.4	99)Roadcuts on both sides of road are in volcanic flows, breccias, and volcaniclastic sedimentary rocks believed to include the mid-Tertiary Needles Range Formation and rocks of the Marysvale pile. Abundant steep fracture surfaces with well-developed gently plunging slickensides indicate lateral movement on an average trend of about N30E.

Interval	Cumula-tive	Observations
		Offset contacts indicate apparent left-lateral displacement of approximately 600 m. The fractures strike parallel to and are along the projection of a system of northeast-trending normal faults that cut Quaternary basalts of the Cove Fort volcanic field to the southwest.
0.4	149.8	100)On right, exit to rest area.
0.5	150.3	101)Cove Fort-Dog Valley Pass.
0.9	151.2	102)On right, exit ramp to Cove Fort, a civilian outpost constructed in 1868 and commissioned by Brigham Young as a bulwark against what was considered to be the threat of Indian depredations. A microseismic survey of this area was made by James Olson, Utah Univ., during the summer of 1975 (Olson and Smith, 1976). Clusters of epicenters were recorded in the vicinity of the old townsite of Cove Fort at 9:00 (fig. 4). At about 1:00 large basaltic cinder cone surmounts basalt lava pile of the Cove Fort field. Northwestern flank of Tushar Mountains between 10:00 and 11:00.
1.0	152.2	103)Between 12:00 and 4:00 scattered dark cliffs formed on basalt are fault scarps that trend northeasterly. The lavas of the Cove Fort area are coextensive with those of the southern Sevier Desert that we viewed earlier. They have been mapped and described recently by Clark (1977) who stated that the lavas are cut by nearly 300 northerly trending normal faults some of which are shown on fig. 4. Clark calculated east-west horizontal extensional strain of approximately 7.5 m per kilometer within the past 1 million years. Basalts are undated, but the older lavas are believed to be less than 1 m.y. based on stratigraphic relationships to dated basalt. At several localities faults of this system are marked by scarps formed on postbasalt alluvium, but there is no evidence of Holocene displacement on any of the faults.
0.5	152.7	104)On left, in roadcut, gently dipping light-colored sedimentary rocks are probably late Tertiary in age (lower part of Sevier River Formation).
0.5	153.2	105)Fault scarps in basalt on both sides of road.

Interval	Cumula-tive	Observations
0.7	153.9	106)On left, fault scarps in basalt. Beyond at base of range is large borrow pit in which rhyolitic ash and pumice beds are interstratified with alluvium. The lower bed has been tentatively identified as the Bishop ash by Glen Izett, U.S. Geological Survey, Denver. The upper bed, which is mostly pumice, may correlate with 0.6 m.y. rhyolitic activity in the Roosevelt Hot Springs area 25 km to the southwest.
0.5	154.4	107)On right, exit ramp to I-70 and Denver.
0.2	154.6	108)Leave Millard County; enter Beaver County.
0.5	155.1	109)On left (east) at base of range is Sulphurdale, an area of active mining of sulphur from mid-Tertiary volcanic rocks. A large area approximately centered on Sulphurdale is being actively prospected for its potential as a geothermal resource area.
1.1	156.2	110)At 9:00, Tushar Mountains composed of mid-Tertiary volcanic strata rise to about 3,000 m.
0.6	156.8	111)On right, exit ramp to Sulphurdale.
1.2	158.0	112)On right (west) across cultivated field, is fault scarp that is cultivated on its northern part, sage covered on its middle part, and supports scattered cedar trees on its southern part. Scarp is 4.3 m high and has a maximum slope angle of 11°, is formed on cobble-bearing alluvium, and is probably pre-Holocene in age. Between 1:00 and 2:00 are steep-flanked silicic cones of the Cove Fort field.
3.5	161.5	113)On right, ranch exit. Drainage in area north of pass is mostly to the southwest across Beaver Valley to the west-flowing Beaver River, which drains a large area of the southern Tushar Mountains. REFER TO FIGURE 5.
1.5	163.0	114)Light-colored exposures of bedrock on both sides of road are volcanigenic sedimentary rocks of rhyolitic composition and probable latest Tertiary age.

Interval	Cumula-tive	Observations
0.6	163.6	115) Between 10:00 and 12:00 is profile view of extensive alluvial surface that has been deeply dissected by streams of the Beaver River system. Prior to the late Quaternary (> 500,000 years ago), Beaver Valley, a southerly continuation of the Cove Fort graben situated between the Tushars and the Mineral Mountains, contained a larger volume of basin-fill alluvial sediments including clastic deposits ranging from silt to boulder conglomerate, ash, pumice, and marl than it does now. Erosional downcutting by Beaver River in the vicinity of Minersville gap about 30 km southwest of here resulted in the removal during the late Quaternary of a large volume of sediment and produced some good exposures throughout Beaver Valley.
2.2	165.8	116) Between 1:00 and 3:00 is another profile view of dissected alluvial surfaces.
0.1	165.9	117) Turn right onto exit ramp to Manderfield, and turn left at top of ramp.
0.7	166.6	118) Roadcuts on both sides of road are unconsolidated to weakly consolidated sand and silty sand of latest Tertiary or Quaternary age.
0.3	166.9	119) Deep roadcut into irregularly bedded alluvial deposits of sand and gravel of probable Pleistocene age. Discontinuous lenses of altered ash of unknown age or source are exposed in roadcut. In upper part of roadcut cobbly and bouldery alluvium that probably represents some of the youngest alluvium deposited prior to erosional dissection is cut by a channel that is filled with reddish silt and sand. This cut-and-fill feature probably dates back to the early part of the episode of erosional dissection of Beaver Valley.
0.3	167.2	120) Roadway passes onto a relatively planar gently sloping alluvial terrace surface that is cut on alluvial sediments. This is one of several terraces formed during dissection of Beaver Valley. It is relatively young because it is not offset by faults that strike toward it from the south and offset older terrace and sediment surfaces.

Interval	Cumula-tive	Observations
1.3	168.5	121) Excellent panorama of Beaver Valley. Between 8:00 and 9:00 are the high peaks of the Tushar Mountains which stand at the heart of the volcanic centers that gave rise to as much as 3,000 m of strata that form the Marysvale pile of mid-Tertiary age. At middle elevations between 9:00 and 11:00 are erosional remnants of a high bench formed by faulted Tertiary mafic lavas (B stands for basalt). The lavas are downfaulted to the west and probably occur in the subsurface beneath the sedimentary fill in Beaver Valley. Their age is estimated to be 23.1 ± 0.2 m.y. on the basis of an unpublished K-Ar determination by Myron Best, B.Y.U. Between 12:00 and 1:30 are the Black Mountains, composed of interstratified volcanic rocks of the Marysvale pile, and the mid-Tertiary volcanic units of the Basin and Range. Between 1:30 and 4:00 are the Mineral Mountains, an upfaulted basin-range block that is composed of Tertiary volcanic rock in its southern part, intrusive rock of late Tertiary age of the Mineral Mountains batholith (the largest pluton in Utah) in its central light-colored high part, and a conspicuous dome composed of rhyolite that is less than 1 m.y. old at the northern end.
1.7	170.2	122) Small cluster of homes and other buildings is the community of Manderfield, which is constructed partly on remnants of an alluvial terrace surface that is probably older than the one on which we have been driving; continue straight.
0.4	170.6	123) Roadway descends onto fertile bottomland which is the active flood-plain of Indian Creek. Continue up hill and prepare to turn out to left at top of hill.
0.4	171.0	124) Turn out to left into borrow pit belonging to Utah Road Comm. and <u>STOP</u>. These excavations are made into gravels that cap a wide-spread extensively faulted erosion surface or pediment. This is probably the oldest alluvial surface in Beaver Valley. Locally the surface is concordant with subjacent strata, but in many places it bevels strata that dip as much as 20°. The surface, here named the Last Chance Bench, extends through this area from the west base of the Tushars southwestward about 20 km to the

Interval	Cumula-tive	Observations
		vicinity of Minersville Reservoir. It is very uneven because it is displaced by at least 50 northerly trending faults, most of which are shown on fig. 5. The resulting fault scarps range in height from less than 1 m to 25 m; and the largest one can be seen to the east of here at a distance of about 1 km. The scarps exhibit a range of maximum slope angle from about 8° to 27°. A large portion of the pediment surface has been tilted to the south-southeast, possibly contemporaneous with faulting. The scarps are pre-Holocene in age on the basis of geomorphic comparison with other scarps in western Utah. Pumice from strata beneath the pediment surface yielded a fission-track age on zircon of about 0.64 ± 0.22 m.y. (Charles Naeser, written commun., 1977).
		Soil profiles that include well-developed pedogenic caliche are exposed in the excavations here. At this and the next 2 stops we will observe calcareous soils of contrasting stages of development (and presumably contrasting ages) that have formed on pediment and terrace surfaces of contrasting ages. At this site, there may be two soils--a calcic soil formed from a gravel parent material buried beneath an A and B ox(?) soil formed on younger finger grained parent material.
		If the large fault that is seen to the east of here is traced southward it crosses alluvial deposits of the North Creek drainage where it is expressed as scarps that are only 1 to 3 m high (not visible from here). There is no obvious development of caliche on those faulted deposits. Where its trace crosses the modern flood-plain of North Creek there is no scarp visible.
		<u>RETRACE</u> route north to Manderfield.
0.6	171.6	125)Manderfield, prepare to turn left (west) on unmarked street.
0.2	171.8	126)Turn left onto road in front of abandoned service station.
0.9	172.7	127)Road descends from one terrace level to another.

Interval	Cumulative	Observations
0.4	173.1	128) STOP at underpass. Excavations east of the underpass are into a terrace surface that is topographically lower and presumably younger than the pediment surface of the previous stop. The surface is faulted locally. At this site there are A and B ± zones, each about 30 cm thick overlying a calcic K about 40 cm thick. The calcic zone is less indurated and thinner than at the previous site. Note thin clay skins on pebbles in Bt zone and the small carbonate nodules and firm cement in the K zone. Continue west from underpass on gravel road (a short segment is paved at underpass).
0.5	173.6	129) Road forks, stay left and proceed south. Poorly exposed light-colored strata to right (west) are gently dipping basin-fill sediments that are beveled by a pediment surface the dissected gravel-capped remnants of which can be seen.
0.6	174.2	130) At right, excavation into light-gray, thick-bedded, well-sorted crystal-poor ash is a patented placer claim. The ash is very clean and fresh, and Glen Izett, USGS (oral commun.) estimated it to be a Pearlette type ash about 0.5 m.y. old.
0.3	174.5	131) Roadway is on dissected terrace surface. Prepare to turn out to right.
0.6	175.1	132) Turn out to right above abrupt descent of roadway and STOP. A small excavation into the lower of two terrace surfaces here reveals A and B ox soil zones each about 15 cm thick overlying a weakly cemented calcic zone about 25 cm thick. Note that clasts in the B zone are not coated with clay skins and the caliche zone lacks carbonate nodules. This terrace is not known to be faulted. It is clearly younger than the surface that was excavated at the previous stop, and the soil developed on it appears to be less well developed than at either of the two previous stops. The alluvial deposits along the modern floodplain of Indian Creek that adjoins this terrace doublet on the south have no carbonate soil developed on them and are probably Holocene in age. Continue south on gravel road.

Interval	Cumula-tive	Observations
0.3	175.4	133)Floodplain of Indian Creek; prepare to turn right at top of hill ahead.
0.7	176.1	134)Turn right (west) at junction with gravel road; proceed west-southwest for 1.5 miles. Mineral Range at 2:00.
1.3	177.4	135)Hilly topography crossed by roadway results from fault offset of the same Quaternary pediment surface that was visited at stop 4.
0.3	177.7	136)Main gravel road turns left (south), proceed straight ahead on lesser gravel road.
0.2	177.9	137)STOP. Walk southwestward for 100 to 200 m along north lip of faulted and dissected gravel-mantled pediment surface. There are at places good exposures of carbonate-cemented gravels. Though this is possibly the oldest surface in Beaver Valley, the pedogenic significance of the advanced stage of carbonate accumulation is not well understood. There may be a complex sequence of multiple soils that produce intergrading profiles that formed in an aggrading environment. In any case, at this locality there is evidence indicating that fault offset occurred after the gravels were cemented--a relationship that is rarely exposed and may be very important. If relative ages are to be assigned to fault scarps from different areas on the basis of their geomorphic expression, it is important to evaluate local factors that may affect the rate at which scarps are modified by erosion. Two factors that could contribute to an increased resistance of this and other surfaces in this area to erosion and thereby affect the rates of erosional modification of fault scarps are (1) mantles of durable gravel and (2) cementation by carbonate. The effect of these factors cannot be evaluated quantitatively at this time. It is believed to be small when averaged over the total time during which the erosional process has operated on the scarps. Fault scarps in this area that resulted from displacements that are significantly greater than the thickness of the cemented gravels do not show anomalously steep slopes in their crestal regions as would be expected if cementation were a highly important retardant to scarp retreat. That is, scarp profiles yield smooth curves with no apparent "cap rock."

Interval	Cumula-tive	Observations
		The faulted surface at this stop has also been tilted to the south-southeast. If projected northward it would lie more than 100 m higher than the gravel-capped surface visible from here across Indian Creek. These relationships suggest a northeast-trending fault along Indian Creek with displacement down to the northwest. The predominant trend of drainages in Beaver Valley is northeast-southwest and some, if not most, of the drainages are probably controlled by northeast-trending normal faults that moved contemporaneous with the north-trending faults. Direct evidence for the faults is generally not found because of the vigorous erosion along the drainages. Return on minor road through cedars to main graded gravel road.
0.2	178.1	138)Turn right (south) onto graded gravel road which traverses, approximately along strike, a pediment surface that has been tilted westward by a fault that has produced the conspicuous scarp visible at left.
1.0	179.1	139)Valley of Beaver Creek ahead; prepare to make a left turn.
0.4	179.5	140)Turn left (east) on gravel road. On left, road passes several erosionally terminated late Quaternary cuestas that strike toward road.
1.1	180.6	141)Turn left (north) at intersection with graded gravel road.
1.4	182.0	142)Paved ramp for I-15 overpass. Follow main gravel road through turns to intersection with business loop to Beaver. The roadway in this area crosses an alluvial surface on which no evidence of a carbonate soil has been found. When properly lighted a low fault scarp can be seen to the east. That scarp passes through the town of Beaver.
1.2	183.2	143)Turn left on business loop to Beaver.
0.3	183.5	144)Enter Beaver.
1.0	184.5	145)Turn left on 300N, proceed to 400E. Turn right on 400E, proceed to 200N, fault scarp on left. Turn right on 200N, proceed to 300E. Turn left on 300E; proceed to Center, fault scarp on left. Turn right on Center, proceed to 200E, STOP (optional).
0.8	185.3	146)The fault scarp that passes through Beaver can be viewed near the center of the block to the southeast, but permission must be obtained to trespass. A very gentle depression parallels the scarp along its toe as

Interval	Cumula-tive	Observations
		it passes through the town of Beaver. The scarp is one of two low scarps (1-3 m) formed on stream gravels on which no evidence has been found for the development of a carbonate soil. The scarps are continuous for about 7 km but have been destroyed by erosion where they are crossed by the active floodplains of North Creek to the north and Beaver River to the south. They are located along strike of larger scarps that are formed on older surfaces, thus indicating recurrent movement. If the lack of a calcic soil can be taken as an indication of youthfulness, the surface faulted here is younger than the terrace at stop 7, which is not known to be faulted. This scarp may represent the youngest fault in Beaver Valley. On the basis of geomorphic comparison with Holocene scarps such as the one visited in Scipio Valley (stop 2), this scarp is pre-Holocene in age--although it is difficult to obtain reliable data because of cultural modification of the scarp. Continue straight (west) on Center Street and proceed to Main Street.
0.2	185.5	147) Turn left on Main Street (business loop) and head out of town.
0.3	185.8	148) On left (east), scarp is truncated by Beaver River.
1.0	186.8	149) On left erosional remnant of planar alluvial surface is about 50 m higher than roadway. Note gravel pit cut into alluvial strata beneath the dissected surface.
0.6	187.4	150) Overpass crosses I-15, prepare to turn left. The alluvial surface ahead on which the coffee shop and service station is constructed slopes toward I-15 and is probably the downdropped and rotated equivalent of the surface above the gravel pit at 5:00. If so, the surface has been displaced at least 70 m by faulting of probable late Quaternary age.
0.1	187.5	151) Turn left onto entrance ramp toward Cedar City. Quaternary fault scarps to left (east) near highway probably represent a southerly continuation of the scarp that passes through Beaver, which is the same fault that is inferred to displace the old alluvial surface a minimum of 70 m.

Interval	Cumula-tive	Observations
0.3	187.8	152)Merge with I-15. On left, large unwooded scarp at distance of about 1.5 km is a compound fault scarp about 28 m high. Where it is crossed by a prominent drainage there is a much lower scarp, about 5 m high, in the young valley alluvium, indicating recurrent movement.
2.7	190.5	153)Quaternary fault scarp trends away from highway at 2:00.
0.9	191.4	154)Enter Black Mountains composed of mid-Tertiary volcanic rocks.
3.2	194.6	155)Pass, enter drainage basin of Parowan Valley.
1.4	196.0	156)Prepare to turn left off incomplete I-15.
0.6	196.6	157)Turn left onto unpaved ranch road toward gravel pit.
0.4	197.0	158)On right, gravel pit.
0.5	197.5	159)Enter gate of Gentry's Lower Fremont Ranch. Roadway trends northeast. On right notice that boulder-strewn surface near roadway is at a higher elevation than sandy surface on other side of valley.
0.8	198.3	160)Turn right into Gentry's Lower Fremont homestead and STOP. Ask for permission to trespass. The purpose of this stop is to demonstrate the care that should be taken in gathering and interpreting geologic data pertaining to late Quaternary faulting. A normal fault that displaces bedrock of middle and late Tertiary age is well exposed along Fremont wash. A low scarp along that fault separates two surfaces that stand at different elevations and appear to be offset in the same direction as the bedrock. Early studies including hand-dug test pits showed that alluvium on the downthrown side is in fault contact with bedrock on the upthrown side. C^{14} age dates of 3700 ± 800 years B.P. were obtained by Meyer Rubin, USGS, on samples of organic sediment collected from alluvial overbank deposits on the downthrown side of the fault. The dated material was assumed by R. E. Anderson to correlate with the faulted alluvium indicating a Holocene fault event. Subsequent trenching and mapping has shown, however, that the faulted alluvium is older than the dated alluvium, and the dated alluvium overlaps the fault. Thus, all that can be concluded at this time is that there has been no movement on this fault in about the last 3800 years.

Interval	Cumula-tive	Observations
		Retrace route to junction with incomplete I-15.
2.0	200.3	161)Turn left (south) onto I-15.
1.5	201.8	162)Divided highway ends.
1.0	202.8	163)On right, fault scarps on unconsolidated alluvium.
2.9	205.7	164)On left, junction with U-28, entering broad expanse of Parowan Valley.
0.9	206.6	165)Ranges on both sides of valley are composed of mid-Tertiary volcanic rock.
		REFER TO FIGURE 6.
4.0	210.6	166)At 3:00 fault scarps in alluvium are highly visible on fan surface when sun is low in western sky.
1.9	212.5	167)On right, rest area.
0.6	213.1	168)On left, gently dipping red and gray lower Tertiary sedimentary rocks (Wasatch Formation) emerge from beneath cover of gray mid-Tertiary volcanic rock. The emergence is related to faulting at the Colorado Plateau--Basin Range margin. The fault here has been named the Paragonah fault.
4.0	217.1	169)Between 10:00 and 11:00, good examples of faceted range-front spurs strongly suggestive of recurrent fault movement.
0.7	217.8	170)On right, exit ramp to Paragonah. On left, between 10:00 and 11:00, a relatively large lobe of mafic lava extends down the cliffs just south of Paragonah. This lobe is the distal end of a long lava flow, dated by Fleck, Anderson, and Rowley (1975) at 0.44 m.y. It originated high on the plateau, flowed westward down the small valley and spread out at the base of the range. It has been displaced by two faults, one near the distal edge which forms the scarp approximately 20 m high and another near the mountain front with about 3 times that height.
1.9	219.7	171)On right, across valley, Quaternary fault scarps that are formed on the distant fan surfaces are clearly visible when the sun is low in the western sky.

Interval	Cumula-tive	Observations
2.1	221.8	172)On left, between 10:00 and 11:00, the southerly trending range front bends and heads southwest toward Cedar City. The south-trending range-front fault along which the red and gray sedimentary rocks were uplifted (the Paragonah fault) continues southward past the town of Paragonah and enters the range. According to Threet (1963) there is no major range front fault between Paragonah and Cedar City. The range front in that area (actually the west margin of the Markagunt Plateau) was said by Threet to be a monoclinal flexure that serves as a structural bridge between the Paragonah fault here and the northern end of the Hurricane fault near Cedar City. The monocline is fragmented by a system of northerly trending faults.
0.5	222.3	173)On right, exit ramp to Parowan; across valley on right is playa surface of Little Salt Lake.
1.5	223.8	174)At 2:00 the notch in the skyline is Parowan Gap caused by stream superposition across the rising of Red Hills structural block during Quaternary time. The Red Hills are composed of highly deformed Cretaceous strata overlain with high-angle unconformity by lower Tertiary sedimentary rock which is, in turn, overlain by small patches of tectonically transported mid-Tertiary volcanic rock and coarse detritus.
1.2	225.0	175)On right, exit to Parowan. At 2:00, good examples of faceted spurs at base of Red Hills. In places along the base of the hills exposures show Quaternary alluvium in fault contact with bedrock.
4.4	229.4	176)On left, Summit Canyon; prepare to exit from I-15.
0.5	229.9	177)Exit to right to Summit and Enoch.
0.4	230.3	178)Turn right at end of exit ramp, follow signs to Enoch, and proceed southwestward along frontage road.
0.6	230.9	179)At 2:30, a small patch of Quaternary mafic lava lies athwart the contact between red and gray sedimentary rocks of early Tertiary age to the north and dark brown mid-Tertiary volcanic rocks to the south. The lava is cut by faults that drop it down to the east beneath Parowan Valley.

Interval	Cumula-tive	Observations
0.7	231.6	180)At 10:00, cone-shaped hill with conspicuous excavation and road cuts is Cinder Hill which is composed of beds of basaltic cinders that rest on basalt lava that Harald Mehnert, USGS (written commun., 1977) has dated by the K-Ar method at about 1 m.y. The cinder beds and the lava have participated in much of the monoclinal flexing and faulting along the range front (Anderson and Bucknam, in press), thus establishing that much of the topographic rise that is seen from here is less than 1 m.y. old.
1.4	233.0	181)On left, geomorphic, structural, and isotopic data indicate the possibility of active tectonism along this segment of the range front (Anderson, 1978). An array of bridged quadrilaterals has been established by high-accuracy angulation. The array extends southeastward from I-15 to the skyline and transects the range front and several structures on the range flank. Periodic measurement of the array should provide data that will be valuable in assessing the nature and amount of current deformation.
1.5	234.5	182)Enter Cedar Valley, site of Cedar City. Prepare to turn right (west).
0.5	235.0	183)Turn right onto paved road, cluster of houses ahead and to right is town of Enoch.
0.5	235.5	184)Turn right at stop sign.
0.3	235.8	185)<u>STOP</u> in front of abandoned shed. This is private property, gain permission before trespassing. West-facing scarp behind shed marks trace of the Enoch fault. A serious effort has been made to determine when this fault moved last. Charcoal extracted from alluvial sands that were deposited across the fault and show no evidence of displacement has been dated by Meyer Rubin, USGS (written commun.), at 5450 ± 200 years B.P. from a site located about 5 km north of here. Carbonaceous sediment from the upthrown block behind the shed has been dated by Rubin at about 9500 ± 300 years. The beds from which the sample was collected appear either to have been flexed along the fault or to have been deposited on the fault scarp as a prograded assemblage. A shallow trench was excavated here to determine the relationship of these older sediments to the faulting, but

Interval	Cumula-tive	Observations
		the effort failed to reach a fault. Additional work is needed. All that can be said now is that the fault has probably not moved in about the last 5500 years. Return southward toward Cedar City.
0.2	236.0	186)Ahead, slightly dissected slopes at 12:00 are dip surfaces on Upper Cretaceous calcarenite sedimentary rocks that form the west-facing monocline.
0.5	236.5	187)Junction with frontage road, bear right.
1.0	237.5	188)At 2:00, low peaks on skyline are composed of plutonic rock of the Three Peaks pluton, one of several Tertiary intrusive masses located within a northeast-trending belt 90 km long that embraces the Iron Springs mining district. The iron mineralization is associated with pluton emplacement and has an approximate age of 21-20 m.y.
0.9	238.4	189)Roadcuts along frontage road and larger cuts along I-15 in highly deformed mid-Tertiary ash-flow tuffs of the Basin and Range, volcanic province. The deformation is probably related to landsliding off the flanks of plutons to the west.
0.7	239.1	190)At 9:00, Fiddlers Canyon.
0.2	239.3	191)Junction with U-130, yield to traffic and proceed ahead.
0.4	239.7	192)Follow business loop under the I-15 overpass and proceed to Cedar City.
1.8	241.5	193)Enter Cedar City, itinerary for first day of field trip ends.

Interval	Cumula-tive	Observations
		194) Itinerary for second day of Field Trip No. 8, Monday, May 1, 1978, covers route from Cedar City to Provo via U-14, US-89, US-28, and I-15. A stop south of Cedar City is included so that the trip does not head into the early morning sun. The log begins in the parking lot of the Best Western Motel at the junction of the Cedar City business loop (Main Street) and U-56. Leave parking lot proceeding west on U-56 (200N).
0.7	242.2	195) Prepare to enter I-15 heading south toward St. George.
0.4	242.6	196) Turn left onto entrance ramp to I-15. Housing development on right is constructed on unconsolidated material that Averitt (1962) has mapped as fanglomerate of late Tertiary age. Note large size of clasts; some are as large as 4 m.
1.2	243.8	197) On right (west) hill is capped by mafic lava of Quaternary age that rests on the fanglomerate. To the west of here, the mafic lava is interstratified with the upper part of the fanglomerate at a locality where an age of 1 m.y. has been obtained on the lava (Fleck, Anderson, and Rowley, 1975). Prepare to exit from I-15 to right.
0.4	244.2	198) Turn right onto exit ramp. The hills on the right are named the Cross Hollow Hills after a superposed drainage that has cut a notch through them as can be seen on the right.
0.2	244.4	199) Turn left (east) at end of exit ramp; follow signs to Hamilton Fort.
0.2	244.6	200) Turn right (south) on frontage road toward Hamilton Fort.
0.6	245.2	201) Between 9:00 and 11:00 at base of range are frontal lobes of a large landslide mass of late Quaternary age.
1.1	246.3	202) At 9:00, at base of range, west-facing fault scarps formed on mafic lava of Quaternary age.
0.6	246.9	203) On right, roadcuts along I-15 reveal faults that displace Quaternary mafic lavas (not visible from here). Prepare to turn left.
0.1	247.0	204) Turn left (south) onto graded gravel road. From 8:00 to 12:00 excellent panorama of Hurricane Cliffs. North Hills from 12:00 to 2:00.

Interval	Cumula-tive	Observations
0.4	247.4	205)At 9:00 is frontal lobe of another large landslide. On skyline above landslide is Square Mountain capped by mafic lava of Quaternary(?) age. The base of the lava is at elevation of 2500 m. Relatively flat ridge on skyline at similar elevation between 10:00 and 11:00 is also capped by Quaternary(?) lava.
0.6	248.0	206)On right, east-facing fault scarps on Quaternary mafic lava. The lava is presumably buried beneath the alluvium on which the roadway is built. The alluvium partially fills a Quaternary graben (the North Hills graben) between the Hurricane Cliffs on the east and the North Hills on the west. The graben projects southward where it is terminated against the Hurricane fault which swings southwestward in a large arc. At 10:00 at base of range is a 12-m scarp formed on very coarse unconsolidated stream gravels of probable late Quaternary age.
2.9	250.9	207)On left, wood-frame terminal of abandoned tramway used for transport of coal mined from Cretaceous strata high in the Hurricane Cliffs.
0.2	251.1	208)Fork in gravel road, bear right.
0.1	251.2	209)Fork in gravel road, bear left.
0.2	251.4	210)Ahead, high mountain mass on skyline is the Pine Valley Mountains composed of a large latite laccolity of middle to late Tertiary age.
0.2	251.6	211)Fork in gravel road, bear right.
0.3	251.9	212)On left, corral, junction with gravel road, turn out and <u>STOP</u>. Walk to southwest down gravel road 0.5 km. Good views of Hurricane Cliffs to left of road. The steep lower part of the cliffs are formed on yellowish-gray limestone and shaley limestone of the Timpoweap Member of the Lower Triassic Moenkopi Formation and the upper part of the underlying Permian Kaibab Limestone (Averitt, 1962). These overturned beds are part of the east limb of the Kanarra anticline--a Sevier-age structure that appears to have controlled the location of the late Cenozoic Hurricane fault in this area (Gregory and Williams, 1947). The trace of the Hurricane fault is located at the base of the cliffs.

Interval	Cumulative	Observations

At this stop we will consider the tectonic significance of clasts of igneous rock found in the upper Tertiary fanglomerate mapped here by Averitt (1962). The deposit is referred to herein as "debris" in order to avoid genetic connotations. We will view the full thickness of the debris from its base where it rests on reddish silty sandstone tentatively assigned to the Kayenta Formation of Triassic(?) age to its top where it is overlain by mafic lava inferred to be about 1 m.y. old. Clasts of mafic lava have not been found in the debris. At this locality the debris contains common very large (to 3 m) moderately well rounded clasts of an igneous rock that Averitt correlated with a small erosional remnant of similar rock that he mapped 11 km east of here at an elevation of 2800 m on the Kolob Terrace. He assumed that the debris here was derived from the east and deposited at the base of an inferred ancestral version of the Hurricane Cliffs created by late Tertiary faulting.

Recent mapping has shown that the small erosional remant high on the Kolob Terrace is actually debris similar to that exposed here and similar to other debris that Averitt recognized as being widespread on the Kolob Terrace. Thus, there is no logical source to the east for the clasts of igneous rock found in the debris. Detailed petrographic studies by R. E. Anderson (unpub. data) have shown that the clasts here and on the Kolob correlate with the intrusive rock of the Pine Valley laccolity of Cook (1957).

If this correlation is valid, it indicates that the Pine Valley laccolity or an intrusive mass similar to it extended far to the north of present exposures and was the source of coarse detritus that spread easterly during an episode of post-emplacement uplift. This interpretation is inconsistent with Averitt's inferred ancestral version of the Hurricane Cliffs. Ancestral cliffs could not have existed if the debris was transported easterly onto what is now the Kolob Plateau.

The debris at this locality has been lowered at least 1 km relative to its equivalent on the Kolob Terrace. The Pine Valley laccolity is approximately 20 m.y. old on the basis of its

Interval	Cumula-tive	Observations
		relationship to dated volcanic rocks (Cook, 1957; Armstrong, 1970). The age of the debris at this locality is thus bracketed by the approximately 20-m.y.-old igneous clasts and the overlying basalt, estimated to be about 1 m.y. old. This large age range does not provide the kind of age limits needed to refine the history of the Hurricane fault. The possibility exists, however, that the mafic lava on the Kolob Terrace correlates with the lava in the North Hills and has been uplifted approximately 1 km in the last 1 m.y. This possibility is based on recent studies by R. E. Anderson which indicate that the mafic lava did not pour down a steep valley in the Hurricane Cliffs as suggested by Averitt (1962, p. 41). Retrace route back toward Cedar City.
3.3	255.2	213) At 2:00 gently north dipping sedimentary strata of the Triassic Moenkopi Formation are situated athwart the northeasterly projection of the overturned Kanarra fold indicating that the fold is not continuous to the northeast.
2.5	257.7	214) Junction of gravel road with frontage road, bear right toward Cedar City.
2.3	260.0	215) Junction of frontage road with I-15 business loop. Turn right toward Cedar City. The town is nestled in a curved reentrant into the range. The range consists of steeply east tilted and locally overturned strata equivalent to those that form the overturned east limb of the Kanarra anticline seen at the last stop. In the northern part of the reentrant north of Cedar City the strata curve westward and form a northerly plunging fold structure. This change in strike is interpreted by Threet (1963) as resulting from the refolding during late Cenozoic time of an earlier fold structure produced during the Sevier orogeny.
1.8	261.8	216) Prepare to turn right.
0.3	262.1	217) Junction with U-14. Turn right (east) toward mountains.
0.8	262.9	218) Enter Cedar Canyon; Coal Creek on right. Steeply east tilted Triassic strata on both sides of road comprise the east limb of the fold structure formed during the Sevier orogeny (Late Cretaceous).

Interval	Cumula-tive	Observations
0.6	263.5	219) Red cliffs on both sides of road are east-tilted Triassic(?) and Jurassic Navajo Sandstone.
0.6	264.1	220) Enter 3-kilometer-wide area of Middle and Upper Jurassic strata that are highly deformed into a series of north-trending fold structures said by Threet (1963) to have formed by compressive forces during the Sevier orogeny.
3.0	267.1	221) On right, junction with road to Right Hand Canyon; continue straight. Yellowish-gray cliffs on both sides of road for next 5 km are formed on Upper Cretaceous sedimentary rocks belonging to the Tropic Shale and the overlying highly resistant Straight Cliffs Sandstone. Note occasional exposure of coal-bearing strata on both sides of road. Also note the subhorizontal attitude as we are now east of the narrow zone of folding that follows the mountain front near Cedar City.
3.1	270.2	222) On left, high atop cliff of Straight Cliffs Sandstone is erosional remnant of Quaternary mafic lava with conspicuous columnar jointing. Road enters narrow part of Cedar Canyon cut in Straight Cliffs Sandstone.
3.0	273.2	223) Canyon widens as it enters the less resistant beds of alternating sandstone and shale of the Wahweap Sandstone of Late Cretaceous age.
2.6	275.8	224) Roadcuts on left are in the Wahweap Sandstone. Spectacular reddish-orange cliffs ahead are formed on the Wasatch Formation of early Tertiary age. The cliffs are part of Cedar Breaks, the chief scenic attraction in Cedar Breaks National Monument.
1.4	277.2	225) On right, road to Webster Flat; on left, exposures of Wasatch Formation. Spectacular views to right for next 3 km look out over the Kolob Terrace toward some of the steep cliffs of Zion National Park. Disagreement exists as to the geomorphic significance of the Kolob Terrace. Averitt (1962) interpreted it in the Davisian sense as a surface of mature topography developed at low elevation near base level during an inter-fault cycle of erosion. According to this view the cliffs that we are now ascending have receded

Interval	Cumula-tive	Observations
		eastward from the Hurricane fault during the inter-fault erosional cycle leaving behind a broad pediment surface that was later uplifted by renewed movement on the Hurricane fault to form the Kolob Terrace. Threet (1963) instead interpreted the surfaces of the Kolob Terrace as a series of stripped structural terraces or benches, developed simultaneously and essentially at their present elevation, by stripping of nearly horizontal beds of contrasting resistance to erosion. According to this view, which is shared by R. E. Anderson, the Markagunt Plateau and Kolob Terrace are still essentially in their first major cycle of erosion.
1.1	278.3	226)Optional stop for view of Kolob Terrace and northern part of Zion National Park.
1.4	279.7	227)Summit.
0.8	280.5	228)On left, junction with U-143 to Brian Head, the dominant high point of the Markagunt Plateau (3,500 m) on the flanks of which is an important ski area; continue straight on U-14. Enjoy the scenic beauty of the mountain meadow of Midway Valley. The plateau in this area is trimmed with spruce, fir, limber, and bristlecone pine.
2.9	283.4	229)On left, view of unvegetated juvenile surface of mafic lava believed to be of Holocene age.
1.8	285.2	230)Leave Iron County, enter Kane County.
0.3	285.5	231)On left, exposures of upper Quaternary basalt and at 8:00 view of broad unvegetated surface on basalt of probable Holocene age.
1.2	286.7	232)On right, Navajo Lake. Though artifically dammed to increase water level, the lake occupies a natural topographic depression formed by damming of a drainage by mafic lava of probable late Quaternary age.
0.9	287.6	233)On right, view through trees of unvegetated dam composed of young mafic lava.
0.5	288.1	234)On right, road to Navajo Lake.
2.2	290.3	235)Gently rolling upland surface for next several kilometers is formed on lower Tertiary Wasatch Formation that can be seen in occasional roadcuts.

Interval	Cumula-tive	Observations
2.3	292.6	236)On left, Meadow View development.
4.0	296.6	237)On left, large roadcuts in Wasatch Formation.
2.0	298.6	238)For next 3 km occasional good views eastward toward the Paunsaugunt Plateau composed of gray Upper Cretaceous strata overlain by reddish orange beds of the Wasatch Formation.
3.2	301.8	239)Begin descent into valley of the Sevier River.
1.6	303.4	240)Junction with US-89 turn left (north). The junction is on the drainage divide between the Sevier River that drains northward to the Great Basin and the Virgin River that drains southward to the Colorado River.
0.4	303.8	241)Poorly exposed strata of Wasatch Formation on both sides of road for next 10 km.
3.8	307.6	242)Leave Kane County; enter Garfield County.
3.0	310.6	243)Assay Creek.
0.7	311.3	244)For next 3 km poorly exposed Wasatch Formation on left (west) and alluvial deposits of the Sevier River Formation of late Tertiary and Quaternary age at the right.
2.7	314.0	245)Mamouth Creek. Road crosses creek and climbs onto surface of Quaternary mafic lava that is well exposed on north side of creek.
1.7	315.7	246)Enter town limits of Hatch.
0.6	316.3	247)Leave town limits of Hatch.
1.8	318.1	248)On left, mafic lava overlies Sevier River Formation. Sevier River on right.
0.7	318.8	249)Roadcut in mafic lava. On left, for next 8 km are numerous roadcuts into the alluvial sands and gravels of the Sevier River Formation.
3.5	322.3	250)On right, old townsite of Hillsdale. Dark-gray mafic lava at base of red cliffs between 1:00 and 3:00 is downfaulted to west on the north-trending Sevier fault, one of several long faults that cut the gently dipping strata of the western part of the Colorado Plateaus province and form a structural region that is commonly

Interval	Cumula-tive	Observations
		referred to as a transition zone between the Colorado Plateau and Basin and Range. The mafic lava is displaced about 200 m on the Sevier fault. That displacement is approximately equal to the topographic relief of what here is the southernmost part of the Sevier Plateau. A K-Ar analysis of the mafic lava by Myron Best (Unpublished data) indicates an age of 0.56 ± .07 m.y. Reddish-orange cliffs are formed on Wasatch Formation.
2.0	324.3	251)On right, junction with U-12; continue north on US-89. River embankments on both sides of road formed on alluvial gravels of the Sevier River Formation of late Tertiary and Quaternary age.
2.5	326.8	252)Between 1:00 and 2:30 gray strata below skyline are mid-Tertiary volcanigenic rocks representing extracaldera facies erupted from calderas located in the Tushar Mountains.
2.7	329.5	253)Large roadcut in Sevier River Formation at crest of rise on left-hand curve, prepare to turn right off US-89.
0.5	330.0	254)Turn right onto unmarked road (paved apron leads to gravel).
0.2	330.2	255)Sevier River.
0.4	330.6	256)Gravel road forks, stay far right. On left, note caliche coatings on clasts on adjacent roadcuts. The caliche is part of a widespread deposit that locally forms a weak cement. Prepare to turn out to left.
0.2	330.8	257)Turn out to left next to city dump and STOP (OPTIONAL). At this stop we will view fault displacement in weakly consolidated gravels of the Sevier River(?) Formation exposed in a roadcut. The fault is one of a system of north-and-northeast-trending structures that form horsts and grabens expressed as scarps in weakly consolidated to unconsolidated Sevier River Formation and alluvium of probable Quaternary age. The fault scarps are localized in a band that extends 13 km to the south and 15 km to the north. Individual scarps in the band are as much as 6 km long. The band occupies the axial region of a contemporary fold that is evidenced by pre-fault fan surfaces that have been tilted away from the band of fault scarps. In the area to the north of here, alluvial surfaces

Interval	Cumula-tive	Observations
		west of the band of faults have been oversteepened whereas the slopes of surfaces to the east of the faults have been decreased and, locally, slope gently toward the Sevier Plateau to the east. Continue on gravel road but prepare to turn left.
0.1	330.9	258)Turn left onto lesser gravel road.
0.2	331.1	259)On left, view northward along graben expressed as opposed scarps formed on alluvium. The fault seen at the previous stop is along strike of the western scarp. Scarps of this system range to 27 m in height and have maximum slope angles that range from 8° to 23°. Scarp morphology indicates a pre-Holocene age for the faulting. The fault scarps and the uplifted area have been deeply dissected by streams flowing westward from the Sevier Plateau. A widespread caliche soil that locally forms a weak cement has developed on the scarps and erosion surfaces.
2.5	333.6	260)Section-line fence, go through gate and proceed for 0.1 mi.
0.1	333.7	261)Bed of Butler Wash passes small cluster of cedars; STOP in wash bottom. Walk up wash, stay to right where wash forks 15 m from road and continue walking for about 0.5 km. At this locality a soil profile consisting of a mature whitish calcic zone is overlain by an immature reddish-brown B and brownish-black A. The soils have been buried beneath alluvial sands and gravel of Holocene age. The humic layer has yielded a C^{14} age of 4370 ± 400 years B.P. according to Meyer Rubin, USGS (written commun., 1977). Walk back to bus. If time permits we will proceed for an additional 1.8 km along gravel road and visit another site where the ancient soil is buried beneath young alluvium. Detrital charcoal from that site has yielded an age of 7000 ± 250 years B.P. The firm caliche cement that is a part of this ancient soil is only preserved where it is buried. Because it follows the grade of paleosurfaces that reflect a fairly advanced stage of dissection of original fan surfaces, it is inferred to be separated in age from the folding and faulting events by an erosional interval of considerable duration. The indicated ages

Interval	Cumulative	Observations
		for the soil and detritus therefore tend to confirm a pre-Holocene age for the faulting as indicated by scarp morphology. What effect the ancient caliche cement may have had on the erosional degradation of the scarps is uncertain, but it should have tended to preserve slopes at high angles. In any case, on the basis of scarp morphology they are probably similar in age to, but slightly older than, those in the Beaver area visited yesterday. Retrace route to US-89.
3.7	337.4	262) Intersection with US-89, turn right (west) toward Panguitch.
0.7	338.1	263) Enter town limits of Panguitch.
0.7	338.8	264) Follow US-89 through turn to right (north).
0.7	339.5	265) Leave town limits of Panguitch, prepare to turn right toward Panguitch airport.
1.4	340.9	266) Turn right, follow signs to airport.
0.2	341.1	267) Sevier River.
1.9	343.0	268) Alluvial surface begins to steepen.
0.4	343.4	269) Profile of grade of alluvial surface between 1:00 and 2:50. If grade is projected eastward it intersects the Sevier Plateau near its summit, indicating that the surface has been tilted westward. Continue on road to airport, which is at 12:00.
0.4	343.8	270) Enter airport grounds.
0.1	343.9	271) Turn right at runway and follow graded shoulder to end of runway (do not drive on runway).
0.6	344.5	272) STOP and walk east across runway. In excavated embankment east of runway, note caliche coatings on clasts and the absence of a firm cement. Continue walking to crest of fault scarp to view graben structure and other scarps to east of graben. Also, view to south shows domal aspect of faulted surface. The city dump near the first stop in the Panguitch area can be seen to the south. Retrace route to US-89.

Interval	Cumula-tive	Observations
3.6	348.1	273) Turn right (north) onto US-89.
3.8	351.9	274) On left, abundant coatings of caliche on clasts exposed in roadcuts, but no firm cement indicated.
1.7	353.6	275) On right, well-developed alluvial surfaces that stand above flood-plain of Sevier River contain the northernmost scarps identified in the Panguitch area. Their morphology indicates at least two periods of movement. Also, low scarps are formed on alluvial surfaces that dissect the high scarps. These young faulted surfaces are, in turn, dissected by younger alluvial surfaces that are not faulted. Calcic soils are formed on all surfaces, and at specific localities each surface plunges beneath alluvial materials of the next younger surface thus providing ideal conditions for the preservation of buried soils. Careful study of soils and buried soils in the Panguitch area may provide a means of approximating the age of faulting.
1.8	355.4	276) At 10:00, exposures include mid-Tertiary ash-flow tuffs of the Basin and Range volcanic province and extracaldera alluvial facies of the Marysvale pile. According to Rowley and Anderson (1975) these rocks form the north-dipping flank of a dome about 5 km in diameter, probably formed by a Miocene concordant pluton. Alluvium of the Sevier River Formation laps onto the dome.
0.7	356.1	277) On left, gravels in roadcut are weakly cemented by caliche.
0.1	356.2	278) On left, junction with U-20, a roadway that joins I-15 about 32 km west of here. (For road log along U-20 see Rowley and Anderson, 1975.) From 10:00 to 2:00 the en echelon faulted west front of the gently east tilted southern Sevier Plateau. Displacement on the frontal faults (the Sevier fault zone) is at least 1500 m. Most rocks of the plateau consist of extracaldera alluvial facies of mid-Tertiary eruptions from the Tushar Mountains.
		REFER TO FIGURE 5.
1.7	357.9	279) Between 10:00 and 12:00 is a dissected pediment surface cut in part on a mid-Tertiary pluton, the Spry pluton of Rowley and Anderson (1975).

Interval	Cumula-tive	Observations
2.7	360.6	280)On left, exposures of the Spry pluton showing relatively flat upper surface that is remnant from an old pediment.
1.0	361.6	281)On right (east) small bridge crosses Sevier River. Spry pluton on left and in nearby hills from 2:00 to 4:00. Note flat pediment surface at 11:00. At 12:00 is Circleville Canyon. According to Rowley and Anderson (1975) the canyon probably resulted from stream superposition from an alluvial fill of late Tertiary age (Sevier River Formation) onto bedrock. The pediment probably formed during and after deposition of the Sevier River Formation.
2.5	364.1	282)Enter Circleville Canyon, cut mostly in extracaldera facies of volcanic strata erupted from the Tushar Mountains. As we drive northward through the canyon note the general decrease in amount of coarse volcanic mudflow breccia and a corresponding increase in lava flows, flow breccias, and dikes. This change suggests that we are approaching the vents from which these materials were extruded (Rowley and Anderson, 1975). The Oligocene-Miocene volcanic geology of the Marysvale field was the subject of a pre-meeting field trip (#2) led by T. A. Steven, P. D. Rowley, and C. G. Cunningham, and an outline of the geology is included in your guidebook. Two recent reports dealing with calderas and associated rocks (Cunningham and Steven, 1977) and stratigraphic revisions and radiometric ages (Steven and others, 1977) of the Marysvale field represent the results of ongoing studies by the U.S. Geological Survey.
6.7	370.8	283)On left, small gray log cabin 100 m off the road in clump of trees is former home of frontier outlaw Butch Cassidy.
0.8	371.6	284)Leave Garfield County, enter Piute County.
1.2	372.8	285)Enter town limits of Circleville. At 10:30 hill with "P" emblem has a conspicuous light-colored scar near its base. The scar marks the exposure of a fault surface that juxtaposes Quaternary alluvium against bedrock. The fault is expressed as scarps 3-5 m high in alluvium to the north and south of the hill (not visible from road). The scarps are probably pre-Holocene. From here

Interval	Cumula- tive	Observations
		northward along the Sevier River valley almost all scarps in alluvium are found at the valley margins as highly dissected discontinuous remnants, which are not conspicuous from the highway. High Tushars from 9:00 to 12:00 consist largely of vent facies of the Marysvale pile.
1.4	374.2	286) Leave town limit of Circleville. Cross Sevier River. Highest peak at 3:00 is Mount Dutton which caps the Southern Sevier Plateau and takes its name from C. E. Dutton, the first geologist to make a scientific study of the High Plateaus of Utah. His attempt to unravel the complex geology of this area was reported in 1880.
3.5	377.7	287) Bridge over Sevier River.
0.7	378.4	288) On right, junction with U-62 to Kingston Canyon. For road log to geology of that area see Rowley and Anderson (1975).
0.9	379.3	289) At 10:00, terraced cemetery is on upper Tertiary and Quaternary Sevier River Formation.
0.6	379.9	290) Enter town limits of Junction.
0.6	380.5	291) On left, junction with U-153, which leads to Beaver.
0.6	381.1	292) Leave town limits of Junction. At 9:30 a low scarp (3.5 m high) formed on unconsolidated Quaternary alluvium can be seen at the base of the range. Low hills at 3:00 consist of Sevier River Formation capped by mafic lava that has been dated by the K-Ar method at 21.1 ± 0.2 m.y. by Myron Best (unpublished data).
2.9	384.0	293) On right, Piute Reservoir. Northwest-trending range front beyond reservoir consists mainly of alluvial facies of the Marysvale pile with one reddish-brown local ash-flow tuff in the middle of the exposed section. A fault along the base of the range block has displaced mafic lava of late Tertiary age down to the southwest from the range crest to the range base where discontinuous exposures of the lava can be seen.
2.8	386.8	294) On right, road to Piute State Park. According to Rowley and Anderson (1975) the strata that comprise the tilted block between 1:00 and 3:00 are volcanic rocks of middle to late Tertiary age.

Interval	Cumula-tive	Observations
		The capping mafic lava has an age of 12.6 m.y. according to Damon (1969) and 12.7 ± 0.7 m.y. according to an unpublished analysis by Myron Best. The volcanic rocks correlate with a similar sequence exposed in the upper part of the high Sevier Plateau margin on the horizon beyond the tilted block. Sparse low fault scarps are formed on Quaternary alluvium behind (east of) the tilted block.
1.6	388.4	295)Note the strong asymmetry of this portion of Sevier Valley indicated by the smooth profile of alluvial fan surfaces that descend eastward from the base of the Tushar Mountains to the Sevier River where they terminate against a fault scarp represented by the low tan hills at 3:00. The strong asymmetry suggests activity on the fault during Quaternary time. At 4:00, alluvial fans composed of Quaternary alluvium derived from the Sevier Plateau appear to be graded to a higher level than those on which we are driving.
2.3	390.7	296)On left, dirt road ascends fan surface to Deer Trail mine visible at 9:00. Tushar Mountains from 7:00 to 11:00 have been uplifted along the northwest-trending Tushar fault zone. Sevier Plateau from 1:00 to 5:00 has also been uplifted on northwest-trending faults of the Sevier fault zone. These two fault zones were considered by Cook and Smith (1967) to rank among the most seismically active in Utah. For the period from 1850 through 1965 approximately 51 earthquakes were assigned to these structures by Cook and Smith (1967) as compared with approximately 105 on the Wasatch fault zone. Two of the earthquakes, with approximate magnitudes (estimated from intensity data) of 6.7 and 6.1, occurred in the Richfield-Elsinore areas on November 14, 1901, and September 29, 1921, respectively. We have not identified evidence of late Quaternary displacement on either of these fault zones in this area.
3.0	393.7	297)At 9:00, Bullion Canyon.
0.4	394.1	298)At 10:00, conspicuous scarp 12 m high across cultivated field is one of several northerly trending scarps near the geographic center of the valley. The scarps were formed by fault offset of a stream terrace along Pine Creek, one of the major creeks draining the

Interval	Cumulative	Observations
		Tushars in this area. Two of the scarps developed along strike of older scarps indicating recurrent fault movement. The age of the stream terrace is not known, but the morphology of the scarps suggests that they are pre-Holocene.
1.2	395.3	299)Enter town limits of Marysvale.
0.5	395.8	300)Leave town limits of Marysvale. Between 9:00 and 12:00, pastel colors produced in volcanic rocks by hydrothermal alteration associated with an episode of uranium-bearing mineralization that has an age of about 13 m.y. (Bassett and others, 1963).
		REFER TO FIGURE 4.
1.2	397.0	301)Enter Marysvale Canyon, also probably produced by stream superposition from a cover of upper Tertiary and Quaternary Sevier River Formation. The upper surface of the rock into which the canyon is incised contains remnants of what was once a pediment surface formed by erosion during the deposition of the Sevier River Formation. The canyon is cut into hydrothermally altered volcanic rocks that are probably vent facies of the Marysvale pile.
2.3	399.3	302)On left, rest area; on right, Hoover truck stop.
0.7	400.0	303)Leave Piute County, enter Sevier County.
0.2	400.2	304)On left, Big Rock Candy Mountain consisting of deeply altered volcanic rock.
2.1	402.3	305)On right, fluted vertical chilled margin of lower to middle Miocene (Bassett and others, 1963) quartz monzonite stock intrudes volcanic rocks.
2.2	404.5	306)Cross Sevier River.
0.8	405.3	307)On right, well-exposed volcanic strata show offset by faults.
1.0	406.3	308)Cross Sevier River.
0.2	406.5	309)Cross Clear Creek, leave Marysvale Canyon.

Interval	Cumula-tive	Observations
0.4	406.9	310)On left, junction with U-4. For a road log up part of Clear Creek Canyon along U-4 see Rowley and Anderson (1975). Between 9:00 and 12:00 northeast-dipping light-colored strata are alluvial beds of the upper Tertiary and Quaternary Sevier River Formation (this is the type locality). Note profile of gravel-mantled pediment that bevels the beds.
0.3	407.2	311)Enter town limits of Sevier.
0.7	407.9	312)On left, greenish-gray beds are in fault contact with salmon beds; all belong to the Sevier River Formation.
0.4	408.3	313)Leave town limits of Sevier.
1.5	409.8	314)Enter town limits of Joseph, Pavant Range on left.
0.6	410.4	315)On right, junction with U-118.
0.9	411.3	316)Leave town limits of Joseph. Joseph hot springs lie along the base of the fault block at 4:00; several other hot springs occur along faults of the Sevier fault zone in the vicinity of Monroe, a town about 8 km to the east.
2.7	414.0	317)On left, fault scarp formed on coarse alluvium is as much as 12 m high and is visible above irrigation canal. Although the scarp is less than 1 km long it suggests late Quaternary offset along a northeast-trending fault that bounds the valley on the west. Evidence of late Quaternary displacement along the range front to the northeast has probably been destroyed by vigorous erosion and deposition at the base of the range.
2.1	416.1	318)Enter town limits of Elsinore.
1.0	417.1	319)Leave town limits of Elsinore; between 12:00 and 3:00 is impressive west face of the Sevier Plateau.
1.7	418.8	320)On right, a large lobate mass that resembles a landslide extends outward from the base of the Sevier Plateau. The surface of the mass contains several scarps and small closed depressions suggestive of landsliding or slumping.

Interval	Cumula-tive	Observations
0.8	419.6	321)At 2:30, across valley, is town of Anabella. Beyond the town an easterly band of en echelon northeast-trending fault scarps are formed on unconsolidated alluvium. The largest scarp crosses the mouth of Water Canyon Creek about 13 km from here. Where it crosses an old alluvial terrace it is 32 m high, but where it crosses a narrow young alluvial terrace adjacent to the modern stream bed it is only 5 m high.
3.5	423.1	322)Between 9:00 and 12:00 are varicolored gently southeast dipping lower Tertiary sedimentary rocks.
0.3	423.4	323)Enter town limits of Richfield; follow signs for US-89.
1.9	425.3	324)Leave town limits of Richfield.
0.6	425.9	325)On right, for next 25 km, a few large and several small dark-colored hills are seen at or near the east edge of the valley. They are composed of west-tilted Tertiary volcanic rocks that form the west flank of a north-northeast-trending shale-cored anticline. The anticline is cored by the Middle-Jurassic Arapien Shale, which is exposed in variegated light-colored hills beyond the dark-colored hills. No scarps suggestive of late Quaternary faulting have been identified in the Sevier River Valley between Salina and Richfield, but Gilliland (1963) reported that beds of Pliocene-Pleistocene age are uplifted and folded along the axis of the anticline.
2.5	428.4	326)On right, road to Venice. On left, gently east dipping varicolored sedimentary rocks in Pavant Range are mostly Flagstaff Limestone of Paleocene and Eocene age.
3.0	431.4	327)On right, U-24 to Sigurd.
0.9	432.3	328)On right, gypsum wallboard plant. Beyond plant are mafic lavas of Tertiary age that dip into valley.
1.0	433.3	329)On right, light-colored rocks are Arapien Shale.
2.6	435.9	330)Between 9:00 and 10:00 are mafic lavas and breccias of Tertiary age.

Interval	Cumula-tive	Observations
2.9	438.8	331)On right, fullers earth plant. Badland topography beyond the plant is developed on complexly folded and faulted Arapien Shale in the core of the anticline. At 12:00, high country is the Wasatch Plateau.
2.1	440.9	332)Cross Sevier River. On right, conspicuous unvegetated scars at base of dark-gray ridge resulted from slumping subsequent to the removal of gravel from the toe of the slope during the mid 1950's when the gravel was borrowed for construction of the road bed between Salina and Richfield. The dark-gray ridge consists of Tertiary volcanic rock, some of which is overturned to the west, indicating that the shale-cored anticline was rising and spreading very actively subsequent to the mid-Tertiary volcanism.
1.6	442.5	333)Enter town limits of Salina.
0.6	443.1	334)Junction with U-4; follow US-89 through sharp left turn (north).
0.7	443.8	335)Leave town limits of Salina. On right, hogbacks of Green River Formation of early Tertiary age.
		REFER TO FIGURE 3.
2.0	445.8	336)On left (west), in middle distance is town of Redmond near which salt has been mined for many years from a salt anticline in the Arapien Shale.
3.1	448.9	337)Leave Salina County, enter Sanpete County.
1.0	449.9	338)Enter town limits of Axtell.
0.8	450.7	339)Leave town limits of Axtell.
2.0	452.7	340)At 2:00, good view of monoclinal flexure at west margin of Wasatch Plateau.
3.5	456.2	341)Enter town limits of Gunnison.
1.5	457.7	342)Junction of U-28 and US-89. Stay to left onto U-28. Leave town limits of Gunnison.
1.9	459.6	343)From 7:00 to 11:00 are the Valley Mountains.

Interval	Cumula-tive	Observations
3.1	462.7	344)On left, town of Fayette. From 11:30 to 4:00 are the San Pitch Mountains, the western flank of which consists of block-faulted Upper Cretaceous and lower Tertiary strata.
7.6	470.3	345)Maple Creek (dry wash). A swarm of lineaments and very subdued scarps have been identified in this area by Woodward-Clyde Consultants on the basis of study of low sun-angle photographs.
2.1	472.4	346)On left, Sevier Bridge Reservoir.
1.5	473.9	347)Leave Sanpete County, enter Juab County.
4.0	477.9	348)On right, fault scarp 316 m high that has maximum slope angle of about 26°.
1.1	479.0	349)On right, fault scarp crosses young alluvium at mouth of small valley.
1.8	480.8	350)On right, for next 8 km, well-developed alluvial fans are graded to the modern streams, and the fan surfaces at the base of the range generally lack evidence of fault displacement.
3.5	484.3	351)Prepare to turn right from U-28.
0.4	484.7	352)Turn right onto gravel road that crosses large borrow pit at mouth of Deep Creek. Drive up gravel road 0.6 km and turn out to right.
0.4	485.1	353)STOP, and walk up road toward canyon mouth about 0.2 km to view cutbank in which 3.4 m of fault offset in alluvium can be seen and above which a scarp of 4.0 m height and 26° slope angle can be seen. The cutbank is on the north side of Deep Creek. A small graben is also visible in the cutbank. Return to vehicle and return to intersection with U-28.
0.4	485.5	354)Turn right onto U-28.
0.7	486.2	355)On right, good view of fault scarp on alluvium at mouth of small canyon.
2.1	488.3	356)Enter town limits of Levan, road log for field trip number 8 ends.

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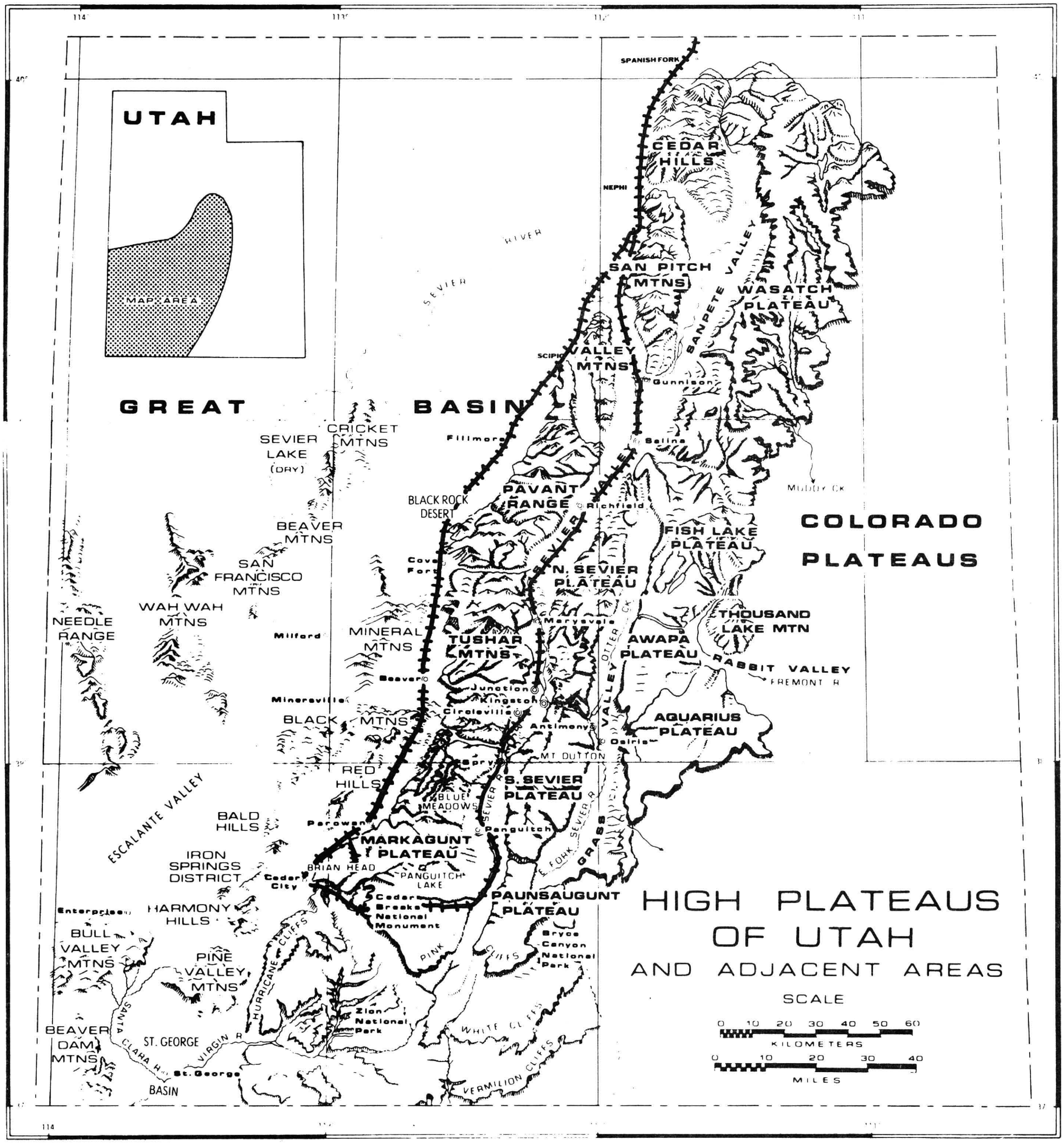
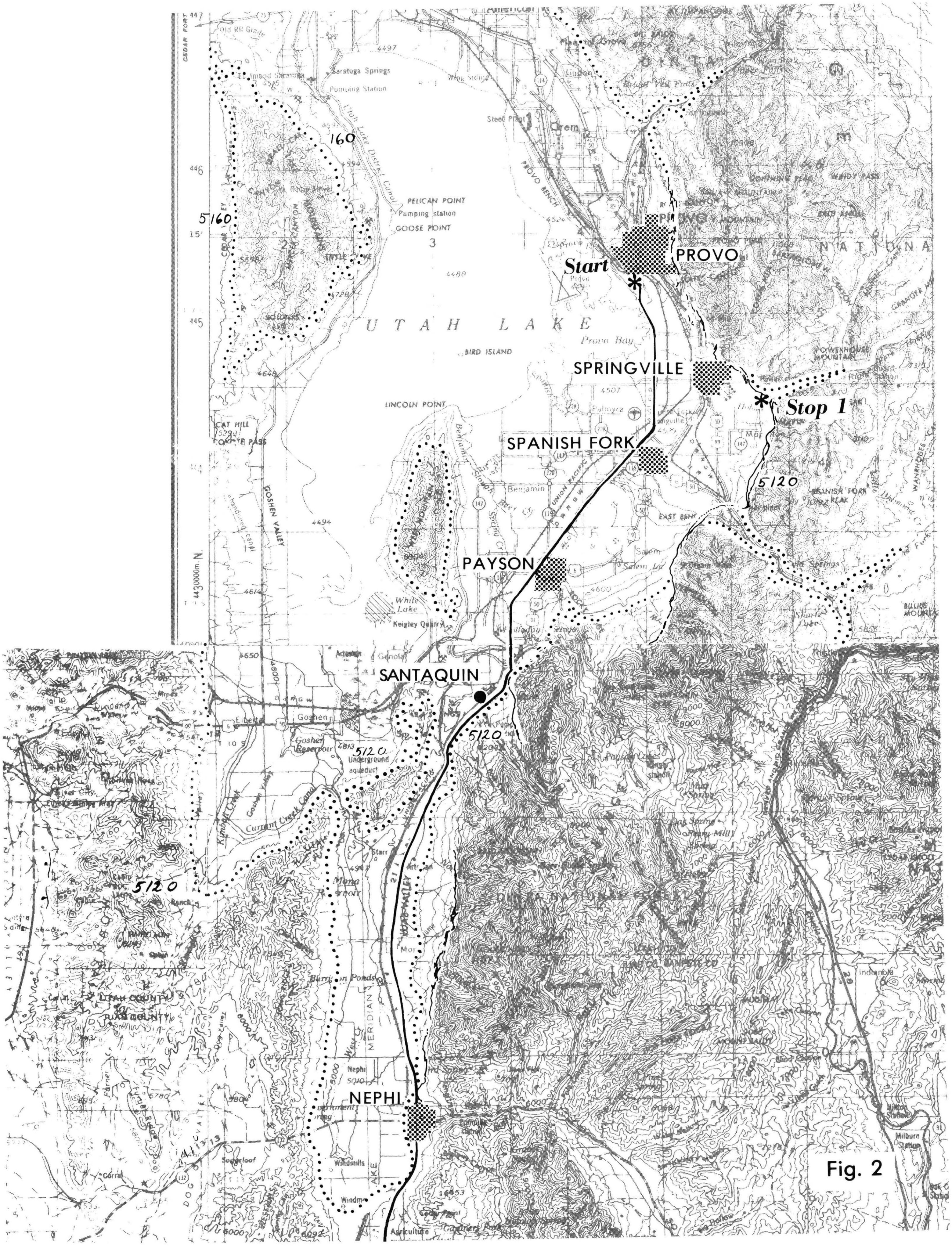


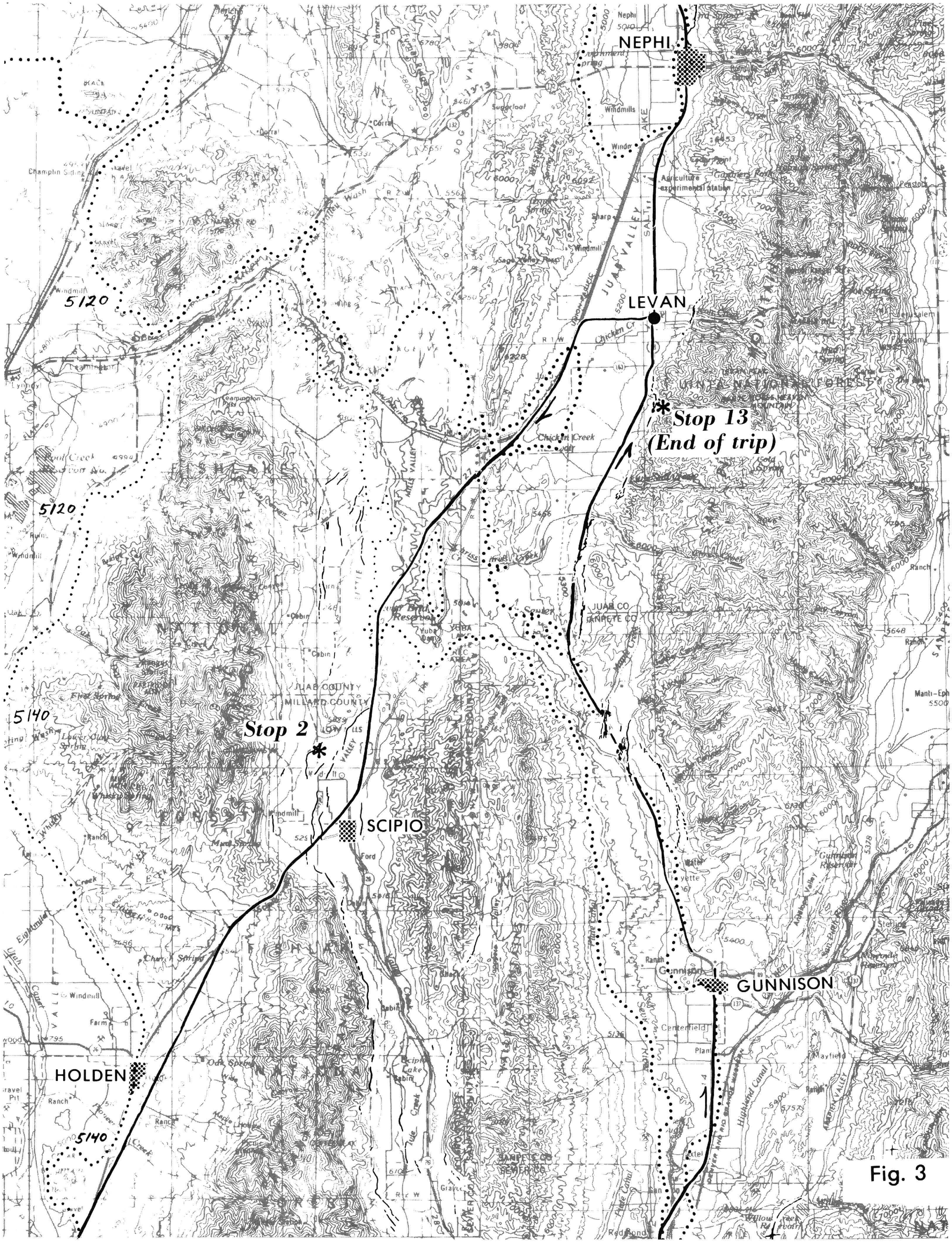
Index map of southwestern Utah showing the High Plateaus and several of the mountain masses of the adjacent Great Basin;hachured line marks field trip route; base map from Anderson and other, 1975.

Fig. 1



PROVO
Start
UTAH LAKE
SPRINGVILLE
Stop 1
SPANISH FORK
PAYSON
SANTAQUIN
NEPHI
5160
160
5120

Fig. 2



NEPHI
LEVAN
Stop 13
(End of trip)
Stop 2
SCIPIO
GUNNISON
HOLDEN
5120
5120
5140
5140
JUAB COUNTY
MILLARD COUNTY
JUAB CO
SANPETE CO

Fig. 3

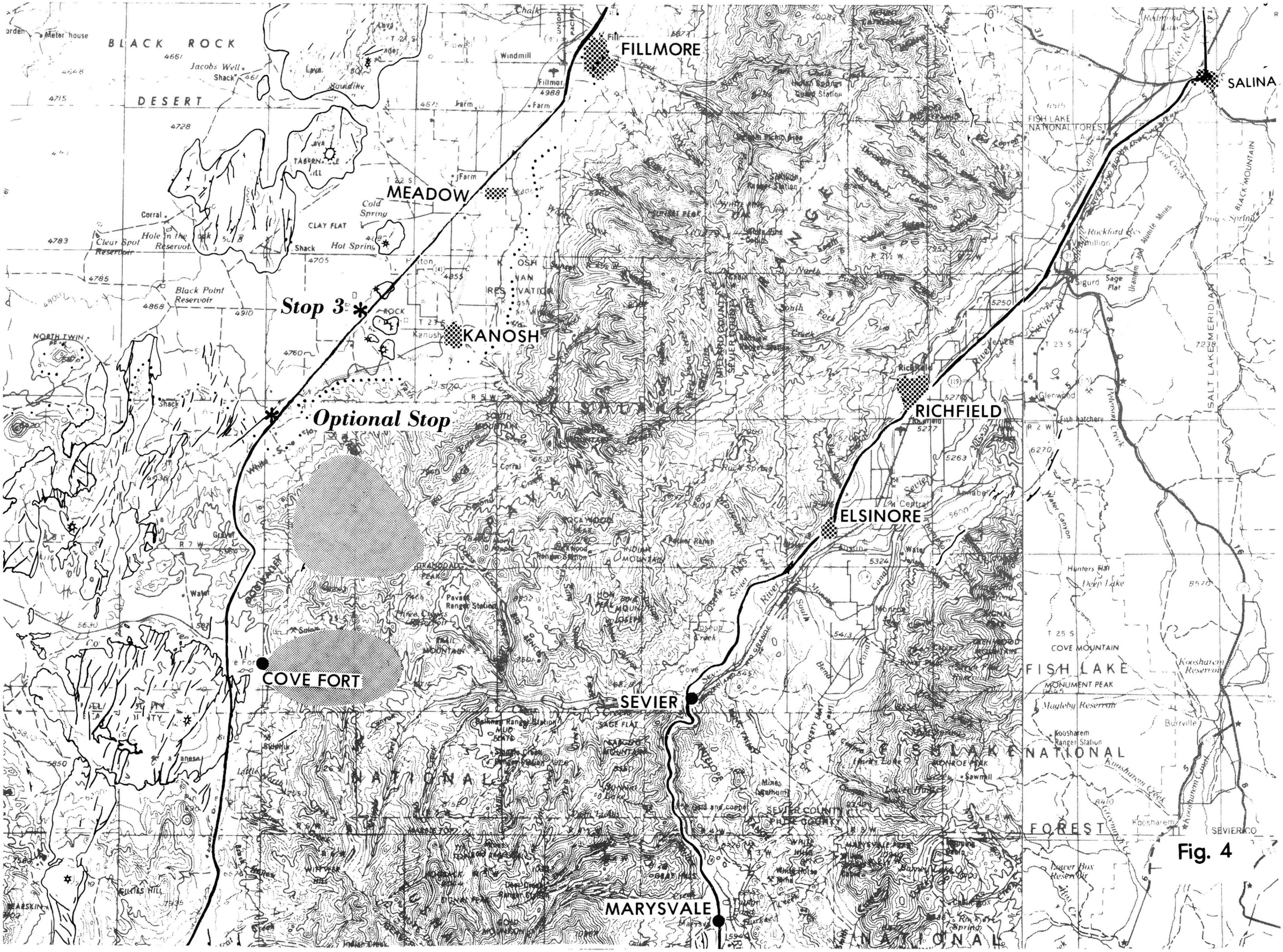

FILLMORE
SALINA
MEADOW
Stop 3
KANOSH
Optional Stop
RICHFIELD
ELSINORE
COVE FORT
SEVIER
MARYSVALE
BLACK ROCK
DESERT
FISH LAKE NATIONAL FOREST
SALT LAKE MERIDIAN
BLACK MOUNTAIN

Fig. 4

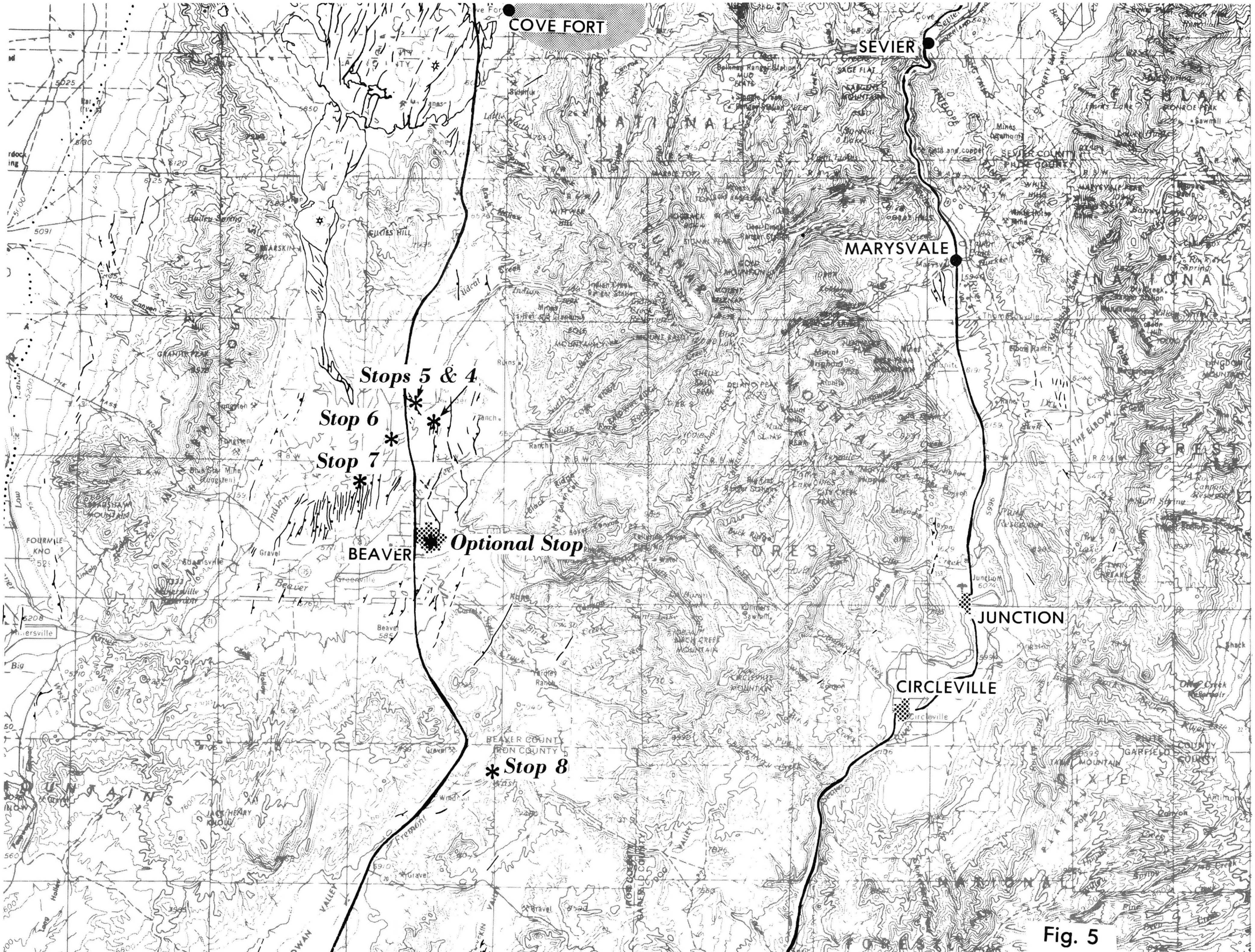

COVE FORT
SEVIER
MARYSVALE
Stops 5 & 4
Stop 6
Stop 7
BEAVER
Optional Stop
JUNCTION
CIRCLEVILLE
Stop 8

Fig. 5

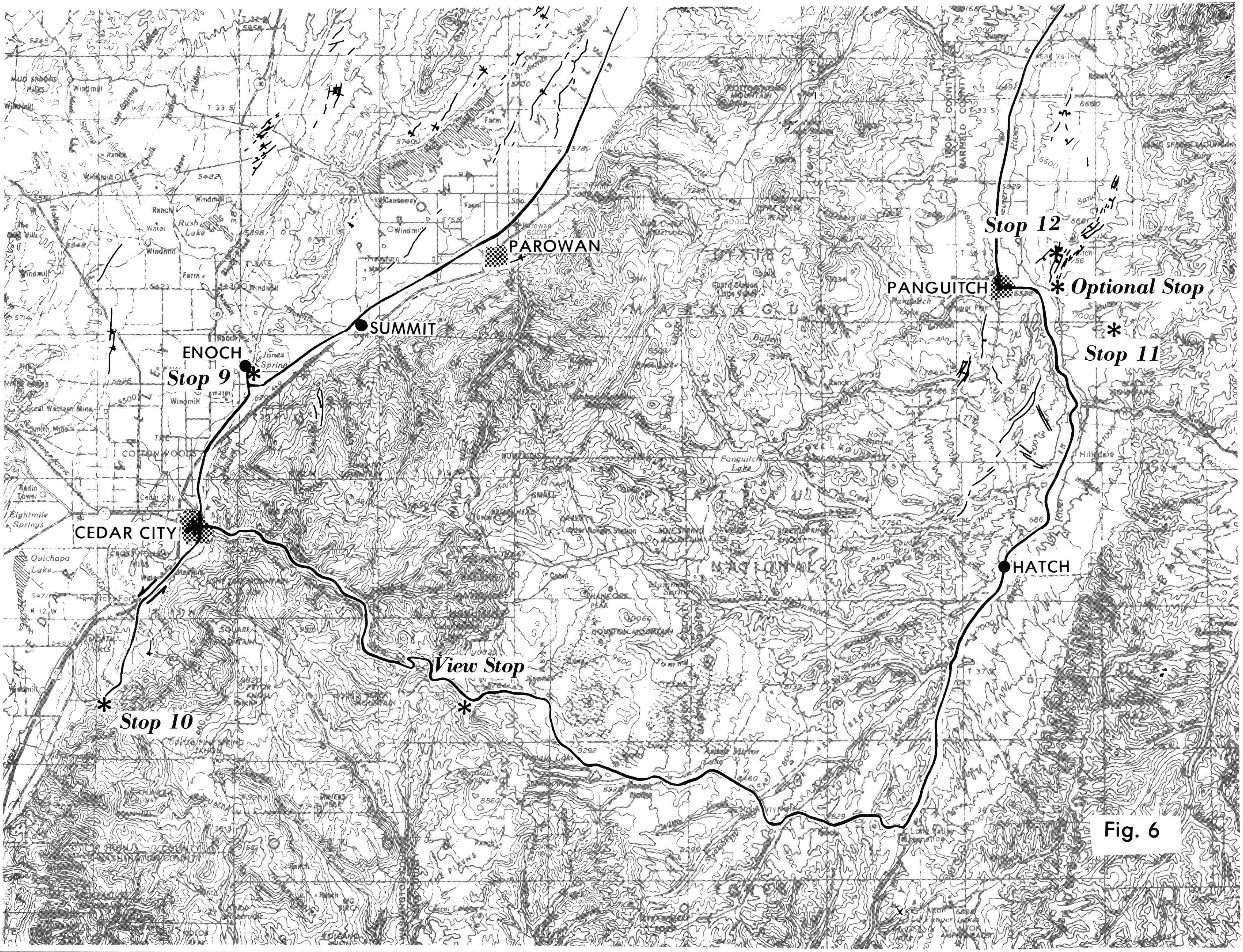

PAROWAN
SUMMIT
ENOCH
Stop 9
CEDAR CITY
Stop 10
View Stop
PANGUITCH
Stop 12
Optional Stop
Stop 11
HATCH

Fig. 6

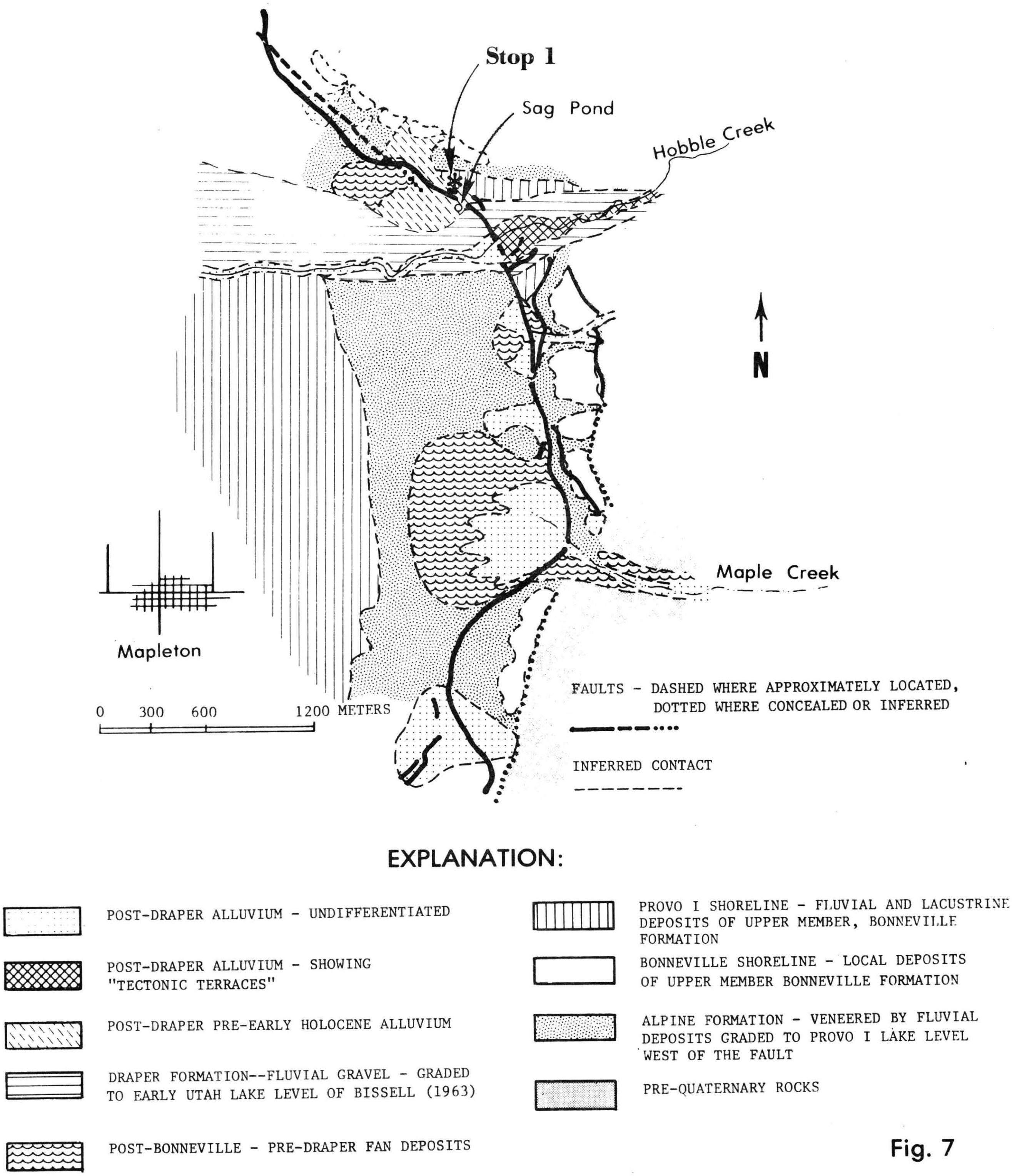


Fig. 7

Figure 7.--Map of the Wasatch fault in the Hobble Creek area, Utah County, Utah (from Woodward-Clyde Consultants, 1975).

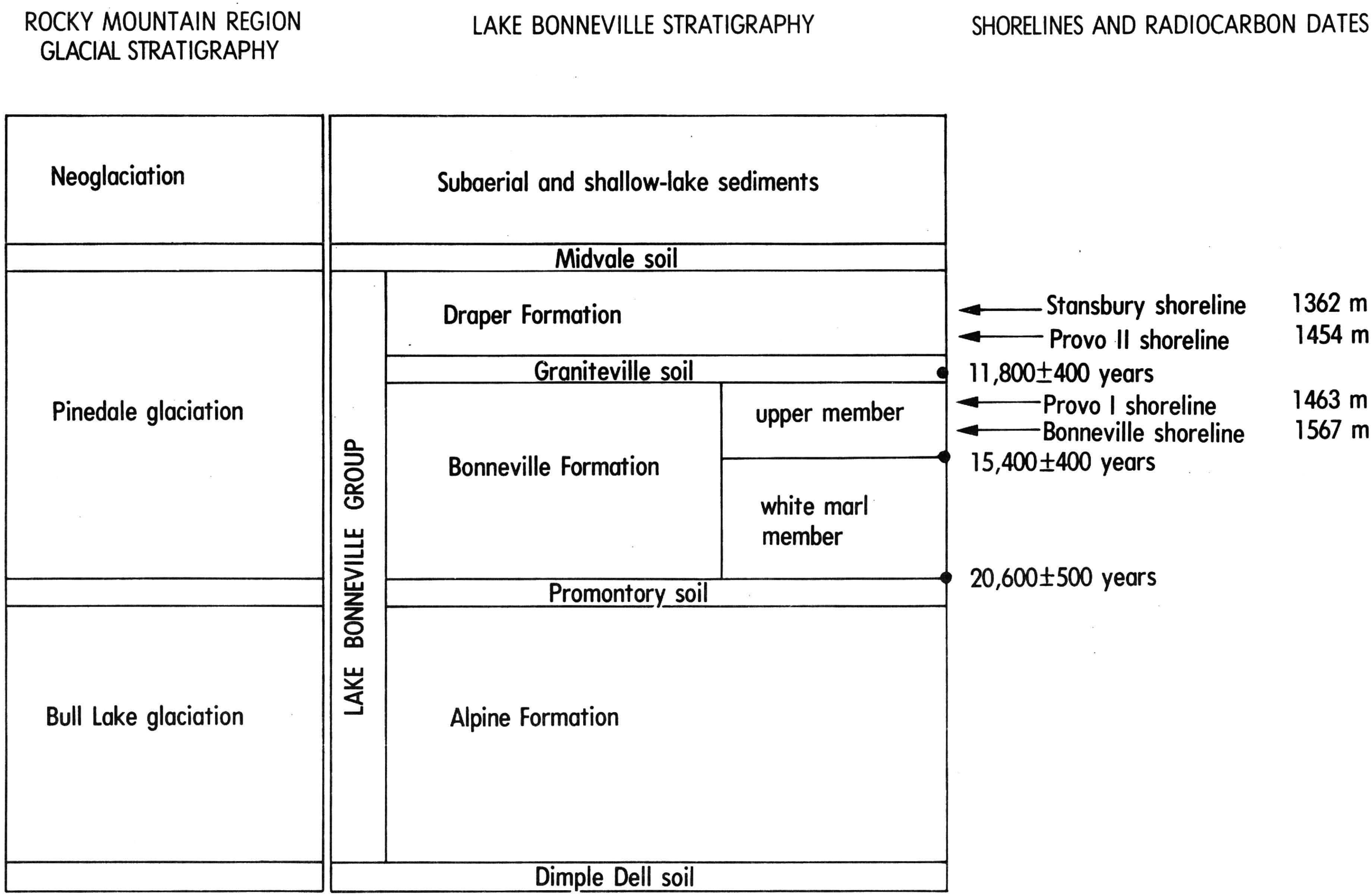


Figure 8.--Diagram showing the relationship between selected aspects of Lake Bonneville stratigraphy (including major episodes of soil development) and (1) glacial stratigraphy of the Rocky Mountain region, (2) elevations of selected Lake Bonneville shorelines, and (3) three radiocarbon dates (dots) chosen by Morrison and Frye (1965) as "landmark" dates that establish main tiepoints for the framewo: of the radiocarbon chronology of Lake Bonneville. Shoreline elevations are for the Provo area (Bissell, 1963) except for Stansbury shoreline elevation which is for the Salt Lake City area (Morrison, 1965).

Fig. 8

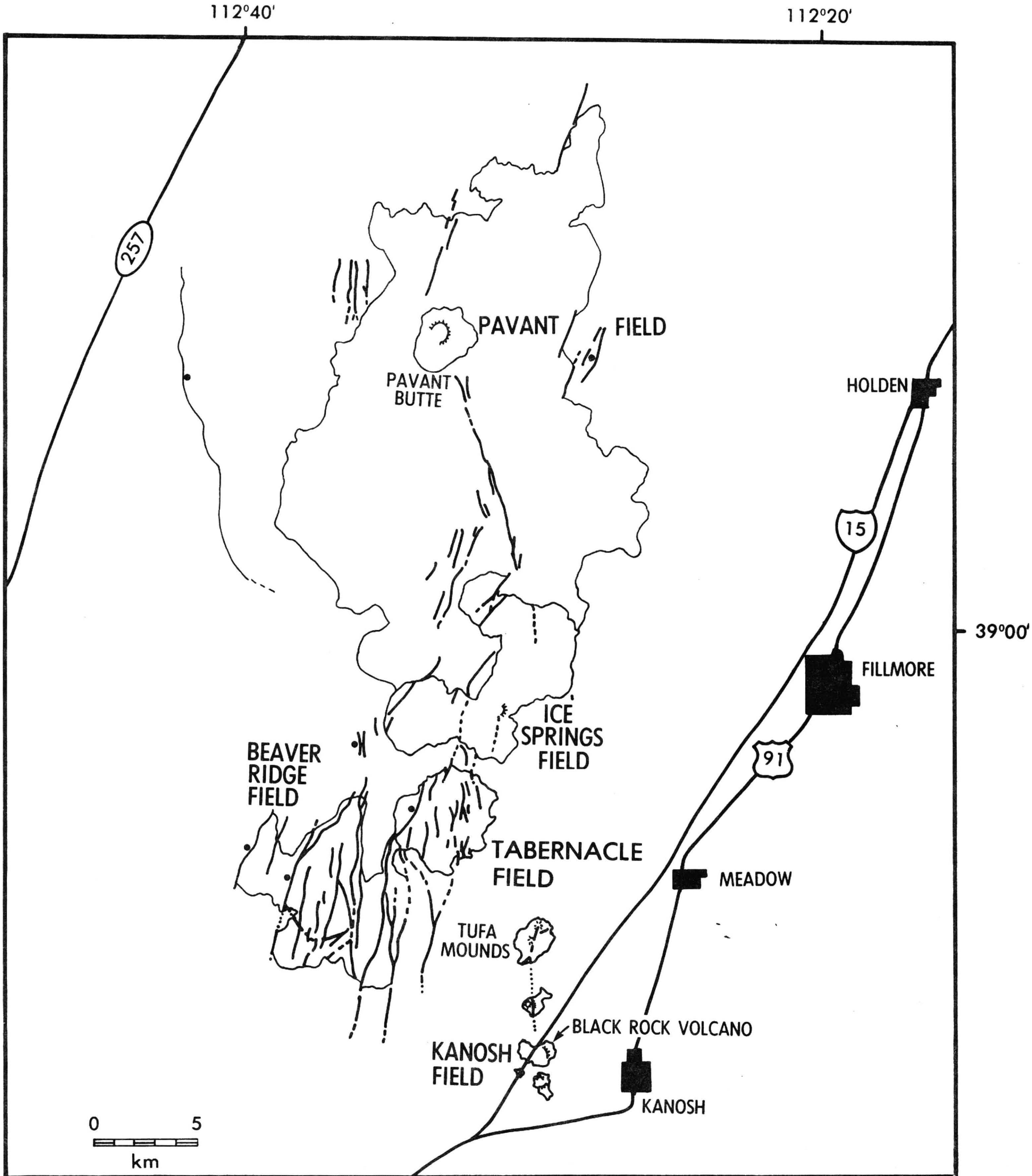


Fig. 9

Figure 9.--Map showing volcanic fields and faults in the southern Sevier Desert area (modified from Hoover, 1974).