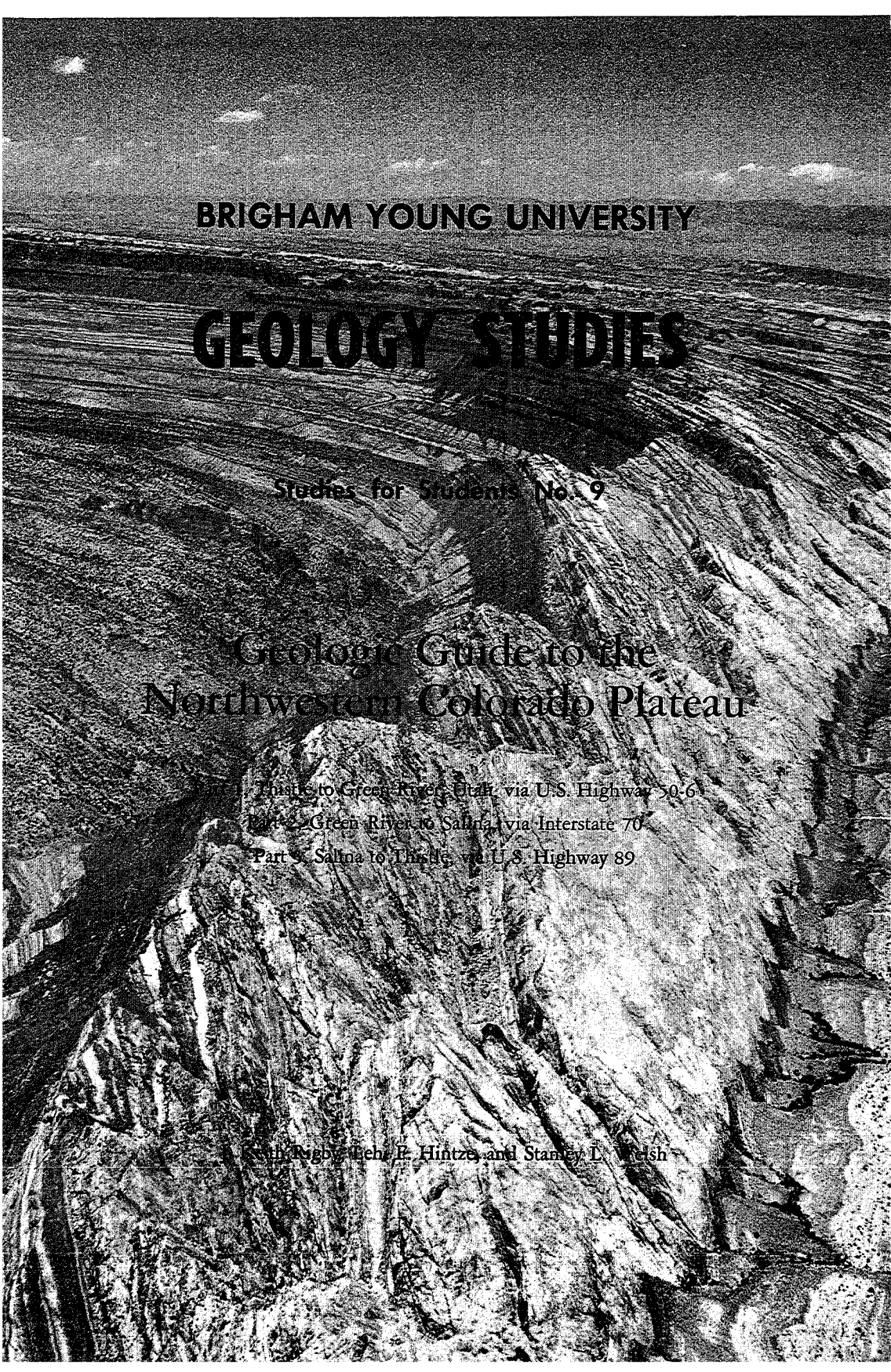


BRIGHAM YOUNG UNIVERSITY

GEOLOGY STUDIES

Studies for Students No. 9

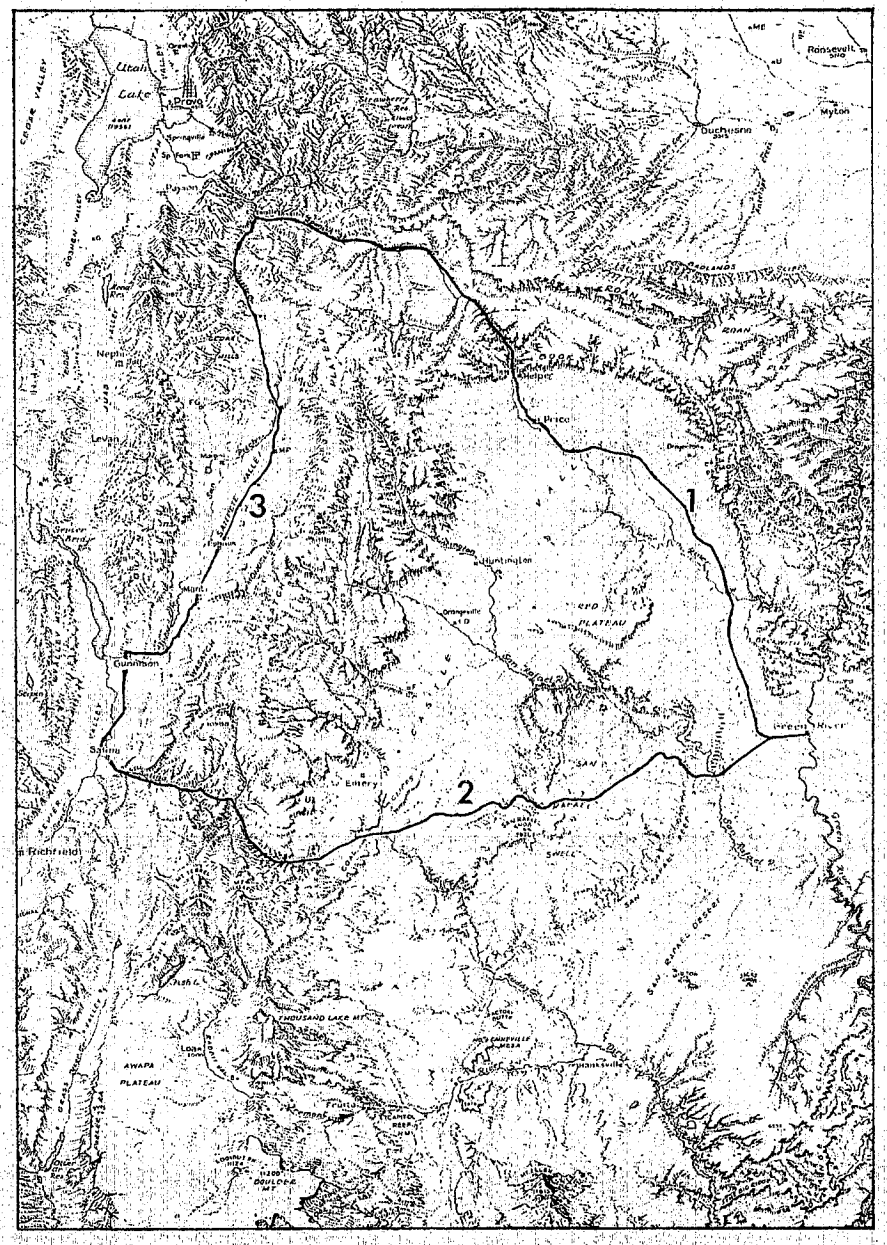
Geologic Guide to the Northwestern Colorado Plateau

Part 1, Thistle to Green River, Utah, via U.S. Highway 50-6

Part 2, Green River to Salina, via Interstate 70

Part 3, Salina to Thistle, via U.S. Highway 89

J. Keith Rigby, Tehs E. Hintze, and Stanley L. Welsh



Index map of the three parts of the road log guide. Part 1 covers Routes 50 and 6 from Thistle to Green River. Part 2 is along Interstate Highway 70 from Green River to Salina and Part 3 is along U.S. Highway 89 from Salina to Thistle. Base from a physiographic map of Utah by M.-K. Ridd.

Brigham Young University Geology Studies

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Editor

J. Keith Rigby

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J. Keith Rigby[1], *Lehi F. Hintze*[1], *and Stanley L. Welsh*[2]

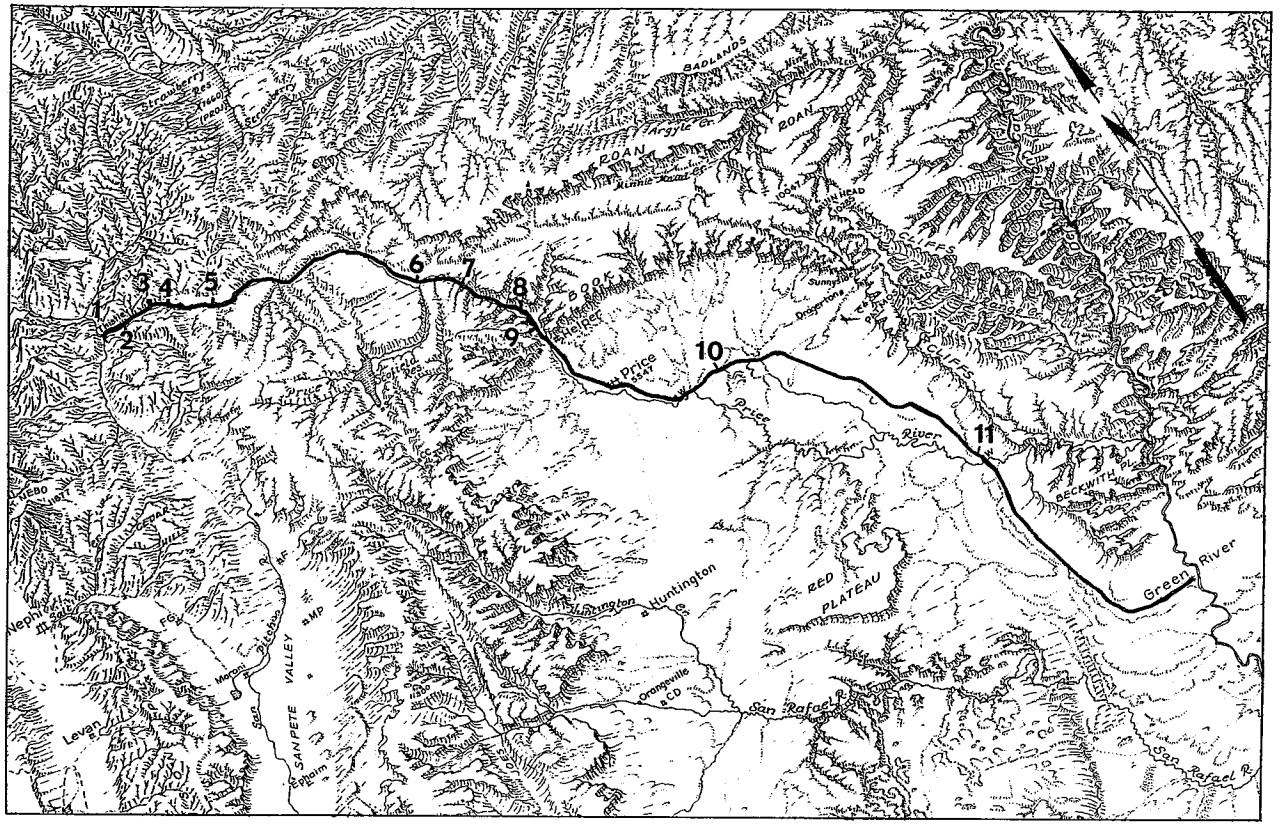
PART 1

THISTLE TO GREEN RIVER VIA U.S. HIGHWAY 50-6

MILEAGE		
Interval	Cumulative	
0.0	0.0	THISTLE (elev. 5030) SEPARATION OF U.S. HIGHWAY 50-6 FROM U.S. HIGHWAY 89. GEOLOGIC STOP 1. PULL INTO THE WIDENED AREA TO THE WEST OF THE JUNCTION ON THE SOUTH (RIGHT) SIDE OF THE ROAD. This stop gives a good view of the Navajo Sandstone, but an even better view can be seen by climbing a short distance up the canyon on the north side of the road beyond the cliff-side exposures. Magnificent cross-bedding in the upper part of the Navajo Sandstone shows from here as marked lineations or irregular beds. The Navajo Sandstone represents an ancient sequence of sand dunes or desert deposits and is part of the same layer of sediments that forms the prominent cliffs in Zion National Park in southern Utah. The soft slope zone in the little narrow canyon, to the east, is in the overlying marine Twin Creek (Carmel) Limestone. A reddish zone separating the two formations is a transitional zone from an arid desert environment to one of an invading sea. The first small ledges on top of the red zone are composed of oolitic limestone, fragments of fossils being rather common. Dipping beds of the upper part of the Twin Creek (Carmel) Formation form the narrows along Spanish Fork Creek east of the highway bridge at Thistle (Text-fig. 2).

Thistle Valley attracted ranchers in the early 1850s—shortly after the settlement of Utah Valley. The Utah and Pleasant Valley Railroad, a narrow-gauge predecessor of the Denver and Rio Grande Western, was built from Springville through Thistle Valley between 1875 and 1879. The small coal-hauling railway extended up the South Fork of Soldier Creek to its head, then down into Pleasant Valley, where it served the coal mines at Winter Quarters and Scofield. As with many other pioneer ventures, cash was often scarcer than goods. As the narrow-gauge rails were being laid, the company, which had stores in Springville, paid its workers

[1]Professor of Geology, Brigham Young University.
[2]Professor of Botany, Brigham Young University.



TEXT-FIGURE 1.—Index map showing numbered geologic stops along Part 1 of the guide. Base map from M. K. Ridd.

what cash was available and, inasmuch as calico was the standard fabric of the time, paid most workers the remainder of their pay in calico. Before long the line was known as the "Calico Railroad."

The Denver and Rio Grande Western, coming from Colorado, took over the Utah and Pleasant Valley and extended track up over Soldier Summit and to Price in 1881-83. A livestock-loading siding was installed at Thistle in 1884. In 1890, standard gauge replaced the narrow gauge, and a branch line was extended south from Thistle to join the Sanpete Valley Railroad at Manti, thence down to mines at Marysvale. Thistle became established as the terminal locomotive facility for this southern branch and the entire valley became filled with railroad yards, loading ramps,

TEXT-FIGURE 2.—Jurassic rocks exposed north of the highway at Thistle. Navajo-Nugget Sandstone (left) and Carmel–Twin Creek Formation (right). A reddish transition zone forms the sandy low ridge in the center of the photograph.

coal and water towers, and other railroad paraphernalia. In 1913 a large roundhouse was built to handle the helper engines on the Soldier Summit run. With the advent of diesel locomotives in the 1940s, the railroads were able to centralize their fueling and maintenance operation in Provo and Salt Lake, making most of the Thistle railroad structures unnecessary.

The vegetation on the Twin Creek Limestone is principally pinyon and juniper dominated. The large trees on the Navajo Sandstone are ponderosa pine. Note the sharp break between the vegetation on the Twin Creek and that on the Navajo Sandstone. This is one of the most northern localities of the ponderosa pine in the Great Basin. It does go farther north in the Colorado drainage but not in the Great Basin. In Utah County it is known only in one other locality—Hobble Creek Canyon.

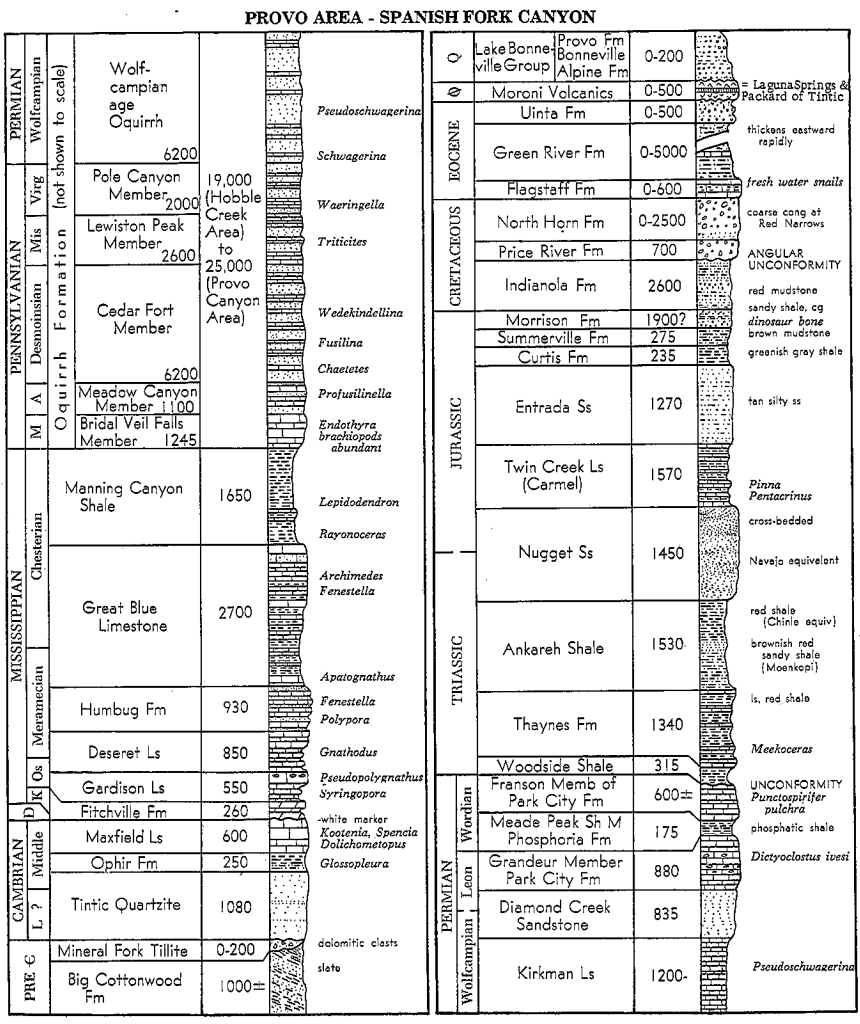
0.5 0.5 Excellent exposures of fine-grained limestone of the Twin Creek (Carmel) Limestone in road cuts on the north (left) (Text-fig. 3).

0.2 0.7 High-level stream terraces can be seen up to 200 feet above the highway both north and south of the highway. These terraces were probably related to a former high level of Spanish Fork Creek when it was adjusted to a Lake Bonneville level. To the north (left) light gray Flagstaff Limestone is visible on top of red North Horn Formation.

This part of Spanish Fork Canyon is a sheep-drive trail. The absence of vegetation near the road is caused by the grazing of sheep. Note the terracing on some of the talus slopes where the sheep have created small trails in their wandering back and forth. The vegetation consists of annuals such as cheat grass and bur buttercups. Practically nothing else survives here because of the sheep.

0.8 1.5 GEOLOGIC STOP 2. ROAD CUTS ON THE NORTH (LEFT) SIDE OF THE ROAD AT THE BEND OPPOSITE A SMALL ROUND HILL ON THE SOUTH SIDE OF THE VALLEY. PULL OFF ON GRADED SHOULDER. Sandstone and conglomerate exposed in the cuts are in the Upper Jurassic Morrison Formation, from which Pinnell (1972) has reported dinosaur bones. This is the same formation that has produced the dinosaurs at Dinosaur National Monument and most of the Jurassic dinosaurs known in North America from Wyoming, Colorado, and Utah. Rocks in the roadcut are dipping to the east. Up the hill to the north, near the skyline, overlying Tertiary rocks are nearly horizontal and are unconformable on the folded Jurassic rocks in the road cut.

Spanish Fork Creek is entrenched below the general level of the flat floodplain of the valley to the south. Such adjustments of the stream course are related to downcutting



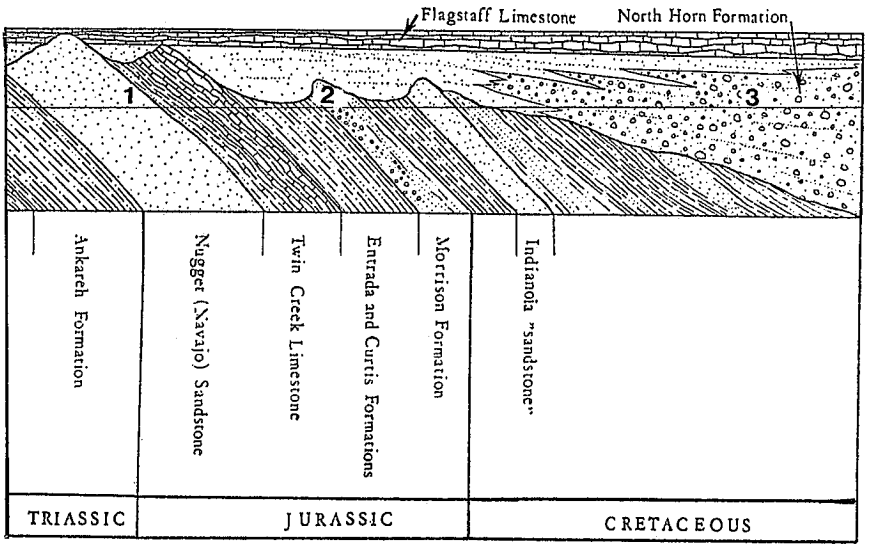
After: Baker (1947),(1964); Hunt and others (1953); Bissell (1962a),(1963); Hardy (1962)
Mississippian: Woodland (1958); Pinney (1965); Permian: McKee and others (1967); Jurassic: Wright and Dickey (1963a); Imlay (1967); Pinnell (1972); Green River Fm: Baer (1969); Flagstaff Fm: Weiss (1969)

TEXT-FIGURE 3.—Stratigraphic section of rocks exposed in the southern Wasatch Mountains near Provo and in Spanish Fork Canyon (from Hintze, 1973).

toward the mouth of the canyon. CONTINUE UP CANYON WITH CAUTION.

0.5 2.0 Steeply dipping beds are exposed low in the road cuts. This is the upper part of the Morrison Formation below the unconformity (Text-figs. 3, 4).

0.2 2.2 Prominent white Indianola sandstone hogback is exposed



TEXT-FIGURE 4.—Generalized section between geologic Stops 1 and 3, showing the relationship of the folded Mesozoic rocks to the overlying Tertiary beds.

above the road on the north (left). This rock exposure is probably part of a barrier island or a beach sequence. Oyster shell fragments occur, but are rare, in the lower part of the sandstone on the west edge of the outcrop. Numerous casts and molds of small clam-type pelecypods occurred in thin beds on the east end of the outcrop, but most have been collected.

Flat-lying Tertiary rocks can be seen above the unconformity on the skyline to the north. Redbeds of the North Horn Formation, between the white, massively bedded, Cretaceous sandstone and the overlying lacustrine limestone that forms the skyline, represent clastic material whose thickness varies with the position of the unconformity.

1.1	3.3	Excellent exposures of the light-colored Tertiary Flagstaff Limestone can be seen up the small canyon to the north, overlying the reddish, very coarse clastic North Horn rocks.
0.2	3.5	Road cuts through Recent or Pleistocene gravel plastered against North Horn Conglomerate of Early Tertiary or Late Cretaceous age. North Horn Conglomerate forms the bedrock ledges in the same general vicinity.
0.8	4.3	Massive conglomerate beds are visible on the north and south sides of the canyon. These form the rugged, irregular ledges, columns, and pillars along the canyon wall. Conglomeratic gravels are composed of fragments of the Oquirrh Formation and older, more resistant units exposed in regions

to the west. The area in the vicinity of Provo and to the west is considered to be the probable source for the gravel. It was deposited here by streams flowing eastward into the sea that occupied much of eastern Utah and Colorado.

0.8 5.1 Alluvial fan of small stream draining in from the north (left). Jointed conglomerate shows well, forming peculiar resistant units both north and south of the highway.

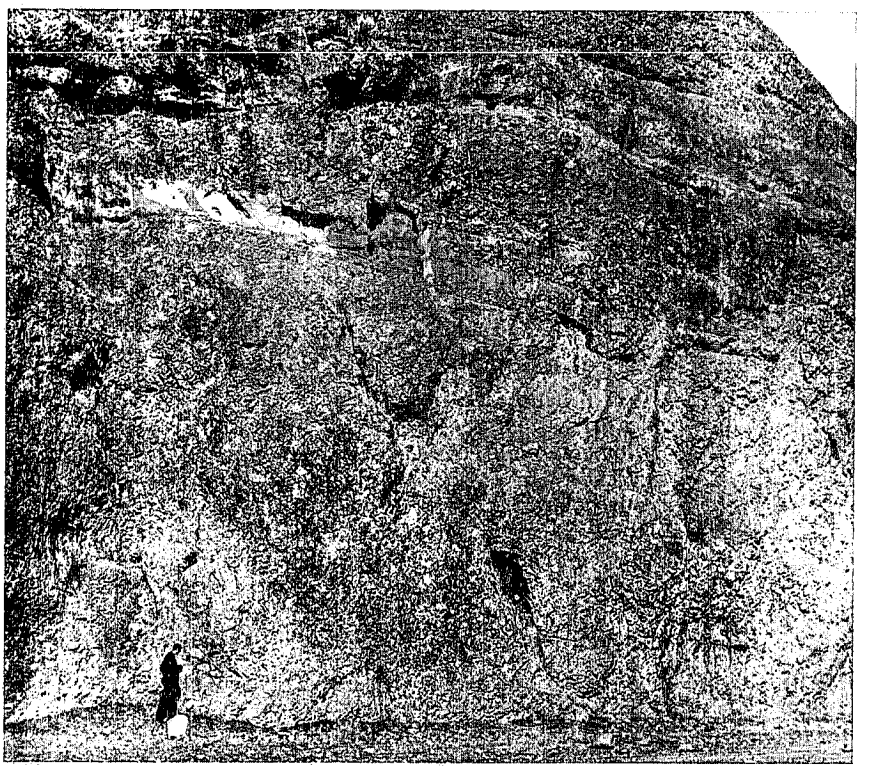
To the south of the highway at mile 5.1 there is a typical streamside forest consisting of narrowleaf cottonwood and box elder. The slope south of the stream has on it a pinyon-juniper—mountain brush vegetative type, the mountain brush being mostly bigtooth maple. Gamble oak is the other principal component.

0.4 5.5 Very shallow cave and a re-entrant into the conglomerate ledges east of the road. For approximately two miles conglomerate will be seen well exposed in cuts immediately adjacent to the road. Notice that, even though some of the blocks are large, rounding characterizes fragments in the conglomerate. Thin-bedded sandstone forms reddish units. Most of the gravels in these cliffs and in the outcrop to the right were eroded from Paleozoic formations. The road continues eastward past road cuts in the North Horn Conglomerate through RED NARROWS (Text-fig. 5).

0.8 6.3 A massive conglomerate fills channels cut into more evenly bedded siltstone and sandstone in the roadcut on the north (left) at road level. Base of the channel has cut down across the evenly bedded sandstone and siltstone. This channel marked the position of one of the streams that transported this debris from the mountains to the west. A smaller channel is exposed in the center part of the road cut a hundred feet to the east. The road continues to the east through conglomerate of the North Horn Formation.

When the highway department was widening the road here, they put down into the rock a charge of blasting powder that was supposed to blast off a small segment of the cliff that could be cleared up in a couple of hours. Unknowingly, however, they drilled into a fracture system, and when they blasted they brought down the whole side of the mountain. It took them more than two days to clear the debris from the road so they could reopen it to highway traffic again.

0.9 7.2 SPRING WITH FOUNTAIN AT ROAD LEVEL. GEOLOGIC STOP 3. PULL OFF ON NORTH (LEFT) SIDE OF HIGHWAY. A broad cone of tufa occurs to the north above the fountain (Text-fig. 6). A similar tufa cone with an overhanging ledge is visible up the canyon, to the east. Tufa is made of calcium carbonate deposited by springs. Leaves of the redbark birch are occasionally preserved in



TEXT-FIGURE 5.—Massive North Horn Conglomerate in fresh exposures along the road cut at approximately Mile 6.0. These are thought to be ancient alluvial fan deposits eroded off the Sevier Mountain belt to the west.

the tufa, where they were gradually covered by spring deposits. These springs are located along fractures where faults have broken the bedrock, forming channels through which spring water can well up. Several conglomerate and sandy beds cut by the faults can be seen across the canyon to the south of the fountain.

These springs wet the surface of the ground for some distance along the canyon. The vegetation growing in this wet area is river birch (the trees with red bark), narrowleaf cottonwood, numerous grasses and sedges, and other plants normally restricted to stream sides.

0.2 7.4 Red siltstone and sandstone of the upper part of the North Horn Formation are exposed here.

0.3 7.7 Drag along a major fault has tilted the beds steeply eastward. This fault bounds the western side of a graben structure, a narrow downfaulted block. The tan and light yellow

TEXT-FIGURE 6.—Small tufa cone north of Highway 50-6 at the fountain-equipped roadside stop (Geologic Stop 3) at the east end of Red Narrows.

gray rocks to the east are in the Tertiary Flagstaff Limestone.

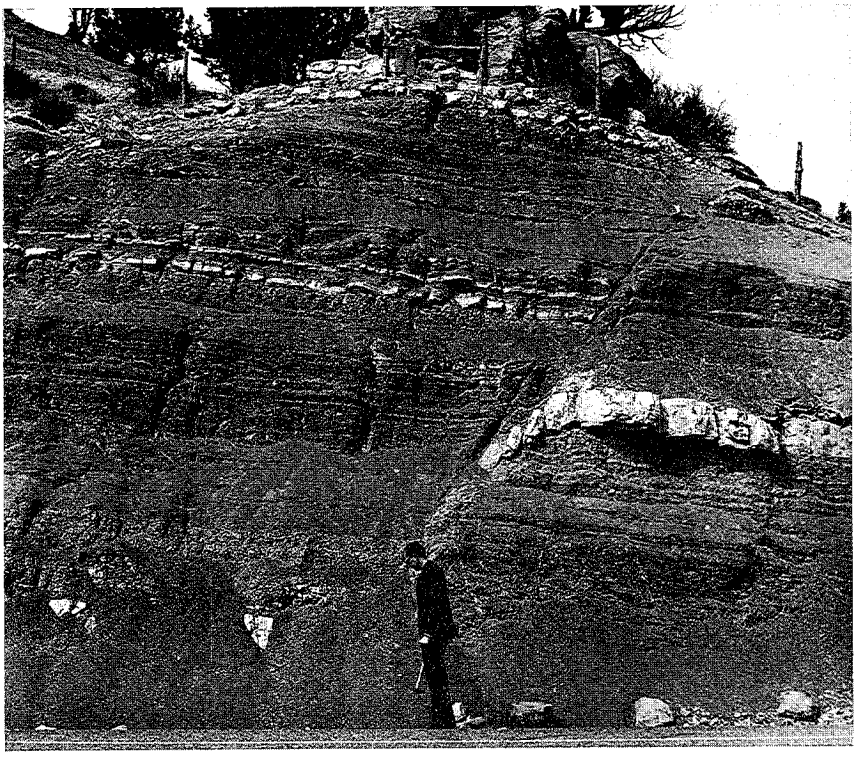
0.2 7.9 GEOLOGIC STOP 4. PULL TO THE NORTH SIDE OF THE ROAD IN THE BROAD OPEN FLAT AT THE BEND. Walk to the north and examine ledges in the Flagstaff Limestone. One of the units near the middle of the ledges is composed of algal balls. These structures were made by algae which gradually developed onionlike, or concentric, masses of limestone as the balls rolled back and forth along the shore or beach of Lake Flagstaff. The onionlike structures grew around snail and clam shells or around twigs. CONTINUE EASTWARD ON U.S. HIGHWAY 50-6.

0.2 8.1 Carbonaceous shale and siltstone of the upper part of the Flagstaff Limestone are exposed in cuts to the north. A crocodile, several turtles, many snails and clams, and much broken plant debris have been collected from this locality. These sedimentary rocks represent sediments in a marginal marshy area in the upper part of Lake Flagstaff history.

0.1 8.2 Small canyon enters from the north. This marks the approximate base of the Green River Formation and upper

beds of the coarse deltaic beds equivalent to the Colton Formation. The road is built for the next several miles through rocks of the Green River Formation.

0.2	8.4	Greenish shale and white limestone of the Green River Formation show in the outcrop to the north (left).
0.2	8.6	Baer's Bluff. This area, which was worked in detail by a graduate student from Brigham Young University, shows the transition from marshy delta sediments in the western part of the outcrop into open lake sediments in the upper or eastern part of the outcrop.
0.2	8.8	JUNCTION OF SHEEP CREEK ROAD TO STRAWBERRY RESERVOIR TO THE NORTH. Continue ahead on U.S. Highway 50-6.
0.2	9.0	JUNCTION OF DAIRY FORK ROAD TO THE SOUTH. Continue ahead on U.S. Highway 50-6.
1.1	10.1	Roadside outcrop of the Green River Formation. Terraces are visible to the south of the road. These terraces are probably part of the same sequence that has been above the general level of Spanish Fork Creek since we left Thistle.
0.3	10.4	GEOLOGIC STOP 5. PULL OFF ROAD TO NORTH JUST BEYOND BRIDGE WALK BACK SHORT DISTANCE TO ROAD CUT. Small faults can be seen here in the Green River Formation. The white limestone bed has been offset, and displacement on the fault can be calculated easily. Notice the fault drag on the upthrown eastern block. A major fault zone, where the rocks have been badly broken and smeared, is developed a short distance to the west of the prominent small fault (Text-fig. 7). The prominent greenish gray ledge above the roadcut is a sandstone that probably represents deltaic deposits of an old river emptying into Lake Green River from the west. CONTINUE EASTWARD (UP CANYON) ON U.S. HIGHWAY 50-6.
0.3	10.7	Green River Formation is exposed in roadcuts to the north (left). The rounded sandstone ledges possibly represent old distributary channels of a delta built out into Lake Green River, part of the same delta complex mentioned earlier.
0.5	11.2	Fossiliferous Green River beds, exposed in roadcuts on the north, are broken by small faults that show drag folds. Northward-dipping older formations below the Green River Formation can be seen ahead on the skyline and to the south forming cuestas on the skyline. Eastward for some distance beyond this point, the road is in a subsequent valley whose position has been determined by more rapid erosion of the soft shaly lower beds of the Green River Formation.



TEXT-FIGURE 7.—Small normal fault in road cuts in the Green River Formation at Mile 10.4 (Geologic Stop 5). Fault drag shows in the white limestone interbedded with green low-grade oil shales of the lower part of the formation.

The evergreen trees north and south of the highway here are Utah juniper. Note the "high lining" of the trees—as if someone had used pruning shears around the bottom of each one. This is caused by animals grazing the trees from the base upwards. While juniper is not particularly edible, it is eaten when nothing else is available. The trees look as though they have been grown in a garden and carefully pruned.

2.0 13.2 Marsh area just beyond the major road cut. This is an abandoned channel of the creek that was displaced to the the south by construction of the highway. Its appearance is typical of abandoned channels.

The next series of roadcuts are all in roughly the same fossiliferous Lower Green River Formation. Not all units are fossiliferous, but gastropods, pelecypods, ostracods, fish fragments, turtles, and bird tracks occur at this level.

1.6 14.8 RAILROAD OVERPASS. Excellent exposures of the Green River Formation occur in cuts near the highway.

The cone-shaped or columnar trees south of the highway are Rocky Mountain juniper. Occasional specimens of pinyon pine are evident to the south of the road. North of the highway the woodland is dominated by Utah juniper, which is broad and rounded.

1.3 16.1 SERVICE STATION AND MOTEL. Green River Formation is well exposed in railroad cuts on the north (left) side of the valley. Notice the lenticularity in some of the white limestone beds in the cut on the hill northwest of the service station.

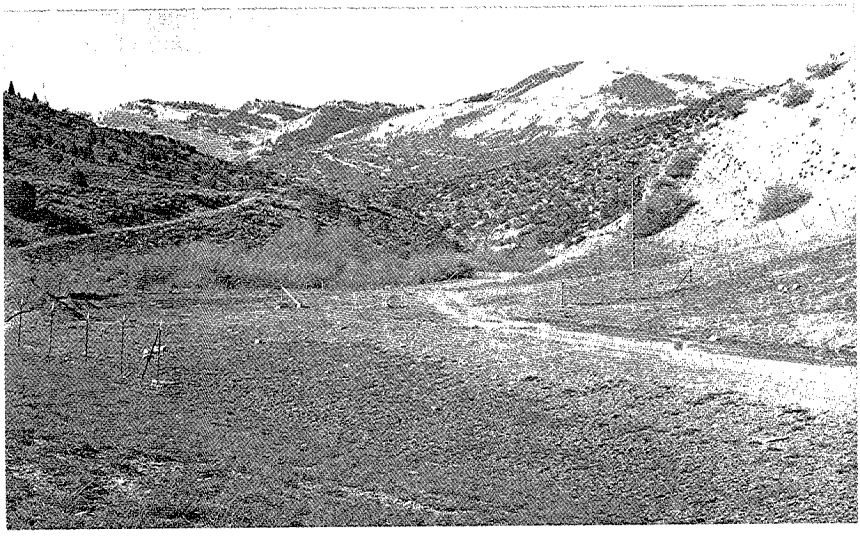
0.6 16.7 Small faults are visible in Green River beds in cuts along the railroad on the north (left) side of the canyon.

0.5 17.2 Lenticular wedging, massive sandstone of the lower Green River Formation visible on the northeast (left) side of the highway, across the canyon between the creek and the railroad.

0.5 17.7 REST AREA AND SKYLINE DRIVE FOREST ROAD JUNCTION TO THE SOUTHWEST (RIGHT). TUCKER. The D&RGW elected not to follow the steep grade of the old coal railroad south from the Clear Creek–Soldier Creek confluence and instead followed the East Fork of Soldier Creek. Thus, the railroad junction at the mouth of Clear Creek became an important loading point and construction camp. A town of 500, originally called Clear Creek, but later changed to Tucker to avoid confusion with the coal town of Clearcreek just over the hill in Carbon County, developed here with a three-stall engine house, coal and water towers, and associated hotels, boarding houses, stores, shanties, and saloons. In 1915 the D&RGW revamped the line, creating a large loop to cut down the steep east-bound gradient, and Tucker was largely covered with fill for the new roadbed.

Looking south into Starvation Creek, one can see broad expanses of aspen intermingled with coniferous forest near the summit. The conifers, mostly Douglas fir, grow on the north-facing slopes—where they can get more water than they could in the drier aspen zone. There is evidence that the coniferous forest is replacing the aspen in some places. Mountain brush occurs on the slopes below and intermingles downward with the pinyon-juniper community. Four main vegetative types are visible from here: aspen, coniferous forest, mountain brush, and pinyon-juniper. Willows and cottonwood occur along the stream course. Continue on U.S. Highway 50-6, through the lower part of the Green River Formation in pinyon-juniper woodlands (Text-fig. 8).

0.2 17.9 CROSS STARVATION CREEK. Excellent bird tracks have been collected in the basal beds of the Green River

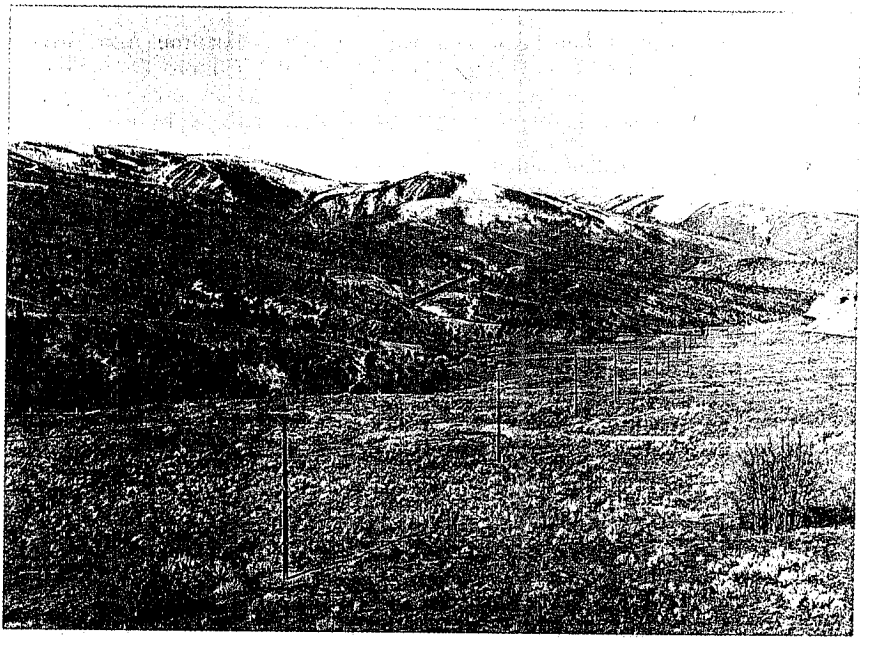


TEXT-FIGURE 8.—View southward, up Starvation Canyon, from near the Skyline Drive rest area. Green River beds are exposed on the right, and older Tertiary beds form the skyline to the south in the Wasatch Plateau. Aspen and Douglas fir woods blanket the high country.

rocks both east and west of here. For the next several miles the canyon is carved in the Colton Formation, a series of red siltstone and shale even softer than the Green River beds, that has eroded to form the valley.

0.6	18.5	Excellent landslide and slump features are visible to the south (right). The hummocky rolling surface is produced by the sliding of the Colton Formation down into the valley from the south. Notice how occasionally the stream has trenched through hummocks on the slide masses. Careful observation will show twisted trunks on some of the trees that have adjusted to downslope movement of their substrate.
0.7	19.2	A landslide mass has deflected the stream channel around the toe of the landslide. There is sufficient creep over the entire surface here that the railroad must be maintained constantly. Landslides here are in rocks of approximately the same age as that of rocks in the landslides developed in Spanish Fork Canyon between Diamond Fork and Thistle.
0.6	19.8	RAILROAD SIDING OF GILLULY. Green River beds form the bluffs to the north; the valley is cut in the Colton Formation. Bluffs to the south expose the algal-ball Flagstaff Limestone, a resistant unit that holds up the ridge.
0.3	20.1	RAILROAD OVERPASS. Reddish Colton rocks are visible in outcrops up the canyon.

0.4	20.5	Large rotated masses of Colton and Green River beds (toreva blocks) are exposed immediately north of the highway.
0.2	20.7	Redbeds of the Colton Formation, a stream floodplain accumulation, are exposed in road cuts on the bend. Both the north and south walls of the canyon are slumping toward the small creek in this vicinity (Text-fig. 9). Toes of the landslide masses are gradually being removed by erosion. This sequence is particularly susceptible to slumping because the shale beds concentrate water and lubricate movement of overlying beds. Numerous small springs issue in the same general vicinity in which the slump masses have formed.
1.3	22.0	The canyon narrows here, largely as a result of slump masses moving into the canyon from the south. The hummocky topography between here and the railroad is characteristic of slumping. The small stream has been displaced northward to near the road by the landslide mass.
1.1	23.1	A spring area on the south side of the canyon is a result of groundwater coming to the surface in the canyon bottom. South of the road along the canyon bottom are small stands of aspen. In the stream bottom are willow, chokecherry,



TEXT-FIGURE 9.—Southwest view (from near Mile 21) of hummocky landslide topography produced by slumping of the lower part of the Colton Formation down into the valley and over the underlying resistant Flagstaff Limestone.

rose, snowberry, and many other components of the mountain brush zone. The black growth on the chokecherry is a fungus that kills the branches on which it grows.

0.4 23.5 Excellent exposures of the deltaic stream-deposited Colton Formation occur in the road cuts.

1.3 24.8 WASATCH COUNTY LINE AT THE WEST EDGE OF SOLDIER SUMMIT.

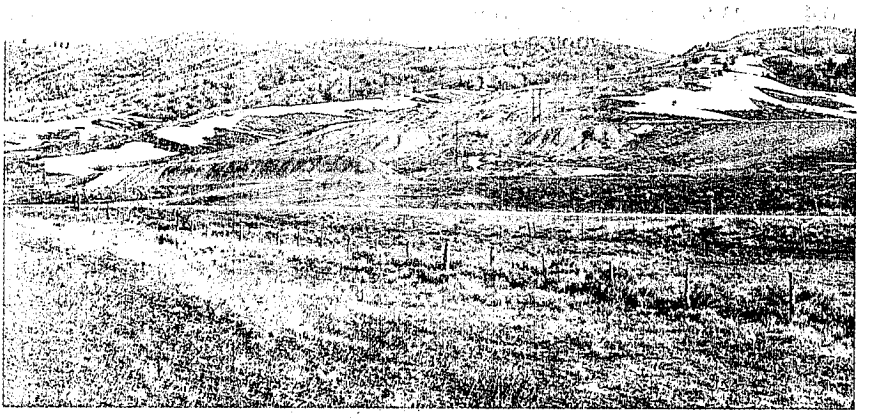
SOLDIER SUMMIT (elev. 7,440). This is the highest point on U.S. Highway 50 in Utah and is known to travelers for its precarious weather. Soldier Summit is on the drainage divide between the Great Basin (drainage into the Great Salt Lake) and the Colorado River (drainage via Price, Green, and Colorado rivers to the Pacific Ocean). Derivation of the name "Soldier Summit" is shrouded in legend. Some say that when the Johnston's Army camp in Cedar Valley was abandoned in July 1861, departing soldiers were caught on the summit in a chilling blizzard and a couple of them died of exposure. Another story alleges that the troops merely passed over on their way east, the soldiers dying of less chilling causes.

When the railroad was built over the summit a wye was constructed to send the helper engines back down to Colton (east) or Tucker (west). A small group of railroad employees lived at the summit; but the town really did not materialize until 1919, when the D&RGW moved its division point from Helper to Soldier Summit, building classification yards, a station, a roundhouse, locomotive shops, plus 70 employee homes, a hotel, a swimming pool, and a YMCA building. Nonrailroad buildings included three stores, two garages, a restaurant, a billiard hall, a real estate office, and a school house. More than 300 people lived in Soldier Summit from 1925 to 1930. In 1930 the division point was moved back to Helper, and most of the equipment and buildings at Soldier Summit were taken to Helper.

South of Soldier Summit is a conifer-aspen forest growing abundantly. To the east is more conifer-aspen forest. Rabbitbrush and sagebrush grow around the foundations of the abandoned buildings in Soldier Summit proper.

0.2 25.0 DOWNTOWN SOLDIER SUMMIT. The White River, to the east, is in a subsequent valley carved in soft reddish siltstone and sandstone of the Colton Formation.

0.4 25.4 Cross the small creek. To the east and north are dumps of abandoned ozokerite mines and processing plants (Text-fig. 10). Ozokerite, a black waxy substance, whose only other commercial occurrence is in Galacia, Austria, has been mined in several places along a narrow 12-mile zone between Soldier Summit and Colton, Utah. Ozokerite, one of the best



TEXT-FIGURE 10.—Waste dumps of Ozokerite mines and processing plant east of Soldier Summit on the Colton Formation and basal Green River beds.

electrical insulators known (with an electrical resistance substantially greater than that of paraffin), was useful in the manufacture of nonconductive coatings and impregnating compounds. A few of its former uses are: as a substitute for beeswax in high-priced altar candles, wax figures, and dolls; as a lining for kegs, barrels, and acid-proof tanks; as sealing wax, shoe polish, and floor polish; as a binder for hair grease and lipstick; and (one of its largest uses) as a component in the manufacture of linen fabrics.

Ozokerite originated in the basal Green River Formation, the lower 500 feet of which contain dark brown, bituminous, fossiliferous limy shales. These beds overlie sandstone and shale of the Colton Formation into which the ozokerite has migrated along small faults and joints. The Soldier Summit Mine was worked to a depth of about 600 feet following a pockety vein of ozokerite. Both low-grade impregnated wall rock and pure ozokerite from veins and pockets constituted the ore. Crushed ore was fed into vats of water; the ozokerite particles floated to the top and were skimmed off and then were put into a boiler to melt the wax so that any remaining impurities would settle out.

Mining and prospecting for ozokerite has proceeded sporadically since 1886. Utah produced 640,000 pounds of ozokerite previous to 1900 and perhaps twice that much since then. Mines were inactive between 1920 and 1940 and since 1945. Utah's production as compared with that of Austria, is very small. Future mining at Soldier Summit seems unlikely, not only because of the pockety nature

of the deposits, but also because litigation by various interests in the area has always impeded development of the Soldier Summit properties. The interested reader should refer to Merrow, 1957, Intermountain Assoc. Petrol. Geol. Guidebook, p. 161-64.

0.15	25.5	Junction with side road leads up White River canyon. Continue ahead on U.S. Highway 50-6. To the east are high-level surfaces of the West Tavaputs Plateau in Green River Formation. To the south and southwest the north end of the Wasatch Plateau is held up by Flagstaff Limestone.
0.55	26.1	Well-defined river meanders along White River east of the road are related to the low gradient of the stream here. Gravel-capped terraces east of the river are cut in the soft reddish Colton Formation. Green River Formation caps the high skyline peaks to the east. Flagstaff Limestone forms the dip slope to the west and southwest, beyond the railroad.
1.1	27.2	The flat floodplain of White River Valley shows very well to the east. The highway is at the contact of Flagstaff Limestone and Colton Formation. Flagstaff Limestone, below, is gray, and the Colton Formation, above, is pinkish, particularly where it is exposed in the cut edges of the gravel-veneered terraces east of White Creek.
0.5	27.7	UTAH COUNTY–WASATCH COUNTY LINE
0.7	28.4	Ranch buildings and tributary canyon to the east. Beyond the buildings, the high bluffs in the distance on Indianhead Peak are held up by Green River Formation.
0.5	28.9	Excellent examples of headward erosion of small gullies can be seen in the soft Colton beds to the east at about 10 o'clock. Small steep gullies have entrenched into terraces on the Colton and into the overlying Green River Formation. The stripped dip surface of the Flagstaff Limestone shows well to the west.
0.7	29.6	CROSS WHITE RIVER. Stream terraces, 40 to 50 feet above the road, form the low escarpment just east of the road. Lower terraces are visible along the valley wall to the west about 30 feet above the stream channel now entrenched somewhat into the floodplain.
1.1	30.7	JUNCTION OF UTAH STATE HIGHWAY 96 WITH U.S. HIGHWAY 50-6. Utah Highway 96 leads west to Scofield Reservoir, which is in one of the major grabens of the Wasatch Plateau. Ahead on the skyline to the southwest is a stripped surface on the Flagstaff Formation, uplifted east of a major fault (Text-fig. 11). Scofield, one of Utah's earliest major coal-mining towns (along with nearby Clearcreek), was shipping coal via the Utah and Pleasant Valley Railroad in 1879. Utah's worst mine disaster occurred

on May 1, 1900, at the Winterquarters Mine near Scofield when 206 men lost their lives in a coal-dust explosion. Although coal mines in this area are nearly inactive now, natural gas was discovered in the area in 1951 in one of the highest gas fields in the United States at a surface elevation of about 9,000 feet. Gas is produced from the Cretaceous Ferron Sandstone, here about 700 feet thick and at a depth of 4,700 feet or approximately 4,100 feet above sea level.

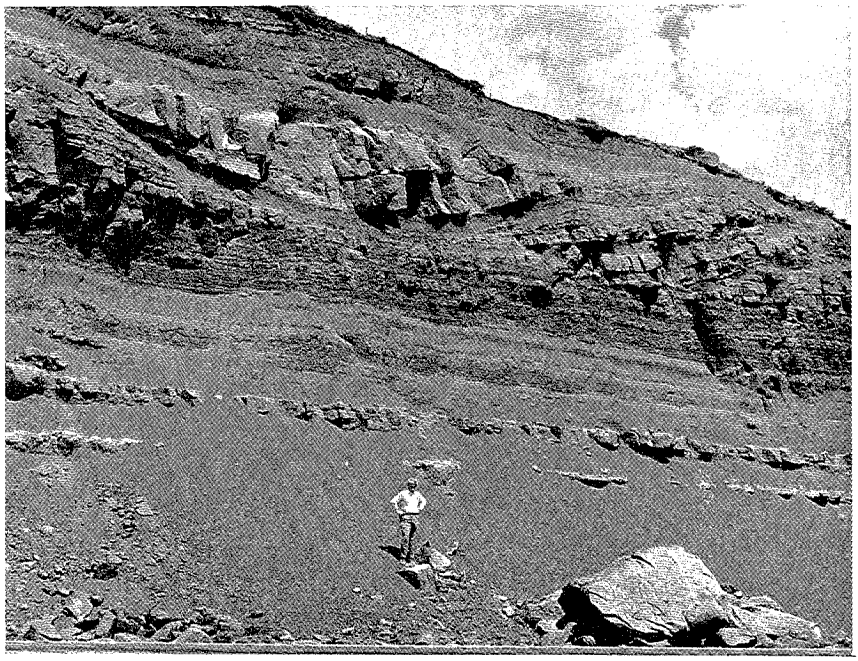
0.9	31.6	Junction. Minor road to the right leads to the old railroad siding of COLTON. This is the type locality for the Colton Formation, the redbeds exposed in the immediate vicinity of the highway. COLTON (elev. 7,190), formerly a railroad town with population of 300, was named after William F. Colton, a D&RGW official. With an eleven-stall roundhouse and turntable, a water and coal tower, and a roadmaster's office, the town serviced helper engines until about 1940, when diesel engines supplanted steam. Diesel locomotives are able to haul heavy coal trains over the summit without servicing; hence, the unnecessary railroad facilities at Colton were removed in the 1950s.
0.5	32.1	Hilltop tavern near the COLTON townsite. Colton beds well exposed to the north of the road are white stream-deposited sandstone and red siltstone.

TEXT-FIGURE 11.—Southeastward over the old townsite of Colton. Major fault forms the abrupt escarpment in the background. The Flagstaff Limestone caps the high stripped surface to the left but is downfaulted beneath the valley and forms the prominent dip slope to the right.

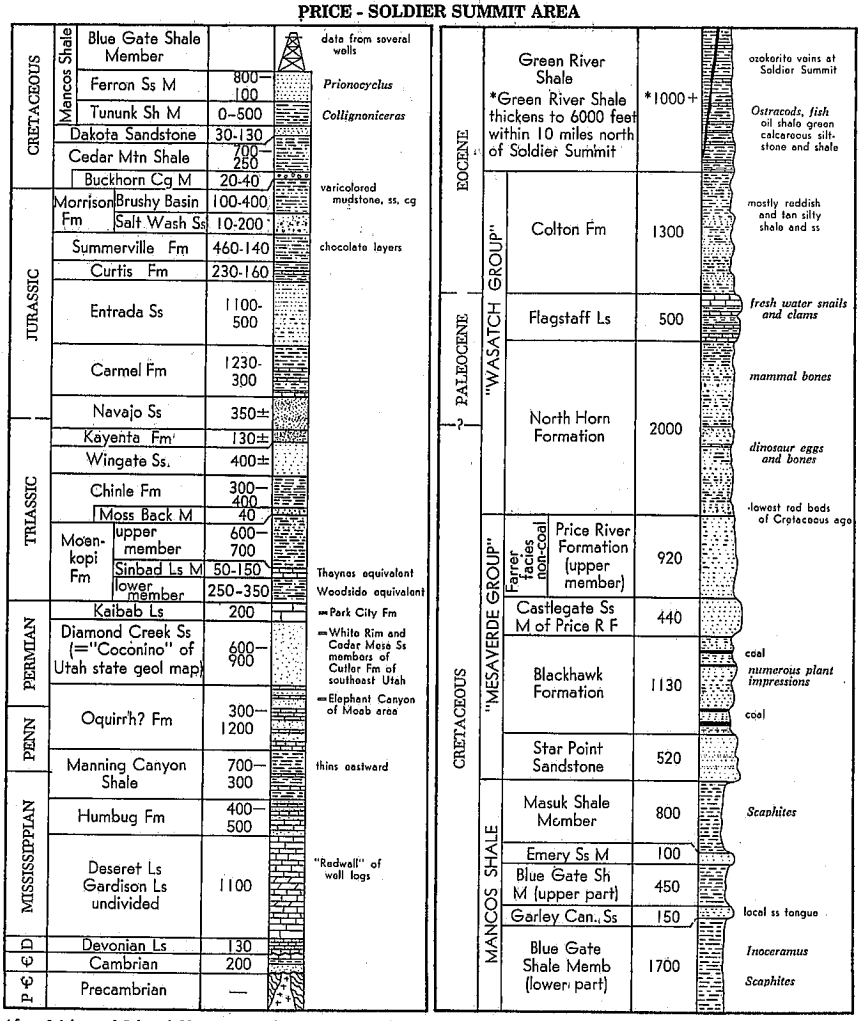
0.4 32.5 GEOLOGIC STOP 6. Double road cuts in Colton Formation expose excellent cross sections of stream channels that cut the flat reddish siltstones (Text-fig. 12).

0.3 32.8 CROSS PRICE RIVER AND THE D&RGW MAINLINE RAILROAD TRACK. Excellent exposures of the reddish Colton Formation, with white stream-channel sandstone, occur on the north side of the canyon for the next several miles. The dip surface to the south is carved on the Flagstaff Limestone, which is at about the level of the road here. High points to the north on the Tavaputs Plateau are in the Green River Formation (Text-fig. 13).

1.3 34.1 Excellently exposed thick channel sandstone of the Colton Formation on the north side of the canyon, beyond the railroad. Road cuts in the immediate vicinity are in basal beds of the Colton Formation. The stripped surface on Flagstaff Limestone to the south is veneered in the lower part by a pebble-and-cobble gravel. The gravel layer dips toward Price River Valley to the north but toward a level 70 to 80 feet above the present position of the stream.



TEXT-FIGURE 12.—Well-exposed cross section of a filled stream channel in the lower part of the Colton Formation at Mile 32.5. The channel fill was produced by a meandering stream in which the meander migrated from right to left before being abandoned.



After: Spieker and Baker (1928); Hansen and Scoville (1955); Heylmun and others (1965); Young (1966); Wright and Dickey (1963a); Baars (1962); Uranium Resources: Johnson (1959); Green River Fm: Baer (1969); Moussa (1969)
see also IAPG Guidebooks 7 (1956), 8 (1957), and 13 (1964)

TEXT-FIGURE 13.—Stratigraphic section of rocks exposed or encountered in wells in the Price-Soldier Summit area (from Hintze, 1973).

1.3 35.4 Outcrops of Flagstaff Limestone exposed on both sides of the double road cut and in the road cuts ahead near the rest area and clump of firs.

0.2 35.6 ROADSIDE REST AREA AND ROAD JUNCTION OF UTAH STATE HIGHWAY EAST TO DUCHESNE. GEOLOGIC STOP 7. Outcrops in road cuts immediately

beyond the highway junction are Flagstaff Formation. The massive limestone unit holds up the resistant surface to the south and the stripped surface to the east.

From this point, the highway cuts down section and leaves the subsequent valley carved in the Colton Formation. Broad extension of the valley is visible to the east. Even-bedded Flagstaff Formation and underlying North Horn rocks are exposed in canyon wall.

To the north of the highway there is a stand of Douglas fir and Rocky Mountain juniper. This is the first stand of conifers along the highway east from Spanish Fork. It is unique here, for it is some distance away from other stands of similar trees. The tree cluster occurs here because it is on a shaded, steep, north-facing slope where there is an extra water supply from seepage (Text-fig. 14).

0.8	36.4	Beginning of Price River Canyon, highway road cuts are in basal beds of Flagstaff Formation. The unit forms even-bedded exposures of the canyon wall.
0.3	36.7	Deep double cut in basal beds of the Flagstaff Formation. Upper beds of the North Horn Formation are visible ahead

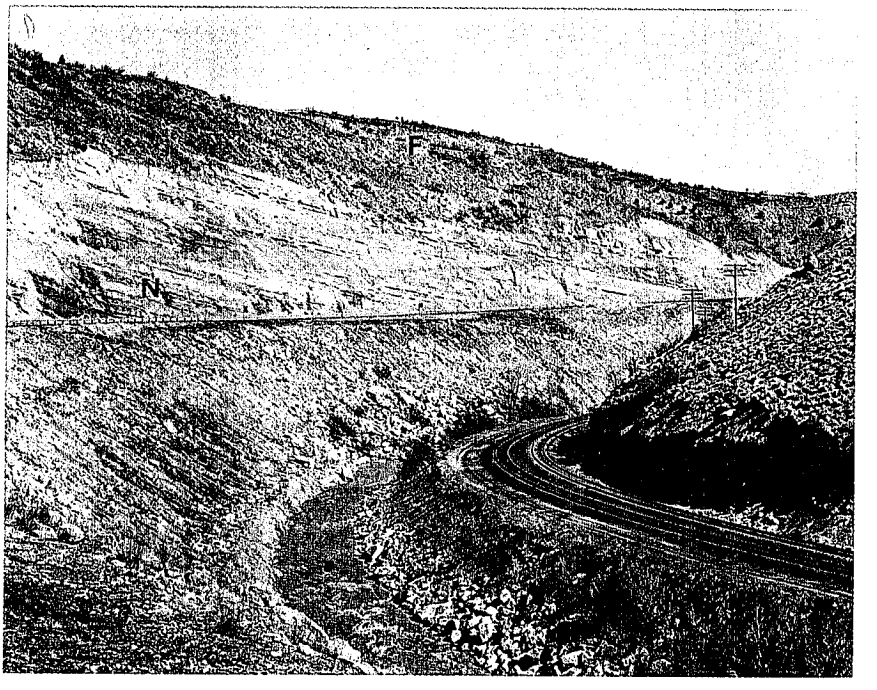
TEXT-FIGURE 14.—Clump of Douglas fir at the roadside rest area at Mile 35.6. The rest area is on Flagstaff Limestone; Colton beds form the valley in the middle distance, and Green River beds hold up the high skyline ridges.

at the lower end of the road cut where red siltstone appears in the section (Text-fig. 15).

0.1 36.8 UTAH COUNTY–CARBON COUNTY LINE. At the lower end of the double road cuts, upper beds of the North Horn Formation are exposed (Text-fig. 13).

0.5 37.3 Sandstone and siltstone of the North Horn Formation visible in the major road cuts on the west side of the road.

In Price Canyon there is an excellent contrast between north-facing and south-facing slopes. Those slopes that face to the south and southwest are dry, for they receive a greater amount of radiation per unit area than do the north-facing slopes, and the vegetation is characteristic of that found in areas having high rates of evaporation: juniper, pinyon, and various species of grass, with some small patches of Gambel oak. The north-facing slopes, being shaded and receiving less energy per unit area, experience a lower rate of evaporation and therefore support a vegetation of Douglas fir, aspen, birch, oak, maple, and many other species requiring more water. The numerous dead trees, particularly along the south-facing slope (which is adjacent to the railroad right-



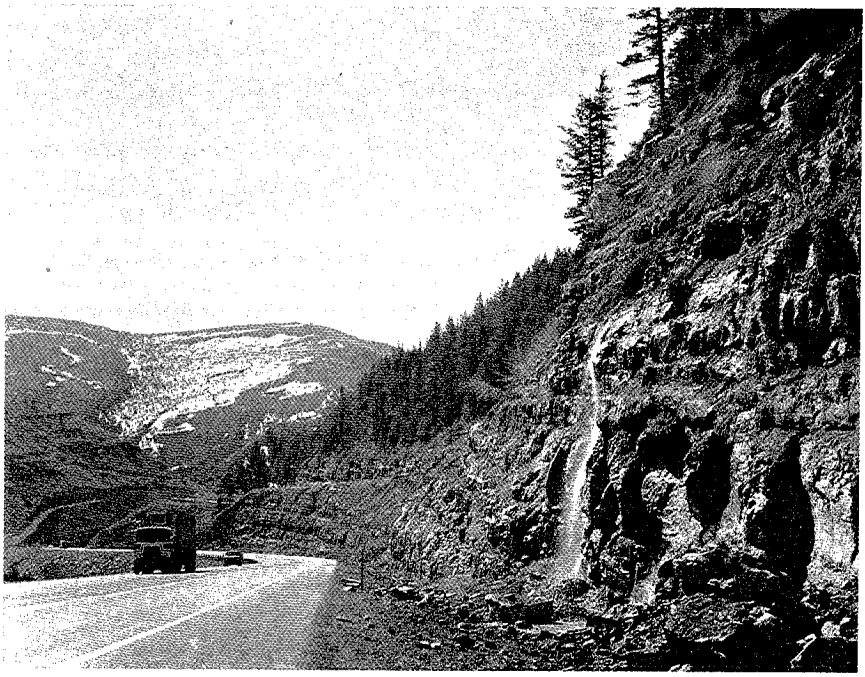
TEXT-FIGURE 15.—View northward up Price River Canyon, showing upper beds of the North Horn Formation (N) beneath the resistant overlying Flagstaff Limestone (F) at approximately Mile 36.5.

of-way), were killed in the numerous canyon fires caused by sparks from the coal-burning engines.

0.4 37.7 Excellent exposures of massive sandstone and carbonaceous siltstone in road cuts, on the south, and in cliff exposures, on the north (Text-fig. 16).

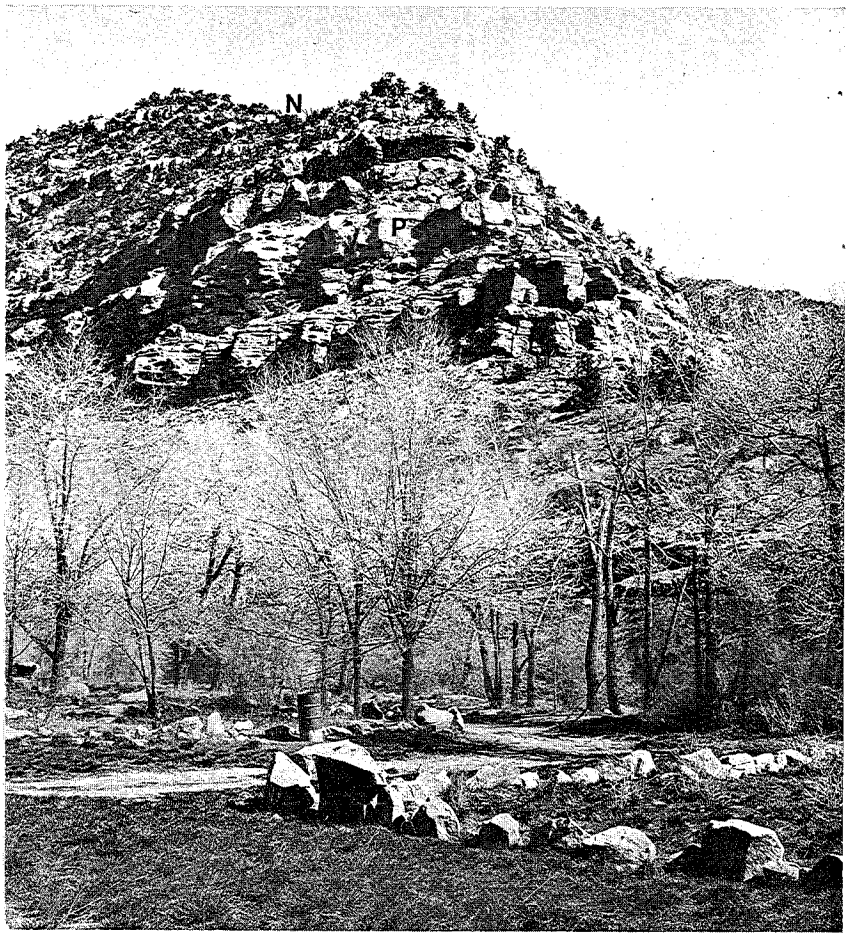
0.6 38.3 CROSS FORD CREEK. A meander that developed along Price River to the east left an abandoned and elevated channel and a meander core east of the highway. The abandoned channel was in about the position of the present highway but has been largely obliterated by recent road cuts. Ford Creek marks the axis of the meander core. Thin beds of shiny black coal are exposed south of Ford Creek in the North Horn Formation. One can collect plant fossils from shaly beds near the coal. The road continues down-canyon in the North Horn Formation.

0.1 38.4 Double railroad tunnels on the D&RGW tracks in the canyon bottom to the east. Massive lenticular cross-bedded fluvial sandstone is exposed in the North Horn beds on both east and west sides of the canyon.



TEXT-FIGURE 16.—View southeastward along U.S. highway 50–6 (at approximately Mile 38) in the North Horn Formation. Massive tan sandstone is interbedded with carbonaceous shale and thin coal. The skyline in the distance is held up by the Flagstaff Limestone. Thick growths of Douglas fir on the south contrast sharply with the sparse juniper and pinyon growth on the north.

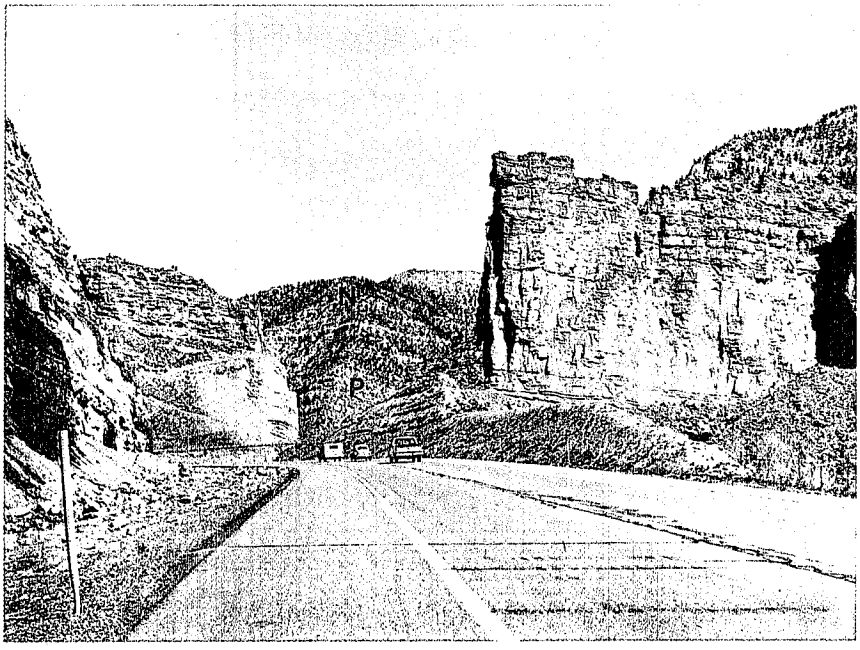
0.7	39.1	PRICE CANYON RECREATIONAL AREA ROAD JUNCTION TO THE RIGHT. CONTINUE ON U.S. HIGHWAY 50-6.
0.6	39.7	Excellent exposures of lower beds of North Horn Formation in road cuts and in massive exposures on the east side of the canyon beyond the railroad.
0.6	40.3	Thin red shale visible in road cut in the highway on the right. Approximate boundary between North Horn and Price River formations. For the next two miles the road is in the Price River Formation, which resembles the overlying North Horn Formation but lacks redbeds and is more massively bedded.
0.3	40.6	Area of perennial road damage and slumping because of cuts made in wet interbedded sandstone and shale in the Price River Formation. Jointed sandstone blocks frequently are dislodged and roll onto the road. Massive channel sandstones are visible in the road cuts and in cliff faces to the east.
0.7	41.3	Junction of minor road to coal mining areas to the southwest. Ahead the lower ledgy zones of the Price River Formation appear distinctively different from the pine-covered slope zone carved on the overlying North Horn Formation.
0.9	42.2	Top of massive cliff of Castlegate Sandstone exposed both east and west of the road (Text-fig. 17). View of the Castlegate directly down the canyon ahead. Workings of old mine visible on the right.
0.4	42.6	SCENIC TURNOUT TO VIEW CASTLEGATE (Text-fig. 18). Basal Castlegate beds are visible in road cuts just beyond the paved scenic lookout point and rest on coal-bearing Blackhawk Formation (Text-fig. 13).
0.4	43.0	Crossing through the abandoned townsite of Royal. The Royal coal mine was up the gully to the southwest. Basal contact of the Castlegate Sandstone with the underlying Blackhawk Formation is visible at the base of the cliff to the east. The Blackhawk Formation is the ledge-and-slope zone beneath the vertical wall of Castlegate Sandstones.
0.7	43.7	Clinkered beds in Blackhawk Formation. The pink color was produced as burning coal baked and oxidized iron in the beds above.
0.3	44.0	Side road to east into community of CASTLEGATE (elev. 6,150), which is centered around the mine to the southeast. Because it was one of Utah's richest coal-mining areas in the late 1890s, it fell prey to Butch Cassidy's gang, who, on April 21, 1897, relieved the paymaster of $9,000 and escaped to Robber's Roost in the San Rafael Swell. The next major disaster to hit Castlegate was the flood of 1917, which



TEXT-FIGURE 17.—Northward view (from the rest area at approximately Mile 42) of the lower massive sandstones of the Price River Formation (P). North Horn beds (N) form the less ledgy slopes high on the skyline to the north. Top of the Castlegate Sandstone is visible through the trees at the lower right.

washed out the town and railroad and killed one person. In March, 1924, a gas and coal-dust explosion in Mine No. 2 took the lives of 173 men. In Utah this disaster was second only to the Scofield disaster of 1900.

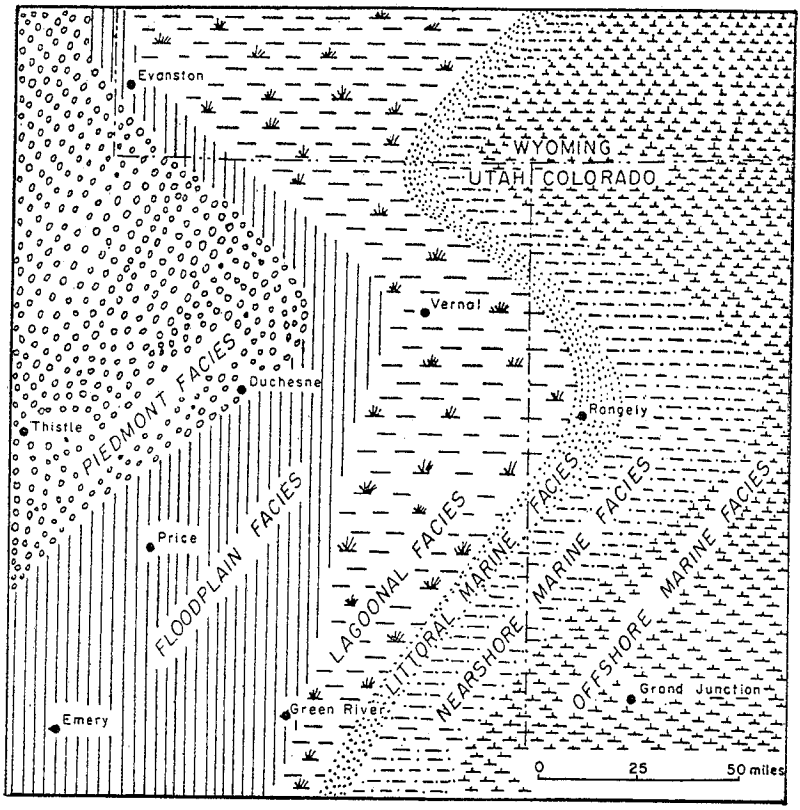
The Castlegate Sandstone and equivalent beds show facies patterns typical of much of the marine to nonmarine upper part of the Cretaceous sequence. Conglomerate facies in the west grade eastward into floodplain facies near Castlegate and Price (Text-fig. 19). Coal-bearing lagoonal deposits, equivalent to the floodplain facies seen here at Castlegate, occur in the eastern part of Utah and western



TEXT-FIGURE 18.—North to The Castlegate, the type locality of the Castlegate Sandstone. Price River (P), North Horn (N), and Flagstaff beds are exposed up Price Canyon in the background.

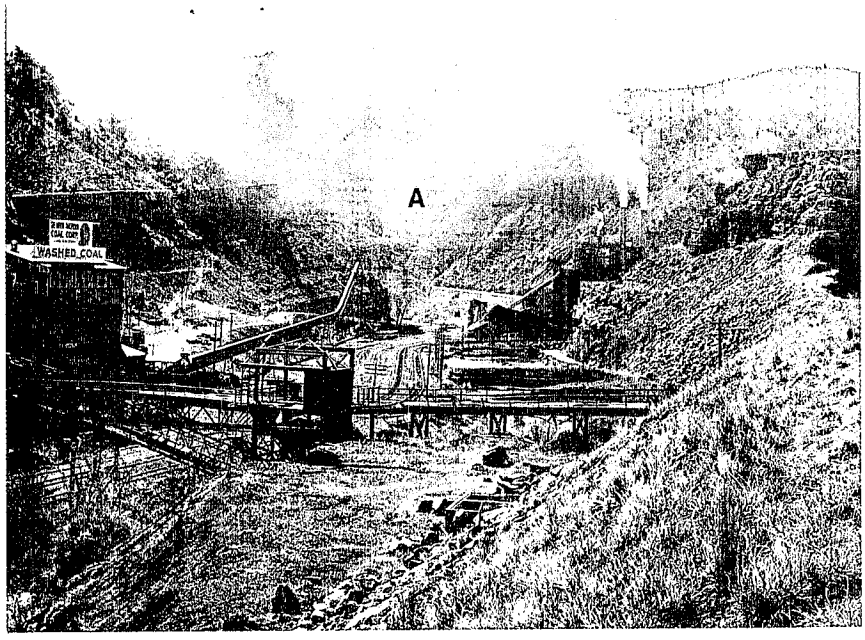
Colorado and will be seen in the uppermost coal-bearing sandstone capping Beckwith Plateau, near Green River. These rocks grade to marginal marine barrier island sandstone and then into open marine deposits in western Colorado.

0.4 44.4 GEOLOGIC STOP 8. ROAD CUT WEST OF THE TIPPLE OF NORTH AMERICAN COAL CORPORATION AT CASTLEGATE. Low in the canyon the Blackhawk Formation forms alternating slopes and ledges and is overlain by the cliff-forming Castlegate Sandstone. The Blackhawk Formation has been subdivided into members, each of which consists of (1) a basal massive, commonly white-capped sandstone and (2) an overlying sequence of lenticular sandstone, coal, and silty shale. This pattern is well demonstrated in outcrops across the valley to the east. The prominent white-capped sandstone ledge just behind the tipple is the basal unit of the Aberdeen Member (Text-fig. 20). The upper part of the Aberdeen forms a slope and consists of the lagoonal coal-bearing sequence. The top of the Aberdeen Member cannot be identified with certainty in this locality because the basal sandstone of the Kenilworth Member is missing. The upper part of the Blackhawk For-



TEXT-FIGURE 19.—A facies map of the Castlegate Sandstone and equivalent rocks in eastern Utah and western Colorado (from Young, 1966).

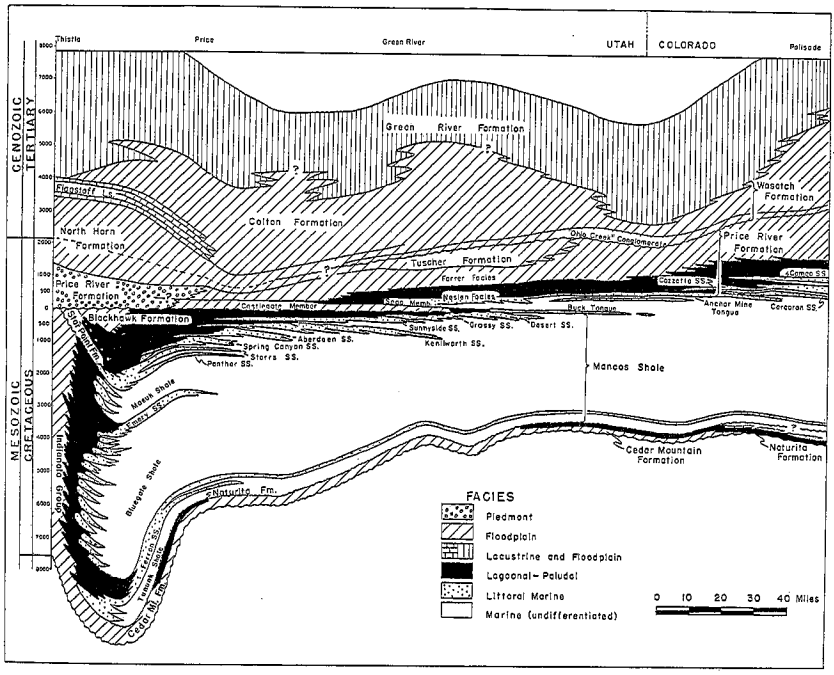
mation is undivided in Price Canyon. Rocks exposed in the west road cut consist largely of the Aberdeen Member (Text-fig. 21). At road level a few feet of the upper part of the basal massive Aberdeen sand is exposed. It is overlain by approximately 3 feet of Aberdeen coal. A number of lenticular lagoonal sandstones, which exhibit scour and fill, and lesser coals extend upward beyond the cut to the base of the Castlegate Sandstone. The Kenilworth coal horizon is in the clinkered zone approximately 100 feet above the road beyond the crest of the cut. The deep road cuts, 100 yards to the south, show many details of the Spring Canyon Member. Coal and carbonaceous shale of the Spring Canyon are capped by a basal sandstone of the Aberdeen Member and, in the southern part of the cut, are underlain by the massive basal Spring Canyon Sandstone. A thin marine shale parting occurs at the top of the Spring Canyon Member below the Aberdeen sandstone. This shale parting is a



TEXT-FIGURE 20.—Coal-mining and electric-generating facilities as seen southeastward from rest area and Geologic Stop 8 near Mile 44.5. Aberdeen Sandstone, A.

westward tongue of the Mancos Shale (Text-fig. 22, 23). An eastward-shifting shoreline of Upper Cretaceous time is indicated by successive eastward interfingering of coal-bearing rocks and sandstone with the Mancos Shale (Text-fig. 21). Each of the members (Aberdeen, Kenilworth, Sunnyside) of the Blackhawk Formation consists of a basal barrier-island sandstone and overlying coal-bearing lagoonal rocks. A sequence typical of coal formation during deposition of a member in coastal lagoon and marginal marine environments is shown diagrammatically in Text-figure 22. Coal-forming organic debris accumulated in swamps that formed during the latter stages of filling of coastal lagoons behind barrier islands. A new barrier formed in front of the old one as the coastline shifted eastward, or sometimes the new barrier island formed on top of the old one where the shoreline was at least temporarily static.

Numerous dinosaur tracks are found in the lagoonal deposits, particularly in the tops of the coals. A most spectacular track locality is in the Kenilworth mine where literally thousands of tracks of many sizes of dinosaurs are exposed on the roof. Utah Power and Light Company's steam generating plant (mine-mouth fed) is located to the left, beyond the roadcut.



TEXT-FIGURE 21.—Correlation diagram of Cretaceous and Tertiary rocks between Thistle in central Utah and Palisade in western Colorado (from Young, 1966).

0.1 44.5 Deep double road cut through lower beds of the Blackhawk Formation. Two thick coals in the lower part of the cut are in the Spring Canyon Member of the formation.

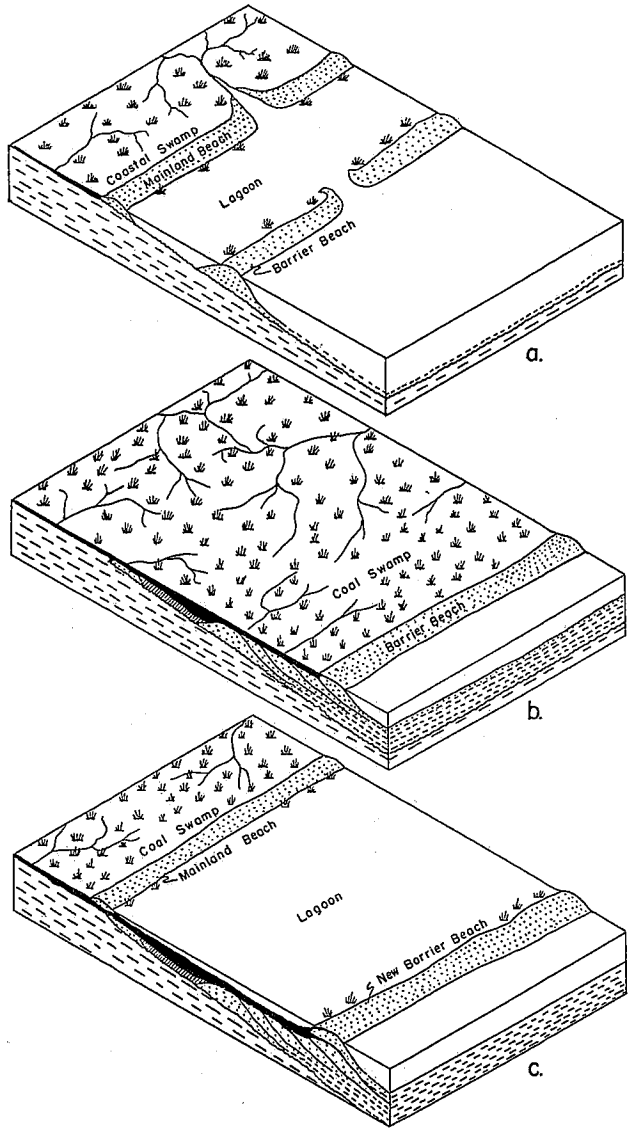
0.2 44.7 COAL-BURNING ELECTRIC GENERATING PLANT OF UTAH POWER AND LIGHT IN THE CANYON TO THE EAST.

To the west of the highway on the slopes is a species of yucca whose swordlike rosettes of leaves stand up green from the grassy slope. Trelease, returning from the Harriman Alaska expedition, stopped here and collected the plant from the slope. He named it *Yucca harrimaniae* in honor of Mrs. Harriman, whose husband founded the expedition to Alaska.

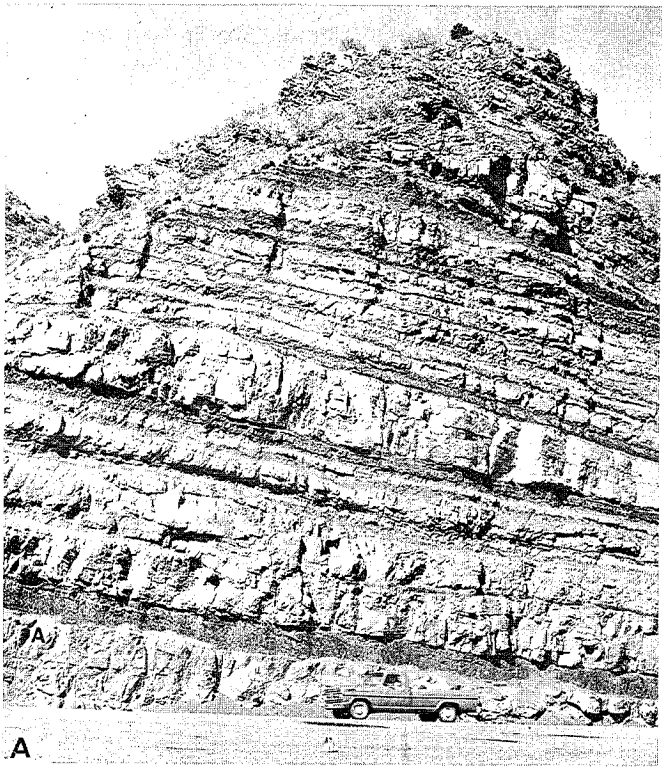
0.2 44.9 JUNCTION OF UTAH STATE HIGHWAY 33 TO DUCHESNE WITH U.S. HIGHWAY 50-6. Continue on U.S. Highway 50-6. Settling plant along the Price River visible in the canyon bottom.

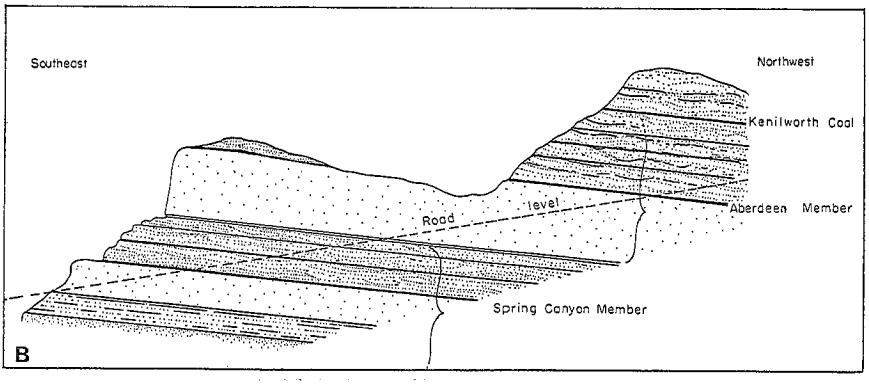
0.3 45.2 Upper beds of the Star Point Sandstone (Text-figs. 13, 20) visible in road cuts opposite a mine waste dump.

0.3 45.5 Port of Entry, a truck-weighing station. On the slope to



TEXT-FIGURE 22.—Generalized sequence of sedimentary environments typical of the barrier-island–coal-swamp sequence well exposed in the Blackhawk and Star Point formations of the Tavaputs and Wasatch Plateaus (from Young, 1966).



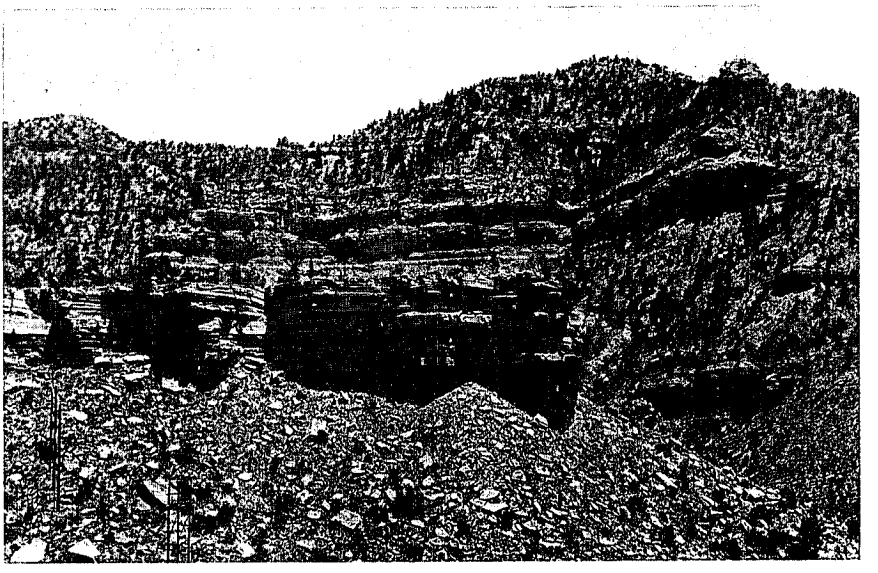


TEXT-FIGURE 23.—Lower part of the Blackhawk Formation in road cuts at Geologic Stop 8. The thick Aberdeen Coal in the lower part of the road cut overlies the Aberdeen Sandstone, A (Text-fig. 20), exposed behind the tipple across the canyon to the east. A, Photograph of road cuts. B, schematic cross section.

the west of the road back of the truck-weighing station are numerous greenish shrubs. This is the plant known as Mormon tea or Brigham tea. It is a conifer related to the pine trees, and produces small cones. These plants have separate sexes. Their branches can be used to brew up a tea that is a bright yellow orange. Some people find it a pleasant drink with sufficient sugar and cream added to it. (But hot water alone isn't too bad when sufficient sugar and cream have been added, either!)

0.1 45.6 Top of the Panther Sandstone visible in the road cuts on the west just beyond the weighing station. The Panther Sandstone forms the lowest well-bedded ledge along both sides of the canyon bottom.

0.4 46.0 GEOLOGIC STOP 9. Base of the Panther Sandstone visible just north of the crossing of Gentile Wash. Type locality of Panther Sandstone is in Panther Canyon to the east (Text-fig. 24). The entire section from the upper part of the Mancos Shale to the Aberdeen and Kenilworth members of the Blackhawk Formation is visible across the Price River from this stop. The Mancos Shale forms the lowermost slope and is largely covered with wash. The prominent lower cliff consists of the Panther Sandstone Tongue of the Star Point Formation and is overlain by a slope-forming unit of marine shale. This in turn is overlain by the Storrs Sandstone, which



TEXT-FIGURE 24.—View eastward into Panther Canyon from Mile 46. The Panther Sandstone is the prominent cliff-forming slabby-appearing sandstone in the foreground. Younger rocks within the Blackhawk and Star Point formations form the white-capped sandstone cliffs and slope zones to the east in the background.

forms a minor cliff midway up the slope, and another slope-forming marine shale. The basal Spring Canyon Member forms a slope and is overlain by the Aberdeen Sandstone, characterized in this outcrop by a white-capped ledge. The overlying Kenilworth Member is only partly exposed in this particular outcrop.

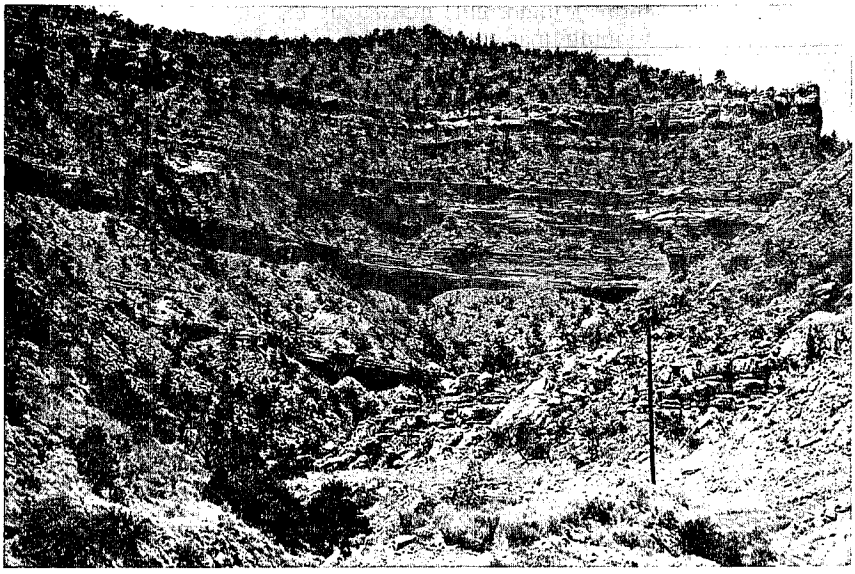
In its type locality the Panther Sandstone is characterized by a relatively thin, well-defined, bedded unit. Internal stratification dips gently towards the east so that a single layer may be traced from the top of the Panther Member at the left, down to the base, and into the Mancos Shale to the right. This is a classic exposure of beach-face stratification in which the sandstone is a time-transgressive unit. Time lines are marked by the inclined planes of stratification. Top of the Panther Sandstone is truncated by erosion. A thin unit of sand, resulting from reworking of the top of the beach face by the subsequent transgressive marine phase, caps the truncated strata. One of the outstanding characteristics of most sandstone units in this part of the section is a gradation from the underlying shales, upward through silt and fine sand, to coarser sands near the top. This is well expressed in the road cut to the west, where coarser clastics increase up-section until the entire unit is dominated by sand. The top of most sandstone units, in contrast, is sharply cut and well defined.

To the west, up Gentile Wash, the same sequence can be seen with upper beds better exposed. The Panther Sandstone forms the lowermost unit, followed by Storrs, Spring Canyon, Aberdeen, and Kenilworth. Both Spring Canyon and Aberdeen sandstones develop white caps (Text-fig. 25).

Numerous well-preserved trace fossils occur within the Panther Sandstone up Gentile Wash. These can be found on any horizon and can be seen in many of the boulders on the slope. They consist of a wide variety of burrows, tracks, trails, feeding marks, and the like (Howard, 1966, 1972).

There is a pinyon-juniper woodland on the slopes west of the road and in canyons to the east. However, the vegetation starts to change here from the pinyon-juniper type to a salt-desert-shrub type. From here to the mouth of the canyon at Helper the vegetation changes abruptly into the salt-desert shrub.

0.1	46.1	Cross Utah Railway Line, which leads to the coal camps to the southwest. Main line of the D&RGW railroad is on the east side of the canyon. Prominent terraces, related to former position of Price River, are visible down the canyon ahead.
1.4	47.5	Railroad crossing in northern Helper. Beheaded pediments cut across Mancos Shale are visible to the east beyond town.
0.1	47.6	HELPER (elev. 5,930), continue on U.S. Highway 50-6. The main community is to the east across Price River.



TEXT-FIGURE 25.—Westward view of sandstones in the lower Blackhawk and Star Point Formations. Each of the three massive sandstones shown here is overlain by coal and is topped by a bleached, white cap typical of the tops of the massive barrier sandstones where they are overlain by coal.

Teancum Pratt brought his two wives here in 1870 while he prospected for coal. For many years the families lived in a dugout, but eventually Pratt acquired nearly the whole district and sold out to the D&RGW in 1883. The town became known as Helper in 1892 because, beginning that year, extra engines or "helpers" were kept here to assist the coal trains up the grade to Soldier Summit. Helper's population has been cosmopolitan: American, Italian, Greek, Austrian, Japanese, and Chinese miners mingling with railroad men. In its more vigorous days, Helper went through a period of outlawry, gambling, and killings, when gunfights were too common to attract much attention. Butch Cassidy's Robber's Roost gang often visited the town.

Mancos Shale is exposed in bluffs both east and west of the road. Both sides of the relatively wide valley are capped by a tan veneer of gravel over pediments.

2.9	50.5	Cross Consumers Wash. Road cuts are in Mancos Shale. Side road leads west to Consumers.
0.2	50.7	CROSS PRICE RIVER. Garley Canyon Sandstone along both the east and west walls of the river valley.
0.2	50.9	Side roads lead to the Carbon County Country Club, to the southwest, and to Helper, to the northeast. Top of the Garley

Canyon Sandstone forms the bluffs both east and west of the canyon beyond the Carbon County Country Club. The Garley Canyon Sandstone is a thin clastic tongue which extends into the Mancos Shale from the west. Bluffs along both sides of the road and the double road cut ahead are in the middle part of the Mancos Shale.

0.2 51.1 Greens of the Carbon County Country Club are visible to the west, beyond the diversion dam along Price River. Bluffs on both sides are capped by Garley Canyon Sandstone.

East of the highway along the railroad embankment, across from the Carbon County Country Club, there are large green plants that have been termed "Castle Valley clover." Actually, the plant is a saltbush of a special type common on the Mancos Shale. It is abundant along the highway eastward from Price, but here it is growing on the fill of the railroad embankment.

2.1 53.2 Side road to Kenilworth. Book Cliffs are visible to the west, with the Wasatch Plateau high on the skyline behind. Gravel cap over the pediment surface in middle distance is partially cemented; the result is that it weathers to a prominent ledge on top of the Mancos Shale on the east side of the canyon, behind Spring Glen.

1.7 54.9 PRICE, WEST EDGE (elev. 5,570). TURN LEFT ON U.S. HIGHWAY 50-6 BENEATH RIO GRANDE RAILROAD THROUGH A SMALL CITY PARK.

Farming began along Price River in 1879, but active settlement awaited the coming of the railroad in the early 1880s. As a coal producer Price then superseded the Scofield–Clear Creek area and, since 1900, has been Utah's leader.

Price was the home of Matt Warner, one-time member of the Robber's Roost gang who died in 1938. For years he terrorized the country as far west as Oregon, and as far east as Colorado. Warner served time in the state penitentiary and later took up ranching near Price. He served two terms as Price city marshal and one term as justice of peace at Carbonville. At one time Butch Cassidy, leader of the Robber's Roost gang, came here to view his own body. Word was spread that the outlaw had been killed by a posse in the San Rafael Swell, south of town. Cassidy, concealed in a covered wagon, drove past the place where his "body" was lying "in state." Several days later, officers discovered that the slain man was Jim Herron, a minor outlaw.

The College of Eastern Utah, Utah's youngest state-owned college, was founded in Price in 1938. Formerly called Carbon College, it now draws about 500 students and has a teaching faculty of 40, including one geologist.

0.5 55.4 Stoplight at west edge of Price Business District.

0.1 55.5 JUNCTION OF U.S. HIGHWAY 50-6 WITH UTAH STATE HIGHWAY 10. Continue ahead on U.S. Highway 50-6. Utah State Highway 10 leads south to Hiawatha and Emery County, on the west side of the San Rafael Swell.

0.2 55.7 Carbon County Courthouse, home of Price City Museum.

1.1 56.8 PRICE, EAST EDGE, junction of the Carbon County airport road with U.S. Highway 50-6. Continue toward Wellington on the highway.

0.8 57.6 The road descends onto one of several terraces of Price River, which is in the valley to the southwest beyond the railroad. The road is approximately 20 feet above the present position of the entrenched stream.

Behind the Book Cliffs to the west, the Wasatch Plateau rises above several pediments that have been cut across Mancos Shale.

1.3 58.9 Eastward extension of the Book Cliffs into the Tavaputs Plateau is visible to the east. Red Plateau and Cedar Mountain are on the north end of the San Rafael Swell, on the skyline to the south.

2.0 60.9 Two pediment levels are visible to the east of the road, both capped by debris brought from the northeast. These pediments are cut across Mancos Shale and are veneered with from 5 to 10 feet of sandstone gravel. Price River, to the west, is entrenched in alluvium of the flood plain.

Along the straight stretch of highway approaching Wellington there is greasewood between the railroad embankment and the highway. The associated tall grass with feathery tops is common reed. Indians used this grass as a shaft in a compound arrow. The grass stems grow exceedingly straight and Indians would insert a hardwood foreshaft into one of the hollowed internodes. The foreshafts would either be fire hardened or have a stone point attached to them. The other end of the shaft would be feathered. Cottonwood trees along the highway west of Wellington are not the narrow-leaf species common in the canyons but are Fremont poplars, having broad, heart-shaped leaves, each with only a few teeth on each side. Fremont poplar is a principal tree of low elevations in the Colorado drainage system.

0.6 61.5 WELLINGTON, NORTHWEST EDGE, at least according to the sign. The main community is ahead a short distance.

0.4 61.9 Enter the west edge of the built up section of Wellington at the road bend.

0.6 62.5 WELLINGTON COMMUNITY PARK (elev. 5,320), at the east end of the business district.

CO_2 is the "natural" gas produced from wells in the Farnham Dome, 5 miles east of Wellington. Shows of flammable gas (methane) mixed with CO_2 have been reported

from within the Moenkopi section near the top of the structure, but no commercial production other than the CO_2 from the Navajo Sandstone at a depth of 2,700 feet has been found here. The Farnham Dome was first drilled in 1921, using cable tools.

In the plant in Wellington "dry ice" and carbonic gas are manufactured for refrigeration and beverages. As it comes from the well, the gas is treated chemically to remove other gases. The carbon dioxide, converted to a liquid, passes through a nozzle and emerges as a fine spray, which crystallizes into "snow." The snow is transferred to molds, where it is compressed by hydraulic pressure into cakes about a foot square. "Dry ice," having a temperature of 114 degrees below zero, does not melt but evaporates, leaving no residual moisture. When lump coal was in demand, before mechanical coal stokers came into common use, liquid carbon dioxide was popularly used for blasting coal. Put up in cartridges, it was electrically detonated.

0.1	62.6	Cross Flood Wash.
0.3	62.9	Side road leads south to dry ice plant, the green concrete building near the railroad at the southeast edge of town.
0.9	63.8	A coal-washing plant along the Denver & Rio Grande right-of-way to the south is on the Price River floodplain. Directly ahead, the low hills are the west plank of Farnham Dome, the structure from which the CO_2 is produced for the dry ice plant in Wellington.
0.5	64.3	Cross Coal Creek. Exposures of Mancos Shale are visible both north and south of the bridge, beneath alluvial veneer of the flood plain.
0.35	64.65	UTAH STATE HIGHWAY 52 TO DEAD MAN CANYON AND COAL CANYON SIDE ROAD TO THE NORTH. Continue ahead on U.S. Highway 50-6. Utah State Highway leads north into the Uintah Basin.
0.35	65.0	Cross Soldier Creek just east of the junction. An excellent view of the southern edge of the Book Cliffs can be seen to the north and east at the base of the southern escarpment of the West Tavaputs Plateau. A well-defined gravel-veneered pediment occurs at the base of the plateau to the north.
1.1	66.1	Roadside outcrops of gray Mancos Shale at the major bend in the road on the western edge of Farmham Dome.
0.3	66.4	Basal exposures of Mancos Shale on top of the Ferron Sandstone in roadcuts. The sandstone is westward dipping and forms a cuesta on the west flank of Farnham Dome.
0.6	67.0	GEOLOGIC STOP 10. BEGINNING OF CAT CANYON. Thick Ferron Sandstone is exposed along both walls

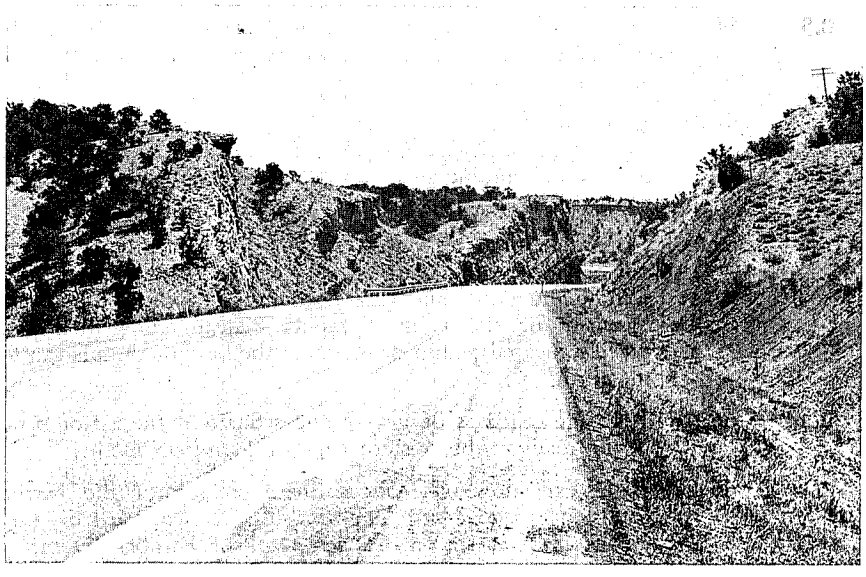
of Cat Canyon. Two small reverse faults duplicate the sandstone sequence and are particularly well expressed on the north side of the road (Text-fig. 26). Ferron Sandstone outcrops show a typical gradational base and an abrupt top, characteristic of most regressive sandstone tongues that interfinger with the Mancos Shale.

0.2 67.2 Gray shaly outcrops of the lower Mancos Shale exposed at the base of the Ferron Sandstone cliff on both the north and south sides of the road.

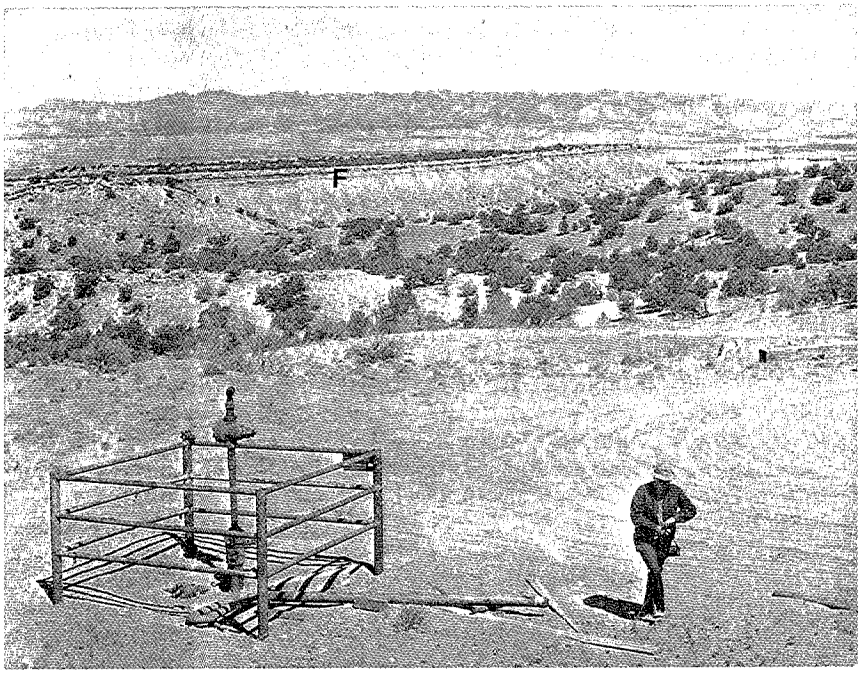
0.4 67.6 Lower Mancos Shale is well exposed beneath the Ferron Sandstone that caps the prominent high bluff both north and south of the road.

This exposure of Mancos Shale is rich with plant species. In the immediate vicinity are Utah juniper, pinyon pine, several species of wild buckwheat, locoweed, flax, rabbitbrush, greasewood, saltbush, shadscale, and many other herbaceous species. Floristically this is one of the richest low-elevation areas in all of the Colorado drainage system. Here, within a square mile, there may be as many as 150 species of plants.

0.3 67.9 The barren reddish knob to the south is in the center of Farnham Dome, near the crest of the anticline. Just south of the knob, in the flat, is the well that produces the carbon dioxide for the dry ice plant at Wellington (Text-fig. 27). Pinyon-covered slopes in the foreground are on Dakota Sand-



TEXT-FIGURE 26.—Eastward along U.S. Highway 50-6 showing folded, repeated Ferron Sandstone in Cat Canyon along the northwest part of Farnham Dome at Mile 67.



TEXT-FIGURE 27.—The producing CO_2 well at the crest of Farnham Dome. Ferron Sandstone (F) forms the juniper-covered cuesta above the valley-forming lower Mancos Shale in the middle distance. Younger Cretaceous and Tertiary rocks rise above the Book Cliffs in the Tavaputs Plateau in the distance.

stone, on top of reddish Cedar Mountain Formation that forms the knob. A subsequent valley is carved on the lower shale of the Mancos Shale to the south of the road.

0.3 68.2 Side road leads southward to the producing well in the center of Farnham Dome. Dakota Sandstone is well exposed in gullies beyond the fence south of the road junction.

0.3 68.5 Roadside outcrops of northward-dipping Dakota Sandstone on the north-plunging nose of Farnham Dome. The broad valley to the east is carved on Mancos Shale. Ferron Sandstone caps small bluffs to the northeast of the road and is thinner than on the west flank of the dome.

0.5 69.0 The road is in Mancos Shale, here somewhat faulted on the east flank of Farnham Dome. The high rounded point ahead on the skyline to the east is Patmos Head at the southern edge of the West Tavaputs plateau. The promontory is composed of Green River Formation.

The vegetation on either side of the road is predominantly shadscale, with some grass interspersed. This is salt-desert vegetative type.

0.8 69.8 Road cuts through weathered sandy Mancos Shale and a dramatically thinned Ferron Sandstone.

1.9 71.7 ROAD JUNCTION OF UTAH STATE HIGHWAY 123 ON EAST SIDE OF GRASSY TRAIL CREEK. Utah State Highway 123 leads east to Sunnyside and the Horse Canyon coal mine. Continue on U.S. Highway 50-6. Oil-impregnated sandstone deposits near Sunnyside are the largest known in the United States. The deposit was first mined in 1892 for street paving in Salt Lake City, but serious development did not come until 1928. The natural asphalt can be laid cold as a paving material. Bituminous beds, ranging from 10 to 350 feet in thickness occur within a zone about 1,000 feet thick in the upper part of the Wasatch (Colton) Formation and the lower part of the Green River Formation at elevations between 9,000 and 10,000 feet near the top of the Roan cliffs seven miles by road from Sunnyside. For a recent account see C. N. Holmes and B. M. Page, Intermountain Assoc. Petrol. Geol. Guidebook, 1956, p. 171-77.

Sunnyside itself is a declining coal and coke town. Jefferson Tidwell found a seam of coal in 1898 and sold it to the Utah Fuel Company for $250. A year later more than 1,200 men were employed in the mines at Sunnyside. Coke made here was shipped to Castlegate for use in smelting. In 1902-03 more than 400 coke ovens were burning at Sunnyside. It boomed as a coke town until 1929, when other products were introduced for smelting. Of the 816 coke ovens once in use, only 6 were operating in 1940.

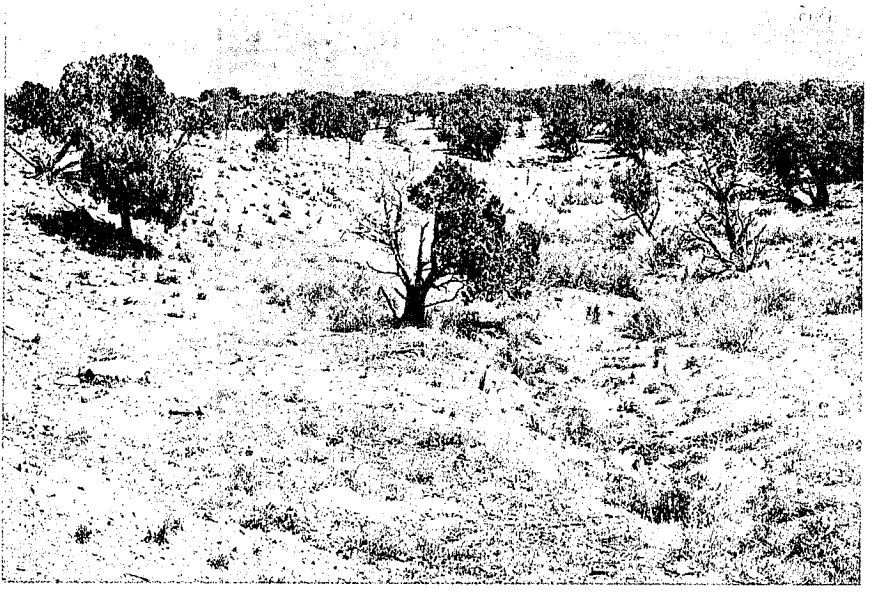
When Sunnyside was in its prime, there existed a strong feeling between southern Europeans and "whites," as the American-born were locally known. Prejudice was not so pronounced where Negroes were concerned. When a teacher who had beaten colored children was run out of town by the parents, the "whites" heartily sanctioned the action. Andrew W. Dowd, community doctor, did much to further the assimilation of foreigners by enforcing rules of sanitation; he discouraged scalding slaughtered hogs in the bathtub, giving chickens the right-of-way in the house, and raising rabbits under the bed.

Children, however, were fascinated by foreign customs. For example, in the manuscript *History of Carbon County,* by the Utah Historical Records Survey, Mrs. Lucile Richens, formerly of Sunnyside, is quoted as saying, "We children used to go down to Jap town after school to watch the Japanese fly kites. . . . They used to make wooden men, painted in bright colors . . . joined at the elbows, shoulders, waist and knees and worked by a windmill in such a way that, when the wind blew, it looked like the wooden men were turning the windmills."

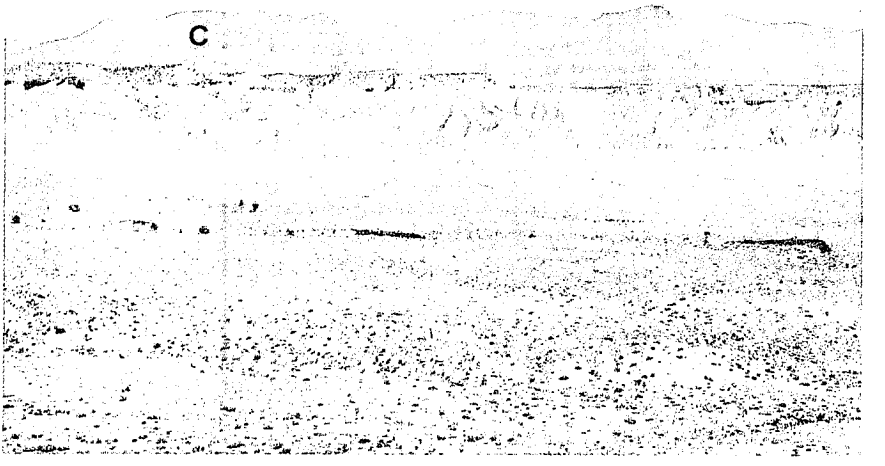
0.7 72.4 Cross over branch line railroad to Sunnyside. The road is built on coarse gravels covering a pediment cut across

Mancos Shale. Only in deep cuts is the shale exposed beneath the gravel cover.

0.6	73.0	Double road cut. Mancos Shale shows below the tan cover of the pediment here and in road cuts to the south.
0.8	73.8	Double road cut through Mancos Shale capped by pediment gravel veneer. Basal part of gravel, cemented by caliche, stands out in a small ledge. The road continues across the flat upland surface of a pediment south of the cut.
1.2	75.0	The road descends from an upper pediment surface onto an intermediate one. Both of these are now being dissected. The scarp of the upper pediment surface shows well in the gravel-capped gray badlands east of the road (to the left). Northward plunge of the San Rafael Swell is visible to the west. Cedar Mountain forms the skyline to the southwest at about 2 o'clock, beyond some oil wells.
2.1	77.1	The road drops off an intermediate pediment level through exposures of Mancos Shale.
0.6	77.7	EMERY–CARBON COUNTY LINE.
0.2	77.9	CROSS BIG SPRINGS WASH. The flood plain of Big Springs is adjusted to the level of Price River, but both are entrenched several feet below the general valley level. The bottomland is occupied by a dense stand of greasewood.
1.2	79.1	CROSS ICELANDER WASH. The road rises to the south onto a pediment surface. To the west along Icelander Wash can be seen eastward-dipping sandy and silty beds of the Ferron Sandstone, which this far to the east has graded out into thin sandstone and silty shale.
3.0	82.1	Utah juniper and pinyon woods both east and west of the road are on a gravel-capped pediment surface (Text-fig. 28).
1.0	83.1	Side roads both east and west. The Horse Canyon road to the east leads to the Horse Canyon Mine.
1.2	84.3	Deep cuts through gravel of alluvial fan. Exposures of Mancos Shale and the pediment surface visible to the east from the southeast end of the cut.
2.4	86.7	View to the east is of the upper part of the Mancos Shale, Blackhawk Formation, Castlegate Sandstone, and Price River Formation forming the first series of cliffs (Text-fig. 29). Younger rocks form the higher area behind the crest of the Book Cliffs escarpment. Cedar Mountain to the west is at the north end of the San Rafael Swell and is the crest of the skyline. Beckwith or Red Plateau, directly ahead to the southeast, is the prominent southwestern end of the West Tavaputs Plateau.
1.8	88.5	CROSS GRASSY WASH. Exposures of Mancos Shale are



TEXT-FIGURE 28.—Juniper woods, populating coarse mudflow debris blanketing the pediment surface near Mile 82. Blackhawk and Castlegate formations form the lower series of prominent ridges and slopes with rocks as young as Green River exposed along the skyline in the far distance.

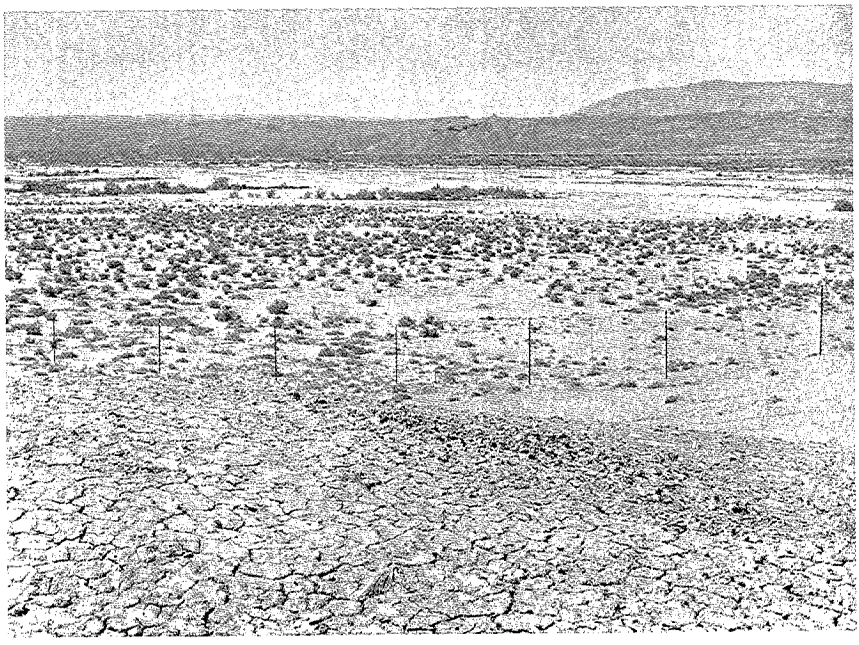


TEXT-FIGURE 29.—View east to the cliff front of the West Tavaputs Plateau beyond badland topography carved in the silvery gray and buff-weathering Mancos Shale. C, Castlegate Sandstone.

visible along both sides of the road here and a short distance ahead. Just south of crossing of Grassy Wash the Mancos Shale outcrop is clothed with a mixture of mat-atriplex, a low-growing saltbush type and the Castle Valley clover (Text-fig. 30). There is shadscale mixed in with the vegetation here. (Shadscale is the principal vegetative cover wherever the Mancos Shale is without a pediment gravel layer.) White encrustations of salt are quite common on the formation here. Upon analysis the surface of the Tropic Shale to the westward has yielded between 20 and 30 thousand parts per million of soluble salts—a good indication as to why saltbush is one of its principal plants. The saltbushes belong to the Goosefoot family of plants, which occur in saline soils throughout the world.

0.4 88.9 Excellent exposures of Mancos Shale. *Ostrea, Inoceramus,* and other fossils occur in silty beds beneath ledges on both sides of the road at the south end of the cut. Shell-fragment prisms of *Inoceramus* are common in material gouged out of the road cut and dumped to the east.

0.8 89.7 CROSS MARSH FLATS WASH. Badlands topography on Mancos Shale shows both east and west. Juniper-covered

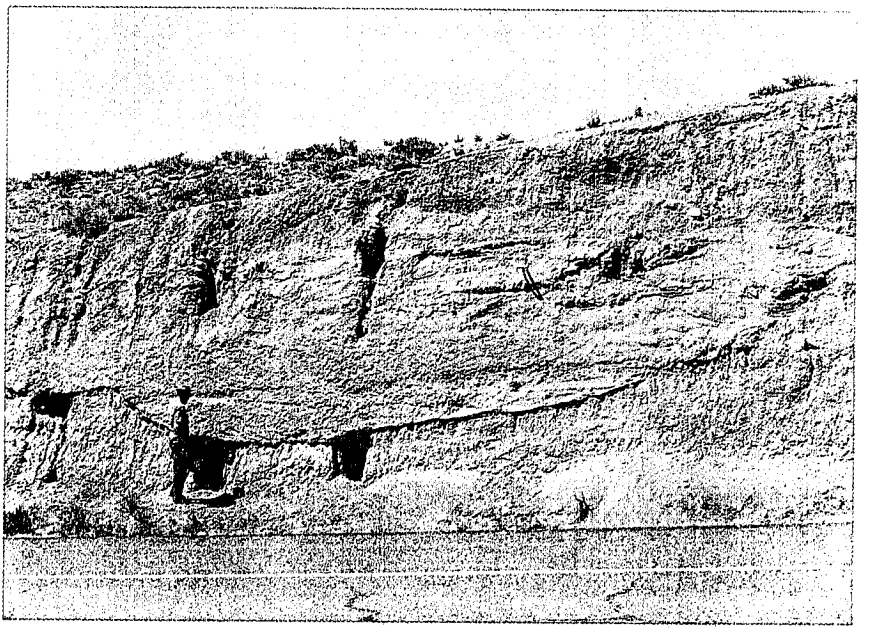


TEXT-FIGURE 30.—Westward along Grassy Wash toward the northeastern flank of the San Rafael Swell. Mat-atriplex, Castle Valley clover, and shadscale blanket the weathered Mancos Shale in the middle distance. Fragments of *Inoceramus* occur in the little-weathered Mancos Shale in the foreground.

dip slopes of the Dakota and older formations to the west show the eastward dip on the east side of the San Rafael Swell. To the east, Castlegate Sandstone—now much thinned from what it is at Castlegate—forms the prominent pinkish brown cliff on the skyline.

1.5	91.2	View to the southwest down into Price River Valley shows that pediment surfaces currently developing in tributaries are adjusted to the modern elevation of the Price River but that older pediments are obviously adjusted to a former high position of the river.
1.6	92.8	Characteristic alluvial plain in Mancos Shale. The alluvial fill is now entrenched by vertical-walled arroyos.
0.7	93.5	Steep-walled road cuts are through weathered Mancos Shale and gravelly pediment veneer (Text-fig. 31).
1.0	94.5	GEOLOGIC STOP 11. ROADSIDE GEYSER TO THE WEST past the south side of WOODSIDE Post Office and the service station.

Woodside (elev. 4,630), now marked principally by a gas station and a geyser, was once a remote farming community known as Lower Crossing, then later as Woodside, for the groves of cottonwoods along the Price River. Population peaked at 300 around 1910-20, and there were sev-



TEXT-FIGURE 31.—Gravel-filled stream channel on a pediment surface carved in weathered Mancos shale in the steep road cuts at approximately Mile 88.

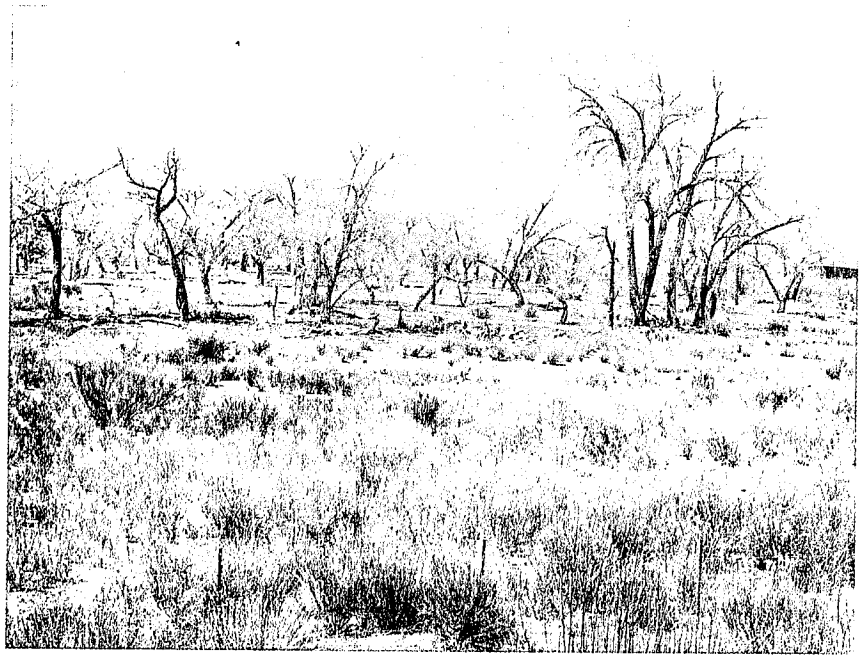
eral businesses and stores, including a railroad hotel, depot, school, and a blacksmith shop. Cattlemen used the town as their headquarters, and extensive stockyards lined the tracks. Three factors combined against Woodside. The Price River overflowed so often with devastating effects that the farmers gradually pulled out. As railroad operations were streamlined, all division offices were moved to Helper. And, finally, cattle ranching dwindled in importance.

In 1910 the D&RGW drilled for water and got it, but it came as a geyser that spouted 75 feet into the air and refused to be capped. Escape of the gas which actuates the geyser has caused a slow decline in the geyser's height. By 1940 it rose only a few feet above the ground with eruptions every few minutes. Now, after some surface modification, the geyser erupts with a three-stage eruption approximately every 45 minutes. The first stage represents an initial loss of pressure and causes a low burbling which builds to a fountain about 20 feet high, followed by a return of the expelled water into the plumbing system—like a flow back down a drain. The second stage is a single short-lived fountain 30 to 40 feet high. The third stage is a relatively high but short eruption, following which water returns down the tube. The well then bubbles gently until the next eruption.

0.2 94.7 CROSS PRICE RIVER. East of Woodside, near the Price River gorge, the uppermost massive cliff is formed by the Castlegate Sandstone. Beneath it, the middle sandstone of the Blackhawk Formation forms a major barrier sequence on the north side of the gorge. As this cliff-forming unit is traced toward the north, it breaks into a succession of white-capped massive lagoonal sandstones, each with coal above it. The bedded basal sandstone here is equivalent to the barrier-island sequence behind which the coals occur at Sunnyside.

The principal shrubby vegetation along the low terrace, both south and north of the river, is an introduced old-world shrub called tamarix (Text-fig. 32). This plant did not arrive along the river here until after the 1920s. Since then it has occupied essentially all of the Colorado drainage stream banks in the southern two-thirds of Utah. The native vegetation nearby consists of Fremont cottonwood, rabbitbrush, seepweed, and a few other weedy species. Streamsides in the state of Utah, particularly those in the warmer, lower elevation parts, have been overgrazed consistently since early pioneer days, leaving very little herbaceous vegetation. Mostly introduced weeds grow in these areas today.

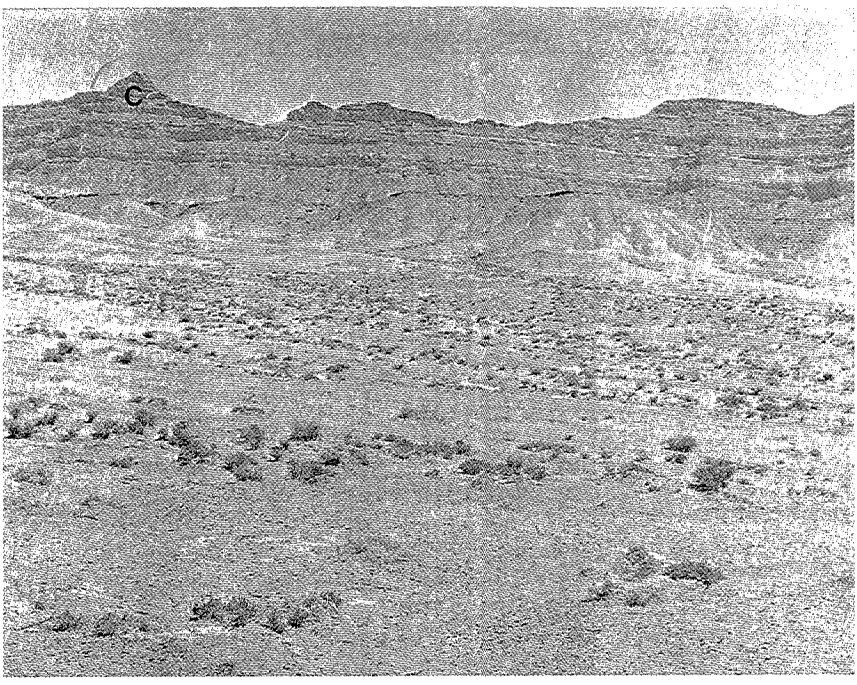
0.4 95.1 Mancos Shale is exposed along both sides of the road. Gorge of Price River Canyon to the east separates Beckwith or Red Plateau, a small, isolated erosional remnant to the southeast, from the main West Tavaputs Plateau directly to



TEXT-FIGURE 32.—Thick growths of tamarix in the foreground and massive old growths of Fremont cottonwood in the background along the south bank of Price River at Woodside.

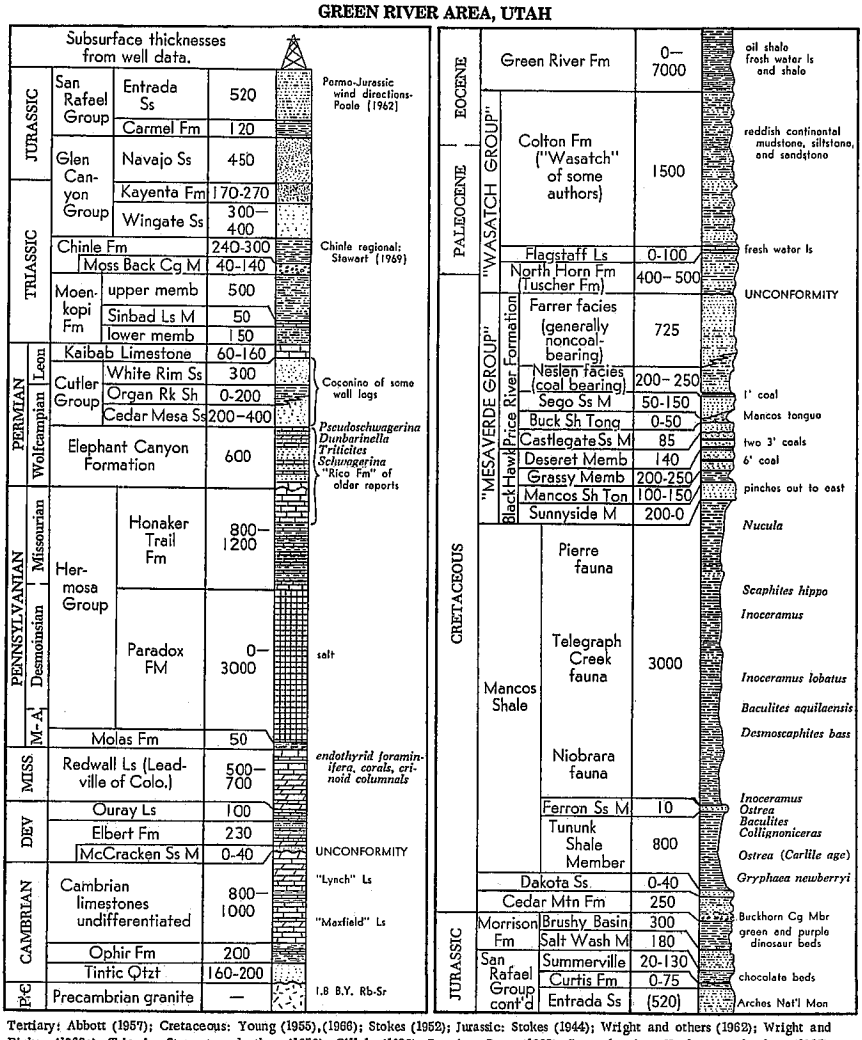
the east. Price River drains into Green River some distance above the town of Green River. Beckwith Plateau is capped by Price River beds, with the highest prominent cliff on the skyline held up by Castlegate Sandstone (Text-fig. 33). Dip slopes to the west, on the east flank of the San Rafael Swell, are on the lower part of the Cretaceous and the upper part of the Jurassic section. This road, south of Price River, although constructed only a few years ago, already shows the characteristic irregularities that develop because of shale heaving on roads built over Mancos Shale.

1.9	97.0	Cuesta of Ferron Sandstone in the Mancos Shale shows well beyond the railroad tracks to the west. Cedar Mountain and Morrison formations form juniper-covered eastward-dipping cuestas on the flank of the San Rafael Swell beyond (Text-fig. 34).
1.8	98.8	ROAD JUNCTION with the county road that leads across the north end of the San Rafael Swell.
1.9	100.7	Silty Ferron Sandstone is exposed in gullies west of the highway. The silty remnant of the tongue causes a small cuesta that is traceable north and south, parallel to the Book Cliffs and the San Rafael Swell.



TEXT-FIGURE 33.—View eastward, to Red or Beckwith Plateau, from a short distance south of Woodside. Mancos Shale is exposed in the foreground and overlain by ledges of Blackhawk Formation capped by the Castlegate Sandstone (C).

0.9	101.6	Road cuts through cuesta of concretionary tan, silty sandstone in the Mancos Shale. The Ferron Sandstone is some distance to the west.
0.8	102.4	OVERPASS OVER THE MAIN LINE OF THE DENVER & RIO GRANDE WESTERN RAILROAD. Thin lenses of silty Ferron Sandstone cap the brownish Mancos terrace across the gully to the west of the road. The tan, flat, alluvial bottom contrasts with exposures of silty Ferron Sandstone. South of the overpass, in the vicinity of the highway are minor dunes and barren gray stripped slopes of Mancos Shale in the vicinity of the highway. The Mancos Shale, visible all around, shows the typical development of the salt-desert shrub. In the drainage bottoms there is some greasewood, but mat-atriplex, "Castle Valley clover," and shadscale dominate on the nearly barren land between drainages.
3.8	106.2	Ferron Sandstone forms a cuesta across the flat to the west of the road. Resistant sandstone beds show above the silty dark-gray shale and below the gray bentonitic shale exposed in cuts near the road.



Tertiary: Abbott (1957); Cretaceous: Young (1955),(1966); Stokes (1952); Jurassic: Stokes (1944); Wright and others (1962); Wright and Dickey (1963a); Triassic: Stewart and others (1959); Gilluly (1929); Permian: Baars (1962); Pennsylvanian: Heylmun and others (1965); Mississippian-Devonian: Parker and Roberts (1966); Cambrian: Baars (1966); Lolelt (1963); Chinle Fm: Stewart (1969)

TEXT-FIGURE 34.—Stratigraphic chart of rocks exposed and encountered in oil wells in the Green River area (from Hintze, 1973).

2.4 108.6 Bend in the highway. The Reef of the San Rafael Swell shows very well towards the south across Saleratus Creek. Beyond the bend, double road cuts are in Mancos Shale. Road-metal quarry in the stream bottom to the left. Road construction material is scarce because Mancos Shale crushes down into a powder. The only suitable locally available material is sandstone gravel swept from the Tavaputs Pla-

teau to the east or from the San Rafael Swell to the west. Consequently, quarries for road material are located in valley bottoms along flooding stream channels.

Catch dams to the south of the road hold water for some time. Tamarix has occupied these areas, so now they are tamarix-filled catchment basins.

1.2 109.8 Prominent covering of sulfate salts is visible on the Mancos Shale to the east of the road, beyond the railroad tracks, in the badland topography carved in the middle part of the Mancos Shale.

The east reef of the San Rafael Swell is visible to the west. It is held up in large part by Navajo and Wingate sandstones.

1.8 111.6 Road crests in sandy Mancos Shale exposures. Brown ironstone concretions on the crest of the hill.

0.6 112.2 ROAD SEPARATION. The road straight ahead leads eastward to Green River. The road to the right (west) leads westward to Salina across the San Rafael Swell along Part 2 of this log.

0.3 112.5 INTERSTATE HIGHWAY 70 AT U.S. HIGHWAY 50-6 JUNCTION BRIDGE OVER I-70.

Mancos Shale road cuts on the north side. The flood plain of Saleratus Wash, one of the tributaries of the Green River, shows well to the southwest with characteristic arroyo development. To the north, prominent cliffs at the southwest tip of the Beckwith Plateau are capped with Castlegate Sandstone, above the ledge-and-slope of the Blackhawk Formation and the gray slope of the upper Mancos Shale at the base of the cliff.

The road swings to the east, parallel to the south face of the Beckwith Plateau and away from the eastern side of the San Rafael Swell. To the east, the East Tavaputs Plateau can now be seen on the skyline beyond the gorge of the Green River. The ragged profile of the La Sal Mountains is visible on the skyline some distance to the east.

1.7 114.2 Leave Interstate 70 at temporary end. The road swings to the north onto old U.S. Highway 50-6.

0.7 114.9 UNDERPASS BENEATH MAIN LINE OF RIO GRANDE AND WESTERN RAILROAD. West edge of the Green River airport is just beyond the underpass.

0.5 115.4 Excellent exposures of lower Mancos Shale occur to the south of the railroad right of way and Interstate 70. The gorge of the Green River between East and West Tavaputs plateaus is to the north.

0.4 115.8 GREEN RIVER, WEST EDGE.

0.3 116.1 GREEN RIVER, MAIN DOWNTOWN INTERSECTION (elev. 4,080). Watermelon capital of Utah, Green River was settled in 1878 as a mail relay station between Salina, Utah, and Ouray, Colorado. With the coming of the D&RGW railroad in 1882 a short-lived land boom hit Green River. Melon growing began in 1917 and has flourished since. Current activity centers around tourists, uranium mining, oil exploration, U.S. Air Force missile testing, and boating on the Green River from the state park at the east edge of town.

Green River has its own geyser, three miles south of town. This came into existence in 1936 when a well, drilled along a fault zone, encountered high gas pressures at 2,000 feet. The geyser still puts out a better spout than the older Woodside "geyser."

Desolation Canyon is the name given to that 50-mile stretch along the Green River above town where the river cuts through the Roan and Book cliffs at the southern margin of the Uinta Basin. The mouth of Desolation Canyon is about 5 miles north of Green River. Many individuals have run the Green River by boat.

The first man to attempt running the Green River appears to have been General William H. Ashley, who went downstream almost to Green River, Utah, in 1825. The name, "D. Julien," with the date 1836, appears several times on the walls of the canyons of the Green River, but little else is known of his trip.

One-armed Major John Wesley Powell made two assaults upon the rivers, one in 1869, the other in 1871. Without maps or charts Powell made his way along the Green and Colorado rivers and through Grand Canyon. Leaving Green River, Wyoming, May 24, 1869, Powell set out with four boats and a crew of nine. His description of the Book Cliffs at the mouth of Desolation Canyon on July 14, 1869, is: "These cliffs are many miles in length, and hundreds of feet high; and all these buttes—great mountain-masses of rock—are dancing and fading away, and reappearing, softly moving about, or so they seem to the eye, as seen through the shifting atmosphere." Powell's account of Green River (Gunnison's Crossing) that same day is: "About two hours from camp, we discovered an Indian crossing, where a number of rafts, rudely constructed of logs and bound together by withes, are floating against the bank. On landing, we see evidences that a party of Indians have crossed within a very few days. This is the place where the lamented Gunnison crossed, in the year 1853, when making an exploration for a railroad route to the Pacific coast."

"An hour later, we run a long rapid, and stopped at its foot to examine some curious rocks, deposited by mineral springs that at one time must have existed here, but which are no longer flowing."

Between Green River (Gunnison's Crossing) and the junction of the Green and Colorado River, Powell gazed upon "a strange, weird, grand region. The landscape everywhere, away from the river, is of rock-cliffs of rock; tables of rock; plateaus of rock; terraces of rock; crags of rock—ten thousand strangely carved forms. Rocks everywhere, and no vegetation, no soil, no sand . . . a whole land of naked rock, with giant forms carved on it; cathedral shaped buttes, towering hundreds or thousands of feet; cliffs that cannot be scaled, and cañon walls that shrink the river into insignificance, with vast, hollow domes, and tall pinnacles, and shafts set on the verge overhead, and all highly colored—buff, gray, red, brown, and chocolate; never lichened; never moss-covered, but bare, and often polished."

Nate Galloway, a trapper, was probably the first man to run the rivers alone. In 1895 he made the trip from Green River, Wyoming, to Jensen, Utah, where he meant to disembark a load of beaver pelts. However, he preferred river hazards to officers looking for beaver poachers and continued on to Lees Ferry, Arizona, by himself.

END OF PART 1

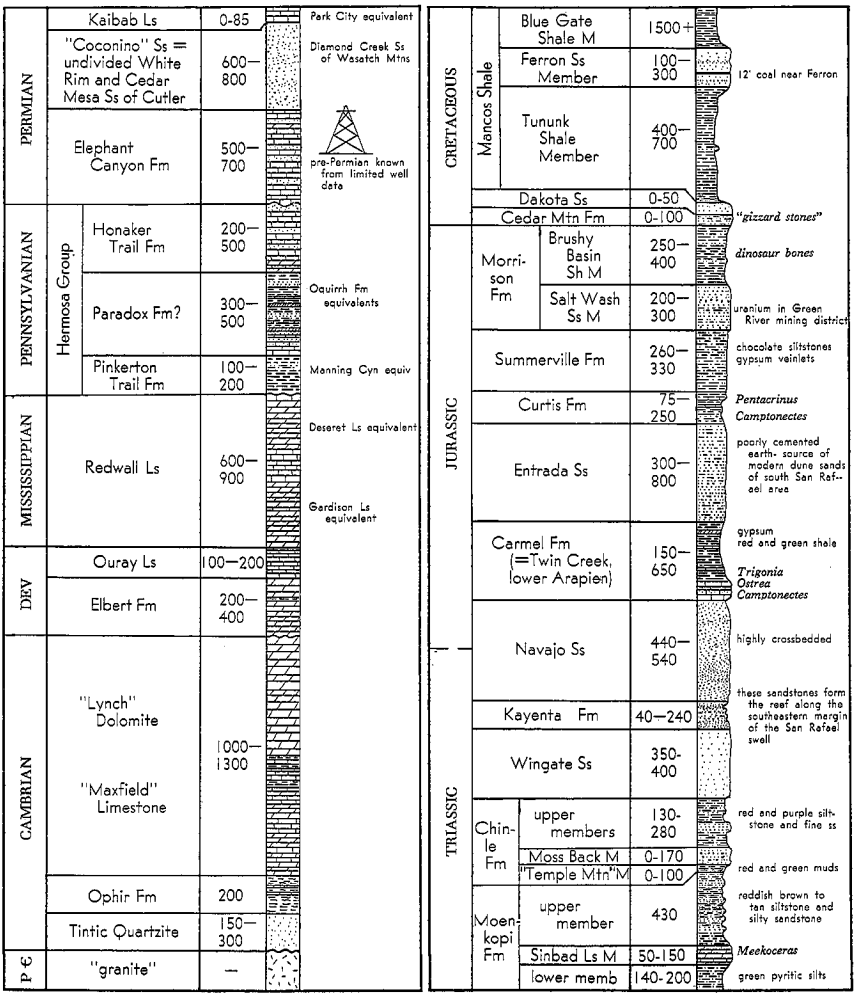
PART 2

GREEN RIVER TO SALINA VIA INTERSTATE HIGHWAY 70

MILEAGE Interval	Cumulative	
0.0	0.0	GREEN RIVER, WEST EDGE. Cross beneath the Denver and Rio Grande Western Railroad main route at the west end of the Green River airport.
0.7	0.7	West Green River Temporary interchange. Join the main freeway at temporary beginning of I-70.
1.7	2.4	CROSS BENEATH THE BRIDGE AT THE PRICE—U.S. HIGHWAY 40 INTERCHANGE WITH INTERSTATE 70.
0.5	2.9	Cross bridge over Saleratus Wash, a drainage off the east flank of the San Rafael Swell. The wash drains into Green River near the community of Green River.

The road now begins to climb up the east flank of the San Rafael Swell on about the Ferron Sandstone dip slope. Ahead the cockscombs and flatirons of the Reef of the San Rafael Swell are in white Navajo Sandstone with the flat-topped core of the Swell on the skyline in Permian and Triassic formations. The San Rafael River crosses through the Reef at the northern notch of the two notches that are ahead at 1:30. Directly ahead, prominent Triassic and Jurassic formations form the steeply dipping east side of the San Rafael Swell (Text-fig. 36).

TEXT-FIGURE 35.—Index map of Part 2 of the road log, showing numbered geologic stops along Interstate 70 between Green River and Salina. The route leads across the San Rafael Swell and between the Wasatch and Fish Lake plateaus.



After: Gilluly (1929); Jurassic: Wright and Dickey (1963a); Temple Mountain Triassic-Jurassic: Hawley and others (1965); Permian: Baars (1962); Devonian-Mississippian: Parker and Roberts (1966); Cambrian: Balk (1956); Morrison Fm: Cadigan (1967); Chinle Fm: Stewart (1969); Permo-Jurassic wind directions: Poole (1962)

TEXT-FIGURE 36.—Stratigraphic section of rocks exposed in the San Rafael Swell and encountered in wells in the subsurface (from Hintze, 1973).

1.6 4.5 Cross beneath power line from Farmington, Four-Corners Power Plant. The road continues up the gentle slope in the middle part of the upper Mancos Shale.

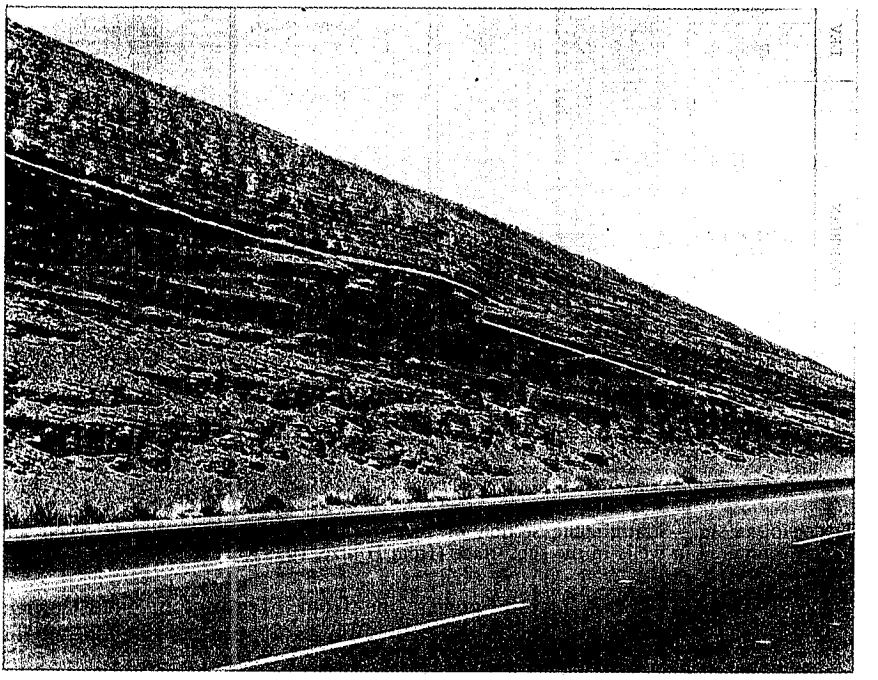
3.2 7.7 Crest of the hill in Ferron Sandstone. View behind is of the Book Cliffs and a slope on the upper part of the Mancos Shale. The shale slope is capped, toward the north by the

Castlegate Sandstone, toward the east by Castlegate Sandstone and younger beds equivalent to the Price River and North Horn formations. The LaSal Mountains are visible to the southeast. These are held up by porphyritic Tertiary intrusive rocks. Ahead the San Rafael Swell dominates the skyline.

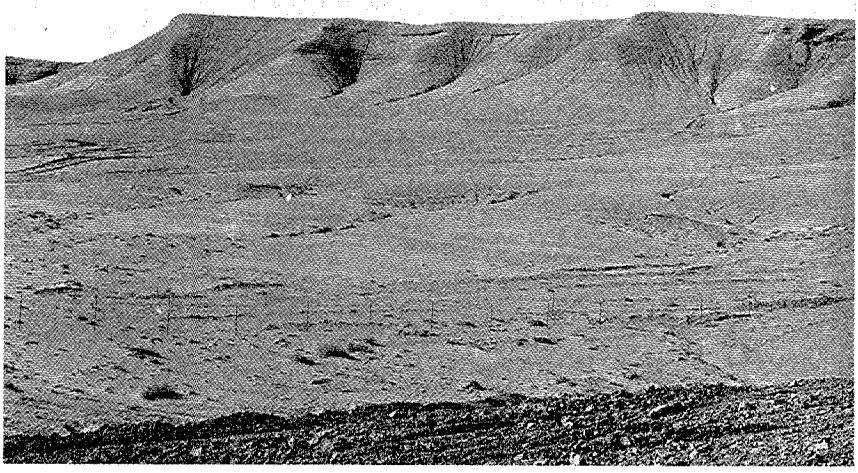
0.2 7.9 Double road cuts through fossiliferous siltstone and sandstone beds of the Ferron Sandstone (Text-figs. 37, 38). Ammonoids and bivalves are common in the lower well-bedded rocks. Black siltstone and flaggy tan sandstone are the distal edge of the massive coal-bearing deltaic sequence to be seen on the west side of the San Rafael Swell. Equivalent rocks are 700 feet thick at Clear Creek where natural gas is produced from Ferron Sandstone.

0.5 8.4 Brown concretionary sandstone in the Mancos Shale. This unit contains abundant fossil clams, preserved in large part as casts and molds (Text-fig. 39).

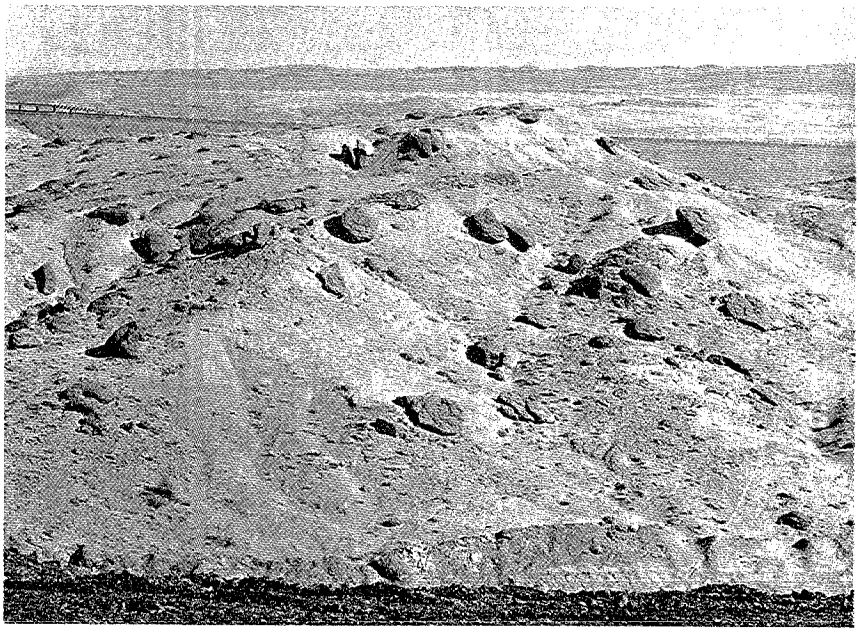
0.3 8.7 GEOLOGIC STOP 1. *Gryphaea* beds exposed in road cuts at the base of the Mancos Shale on both the north and the south (Text-fig. 40). Road slopes down the cuesta face



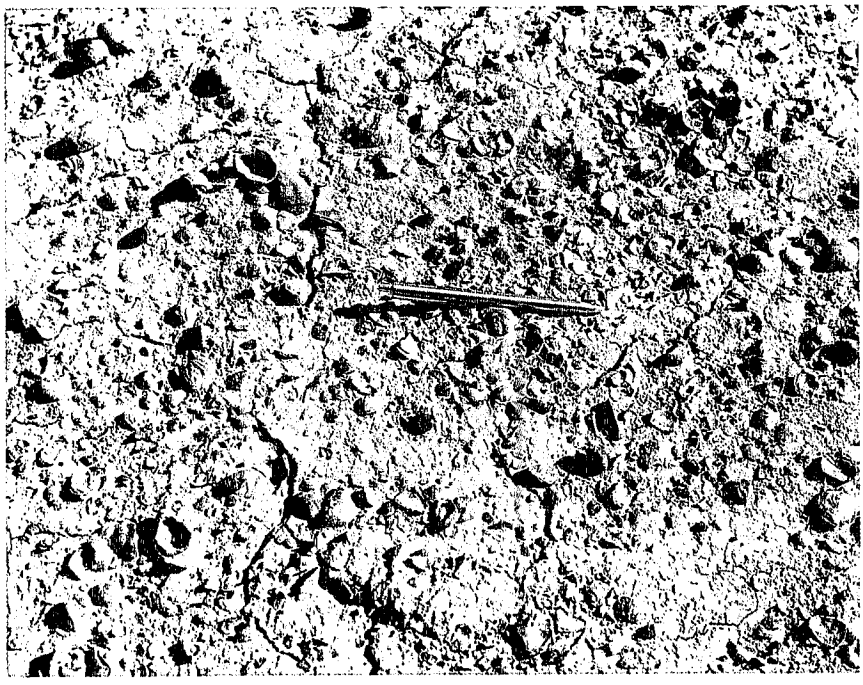
TEXT-FIGURE 37.—Small thrust fault along the north wall of cuts through the Ferron Sandstone in the eastbound lane of Interstate 70. The small fault has offset a white volcanic ash bed near the base of the Ferron Sandstone.



TEXT-FIGURE 38.—View northward along gentle cuesta capped by the Ferron Sandstone. Ammonoid-bearing shale forms the striped beds immediately beneath the sandstone and above the silvery gray, massive, slope-forming part of the Mancos Shale.



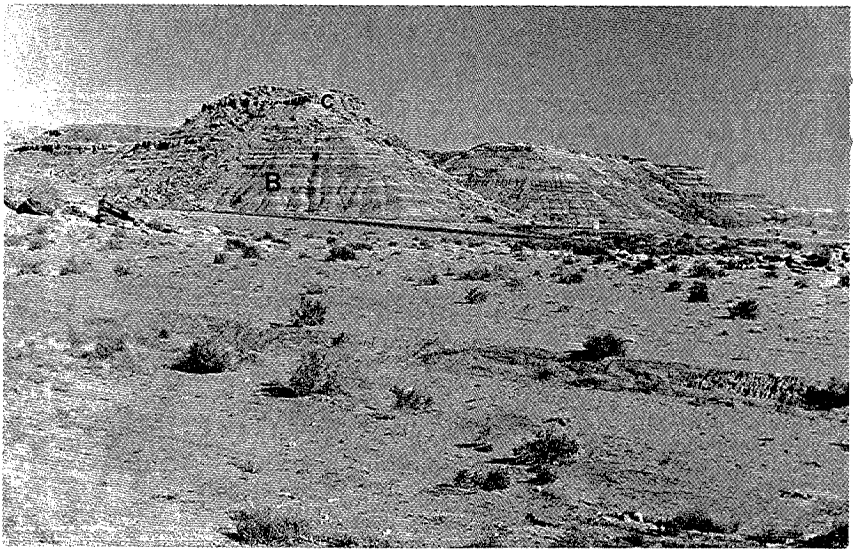
TEXT-FIGURE 39.—View southward from the westbound lane at approximately Mile 8.4. Large sandstone concretions in the lower part of the Mancos Shale contain abundant molds of fossil oysters and clams.



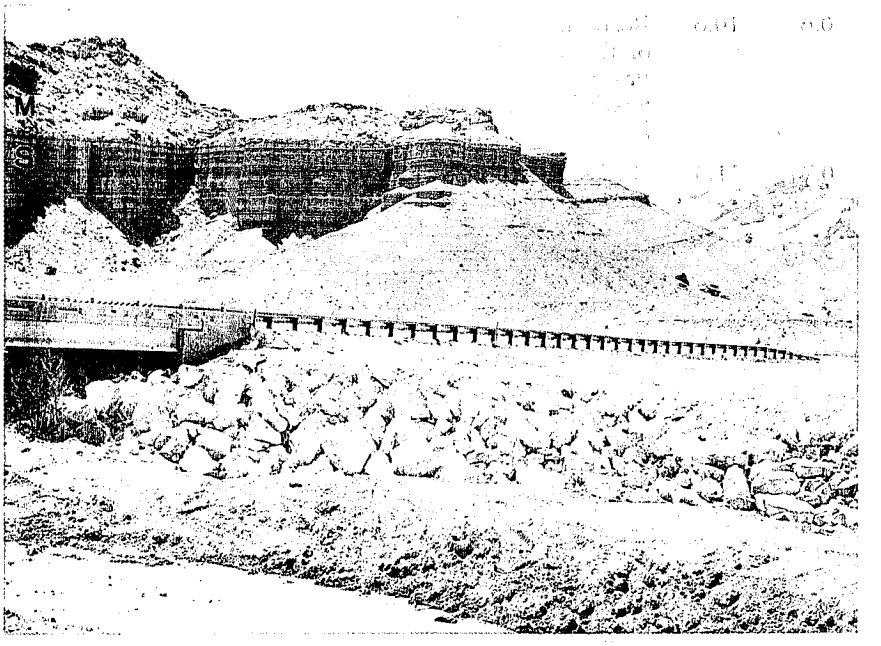
TEXT-FIGURE 40.—Weathered surface of *Gryphaea newberryi* beds at the base of the Mancos Shale at Geologic Stop 1 (Mile 8.7). This species of fossil oyster occasionally makes reefs 10 to 20 feet thick at other localities, such as near Hanksville to the south.

		across the basal part of the Mancos Shale and onto gray green Cedar Mountain Formation, which makes up most of the road cut.
0.2	8.9	Cross the trace of the Buckhorn Conglomerate that separates the light-gray, ashy Cedar Mountain beds above from the purple and maroon Morrison Formation below.
0.4	9.3	Double road cut through upper Morrison sandstone. Excellent channel fillings of sandstone and conglomerate make lenses in less resistant shale of the Brushy Basin Member.
0.7	10.0	PASS BENEATH BRIDGE OF THE HANKSVILLE INTERCHANGE. Road to the south leads to Hanksville, Capitol Reef, and Bull Frog Basin on Lake Powell. Beds to the north are the lower Brushy Basin Member of the Morrison Formation. The thick conglomerate along the crest of the cuesta to the south is the Buckhorn Conglomerate, the basal member of the Cedar Mountain Formation (Text-figs. 36, 40). It forms the large, angular, dark, lichen-covered blocks. Salt Wash Member forms the massive, light-gray sandstone cliffs ahead to the west.

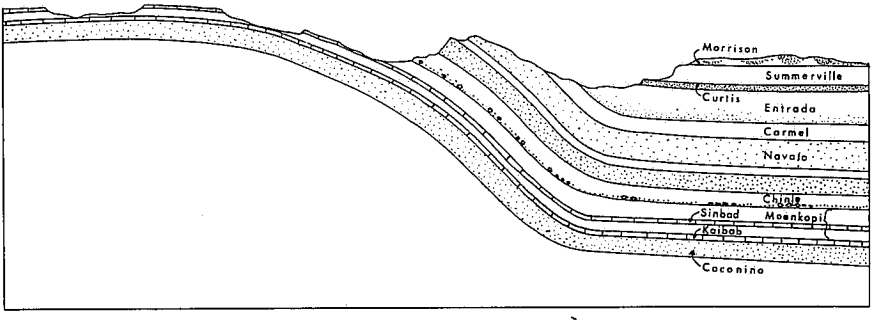
0.6	10.6	Road cuts through massive, cross-bedded, fluvial sandstone of the lower Saltwash Member of the Morrison Formation. Eastern end of the outcrop shows characteristic maroon mottled mudstone and sandstone. Individual channels can be traced out for some distance along their trace.
0.7	11.3	BRIDGE ACROSS THE SAN RAFAEL RIVER. Uppermost gypsiferous marine (?) beds of the Summerville Formation are exposed below massive lower Morrison sandstone that forms the dark-brown ledgy beds along the crest of the canyon walls (Text-figs. 36, 42). Here tamarix occupies the entire terrace along the San Rafael River and has replaced the willows that used to grow here. However, there are still a few patches of reed grass growing along the edge of the tamarix thicket, and an occasional Fremont poplar sticks its head up above the mass of tamarix.
0.6	11.9	Greenish Curtis Formation exposed to south below castellate Summerville beds. Both formations are well exposed north and south of the road in the vicinity of the San Rafael River. To the west the "Stone baby" bed of the middle part of the Entrada formation is the massive sandstone at the beginning of the curve in the climb up the east flank of the San Rafael Swell (Text-fig. 43).
0.6	12.5	Soft-sediment deformation in siltstones of the lower part of



TEXT-FIGURE 41.—View southward from near the Hanksville interchange. The Brushy Basin Member of the Morrison Formation (B) is the candy-striped beds. Conglomerate- and sandstone-filled stream channels of the Cedar Mountain Formation (c) cap the gentle cuesta.



TEXT-FIGURE 42.—Southward from the bridge over the San Rafael River to chocolate brown castellate cliffs of Summerville Formation (S) capped by debris-covered slopes of the Salt Wash Member of the Morrison Formation (M). The prominent ledge at the contact is a massive unit of gypsum.



TEXT-FIGURE 43.—A generalized structural cross section through the eastern flank of the San Rafael Swell. The flexure along the eastern flank is typical of monoclines in the Colorado Plateau where rocks on either side of the flexure are nearly horizontal.

the Carmel Formation shows near east end of the rest areas. Entrada Formation is exposed at the base of the cliffs to the south.

0.3 12.8 GEOLOGIC STOP 2. REST AREAS are built on Carmel limestone and sandstone. The prominent dark-pinkish and

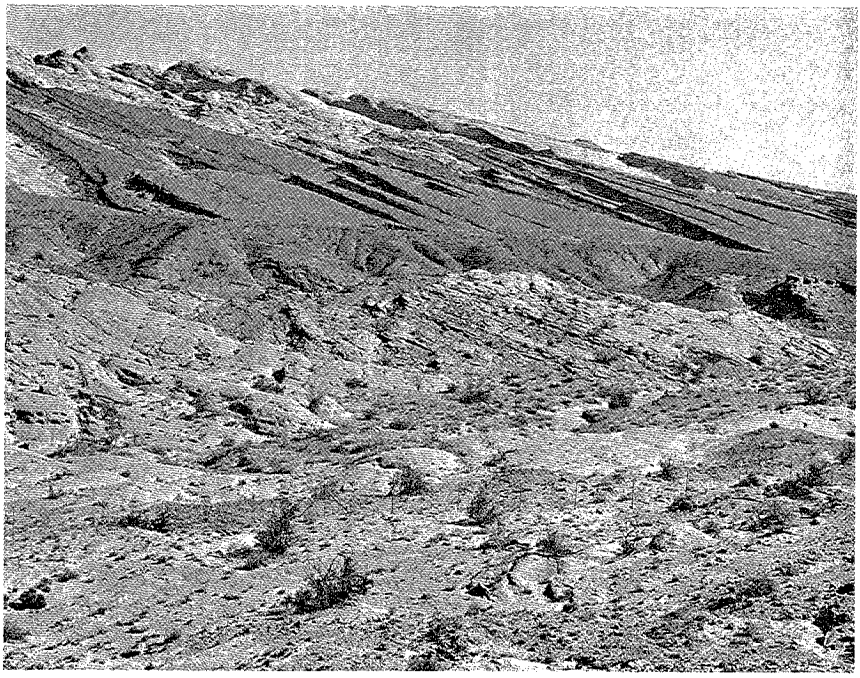
bedded tan beds both north and south are the basal fossiliferous limestone and sandstone of the Carmel Formation, on top of the light-gray to buff Navajo Sandstone (Text-fig. 44).

0.2 13.0 EAST END OF REEF NARROWS ROAD CUT. Basal Carmel beds are exposed along the east flank of the San Rafael Swell, above Navajo Sandstone. Road climbs through Navajo Sandstone.

0.2 13.2 Irregularly flaggy bedded Kayenta Formation at road level. It is the more or less distinctly bedded unit that forms a recess between the massive cross-bedded Navajo and Wingate sandstones.

0.2 13.4 Top of the Chinle Formation and base of the Wingate Sandstone at road level. Wingate Sandstone forms the prominent high cliffs both north and south of the road and Chinle beds are maroon shale and mudstone.

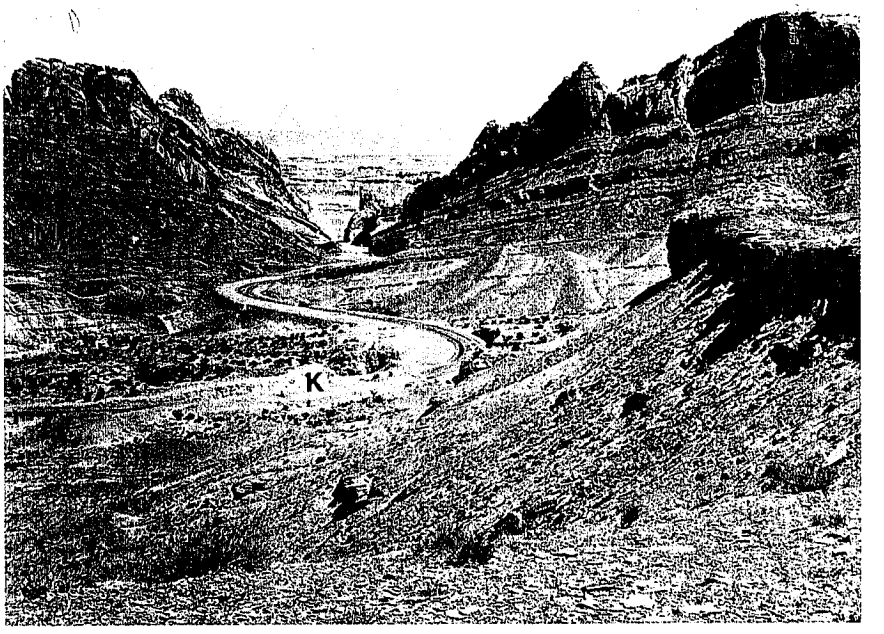
0.2 13.6 The road leaves the narrow canyon cut through Moenkopi and Chinle beds. Chinle Formation includes the prominent,



TEXT-FIGURE 44.—Northward view (from near the highway rest area) of the steep eastward-dipping dark basal Carmel Limestone and upper, light-gray Navajo Sandstone. The marine fossiliferous limestones of the Carmel form the dark flatirons along the monocline.

red massive sandstone ledge that overlies prominent, maroon to brownish red mudstone.

0.2	13.8	The highway crosses the Sinbad Limestone which separates the tan lower part of the Moenkopi Formation from the red upper part.
0.6	14.4	Deep gully cut through the upper part of the Kaibab Formation almost down to the cross-bedded Coconino Sandstone at the road. Double road cuts show the characteristic ragged, cherty upper part of the Kaibab Formation. Road climbs through the tan Moenkopi beds after leaving the road cuts (Text-fig. 45).
1.5	15.9	EXIT TO REST AREA. GEOLOGIC STOP 3. Roadside rest area on the westbound lane is on the upper part of the Kaibab Limestone, which is well exposed in the narrow canyon to the north. White and tan Coconino Sandstone is exposed in the lower half of the canyon wall below the flaggy-bedded dolomitic and cherty Kaibab Limestone (Text-figs. 46, 47).
0.1	16.0	Entrance from rest area road onto Interstate 70 westbound.



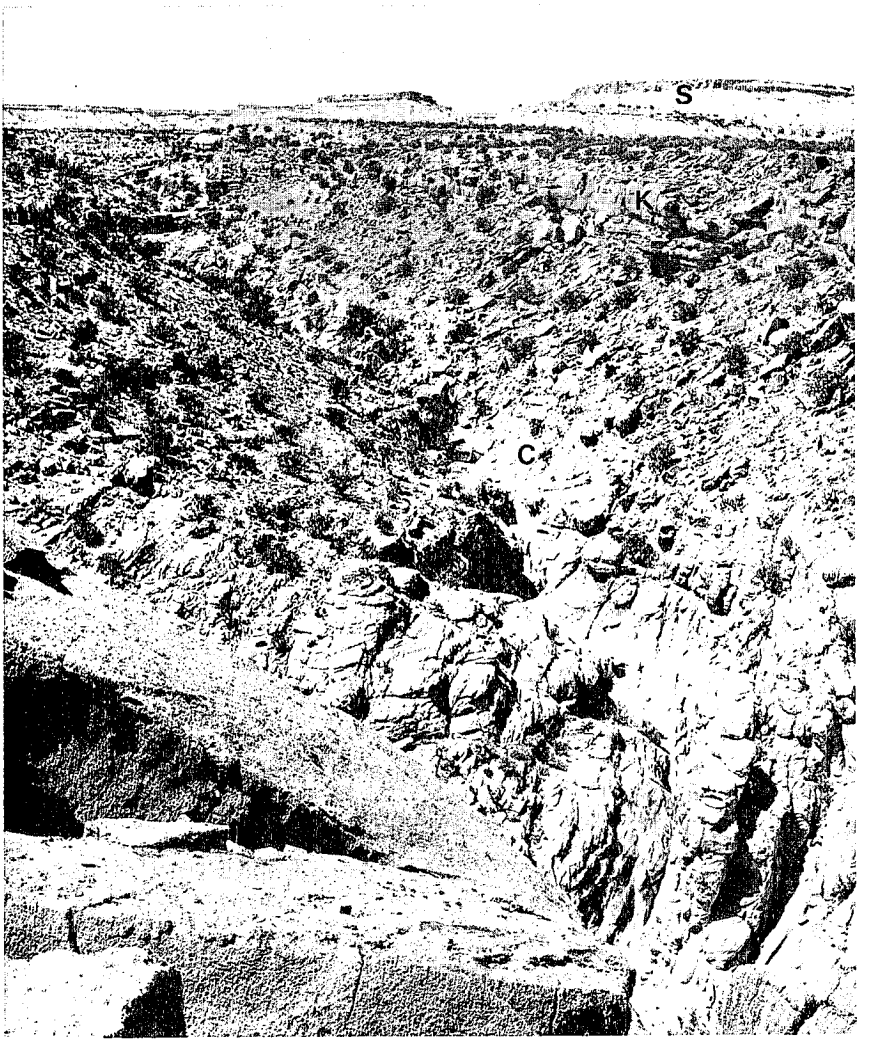
TEXT-FIGURE 45.—View eastward, toward the narrows through the San Rafael Reef, from the rest area on the eastbound lane at approximately Mile 15. Light-colored rocks near the bend of the road in the middle distance are Kaibab Limestone (K) overlain by the slope-forming Moenkopi (M) and Chinle (C) Formations. Prominent cliffs along the skyline are held up by Wingate and Navajo sandstones.

TEXT-FIGURE 46.—View northward from the rest area in the westbound lane at approximately Mile 15.9, showing the steep eastward dip of the monocline along the east side of the San Rafael Swell. Rocks in the foreground are Kaibab Limestone overlain by light slopes and ledges of the Moenkopi Formation (M). Chinle (C) and Wingate (W) formations cap the cuestas on the skyline. The West Tavaputs Plateau is visible through the gap in the far distance.

The road continues to climb, essentially on the Kaibab-Moenkopi contact, up the east flank of the Swell.

Pinyon-juniper woodland, dwarfed and somewhat depauperate, occurs mainly on Kaibab Limestone and down into the canyons entrenched through it into Coconino Sandstone.

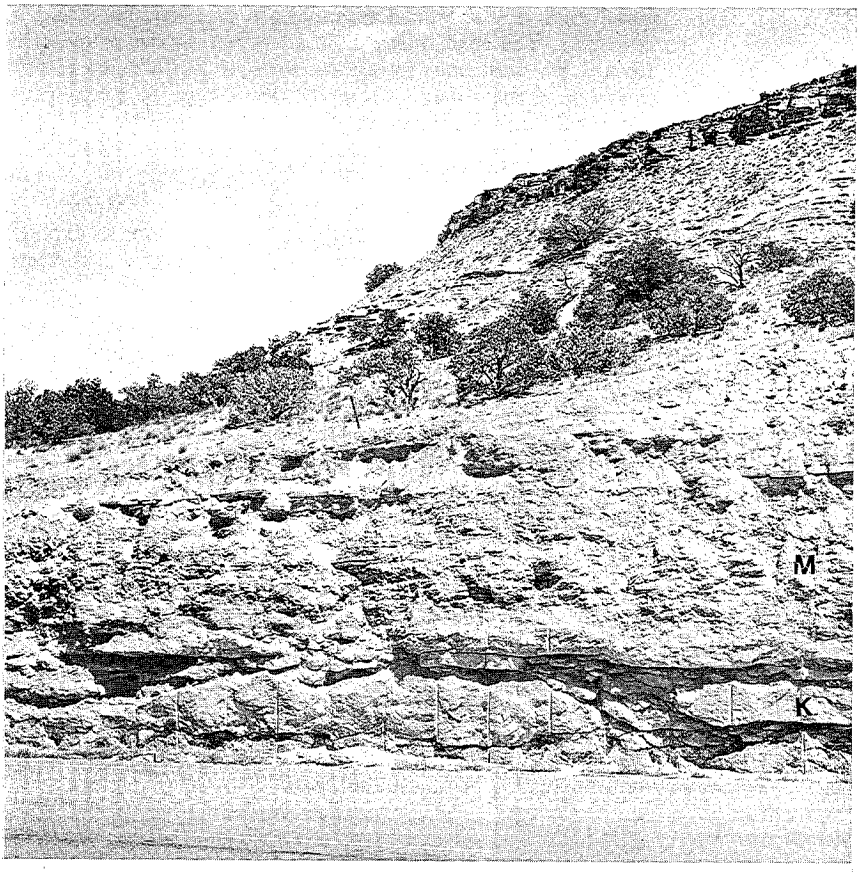
0.9	16.9	High road cuts in lower Moenkopi beds. Cross-bedded Coconino Sandstone is exposed in gullies to the north. The road continues to the west, essentially on the Kaibab-Moenkopi contact.
0.8	17.7	Long road cut on south side of eastbound lane shows ragged, cherty Kaibab with lenses of chert debris at the unconformity between the Kaibab and the overlying Moenkopi Formations (Text-fig. 48). The westbound lane is on Kaibab Limestone at the unconformity.
0.9	18.6	Kaibab Limestone in road cuts unconformably underlies angular cherty lag gravels at the base of the Moenkopi Forma-



TEXT-FIGURE 47.—View northward from the rest area of the westbound lane of Interstate 70 at Mile 15.9. Light-colored sandstones in the gorge are called the "Coconino" Sandstone (C) and are overlain by the rim-forming Kaibab Limestone (K) at the level of the rest area. The Sinbad Limestone Member (S) of the Moenkopi caps the skyline in the distance. The sandstone has been eroded to form numerous potholes along the bottom of the gorge.

tion. Lower Moenkopi beds, up to the Sinbad Limestone, form the small hills on both sides.

0.9 19.5 Kaibab Limestone is exposed here and there with an eroded upper surface into which basal Moenkopi beds have been channeled. Kaibab Limestone has a ragged upper surface

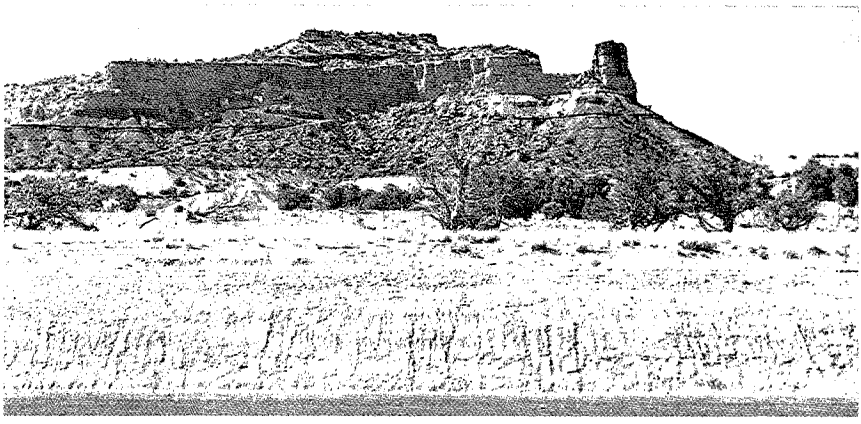


TEXT-FIGURE 48.—Erosional surface (disconformity) between the Kaibab Limestone (K) and the lower Moenkopi Formation (M) near Mile 17. White angular chert fragments fill channels cut into the Kaibab Limestone. The Sinbad Limestone Member caps the hill on the skyline.

upon which channels are eroded and partially filled with cherty debris.

0.4	19.9	Crest of steep climb. Double road cuts in basal Moenkopi beds. The road flattens after the steep climb up the east flank of the San Rafael Swell. Brake-test area in eastbound lane.
0.3	20.2	Temporary end of freeway at west edge of Brake-test area.
0.5	20.7	Cross a major drainage. Tan carbonates on both the northwest and the southeast sides of the bridge are the upper few feet of Kaibab Limestone. Lower Moenkopi beds to the north and south form a cuesta capped by the Sinbad Limestone.

1.3	22.0	Basal beds of the Sinbad Member are exposed ahead and in road cuts. The road makes a broad sweeping curve and rises toward the west onto lowermost beds of the Moenkopi Formation and then onto a stripped surface held up by the resistant sandy Sinbad Limestone.
2.9	24.9	Small quarries expose Sinbad beds.
0.8	25.7	Calcareous sandstone of the Sinbad Limestone Member, in the lower tan part of the Moenkopi Formation, is exposed on both sides of the road and in the cuesta cap both south and north.
0.8	26.5	RANCH ROAD INTERSECTION of the major north-south roads through the central part of the San Rafael Swell. The broad plain here is a grassland with mixed sand dropseed, blue grama, and galleta. Meadowlands have made the center of the San Rafael Swell an important grazing land for sheep and, to some extent, cattle and horses, particularly during the winter season.
0.8	27.3	Resistant ledge in the lower part of the Moenkopi Formation to the southeast is held up by the Sinbad Limestone member. The lowermost greenish part of the formation associated with the Sinbad Limestone is marine, in contrast to the tidal-flat redbeds.
1.5	28.8	Road is in the lower part of the Moenkopi Formation. In this area it is a greenish tan unit. Some feel this color is related to hydrocarbon reduction of the normally reddish iron-stained beds in the lower part of the section over the central part of the San Rafael Swell.
1.0	29.8	The prominent sandstone cliff on the north is the Mossback Conglomerate of the Chinle Formation (Text-fig. 49).
1.0	30.8	Cut through thick Mossback Sandstone. Cliff north of road shows good fluvial sedimentary structures. The prominent Mossback cuesta separates a slope carved on overlying Chinle Shale ahead from one on the underlying reddish Moenkopi beds behind. The Moenkopi Formation here resembles the Entrada and Summerville Formations in weathered exposures. The road rises to the west into poor exposures of Chinle Formation, with prominent Wingate Sandstone cliffs to the north.
0.9	31.7	East end of the road cut between small hills at promontories exposes greenish beds at the top of the Chinle Formation. The road continues to the west through poor exposures of Chinle Formation.
0.4	32.1	Pass between outcrops of cross-bedded basal Wingate Sandstone. Note the clustering of Utah juniper and pinyon pine at the base of the sandstone around the margins of the open meadow or prairielike grasslands here. This is caused by



TEXT-FIGURE 49.—View northwestward to the bold escarpment held up by the Moss Back Conglomerate Member of the Chinle Formation. The low rolling country in the foreground is carved on the upper Moenkopi Formation. Some Chinle beds are exposed on the bluff above the Moss Back cliff. Roads climb up the Moenkopi escarpment to uranium glory holes in the lower part of the Moss Back.

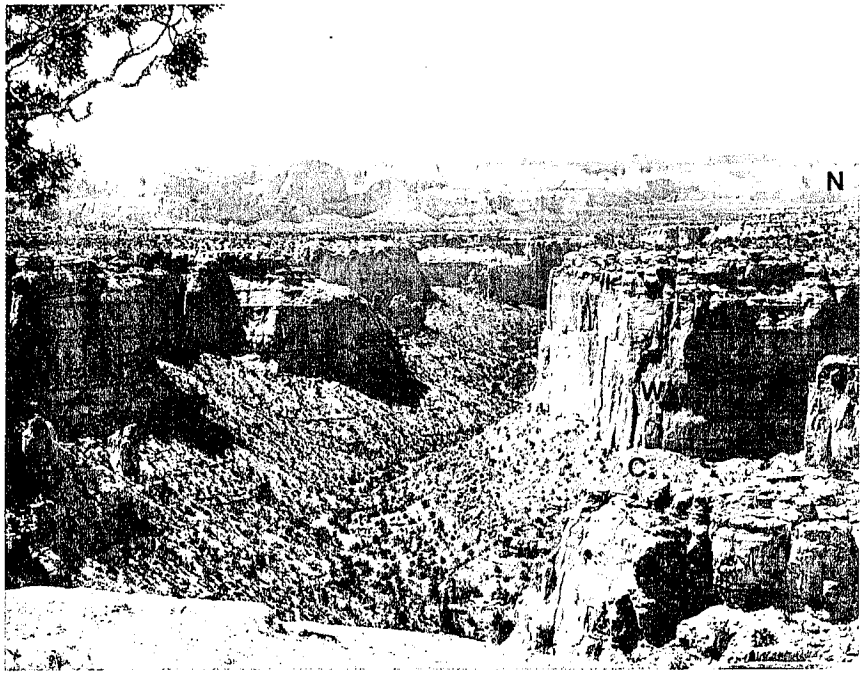
water draining from the slickrock which erodes to form huge funnels that concentrate the water at their base, allowing more vegetation to flourish here than in the ordinary pinyon-juniper woodlands nearby.

1.1 33.2 Wingate Sandstone exposed in the road cut and in a cuesta of prominent cross-bedded sandstone to the north.

0.9 34.1 GEOLOGIC STOP 4. SAN RAFAEL KNOBS REST AREA between prominent high hills of Navajo Sandstone. Basal Kayenta beds are at freeway level. The prominent sharp angular cliffs to the northeast and southeast are held up by Wingate Sandstone, and rounded cliffs to the northwest are held up by Navajo Sandstone. Wingate Sandstone in the vicinity of the road is bleached and is not typical of the formation over much of the Colorado Plateau, where it is a reddish brown. Deep canyons to the northwest cut down into Chinle Formation (Text-fig. 50).

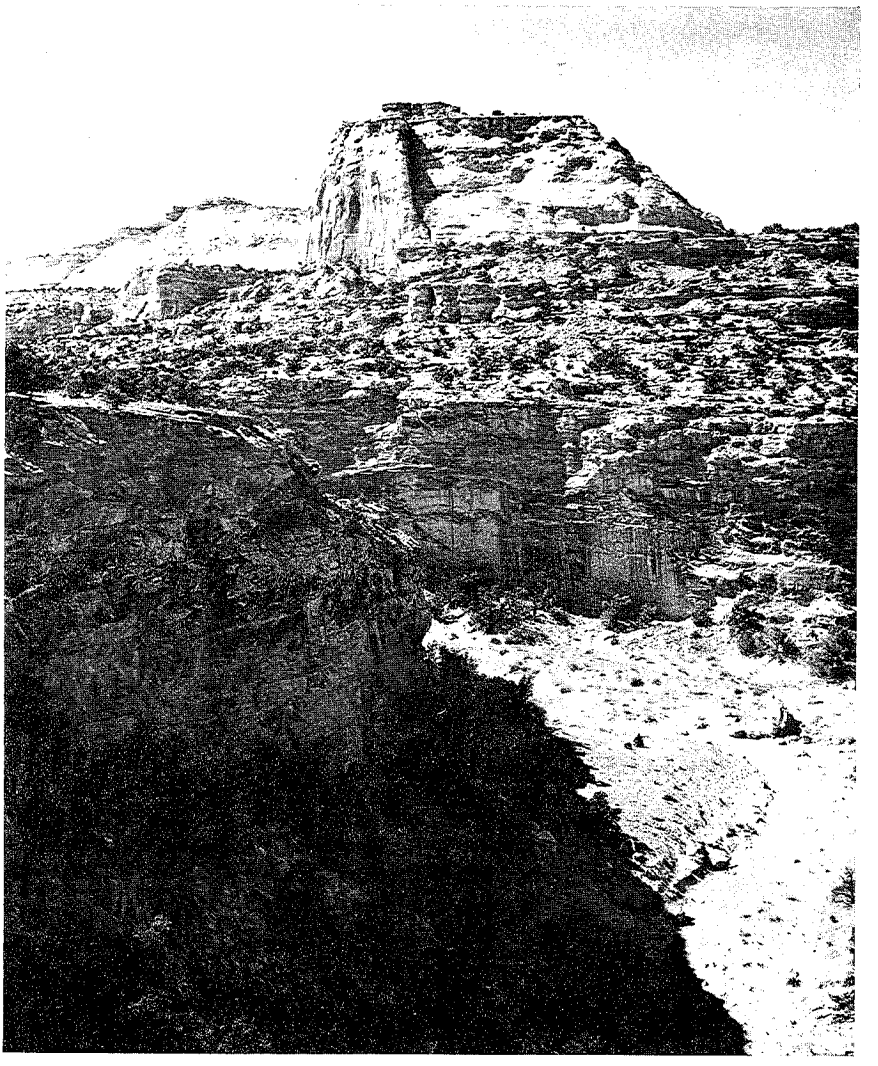
There is Douglas fir in the bottom of the deep box canyon going off to the northwest. Douglas fir commonly grows at very low elevations in the canyons in the Colorado Plateau, particularly on canyon bottoms. Because the canyons receive less sunlight than does the surrounding higher flat country (or mesa tops) above them, they have less evaporation, producing what is known as "the canyon effect," and allowing mesophytic trees to grow in the canyon bottoms.

2.5 36.6 CROSS A HIGH BRIDGE over canyon cut in Wingate Sandstone. The stripped surface at road level is on Kayenta beds. The latter are horizontally bedded and channelled, with some argillaceous units (Text-fig. 51).



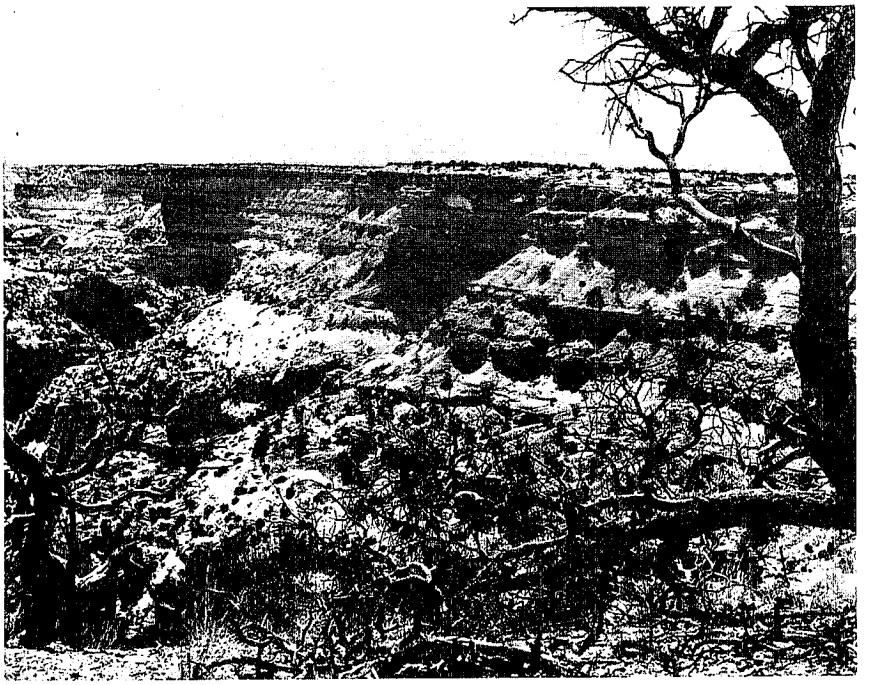
TEXT-FIGURE 50.—View northwestward from the San Rafael Knobs rest area, westbound lane. The rest area and the juniper-covered tablelands are in the Kayenta Sandstone; cliffs down into the valley are in Wingate Sandstone (W) and lower reaches of the valley are in Chinle beds (C). Rounded cliffs of Navajo Sandstone (N) form the escarpment in the near distance. The Wasatch Plateau rises in the far distance along the skyline.

0.9	37.5	Exposed near the road are prominent sets of cross-beds of Navajo Sandstone separated by weakly dolomitic horizontal beds that are more resistant. Irregularly ledgy beds are in the Kayenta and lowermost Navajo sandstones.
0.3	37.8	Double road cuts in horizontally and weakly cross-bedded Navajo Sandstone (see Sanderson, 1974).
0.3	38.1	Road climbs from Justensen Flats in cross-bedded and jointed Navajo Sandstone.
0.5	38.6	Basal fossiliferous limestone beds of the Carmel Formation and top of cross-bedded Navajo Sandstone are exposed in the eastern part of the road cut.
0.4	39.0	End rapid rise through massive gypsum and redbeds in the lower part of the Carmel Formation.
0.1	39.1	COPPER GLOBE AND MORE RANCH ROAD north and south from the freeway. Freeway continues ahead in Carmel Formation.



TEXT-FIGURE 51.—Westward from the high bridge at Mile 36.6. Vertical cliffs below bridge level are Wingate Sandstone; irregularly bedded Kayenta rocks are at bridge level; and Navajo Sandstone caps the escarpment in the distance.

0.4	39.5	Massive gypsum in the lower Carmel Formation is exposed on both sides of the road.
0.5	40.0	Access ranch road joins the main freeway. Carmel is exposed in road cuts on both sides.
1.1	41.1	GEOLOGIC STOP 5. SIDE ROAD TO THE EAST TO AN OVERLOOK on lower part of the Carmel Formation



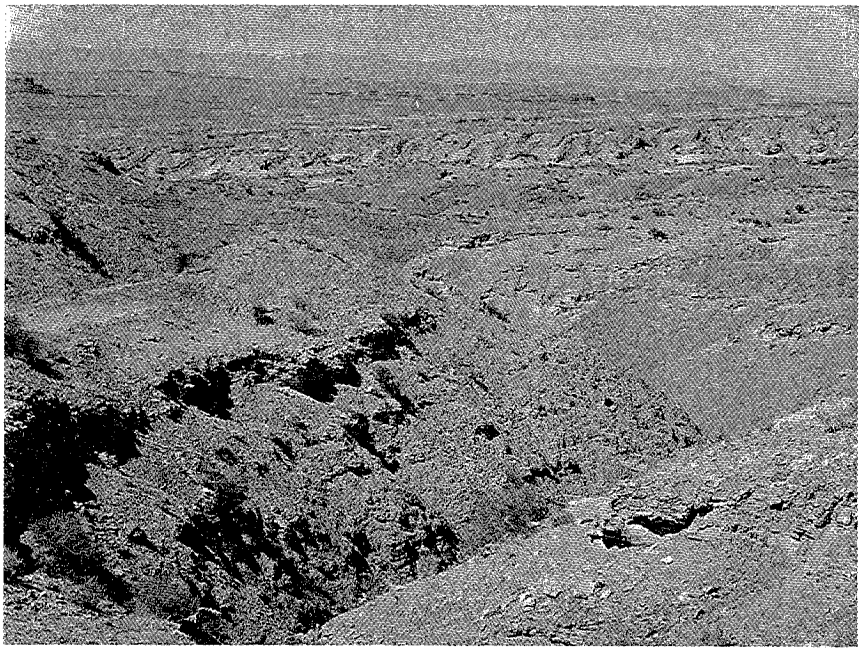
TEXT-FIGURE 52.—Southwestward from the rest area at Mile 41.1. Navajo Sandstone forms the massive light outcrops in the lower part of the canyon wall and is capped by well bedded Carmel Formation along the upper part of the escarpment. The Fish Lake Plateau forms the skyline in the distance.

above canyons cut into the underlying strongly cross-bedded Navajo Sandstone (Text-fig. 52). Rocks in the immediate vicinity are greenish middle Carmel beds. The road begins long descent down west dip slope of San Rafael Swell.

0.6 41.7 Thin even-bedded greenish sandstone that characterizes the middle part of the Carmel Formation is exposed in road cuts and in outcrops north and south of the road. Open areas provide views of vista of Wasatch Plateau to the west and Fish Lake Plateau to southwest.

1.0 42.7 The generally popcornlike weathered surface near the road is on a thick massive gypsum bed in the Carmel Formation. Exposures in the road cut show fresh white alabaster gypsum, but the upper surface, having a brown, dirty, popcornlike appearance, shows how it characteristically weathers and drapes into drainages (Text-fig. 53).

0.7 43.4 Massive gypsum exposed in the road cuts in variegated Carmel beds. The Carmel here forms a stripped surface, the overlying, easily eroded Entrada beds having been removed. The gypsiferous beds are very poorly covered with vegeta-



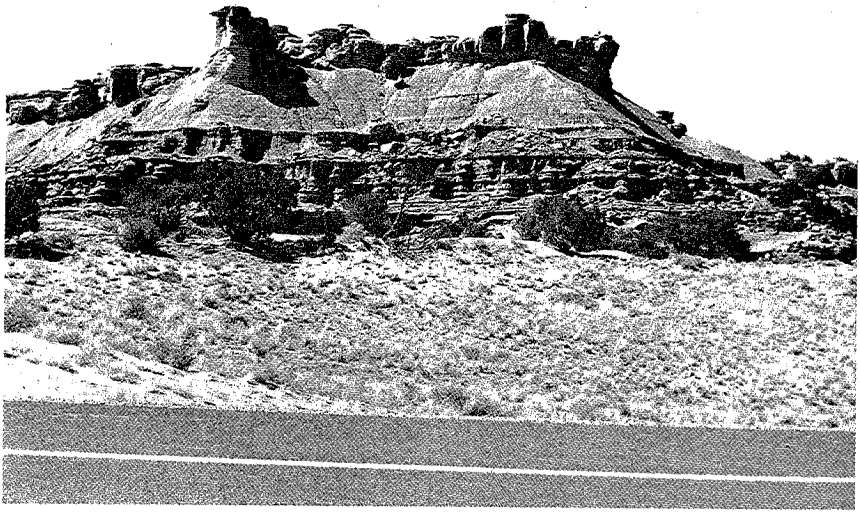
TEXT-FIGURE 53.—View northward across draped gypsum beds in the upper part of the Carmel Formation. Gypsum is plastic and has flowed like frosting into the small gullies at approximately Mile 43.

		tion; a few ephedra bushes, some shadscale, and a little rabbit brush forms the main vegetation. Plant cover is very sparse.
0.6	44.0	Massive beds in the vicinity of the road cuts are gypsum. For the next few miles the road drops down the west flank of the San Rafael Swell, cutting slowly stratigraphically upward within the gypsiferous upper part of the Carmel sequence.
0.4	44.4	Contact of the basal red brown argillaceous lenses of the Entrada Sandstone with the more gypsiferous variegated upper beds of the Carmel Formation. Carmel lenses show massive nodular gypsum associated with the interbedded marine and nonmarine rocks in the upper part of the formation. Some steep dips near contact are related to gypsum heaving.
1.2	45.6	Side road from the south is near road cuts in the lower Entrada Formation where lacy gypsiferous veins cut through even the massive mudstones. The highway continues to the west in lower Entrada Formation.
1.4	47.0	Fish Lake Plateau and Boulder Mountain are visible to the southwest. Excellent exposures of alternating massive dolo-

mitic siltstone and gypsiferous siltstone in the middle part of the Entrada Formation (Text-fig. 54).

0.6	47.6	Cross a gully where ripple-marked and gypsiferous, laminated Entrada Sandstone is well exposed both northwest and southeast of the road. The Entrada Formation probably represents marginal tidal and fluvial deposits.
0.7	48.3	"Stone baby" beds of the Entrada Formation in alternating dolomitic siltstone and gypsiferous shale. To the east the Entrada forms the valley lined with rock pillars, and the Carmel Formation forms most of the dip slope along the west flank of the San Rafael Swell beyond. Curtis Sandstone caps the jointed cuesta to the west (Text-fig. 55).
0.2	48.5	Deep double road cuts through the greenish Curtis beds. The east end of the road cut is at the shaly base of the formation.
0.3	48.8	GEOLOGIC STOP 6. TURN OFF TO VIEW AREA, which is on the edge of the cuesta held up by the Curtis Sandstone. The view area and road cut in the immediate vicinity are in the flat-bedded Curtis Sandstone, a marine

TEXT-FIGURE 54.—Complex lensing and channels in the upper part of the Entrada Formation at Mile 47. The prominent white stringers are crystalline gypsum. The Entrada Formation is thought to be a tidal-flat deposit.



TEXT-FIGURE 55.—Westward across upper Entrada beds to cliffs capped by the light green Curtis Sandstone from near Mile 48.0.

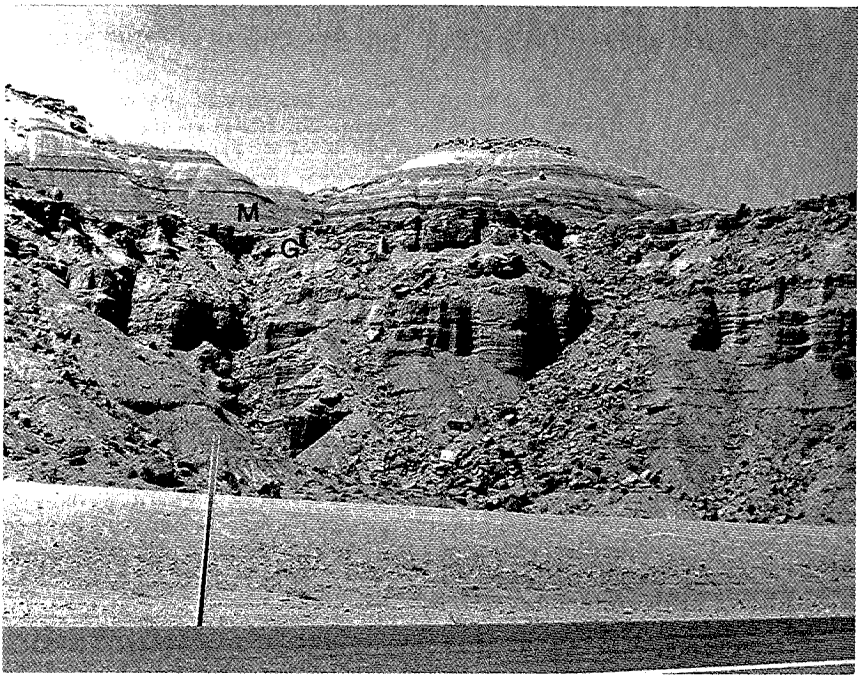
sequence in the dominantly nonmarine red Jurassic section (Text-fig. 56).

0.1	48.9	Greenish platy sandstone along both sides is upper Curtis Sandstone.
0.5	49.4	Triple road cuts through the reddish Summerville Formation as the road rises from the gray green Curtis Sandstone. Summerville rocks probably represent tidal-flat deposition in a regression associated with the earlier transgression of the Curtis Sea.
0.5	49.9	Excellent exposures of ripple-marked sandstone, which is common in the Summerville Formation.
0.2	50.1	Laminate, deep-red, gypsiferous bands of the Summerville Formation form the rather characteristic strongly banded castellate exposures beneath a thick bed of gypsum, the upper resistant ledge (Text-fig. 57). A basal Morrison sandstone caps the hills to the south and west.
0.2	50.3	Massive sandstones to the south are in the basal thin Salt Wash Member of the Morrison Formation, beneath the laminated more consistently well bedded Brushy Basin rocks exposed in the barren slopes to the north.
0.7	51.0	Large blocks of Buckhorn Conglomerate on the north side.
0.4	51.4	Variegated pinkish Brushy Basin Member of the Morrison Formation exposed in road cuts. The cuesta cap of Buck-

TEXT-FIGURE 56.—View southward along the Curtis escarpment from the rest area at Geologic Stop 6. The light-green Curtis Sandstone is a marine unit deposited between the tidal-flat deposits of the underlying Entrada Formation and the overlying Summerville Formation.

horn Conglomerate, both north and south of the road, erodes to form large angular blocks.

0.2	51.6	Lensing Buckhorn Conglomerate, the basal member of the Cedar Mountain Formation, is exposed on both sides of the road. This persistent conglomerate separates the gray, ashy-appearing, Cedar Mountain rocks above from the more pinkish Morrison Formation below. Flat-topped mesas northwest and southwest are capped by Ferron Sandstone.
0.4	52.0	Beginning of passing lanes. Thin Dakota Sandstone caps the cuesta on both sides of the road ahead, with Cedar Mountain beds forming the lower gray, barren landscape.
0.3	52.3	Ashy, gray, Cedar Mountain beds beneath the very thin cross-bedded Dakota Sandstone forms most outcrops along either side of the road.
0.2	52.5	Exposures of cross-bedded Dakota Sandstone on both sides of the road.
0.3	52.8	MUDDY CREEK BRIDGE. Mancos Shale is well exposed in cuts down river to the south and in slopes ahead. The contact of Mancos Shale and cross-bedded underlying Dako-



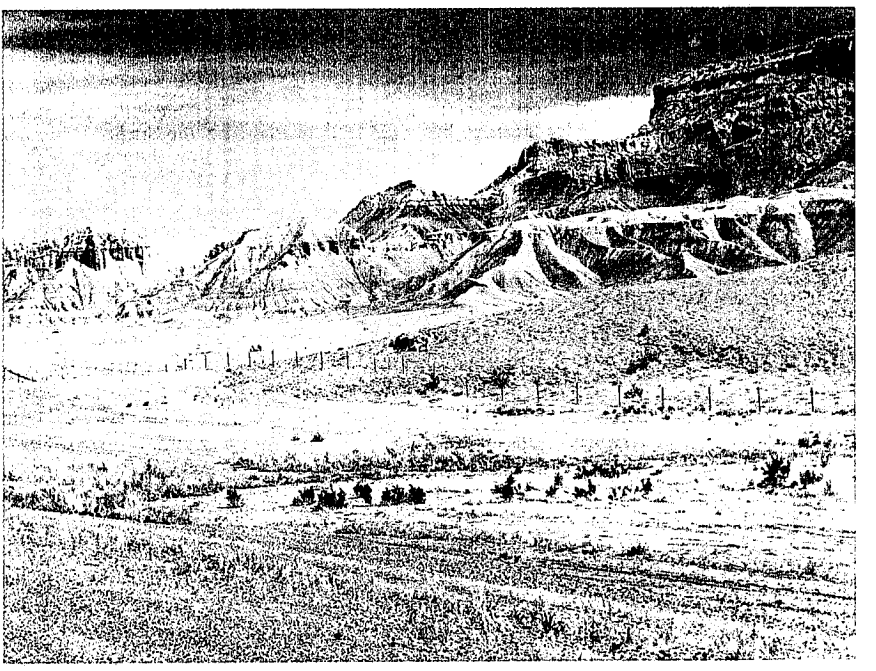
TEXT-FIGURE 57.—Westward view of the upper part of the Summerville Formation capped by a resistant thick gypsum bed (G) and overlain by the striped Morrison Formation (M), which forms the rounded slopes on the skyline. Photograph from near Mile 50.

ta Sandstone is not well exposed here because of alluvium along the river.

Alluvium along the river channel is occupied by greasewood, big rabbitbrush, and Fremont Cottonwood. On the lower terrace level the ever-present weedy tamarix occurs on point bar meanders along the stream. Mancos Shale outcrops west of the bridge appear as barren castellate upper portions, but the lowland areas are occupied by the mat-atriplex or mat-saltbush and with some greasewood plants. Cottonwood trees along the stream course of Muddy Creek occur here on two levels. Those trees on the upper terrace started to grow when the stream course was on that level. The stream channel became entrenched, however, and a new series of base leveling began. A new stand of cottonwoods became established on the new terrace, leaving the older, abandoned trees on the upper level to die because of lack of water. This change has taken place within the last 50 to 60 years.

0.5 53.3 Crossroads—road leading north and south generally on the lower Mancos Shale. Ivie Creek joins Muddy Creek.

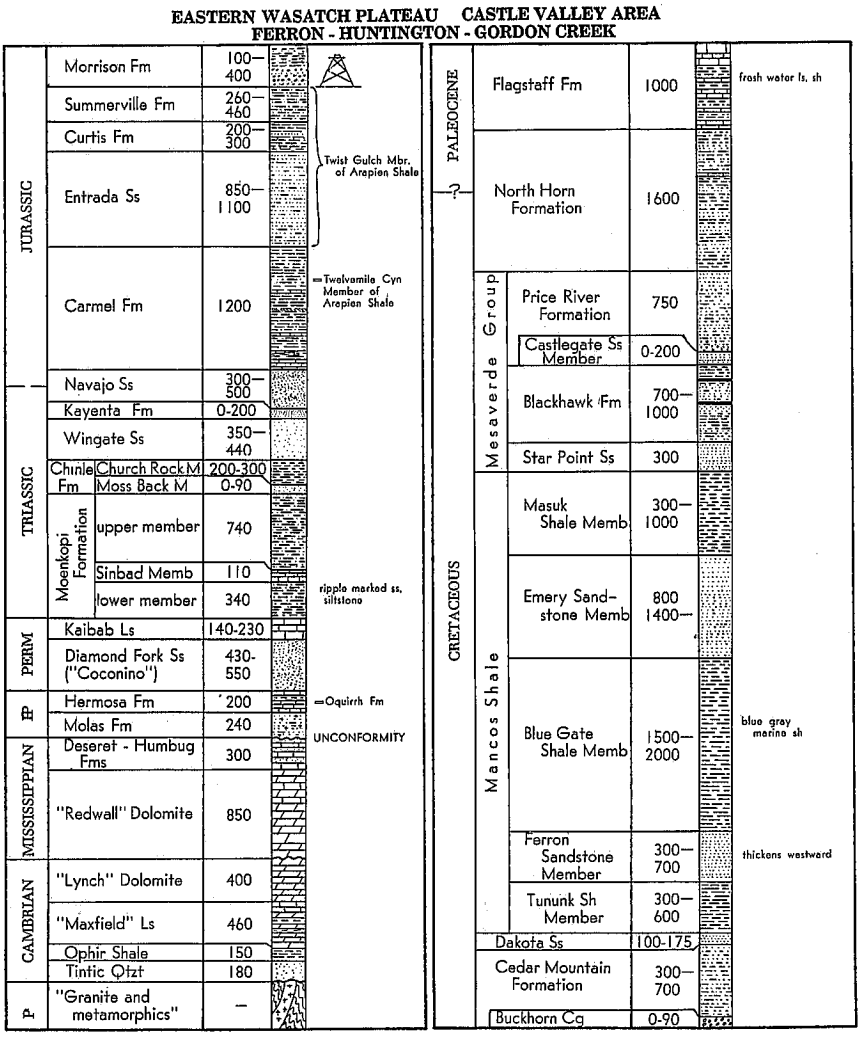
1.0	54.3	Terraces of Mancos Shale are veneered by a thick gravel cover. Silvery gray color is rather typical of the unit (Text-fig. 58).
0.7	55.0	Ivie Creek, a major drainage, has formed the gorge to the northwest through the Ferron Sandstone cuesta. Upper Ferron Sandstone has been clinkered to the north, where burning coals have produced reddish rocks above. Gray Mancos Shale slopes are veneered here and there with yellowish sandstone rubble.
0.6	55.6	Old turn-of-the-century homestead to the north. Ferron Sandstone caps the amphitheater to the north, west, and south. Vertical-walled entrenched gully is characteristic of a Mancos-based alluvial valley fill (Text-fig. 59).
0.4	56.0	GEOLOGIC STOP 7. Base of the Ferron Sandstone is visible directly ahead in a deep double road cut above silty Mancos Shale. The lower cliff exposes a typical regressive sequence of thin interbedded sandstone and siltstone that grades up into thin-bedded sandstone and, finally, into a massive sandstone. Bedding in the massive barrier island sandstone, if traced unit by unit eastward, can be seen to shingle downward to the east.



TEXT-FIGURE 58.—Silvery gray Mancos Shale exposed south of the Interstate highway and west of Muddy Creek at approximately Mile 54. Ferron Sandstone caps the escarpment high on the right.

TEXT-FIGURE 59.—Turn-of-the-century homestead along Ivy Creek. Recent arroya development has entrenched into the soft valley fill. Ferron Sandstone forms the two series of cliffs in the background. The lower series of cliffs are formed by barrier-island development. Upper rounded pink and light-gray sandstone cliffs are carved on fluvial sediments.

0.2	56.2	UPPER END DEEP ROAD CUTS. Two- to three-foot coal exposed in road cuts on both the north and the south sides. The pinkish clinkered zone north of Ivie Creek resulted from burning of these coal beds.
0.1	56.3	Coally section is exposed both north and south. The road continues to rise through the upper sandy Ferron tongue.
0.4	56.7	Major channel sandstone, with coal above and below. The sequence represents deposits from coal swamps, with an interbedded fluvial sandstone (Cleavinger, 1974).
0.4	57.1	Top of Ferron Sandstone and base of middle part of the Mancos Shale (Text-fig. 60). Channel sandstone and coal are well exposed in road cuts both north and south.
0.9	58.0	SEVIER COUNTY–EMERY COUNTY LINE. Road is in a small canyon through a tan-weathering, slightly silty unit in the Mancos Shale, littered with black andesite boulders from the Fish Lake Plateau. Grassland here consists of blue grama, with lots of prickly pear cactus growing in it. It is a heavily vegetated,



After: Johnson (1959); Hansen and Scoville (1955); Heylmun and others (1965)
Jurassic: Wright and Dickey (1963a); Flagstaff Fm: Weiss (1969); see also IAPG Guidebook 5 (1964)

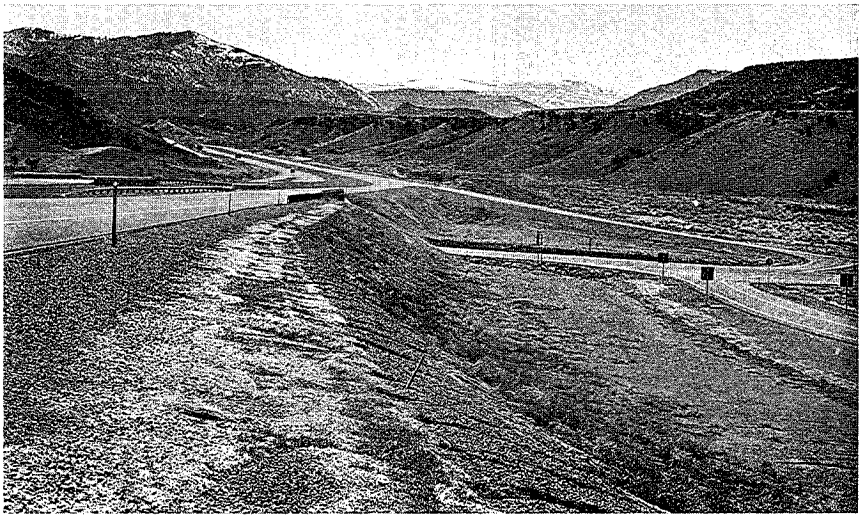
TEXT-FIGURE 60.—Stratigraphic chart of formations exposed in the eastern Wasatch Plateau and encountered in wells drilled along the west side of the San Rafael Swell (from Hintze, 1973).

probably productive, grassland. The area has been grazed by sheep and cattle.

1./ 59.7 BEGINNING OF DIVIDED INTERSTATE HIGHWAY. To the north the Book Cliff sequence is well displayed, the prominent Starpoint Sandstone (the middle cliff-forming unit) separating gray Mancos Shale slopes below from the

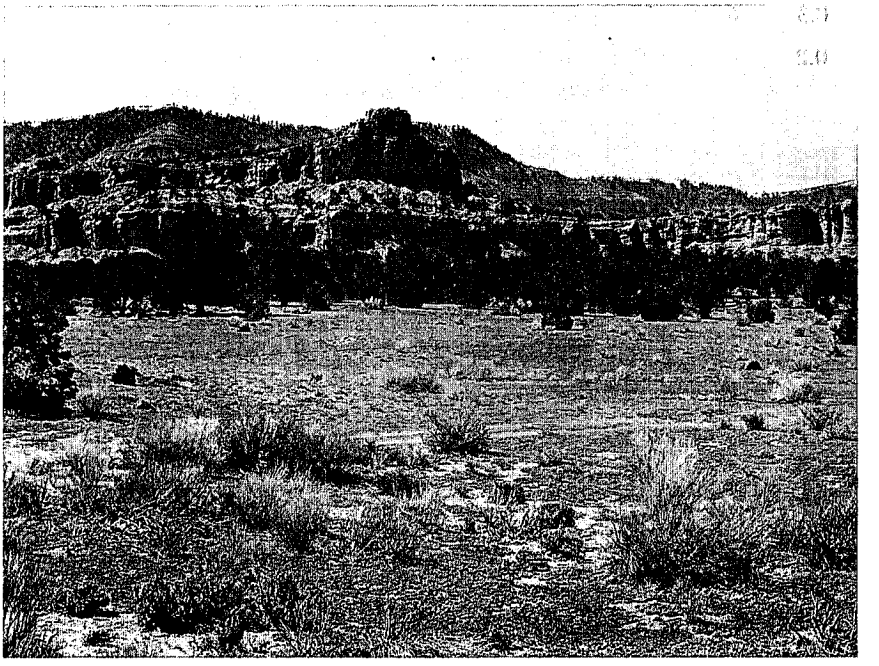
somewhat clinkered upper part of the Cretaceous section, the Blackhawk Formation. Blackhawk exposures are capped for some distance by the Castlegate Sandstone. High on the plateau to the northwest, light-colored Flagstaff Limestone and Green River Formation form the upper surface. To the southwest and directly ahead, volcanic rocks of the Fish Lake Plateau form timber-covered rolling topography.

0.4	60.1	The road drops westward onto the upper, eastward-sloping, gravel-covered pediment surface through a relatively thick, yellow, weathered zone of Mancos Shale.
0.7	60.8	BRIDGE ON BOTH EAST AND WEST LANES OVER THE PRICE-EMERY INTERCHANGE ROAD. Mancos Shale is well exposed below a thick pediment-gravel cover in road cuts near the exchange. Several terraces are evident to the west and north; all cut across Mancos Shale (Text-fig. 61).
0.9	61.7	Temporary end of Interstate 70 (1974). Bedrock here is gently westward-dipping Mancos Shale veneered by a thick, almost bajada-like, sequence of andesite gravel from the Fish Lake Plateau. This cut pediment dips toward the east into the Last Chance Canyon area.
0.3	62.0	Cross a major drainage from the south.
0.2	62.2	Road cuts through the Mancos Shale beneath a broad pediment surface and a thin gravel veneer.



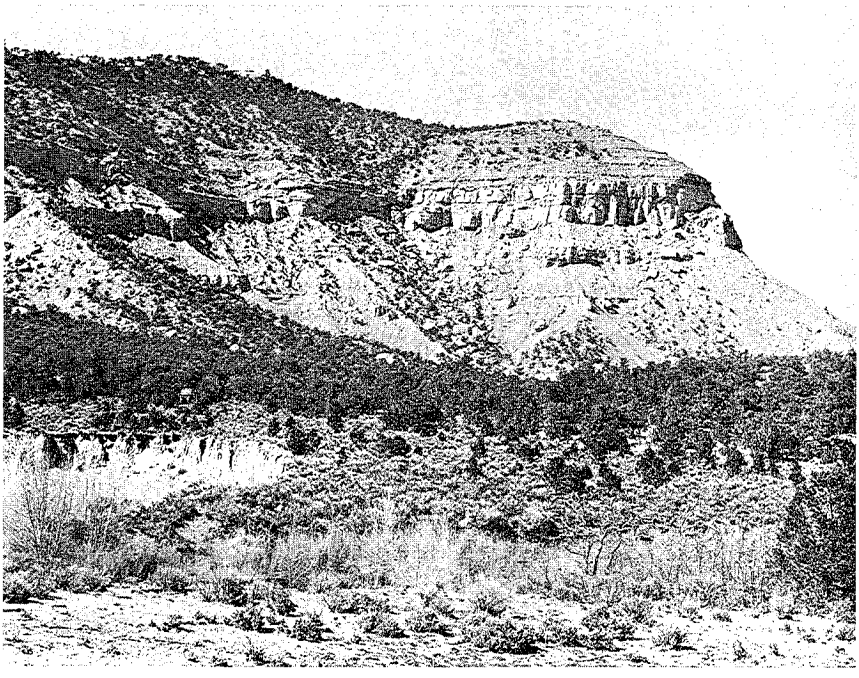
TEXT-FIGURE 61.—View westward up Ivy Creek from the Emery-Huntington Interchange. Prominent terraces along Ivy Creek are cut across Mancos Shale. Andesite boulders mantle terrace tops. Volcanic uplands of the Fish Lake Plateau form the skyline ahead and to the left.

0.2	62.4	FREMONT JUNCTION. The main highway continues westward.
0.4	62.8	Excellent exposures of Emery Sandstone. Three or four pulses of regressive sandstone are exposed below upper Mancos Shale (Text-fig. 62). Pinyon-juniper woodland extends down the terraces on the north-facing slope and in the canyon bottom. The understory here consists of blue grama grass and other short grasses of a prairie vegetative type, mixed with rabbit brush and big sagebrush growing underneath the pinyon and juniper, all in a peculiar assemblage.
0.5	63.3	Gravels of andesite boulders veneer the terraces in the canyon bottom.
0.6	63.9	ENTERING FISH LAKE NATIONAL FOREST, just west of a major drainage crossing from the south.
0.6	64.5	To the north the massive Star Point Sandstone overlies thin-bedded sandstone that grades down into the silty upper part of the Mancos Shale (Text-fig. 60). The clinkered horizon on the promontory high on the skyline is a result of burning of coal in the Mesaverde Group (Text-fig. 63).

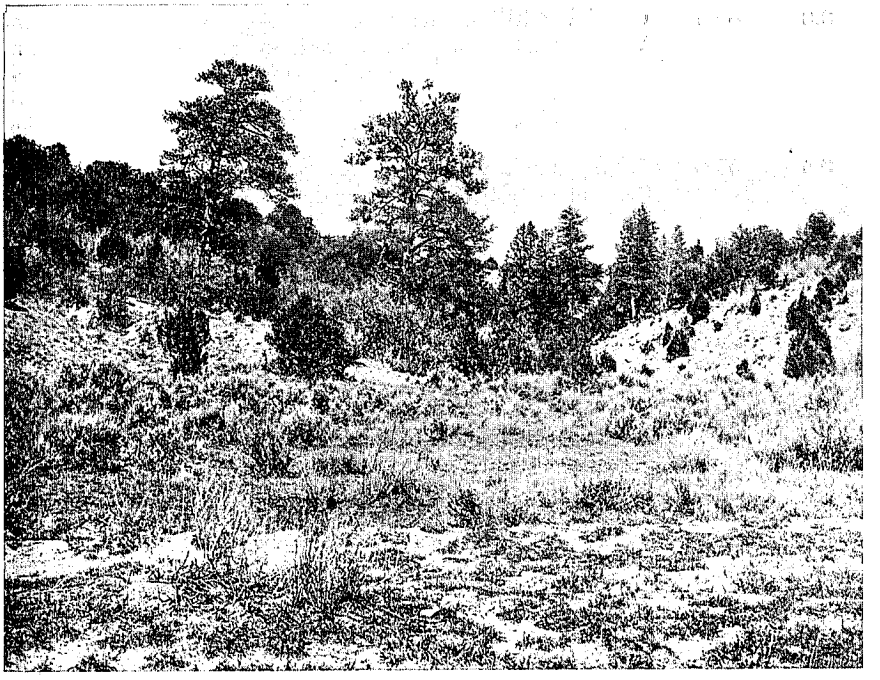


TEXT-FIGURE 62.—View northward to barrier island sandstone deposits of the Emery Sandstone at Mile 62.8. Juniper and pinyon parklands are on gravel terraces veneering Mancos shale.

0.8	65.3	CLEAR CREEK crosses the road. At about this point Mancos Shale disappears beneath the prominent Star Point Sandstone, a typical regressive sandstone sequence. It has a basal part of laminated and bioturbated siltstone to sandstone that grades upward into a massive sandstone on top.
0.3	65.6	Campground, with drinking water, in the headwaters of the canyon. The cross-bedded, regressive Starpoint Sandstone shows well to the north.
0.2	65.8	Side road to Red Creek, toward the south, leads to a coal mine in Cretaceous beds on the flanks of the plateau. The cliff in the canyon bottom is held up by Star Point Sandstone, just underneath the coal in the lower Mesaverde Group.
1.2	67.0	Ponderosa pine and Douglas fir occur in a small canyon on the north side of road (Text-fig. 64).
0.9	67.9	SUMMIT (elev. 7,900) Divide between Salina Canyon and the Ivie Creek drainage. Bleached sandstone on the north is associated with coal in the Blackhawk formation. Rocks



TEXT-FIGURE 63.—View northwestward to the eastern escarpment of the Wasatch Plateau with prominent sandstone cliffs of the Mesaverde Group above slopes on the Mancos shale. The Star Point Sandstone (Text-fig. 60) is the most prominent cliff-forming unit. Price River Formation forms the upper ledge and slope zone. Cottonwood poplars line Ivy Creek which is here entrenched in deep valley fill.



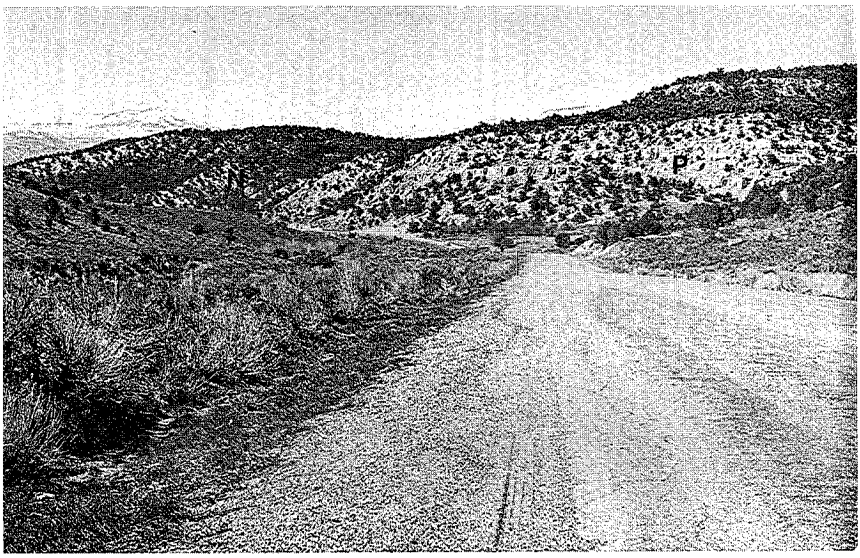
TEXT-FIGURE 64.—Douglas fir and ponderosa pine glade at Mile 67, east of the divide between Ivy Creek and Salina Canyon. Mountain mohagany, sagebrush, and juniper form the low shrubby cover in the foreground.

in this part of the Wasatch Plateau are still dipping westward off the San Rafael Swell. The plateau has a rounded, mature topography; even the prominent sandstones of the upper part of the Blackhawk Group form only low outcrops. Springs in the vicinity are probably related to the alternating shale and sandstone character of the beds. To the south, up some of the gullies, stands of aspen and conifers form thick cover on the north side of the Fish Lake Plateau. Vegetation near the road is a mixture of many different plants, some from lower elevations and some from higher, including the evergreen curled-leaf mountain mahogany, oak brush, pinyon pine, and Utah juniper. Just below the crest is ponderosa pine, and Douglas fir occurs in some of the small pockets. Big sagebrush is a common component, as are manzanita plants, which are the bright green, low rounded hemispherical shrubs. Serviceberry occurs on both sides of the summit, mixed in with the general vegetation.

0.5 68.4 Junction, Aspen Road to the south. The highway is on flat valley fill flanked by knobby weathering Cretaceous Blackhawk rocks on both sides. White bleached sandstone suggests overlying coal beds to the east. From Little Creek

down canyon for some distance, the stream is deeply entrenched in the alluvial fill.

2.6	71.0	View directly down the canyon of Mount Musinia on the skyline. At about this point along the highway the road swings parallel to the fault trace of the east boundary fault of the Musinia graben, with Price River and Blackhawk beds exposed on the east and with downdropped reddish Northhorn beds, under the oak-covered area, to the southwest.
0.8	71.8	Broad open section of the valley along the fault trace with iron-stained sandstone east of the road, and reddish poor exposures of upper North Horn beds to the west. An excellent view of nipple-shaped Mount Musinia can be seen directly ahead. The peak is in Flagstaff Limestone.
0.6	72.4	The highway continues along the trace of the east boundary fault. To the north, directly down the road, ledgy Price River and Blackhawk sandstone is exposed east of the fault. The rounded, juniper-covered area to the left is of downdropped North Horn beds (Text-fig. 65).
0.4	72.8	Spring area and marsh with river birch in the lowlands along the fault trace.
0.5	73.3	Crossing the boundary fault trace onto reddish argillaceous



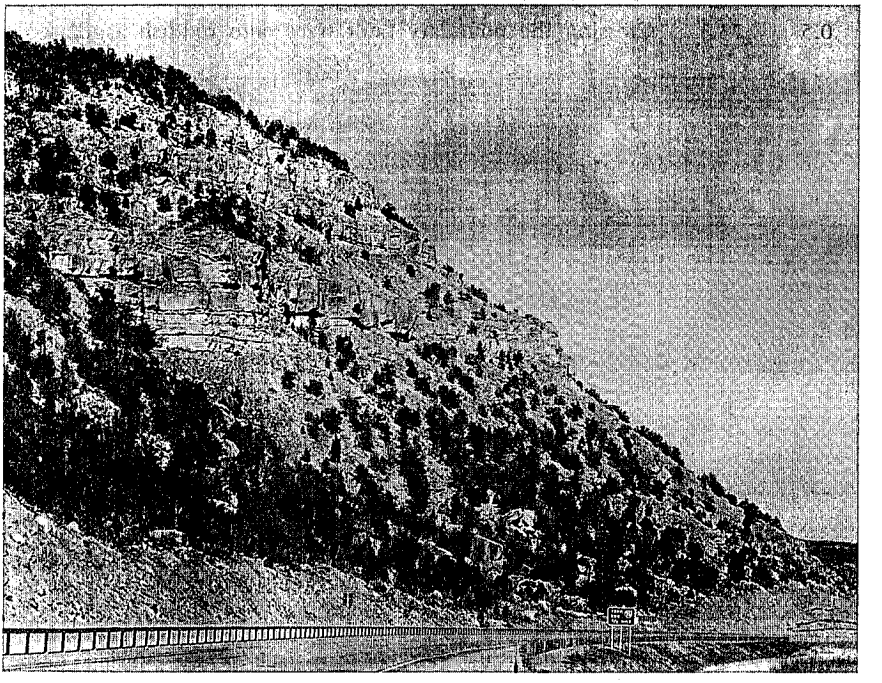
TEXT-FIGURE 65.—Northward along the east boundary fault of the Musinia Graben from near Mile 72.5. Ledges directly ahead are Price River beds (P) east of the fault, and the rounded, juniper-covered hills to the left are down-dropped North Horn Formation (N) west of the fault. Springs in the meadowland near the bend of the road originate near the fault trace.

North Horn beds on the west side of the fault. North Horn Formation forms characteristic rounded hummocky surfaces in here because it is primarily an argillaceous sequence this far to the south.

0.8 74.1 Argillaceous pink and gray North Horn Formation exposed on both sides of the road as well as ahead in the canyon bottom in the Musinia graben. The ledge approximately half way up the slope on the west side of the Musinia Valley, ahead, is the Castlegate Sandstone.

0.9 75.0 CROSS CREEK. Exposures of North Horn beds in the immediate vicinity are pinkish and gray argillaceous beds of the upper part of the formation. The fault trace shows well towards the north where the pinkish beds have been faulted against tan Cretaceous sandstone.

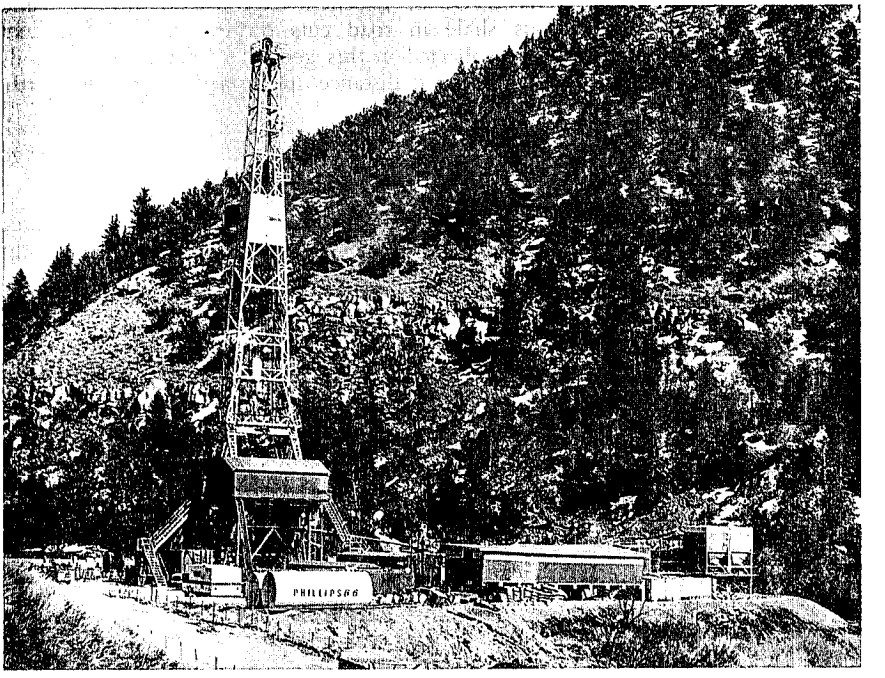
1.3 76.3 TEMPORARY BEGINNING OF INTERSTATE 70 FREEWAY (1974). Road crosses the major west boundary fault of the Musinia graben. Rocks immediately east of the fault are reddish North Horn siltstone beds that have been down-faulted against Blackhawk beds on the west (Text-fig. 66).



TEXT-FIGURE 66.—Coal-bearing Blackhawk beds exposed west of the western boundary fault of the Musinia graben at Mile 76.5. Excellent fossil plants may be collected from some of the silty units in the lower slope.

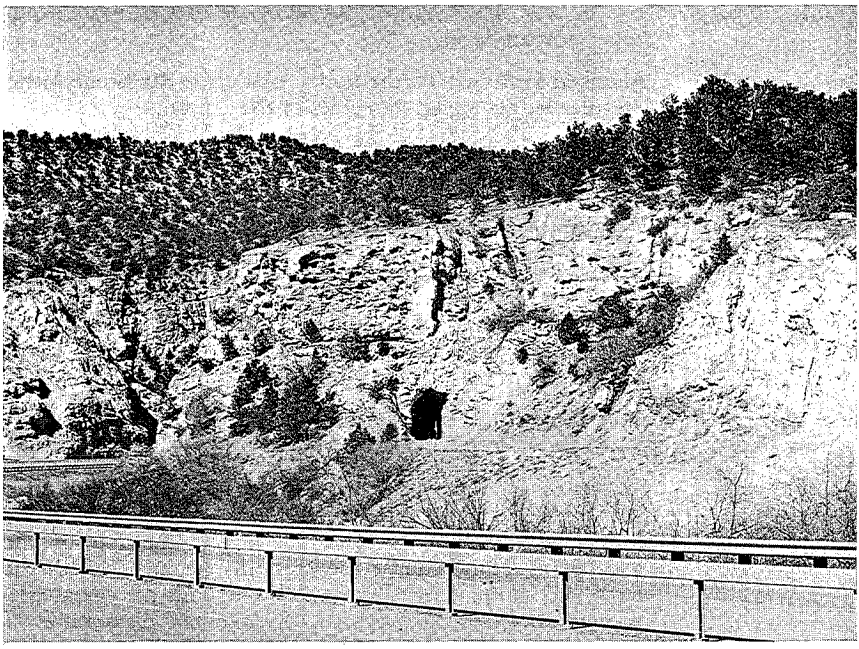
0.5	76.8	GEOLOGIC STOP 8. Excellent exposures of thin coal and carbonaceous shale in road cuts on the north. Excellent plants can be collected in this general area out of the sandy slope zone and a short distance up the hill toward the north.
0.3	77.1	Sevier Valley Coal Mine, on the south in middle Blackhawk beds, supplied coal to Sevier Valley until a few years ago (Text-fig. 67).
0.2	77.3	Steeply tilted beds in the road cut on the north are related to fault drag along one of the north-south faults of the southern plateau.
1.1	78.4	Phillips Petroleum Company well site south of highway (Text-fig. 68).
0.7	79.1	Excellent exposures of thin streaks of coal and fossil-bearing carbonaceous shale in road cuts on the north side. The road continues through the Blackhawk Formation, with Castlegate Sandstone forming the prominent ridge along the canyon wall. Price River beds have been stripped back to form a plateaulike surface on either side of the canyon wall.

TEXT-FIGURE 67.—Southward view of Douglas fir and ponderosa pine woods at the site of the old Salina Canyon Coal Company mine. A narrow-gauge railroad connected the mine to Sanpete Valley and the old railroad bed can be seen as segments parallel to the freeway in the lower part of the canyon.



TEXT-FIGURE 68.—Phillips Petroleum Company well (1973) at Mile 78.4. Ledges in the background are in the Blackhawk Formation.

0.2	79.3	Road cuts both on the north and south sides of the canyon wall expose thin streaks of coal in the dominantly sandstone section.
0.3	79.6	GEOLOGIC STOP 9. Carbonaceous shale at the base of the massive, cliff-forming Castlegate Sandstone contains abundant plants.
0.4	80.0	FIRST RAILROAD TUNNEL is in basal beds of the Castlegate Sandstone.
0.2	80.2	SECOND RAILROAD TUNNEL on the south side of the road is also in Castlegate Sandstone near where the Coal Hollow fault crosses the road. Russian olive, an introduced Old World, weedy tree, grows along the stream west from the second railroad tunnel (Text-fig. 69).
0.4	80.6	WATER HOLLOW. Cross a major fault at the western edge of the Water Hollow graben, with Castlegate Sandstone, on the east, dropped down against Blackhawk Formation on the west. Fossil insects and plants have been collected from ironstone beds near the road, east of the Water Hollow road.



TEXT-FIGURE 69.—Eastward view of railroad tunnels dug through massive Castlegate Sandstone at Mile 80.2. Russian olive trees flourish along Salina Creek in the foreground. Junipers, pinyon, and Mt. mahogany woodland have developed on Price River beds above the Castlegate Sandstone.

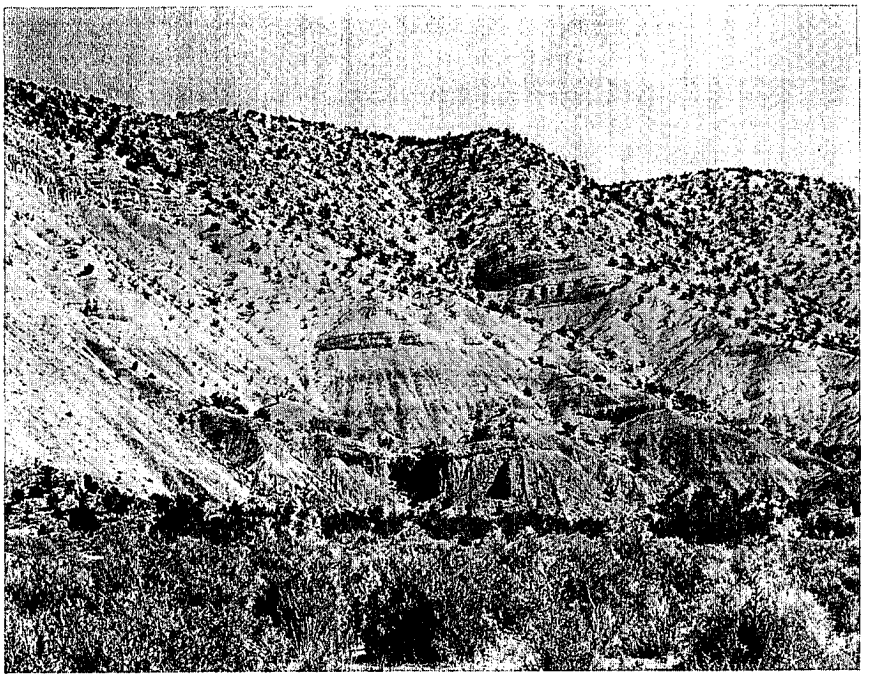
0.5	81.1	Exposures of thin coal and fluvial sandstone in the road cut on the north are Blackhawk beds west of the fault at the west edge of Water Hollow graben.
0.1	81.2	Pink clinkered zone was produced when coal burned. The oxidized zone makes a red streak on the north canyon wall.
0.2	81.4	Site of old coal mine on north wall approximately 100 feet above the canyon bottom.
0.3	81.7	Brown Canyon to the north. Outcrops of Castlegate Sandstone form the rim both north and south. Some minor exposures of coal-streaked shale, siltstone, and thin-bedded, upper delta-plain sandstone of the Blackhawk Formation are exposed near road level.
0.6	82.3	Road cuts both to the north and the south show coal streaks in the upper Blackhawk group beneath massive Castlegate Sandstone. Some of the coal and carbonaceous shale beds have yielded rather nice fossil plants and thin-shelled mollusks in this area, although most of the channel fills contain only macerated plants. Most productive horizons are approximately 10 feet below the thickest coal, which is overlain by thick sandstone.

0.1	82.4	Top of Blackhawk Formation and base of Castlegate Sandstone at road level.
0.2	82.6	Alumbed Hollow. To the north, Castlegate Sandstone forms irregular ledges along both sides of the canyon.
0.5	83.1	Deep double road cut with thin coally streaks in the main, massive Castlegate Sandstone.
0.3	83.4	Slightly coally beds in the Castlegate Sandstone.
0.4	83.8	Light-colored Castlegate Sandstone forms a bold cliff near road level. The upper part is channeled and burrowed; the lower part is massive, light-gray sandstone. This is part of one of the most extensive sandstone sheets exposed in the Wasatch Plateau.
0.2	84.0	Light reddish shale in the lower fluvial sandstones of the Price River Formation.
0.4	84.4	Exposures on both sides of the road cut are interbedded flow-folded shale and thin sandstone in the Price River Formation. A massive sandstone marks the top of the Price River Formation at the crest of the hill to both the north and south. Price River sandstone units are characteristic grayish tan to buff-colored upper deltaic plain facies of the Price River Formation. Here they are complexly cross-bedded and channeled.
0.8	85.2	ROAD SOUTH TO GOOSEBERRY YOUTH CAMP AND U.S. FOREST SERVICE ACCESS ROAD. INTERSTATE 70 temporary ending just before the road junction (1974). Price River beds dip westward beneath the canyon floor near the junction.
0.8	86.0	Ranch buildings on north side of road (Text-fig. 70).
0.5	86.5	Road mainly on the North Horn Formation, locally on landslide material of the Rattlesnake Hill slide.
1.1	87.6	Small fault that puts Green River beds against reddish North Horn Formation. The resistant ledge on both sides of the canyon is the Flagstaff Limestone. A small slump of Colton rocks locally covers the ledges on the south side of the canyon.
0.3	87.9	Transition from North Horn–Flagstaff beds into Colton redbeds is overlain by Green River Limestone on the walls of the canyon, both north and south of the road. Unconformity appears from beneath the canyon floor.
0.3	88.2	Unconformity exposed in road cuts, with Tertiary Flagstaff and North Horn beds above the unconformity and Upper Cretaceous Price River rocks below. Older rocks appear below the unconformity to the west.

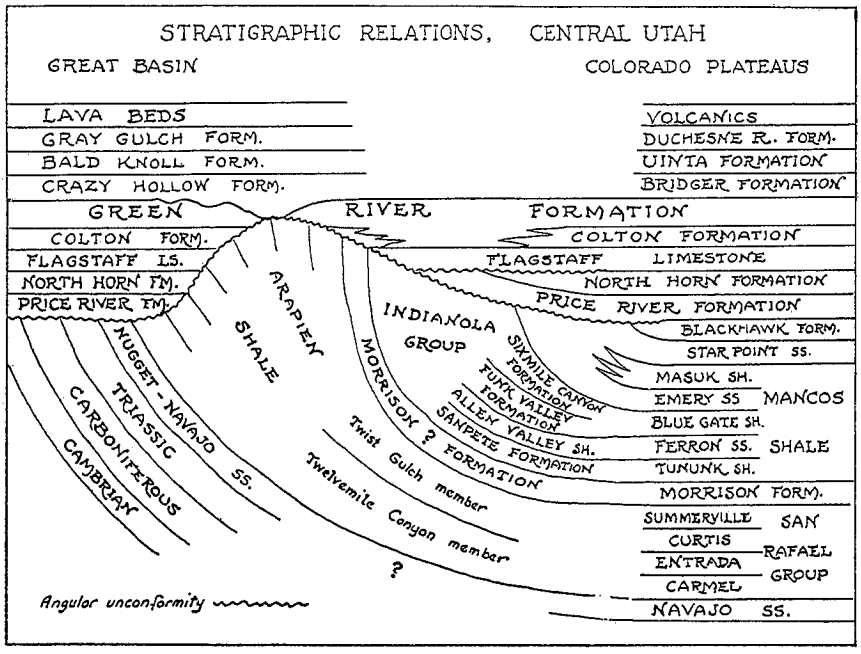
TEXT-FIGURE 70.—Ranch buildings on a broad landslide mass at Mile 86.

0.2	88.4	Marine Cretaceous Allen Valley Shale is above the Sanpete Formation but beneath the unconformity. Both are well exposed in road cuts.
0.3	88.7	Cretaceous Sanpete Formation of yellow gray sandstone and soft shale north of the road is angularly overlain by the unconformable Flagstaff Limestone.

0.2	88.9	Road cuts in nearly vertical Jurassic Morrison conglomerate and variegated shale (Text-figs. 71, 72).
0.3	89.2	GEOLOGIC STOP 10. PULL OFF TO NORTH. Well-developed angular unconformity of Flagstaff, Colton, and Green River beds overlying Twist Gulch Formation (Upper Arapien Shale) exposed in valley wall on the north. Older rocks are standing vertically, and Tertiary rocks are nearly horizontal. The Flagstaff Formation is a thin calcareous unit at the base of the receding reddish shale slope carved on the soft Colton beds. The Green River limestones that form the upper light-gray cliffs and ledges are well exposed near the skyline. To the east, younger beds of Jurassic and Cretaceous ages appear beneath the unconformity. Dip of pre-unconformity beds decreases to the east.
0.3	89.5	LEAVING FISHLAKE NATIONAL FOREST.
0.3	89.8	Dark Arapien Shale is overlain by the Gray Gulch Formation; Green River Formation is faulted down against these rocks east of the draw. Green River rocks are exposed on both sides of the canyon, east of the old calcite mill workings.

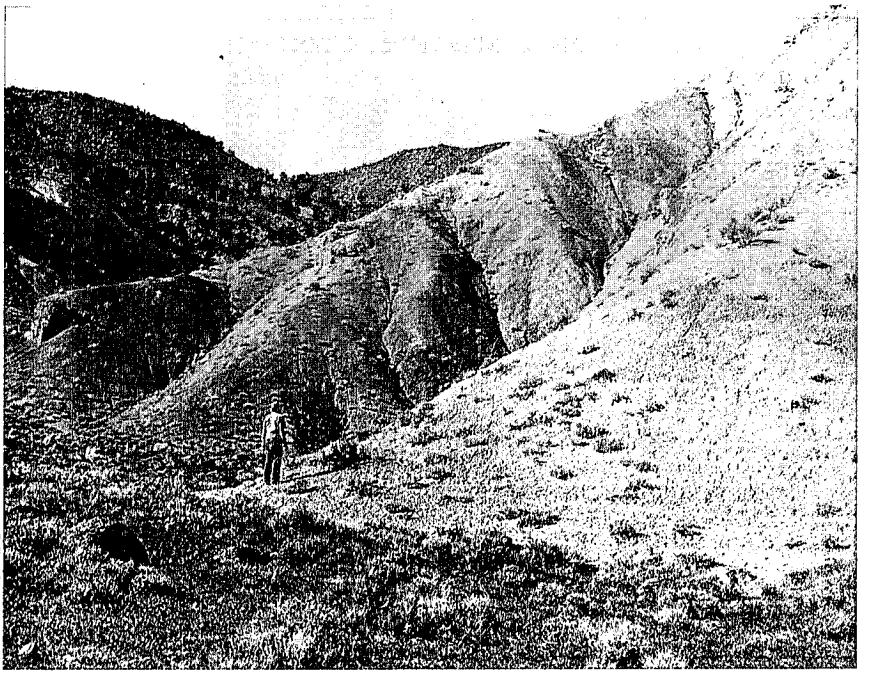


TEXT-FIGURE 71.—Angular unconformity between vertical Jurassic Morrison (?) Formation and Cretaceous Indianola Group and overlying Late Cretaceous–Early Tertiary North Horn Formation exposed at Mile 89.2 in the north wall of Salina Canyon.



TEXT-FIGURE 72.—A diagram of stratigraphic relations and a nomenclature showing the major angular unconformity separating the Mesozoic and earlier Cretaceous formations from the later Cretaceous and Tertiary rocks. The conclusions shown are those of Speiker, an early worker in the Wasatch Plateau (from Speiker, 1949).

0.2	90.0	Conglomerate and breccias of the Tertiary Gray Gulch Formation south up Gray Gulch.
0.2	90.2	Junction of U.S. Forest Service road with highway. Continue on main highway toward Salina.
0.5	90.7	Excellent exposures of the Arapien Shale overlain by Gray Gulch Formation (Text-fig. 73).
1.2	91.9	MOUTH OF SALINA CANYON. Excellent exposures of lower red Arapien Shale overlain by Gray Gulch Formation and volcanic rocks. Arapien Shale is well exposed on both sides of the mouth of the canyon. Roadside exposures have abundant selenite crystals. Several terraces are developed along Salina Creek and are capped by a volcanic boulder residue. Toward the southwest, reddish rocks begin to appear in the Flagstaff Formation. These red units are traceable toward the south and grade into the Cedar Breaks Formation exposed in the Bryce Canyon and Cedar Breaks areas. Equivalent rocks are covered by volcanic rocks in the intervening Fish Lake Plateau. Far in the distance to the southwest the high peaks of the Tuschar Range can be seen on the skyline.



TEXT-FIGURE 73.—Massive gypsiferous Arapien shale along the north side of the mouth of Salina Canyon at approximately Mile 90.5. These salty outcrops have a peculiar flora of selenium- and salt-tolerant plants.

1.0	92.9	Salt-bearing Arapien Shale at southeast edge of SALINA.
0.5	93.4	Turn west on Utah Highway 4.
0.3	93.7	JUNCTION OF UTAH HIGHWAY 4 WITH U.S. HIGHWAY 89 IN SALINA. Turn north at the junction in the center of downtown Salina onto U.S. Highway 89—for a continuation along the route of Part 3.

Salina (elev. 5,160) first settled in 1866, was vacated during Indian troubles of the sixties and resettled in 1871. It is a turkey-, livestock-, farm-, coal-, and salt-shipping center.

The Black Hawk War began in April 1865. A smallpox epidemic in Gunnison apparently was a factor: several Indians contracted the disease, and some of them died. The survivors blamed the epidemic on the white people, and a series of raids followed. Actual hostilities are believed to have started in Manti when John Lowry pulled "Indian Jake" from his horse by the hair and then went home for a pistol. The Indians were gone before he came back; but the Ute Black Hawk War, of all Utah's Indian wars the most disastrous for the white people, was launched. It consisted

primarily of a series of Ute guerilla raids, a white pursuit, and a Ute ambush. Many Utah settlements, including Richfield, were abandoned during the late sixties and were not resettled until the early seventies. No detailed history of the conflict has been written. Raids, livestock thefts, and occasional killings on both sides continued for more than three years. In August 1868 Colonel F. H. Head, Superintendent of Indian Affairs, held a council with the principal Utah chiefs, including Black Hawk, and signed a treaty in Strawberry Valley that officially ended the war—although some raiding continued, necessitating other treaties.

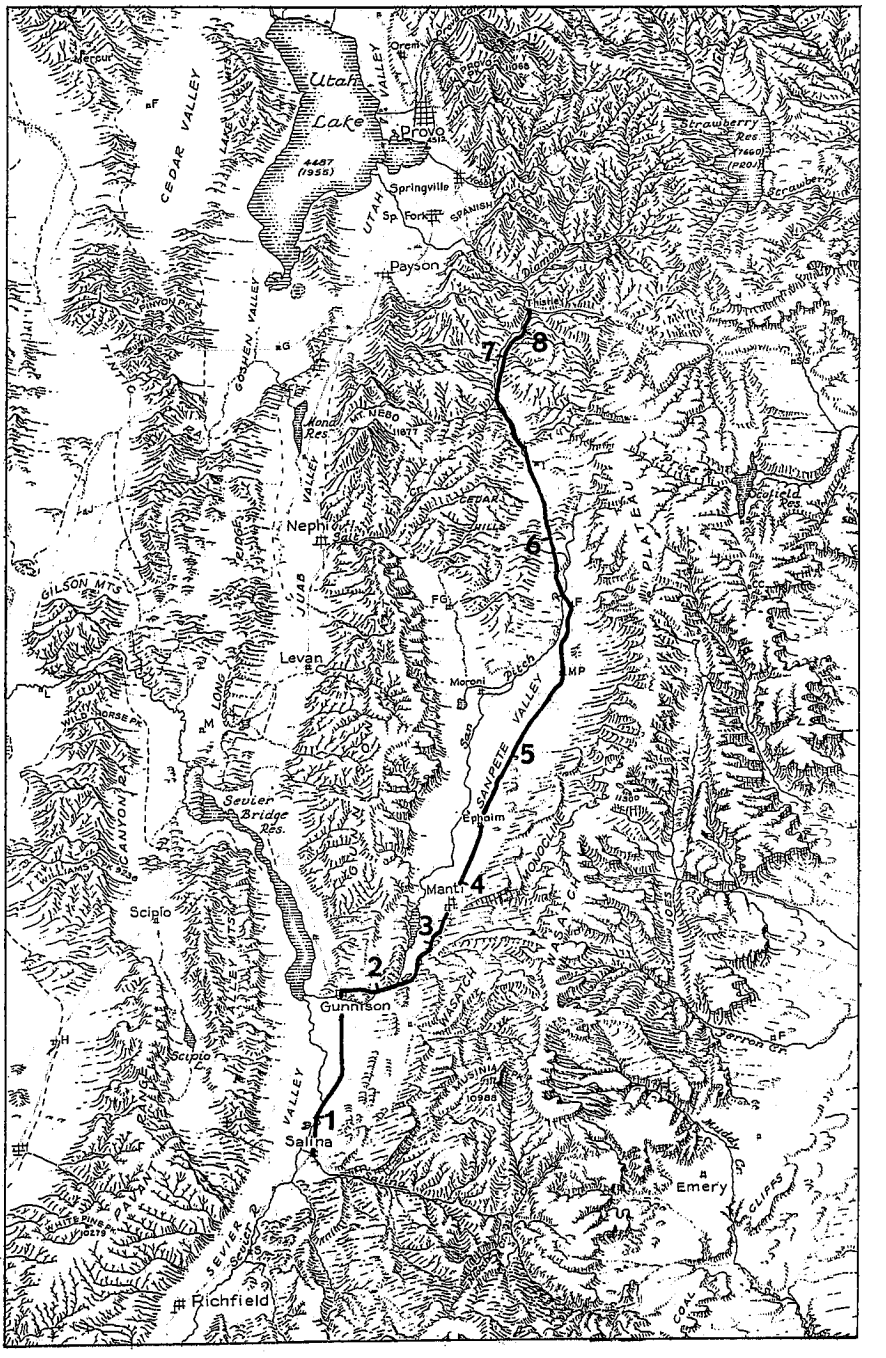
END OF PART 2

PART 3

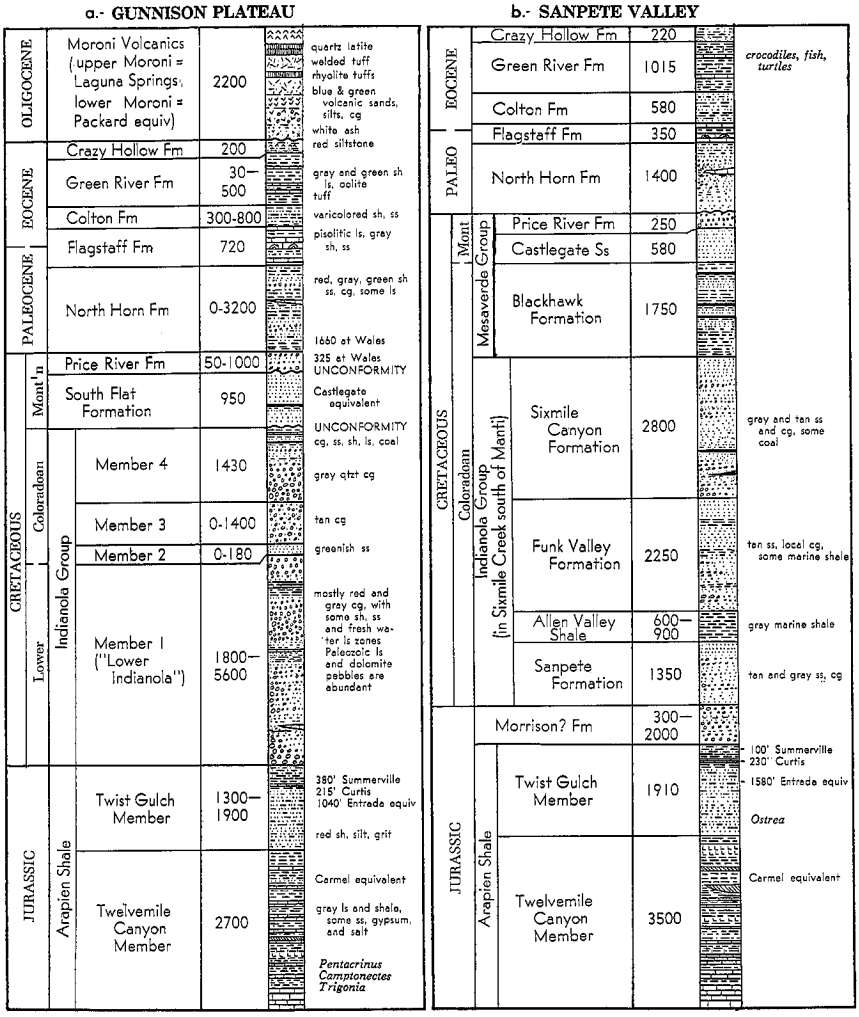
SALINA TO THISTLE JUNCTION VIA U.S. HIGHWAY 89

MILEAGE Interval	Cumulative	
0.0	0.0	JUNCTION OF U.S. HIGHWAY 89 WITH UTAH STATE HIGHWAY 4 IN CENTER OF SALINA. Utah State Highway 4 leads toward Salina Canyon and junction with Interstate 70; U.S. Highway 89 leads north.
0.5	0.5	SALINA, NORTH EDGE.
0.3	0.8	Cross D&RGW Railroad.
0.3	1.1	Junction of Utah State Highway 256, north to Redmond, with U.S. Highway 89.
1.9	3.0	Small water gaps through the Green River cuesta show Arapien shale beneath slumped late Tertiary volcanic rocks along the plateau flank (Text-fig. 76).
0.7	3.7	GEOLOGIC STOP 1. Secondary road crosses the highway. Westward it leads to REDMOND; eastward to the base of the monocline. Fossil snails can be collected from vertical Green River beds exposed near road level in canyon narrows to the east and to the southeast.

Redmond (elev. 5,135). Salt-mining center for central Utah. Utah's geologic history has furnished the state with three salt-producing areas: the Great Salt Lake where salt forms today; the potash mines near Moab where evaporites formed in the Pennsylvanian Paradox Basin 300 million years ago; and in Sanpete Valley, where the Arapien Shale (named after a famous Utah Indian Chief of the 1850s) yields commercial salt and gypsum (at Sigurd) that formed evaporating marine waters during Jurassic time, 150 million years ago. The salt is mined about 2 miles north of Redmond in open pits about 50 feet deep. The salt has a red



TEXT-FIGURE 74.—Index map to Part 3 of the road log, along U.S. Highway 89 between Salina and Thistle. Numbers indicate geologic stops along the route.

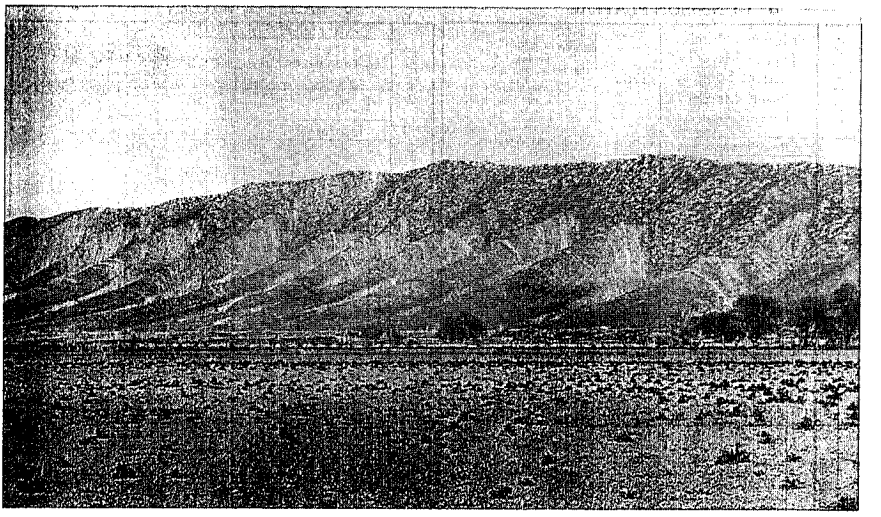


After: Spieker (1949); Hardy (1962)
Jurassic: Wright and Dickey (1963a); Hardy (1952); Gilliland (1963); Cretaceous in part: Hunt (1954); Thomas (1960); Colton Fm: Mercantel and Weiss (1968); Flagstaff Fm: Weiss (1965), (1969)

TEXT-FIGURE 75.—Stratigraphic section of rocks exposed along the western flank of the Wasatch Plateau and in the Gunnison Plateau to the west (from Hintze, 1973).

color from red clay impurities; it is sold in blocks or crushed sizes, mostly for livestock and turkey feed, but also for salting highways during icy winter months.

0.6 4.3 Double road cuts through alluvial fan gravels eroded from some of the major canyons in the Wasatch Plateau to the east. Steeply dipping Green River beds are exposed in hogbacks to the east. The small community of Redmond, to



TEXT-FIGURE 76.—Eastward view of steeply dipping Green River rocks forming prominent flatirons along the Wasatch monocline north of Salina at approximately Mile 4.

the west, was named after the red mound visible beyond town.

1.3	5.6	Sanpete County–Sevier County line. Salt mines are directly west of county line marker.
0.5	6.1	JUNCTION UTAH HIGHWAY 256 WITH U.S. HIGHWAY 89. The state highway leads southwestward to Redmond. The barren, low hills across the valley to the west exposed salt-bearing Arapien beds that have been mined in open pits. Massive beds of gypsum have also been mined from Arapien beds to the south, near Sigurd, where the gypsum is processed into plaster board. Steeply dipping Green River, Flagstaff, and Colton beds are exposed in fault-broken cuestas immediately east of the road. Barren gray and pinkish exposures beyond the Tertiary cuestas are of Arapien shale. The plateau skyline is capped in part by tuffaceous Late Tertiary volcanic rocks.
1.0	7.1	Secondary road toward the west leads across Sevier Valley into the salt mine area, from which point another good road leads southward to Redmond.
0.2	7.3	Entering the small community of AXTELL.
1.5	8.8	On the east side of the valley, steeply dipping Colton, Green River, and Flagstaff beds form red-and-white striped exposures at the base of the monocline, in a complexly faulted area. Prominent barren hills to the east are the Arapien Hills.

2.3 11.1 Abandoned sugar-processing plant on the east. Barren Arapien Shale forms the low hills at the east edge of the valley at the base of the Wasatch Plateau.

0.2 11.3 Entering Centerfield. Tertiary beds of the Valley Mountains to the west are exposed above the broad bajada of merged alluvial fans.

1.5 12.8 ENTERING GUNNISON AND LEAVING CENTERFIELD, opposite the Gunnison Valley Elementary School. Mt. Musinia is the high, white, nipple-shaped peak on the Wasatch Plateau skyline to the southeast. It is held up by Flagstaff Limestone, which is also exposed in the westward-dipping Wasatch monocline beyond the barren Arapien Shale hills.

GUNNISON (elev. 5,215). Named for Captain John W. Gunnison, United States topographical engineer in a federal railroad survey who, along with seven of his men, was killed in an ambush near Sevier Lake in western Utah early on the morning of 26 October 1853 by Pavant Chief Moshoquope and his followers in reprisal for the killing of Moshoquope's aged father by the Hudspeth California emigrant train two weeks earlier.

Gunnison is a turkey- and sheep-raising center. Benjamin Brown, one of Gunnison's early settlers, organized the Utah Poultry Cooperative Association, which established a method for putting uniformly-sized fresh eggs on the eastern market.

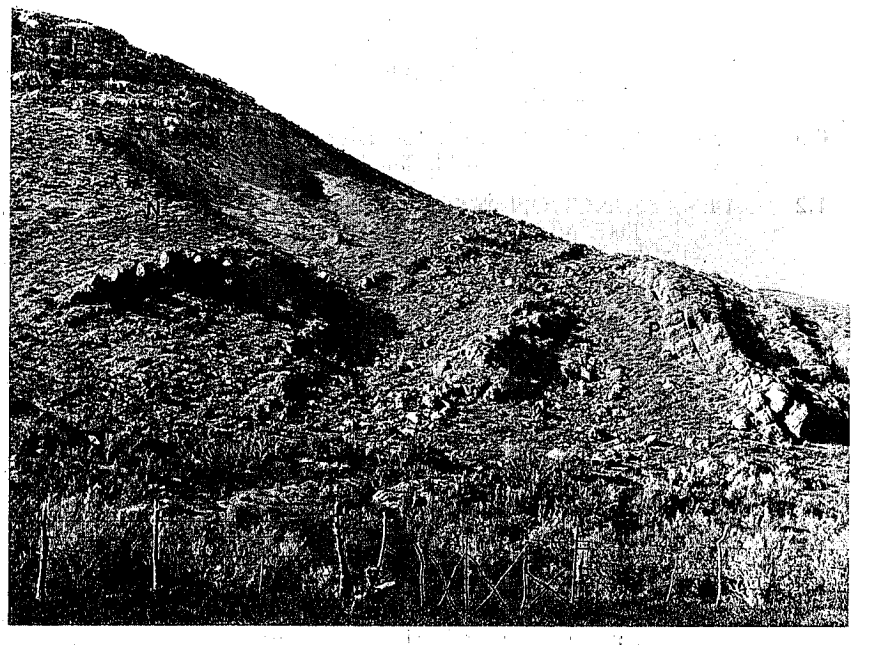
0.3 13.1 Junction near Gunnison High School. Utah State Highway 137 leads eastward to Mayfield.

1.2 14.3 JUNCTION WITH UTAH STATE HIGHWAY 28 AT THE NORTH EDGE OF GUNNISON. Directly behind, Tertiary beds form the gray slopes in the Valley Mountains west of Gunnison. The state highway leads northward and joins U.S. Highway 91 at Levan. Turn east from the city park on U.S. Highway 89.

1.4 15.7 Poor outcrops of Green River beds occur in the immediate vicinity of the road. To the north the flat upland surface of the Gunnison Plateau is controlled by gently folded Tertiary rocks. Colton, late Tertiary reddish, beds are exposed in the immediate vicinity of the road and just west of town where the "G" has been built on the low hills.

1.3 17.0 The highway crosses a small east-west fault that drops the cliff-forming Green River limestone down to near road level on the north; to the south, the limestone is some distance above road level. North-south-trending Antelope Valley to the east is eroded in reddish Colton beds that are exposed some distance to the north of the road along the strike.

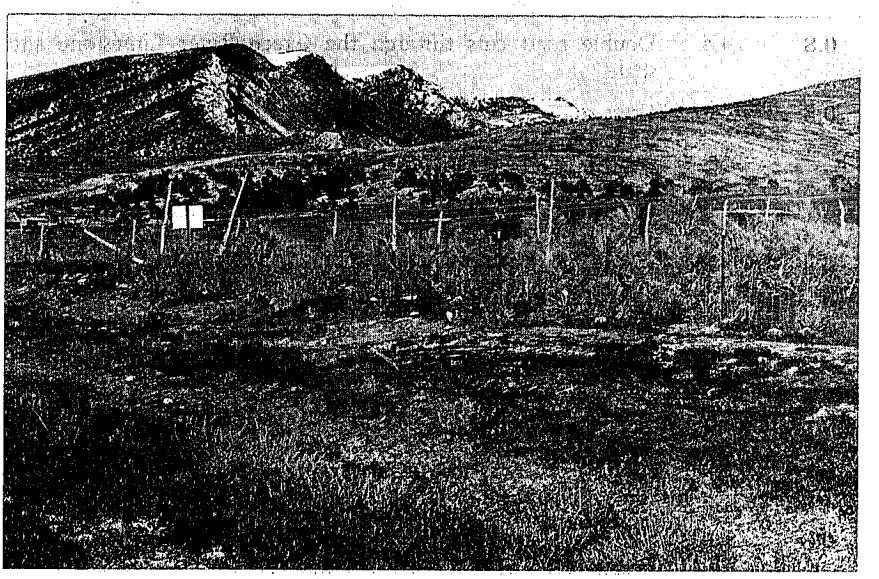
1.0	18.0	Badly broken and fractured Flagstaff beds exposed in the road cuts. To the southeast, barren Arapien Shale is well exposed in Arapien Valley, the type area of the Formation.
0.3	18.3	Tan and reddish conglomeratic sequence is overlain angularly by Flagstaff Limestone.
0.2	18.5	GEOLOGIC STOP 2. Vertical North Horn–Price River conglomerate on the north in double angular unconformity produced by folding and erosion or by complex structural patterns not now well understood (Text-fig. 77).
0.8	19.3	CROSS SAN PITCH RIVER. Complexly folded, somewhat faulted Price River and North Horn beds form the low rounded hills to the north. Arapien Shale forms the barren hills to the southeast. Directly behind the tan cliffs on the hills in midvalley are Green River beds.
0.2	19.5	CROSS D&RGW RAILROAD. Light-colored sandstone and soft pink shale to the north, though mapped as Morrison Formation, are involved in complex structures and could be much younger.



TEXT-FIGURE 77.—Angular unconformity between Price River (P) and North Horn (N) conglomerates in the lower right foreground, and between Flagstaff Limestone (F), along the skyline, and North Horn Formation in the upper left. Exposures are on the north side of the highway at Mile 18.5.

0.3	19.8	Bend in the road between Arapien Shale exposures at the south edge of a small reservoir.
0.4	20.2	Green River shale exposed above Arapien Shale both east and west.
0.5	20.7	Junction with Utah State Highway 137 to Mayfield. Continue ahead on U.S. Highway 89.
0.3	21.0	GUNNISON RESERVOIR TO THE WEST.
0.9	21.9	Entering Sterling.
0.7	22.6	NORTH EDGE OF STERLING, SIX-MILE CREEK. To the west, Arapien Shale forms the immediate hills and is capped by Green River Limestone. To the east, Flagstaff Limestone forms Black Mountain, the high, prominent peak on the skyline of the Wasatch Plateau. Steep dips on the monocline are expressed in Flagstaff and Green River Limestone east of Sterling.
0.1	22.7	Junction of side road to Six-Mile Canyon and Palisade State Park to the east.
0.9	23.6	Crest of broad bend in highway. To the west, massive conglomerates in Morrison(?), Price River, and North Horn formations are visible beneath Green River beds. Manti Temple is directly ahead in Sanpete Valley.
0.8	24.4	Double road cuts through the Green River Limestone and shale.
0.8	25.2	Crest of small alluvial fan. Vertical Cretaceous Sanpete Sandstone shows well in hills to the east. To the west, reddish Arapien Shale is exposed in hills across the valley and is capped by Green River Formation on the skyline to the west.
0.4	25.6	GEOLOGIC STOP 3. Cretaceous Sanpete Sandstone stands directly on end in road cuts on the southeast side. This sandstone hogback continues to the south and separates Allen Valley from the main valley.
0.2	25.8	Junction with the highway to Palisades State Park. The Palisades road leads northward through Allen Valley, which is carved in steeply folded shale and flanked on either side by Cretaceous sandstone hogbacks. This is the type area of the Allen Valley shale, a western tongue of Mancos Shale.
0.8	26.6	Small-volume hydrogen sulphide springs to the east are in nearly vertical Cretaceous Funk Valley Formation in the Indianola Group. Distinctive prominent tan sandstones occur above, with some interbedded shale and minor coal in lower exposures.
0.2	26.8	Double road cuts through landslide and mudflow debris.

0.9	27.7	CURVE AT THE SOUTH END OF MANTI. Reddish colored hills to the southeast are slump masses of Colton that moved down the westward-dipping Wasatch monocline. The monocline is somewhat faulted, as is shown by offsets in Flagstaff Limestone on the north side of Manti Canyon (Text-fig. 78).
0.2	27.9	Road east to Skyline Drive in the Manti National Forest leads up Manti Canyon.
0.6	28.5	Sanpete County Courthouse on the east, made of Green River Limestone—as are the Manti Temple and many of the older buildings in Manti and Ephraim. Manti (elev. 5,530), founded in 1849 shortly after pioneers entered Utah, is the Sanpete County seat. The Manti Temple was started in 1877 and completed in 1888 at a cost of a million dollars. Mormons settling Sanpete Valley were quick to utilize the maximum agricultural capabilities of the valley. A little higher in elevation than Utah and Salt Lake Valleys, it has a shorter growing season. Sanpete Valley towns attained their zenith around the turn of the century, as is indicated by some of the larger homes of early sheepmen and ranchers. Sanpete Valley has never been able to support its best crop—children—many of whom have had to leave the valley to seek their livelihoods.



TEXT-FIGURE 78.—Northeastward, up Manti Canyon from south of town, at Mile 27.2. The low, rounded hills in the foreground are part of a landslide mass of Colton beds. The "sawtooth" skyline along the north side of the canyon is produced by a series of fault blocks offsetting the resistant Flagstaff Limestone that forms the cuesta, at the right, at the mouth of the canyon.

0.4	28.9	Small park at the west base of the Manti Temple Hill in a broad S-curve in the highway, at the north end of town (Text-fig. 79).
0.4	29.3	MANTI NORTH EDGE, at the northeast edge of the cemetery.
0.1	29.4	Side road, eastward to Manti Temple.

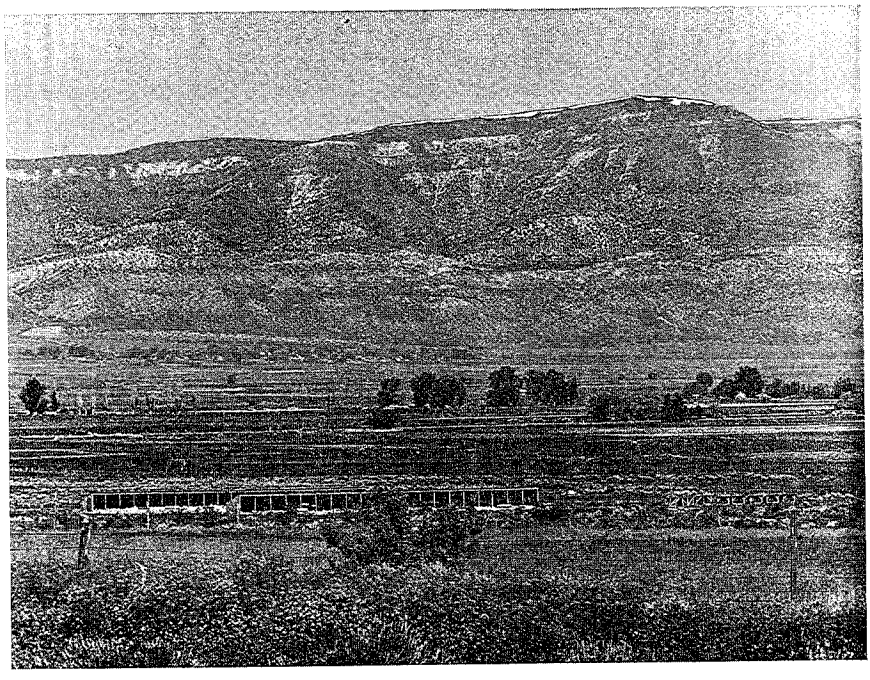
TEXT-FIGURE 79.—Manti Temple as seen from the southwest. The temple is composed of oolitic limestone of the Green River Formation. Excellent exposures of the unit can be seen in the parking lot to the southeast.

1.4	30.8	Outcrops of Crazy Hollow sandstone and limestone in farmyard exposures east of the road.
0.2	31.0	GEOLOGIC STOP 4. Prominent quarry to the east in Green River Formation on the northeast side of Temple Hill is the one from which much of the fossiliferous oolitic limestone for the Manti Temple was obtained. Flagstaff Limestone forms the prominent cuesta at the front of the Wasatch Plateau and clearly shows the faulted monoclinal structure of the western margin of the plateau. Red North Horn rocks are exposed beneath the Flagstaff caprock in Manti Canyon and canyons to the north.
1.8	32.8	Low, rolling, hummocky topography at the base of the Wasatch Plateau to the east is carved on slumped Colton beds stripped from the westward-dipping surface of the Flagstaff Limestone. To the west, Price River and North Horn beds are exposed in the base of the Gunnison Plateau. Flagstaff Limestone forms a prominent shoulder below the retreating Colton Formation that is capped in the high country by Green River beds.
2.3	35.1	EPHRAIM, SOUTH EDGE, junction of Utah State Highway 29 with U.S. Highway 89. The state highway leads eastward over the Wasatch Plateau to Emery County. Ephraim is the home of Snow College.
1.3	36.4	EPHRAIM, NORTH EDGE
1.7	38.1	Blocks of oolitic Green River limestone obtained from the large quarry to the east, at the base of the monocline, were loaded onto the railroad here. The stone was used in constructing many of the older buildings throughout Sanpete Valley.
1.3	39.4	Tan beds of the Crazy Hollow Sandstone are exposed in a low cuesta west of the road.
0.9	40.3	JUNCTION OF UTAH STATE HIGHWAY 11, WITH U.S. HIGHWAY 89. The state highway leads northwestward to Moroni, and eastward to Spring City, through a gap in the Green River cuesta. Green River rocks are exposed in road cuts at the base of the westward-dipping cuesta. Westward-dipping Flagstaff, Colton, and Green River beds are well exposed on the Wasatch Monocline to the east. The prominent ledge is the Flagstaff Limestone, which is broken by several small faults that parallel the monocline and the western Wasatch Plateau front. Mt. Nebo is visible to the northwest across the valley.
2.3	42.6	GEOLOGIC STOP 5. Junction of Utah State Highway 30 with U.S. Highway 89. Continue on U.S. Highway 89. Green River rocks are exposed in cuts immediately south of the junction. The small community of Wales is at the base of

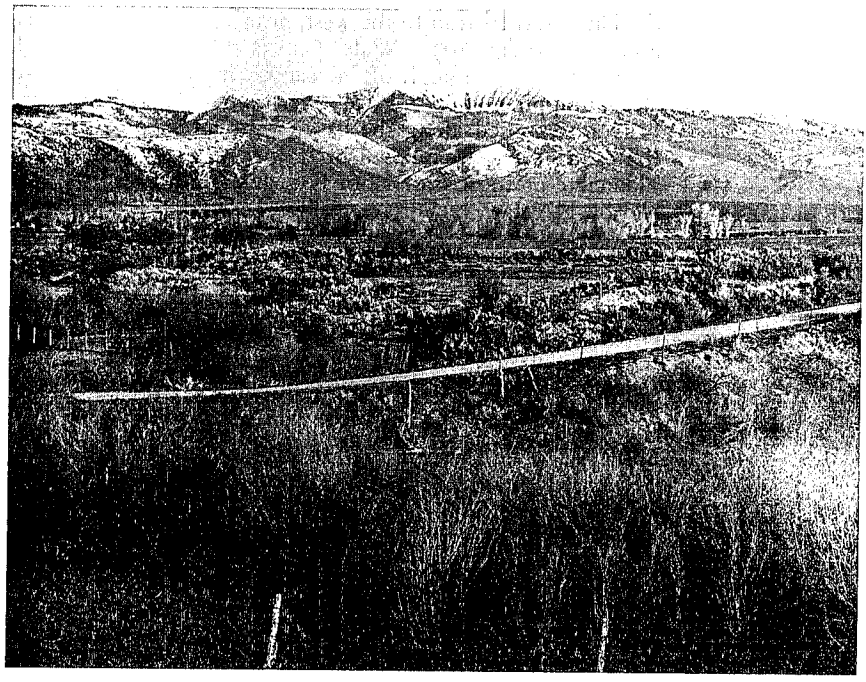
the Gunnison Plateau to the west, near the toe of the alluvial apron (Text-fig. 80). Wales Gap is at the head of the alluvial fan at the mouth of the canyon beyond Wales. Here, steeply dipping, reddish Price River, Indianola, and Morrison beds are exposed along the base of the mountains. Most of the escarpment is composed of steeply to gently folded conglomerate of the North Horn Formation; however, it is capped by Flagstaff Limestone. Colton beds form the upper recessive slope and are capped by Green River beds, which form the skyline. Geology of the base of the plateau is complex.

4.3 46.9 Mount Nebo, on the skyline to the northwest, is the southern terminus of the Wasatch Mountains. Salt Creek Canyon separates the southern Wasatch Mountains and the Cedar Hills from the more southerly Gunnison Plateau.

1.3 48.2 MOUNT PLEASANT, SOUTH EDGE, at junction of Spring City road, (Utah State Highway 11) with U.S. Highway 89. Mt. Pleasant (elev. 5,860) is a leading Rambouillet sheep center. Rambouillets are sold chiefly for breeding pur-



TEXT-FIGURE 80.—View westward across Sanpete Valley to the small farm community of Wales and the Gunnison Plateau in the distance. Conglomeratic Cretaceous beds are exposed as the reddish units in the foothill belt and are overlain unconformably by Tertiary North Horn and Green River beds that form the upper slopes and cliffs of the Plateau.



TEXT-FIGURE 81.—View southeastward across Sanpete Valley, near the community of Spring City, to Brigham's Chair on the crest of the Wasatch Plateau. Steep westward dips of the Paleocene and Eocene rocks are along the Wasatch monocline.

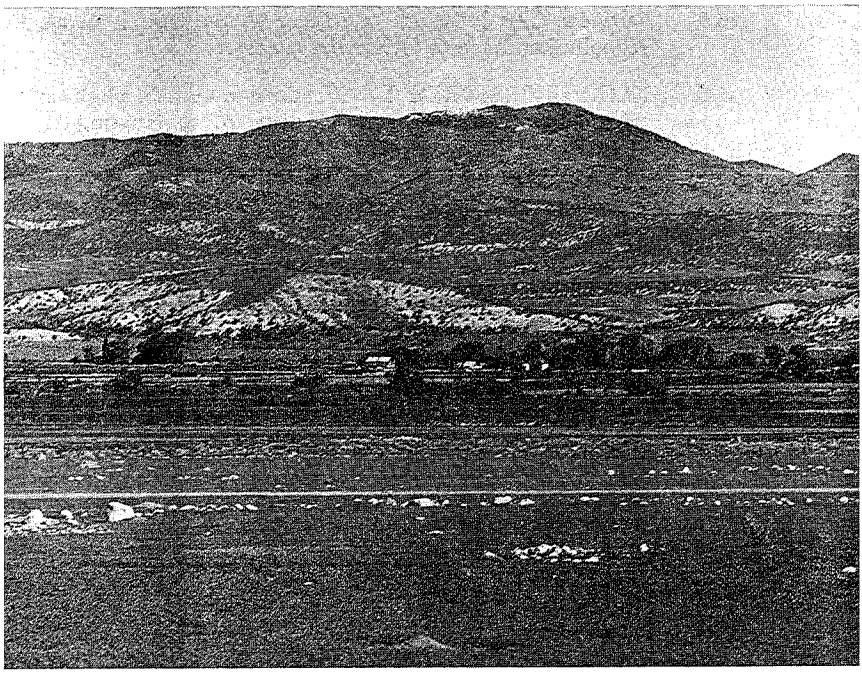
poses, to improve herds elsewhere. Before the turn of the century, Mt. Pleasant people ranged their sheep municipally. The animals were leased to herders, who guaranteed a specific increase; payments to the herder were made *pro rata,* and he was given a bonus of all lambs over the specified quota.

John Henry Seely, a Mormon pioneer, a foremost advocate of blooded stock, imported Rambouillet sheep and shorthorn cattle. Before Seely's importations, western sheep had sheared two- or three-pound fleeces; but, by crossing the western sheep with Rambouillet purebreds, he developed individual sheep that sheared thirty-five-pound fleeces. One ram was sold to the Russian government for $6,000.

Large boulders on the surface of the alluvial fan have been transported from Pleasant Creek as mudflow rafted debris (Text-fig. 82). Moroni is the community to the northwest at 2 o'clock. Type locality of the Moroni Formation is in the Cedar Hills, north of town.

1.5 49.7 MOUNT PLEASANT, NORTH EDGE.

1.2 50.9 RAILROAD CROSSING. Green River rocks exposed in the base of the Cedar Mountains to the west. The Gunnison



TEXT-FIGURE 82.—View northwestward from approximately Mile 48 (near the Mt. Pleasant airport). Coarse boulders in the foreground are mudflow-transported debris from the Wasatch Plateau to the east. The Cedar Hills in the background are held up by mid-Tertiary Moroni Formation, which caps the light-gray exposures of Green River Formation.

Plateau forms the skyline beyond the Cedar Mountains, with Price River-North Horn rocks exposed at its base and Green River rocks on the skyline. The road descends northward from the broad alluvial fan produced by Pleasant Creek and associated streams draining the western front of the Wasatch Plateau.

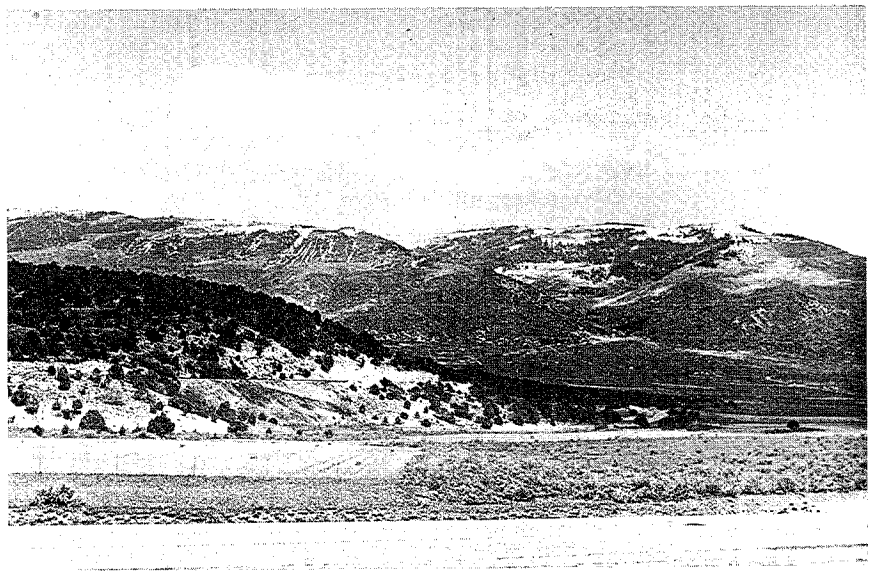
2.4 53.3 Cliff-forming sandstones west of the valley are in Green River Formation. Springs in the vicinity of the road issue at the toe of an alluvial fan from Birch Creek to the east.

1.4 54.7 FAIRVIEW, SOUTH EDGE (elev. 6,030). Green River beds are exposed in the base of the hills on the west of the valley. The Wasatch Monocline is well expressed by Green River and Flagstaff rocks in the Wasatch Plateau east of the valley. Sanpete Valley is in part a partial graben, a long, linear, down-faulted structure with a prominent fault along the western margin, much in the fashion of a hinged trapdoor. The road is in a subsequent valley carved in the Green River Formation, on top of the resistant, massive cuesta-forming limestone.

1.3	56.0	Fairview City Museum, one block to the east, is in an old schoolhouse made of Cretaceous sandstone.
0.6	56.6	FAIRVIEW, NORTH EDGE, junction of U.S. Highway 89 with Utah State Highway 31 eastward to Huntington, up Cottonwood Canyon (the V-shaped notch to the east). Much of the northern part of the community of Fairview is built on a broad alluvial fan constructed by debris washed out of Cottonwood Canyon (Text-fig. 83).
0.2	56.8	CROSS SAN PITCH RIVER. Here the San Pitch River is 6 to 8 feet below its floodplain and has additional narrow terraces 6 to 8 feet above the floodplain.
0.3	57.1	Green River Limestone exposures at the south end of the cuesta, at the margin of San Pitch River floodplain.
0.6	57.7	Additional outcrops of the tuffaceous Green River Formation can be seen in road cuts. The hills to the west are the Cedar Hills, which are capped by volcanic rocks of the Moroni Formation.

TEXT-FIGURE 83.—View northward along Sanpete Valley from the north edge of Fairview. Green River beds form the prominent westward-dipping cuesta along the west side of the valley. Coarse boulder debris in the foreground is near the distal edge of the alluvial fan built out from Cottonwood Creek and the Wasatch Plateau to the east.

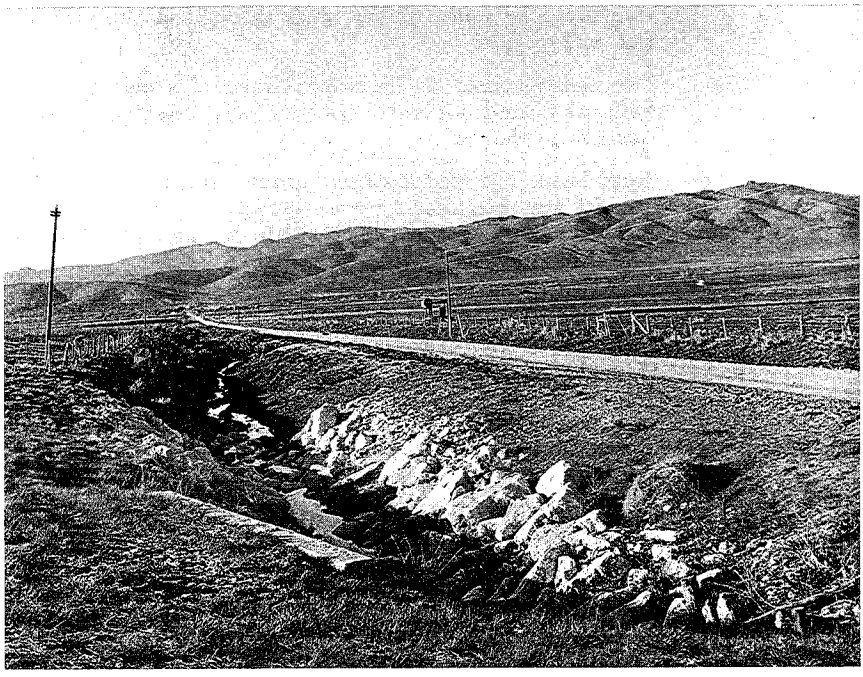
0.2	57.9	Green River Limestone exposures in road cuts on the east (right).
0.3	58.2	Prominent bend in the road. A wind gap is developed to the east, separating two cuestas of Green River Formation. To the southwest a broad, high, upland terrace was adjusted to a former high position of the San Pitch River.
0.5	58.7	Exposures of tuffaceous limestone in the Green River. Some of these limestone beds are algal-ball sequences; some, merely tuffaceous, volcanic ash-type shales.
0.9	59.6	Exposures of massive and blocky limestone in the Green River Formation occur in road cuts to the east. This is the resistant unit that holds up the cuesta top.
0.8	60.4	Subsequent valley development is particularly well shown here. Bedrock of the stripped limestone surface is exposed to the east. Alluvial fans and terracing are visible to the west. These alluvial fans are composed of material washed in from the volcanic rocks of the Moroni Formation exposed in the high hills one or two miles to the west.
1.6	62.0	Junction of gravel road to the east from the farming community of Milburn, in Sanpete Valley. Rest area to the west. A water gap is formed in the cuesta of Green River Formation to the east (right) (Text-fig. 84).



TEXT-FIGURE 84.—View eastward from the highway rest area at Mile 62. Green River Limestones are well exposed in railroad cuts in the middle distance. The terraced front of the Wasatch Plateau beyond Sanpete Valley is held up by Late Cretaceous and early Tertiary sedimentary rocks.

Prominent shoulders on the west-facing edge of the Wasatch Plateau to the east are held up by resistant sandstone beds in the upper part of the Tertiary and Cretaceous North Horn Formation. The plateau surface on top is in the Flagstaff Limestone, however.

0.8	62.8	RAILROAD OVERPASS OVER D&RGW RAILROAD. GEOLOGIC STOP 6. PULL OFF ROAD TO LEFT JUST BEFORE BRIDGE. Road cuts are in exposures rather characteristic of the upper part of the Green River Formation. Abundant fish and turtle fragments, small ostracods, and snails can be collected out of the ledge-forming unit visible near the top of the road cut on the north side of the old road. Examine some of the loose blocks that have tumbled down: the best material is frequently exposed by weathering of the blocks.
0.6	63.4	Outcrop of thick Green River Limestone bed that forms the crest of the cuesta. It holds up the erosional surface because of its resistance. The softer shales above the limestone have been stripped away. The bed is in large part an algal limestone with crinkled laminae. One may also collect fossils from this bed. Mt. Loafer, ahead on the skyline, is in the Wasatch Mountains and is held up by Oquirrh beds. Cirques have formed on the high peak.
0.8	64.2	Excellent outcrops of green shale and white limestones of the Green River Formation in the road bend. Many of the limestone beds are fossiliferous, and some of the shale beds associated with the limestone have an abundant leaf flora.
0.6	64.8	Outcrop of shale and limestone of the Green River Formation in cut on the east. Notice the small gully below the general level of the valley to the west. It is 8 to 10 feet deep and is cut through soft alluvium, leaving almost vertical arroyo banks.
1.6	66.4	Green River Formation is well exposed to the east and forms bluffs on both sides of the valley, where it is capped here and there by high-level terrace gravels.
0.8	67.2	Cross bridge over small gully. This gully is an excellent demonstration of headward erosion. Shortly after the highway was constructed and the channel deepened, all the area immediately to the southwest of the road and bridge was flat land. The gullies now cutting into the soft farmland have developed in the past 15 years, largely as a result of the lowering of the stream channel. Before bridge construction the water normally had been widely spread; now the water is concentrated and has a lot of erosive power (Text-fig. 85).
2.3	69.5	JUNCTION OF SIDE ROAD FROM INDIANOLA, the small farming community to the east. Light-gray and tan



TEXT-FIGURE 85.—View northeastward along county access road to the small community of Indianola. Rounded mature topography beyond the community is on Cretaceous and Tertiary coarse clastic sediments and has developed at the northwestern edge of the Wasatch Plateau.

cones near the valley floor to the southwest are composed of tufa deposits from warm springs. Mormon baptisms were held in these small warm springs in the early days.

0.6 70.1 CROSS UTAH COUNTY–SANPETE COUNTY LINE AND LEAVE THISTLE VALLEY. The high peaks to the east are on the northern part of the Wasatch Plateau. Thistle Valley separates the Wasatch Range, to the west, from the Wasatch Plateau, to the east.

0.2 70.3 HISTORICAL MARKER OF AN INDIAN MASSACRE that took place in the vicinity of the clumps of willows to the west. The gravel quarry is in tuffaceous gravels probably derived from the Moroni Formation.

6.4 76.7 Road rises from the floodplain of Thistle Creek. Gravel terraces show in road cuts to the east. Here Thistle Creek has entrenched only slightly into the broad fluvial floodplain of the valley. The floodplain is in large part a depositional feature, having filled in a much more deeply excavated valley to the level of the present relatively flat surface. Some abandoned meander channels of Thistle Creek can be

recognized by more marshy areas throughout the generally flat valley floor.

0.3	77.0	Two ranch houses on the west. Gravel was obtained from both weathered Moroni Formation and terrace gravels in quarries to the east.
0.6	77.6	Road bend. The road has risen up the southern margin of an alluvial fan. High-level terrace gravels are visible both east and west of the road. Grayish bedrock outcrops are of the Moroni Formation.
0.3	77.9	Excellent development of high-level terraces, part way up the western valley wall, that now are being eroded.
0.5	78.4	Here the road is on one of the higher terraces. Notice the flat upland surface, now veneered by alluvial fan material out of canyons to the east. Boulders and gravel here are relatively fine, which would suggest that the veneer is composed of stream-washed rubble rather than mudflows. Equivalent terraces seen across the valley to the west mark a former level of Thistle Creek.
1.5	79.9	Roadside cuts are through terrace gravels which have partially filled Thistle Creek Valley and suggest 2 or 3 cycles of development for the valley.
0.7	80.6	Ranch house (east) and a small reservoir west of the road. Somewhat ahead to the northeast, red rocks of the Indianola and Price River formations form the skyline (Text-fig. 86).

TEXT-FIGURE 86.—Northeastward to the Birdseye Quarry (arrow) from approximately Mile 80. The quarry is in pisolitic North Horn Formation, according to Pinnell (1972). Juniper-covered hills to the right expose the Indianola Formation.

This is the type section of the Indianola Formation. Gray outcrops of the Moroni Formation, with terraces etched into their surfaces, can be seen across the valley to the west and southwest.

0.2 80.8 Folded conglomerate and redbeds of the Indianola Formation visible in hills to the east.

0.1 80.9 Poor road-cut exposures of the gray, tuffaceous Moroni Formation.

0.5 81.4 The backslope of Mt. Nebo is visible to the southwest at the creek junction. Coarse terrace gravels and the underlying tuffaceous Moroni Formation are visible to the east of the road.

0.5 81.9 Junction of a major tributary of Thistle Creek from the southwest.

0.6 82.5 Terraces visible off to the west are 30 to 40 feet above the valley floor. As these terraces are traced upstream they converge, but here they are still widely separated. This terrace is the same as the intermediate terrace in the community of Birdseye.

0.8 83.3 Exposures of terrace gravels, probably mudflow debris and alluvial fan outwash from the high country at the headwaters of the canyons to the east. The very coarse, irregularly sorted large blocks were probably rafted here by mudflows. Coarse texture and angular shape of fragments distinguish these fan deposits from the rounded stream terrace material below.

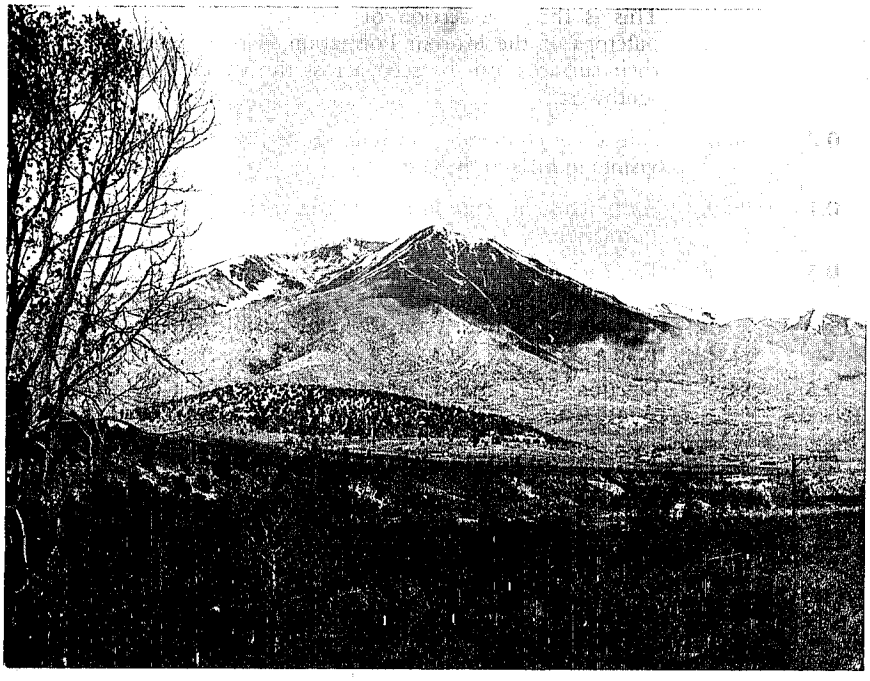
0.3 83.6 Gravel quarries visible in terraces to the west, north of the ranch. These quarries, developed for road metal during construction of the highway, show the coarse cobble and boulder nature of the deposit. Vertical Oquirrh beds show in Mt. Loafer to the north (Text-fig. 87).

0.3 83.9 Road cuts through tuffaceous beds of the pink Moroni Formation.

0.4 84.3 GEOLOGIC STOP 7. BIRDSEYE AND JUNCTION OF THE ROAD TO BENNY CREEK CANYON. The high, flat, upland surface to the southwest is held up by Tertiary rocks that angularly overlie the folded Paleozoic formations. Excellent exposures of the pinkish tuffaceous volcanic rocks occur east of the junction, near the church house. The Birdseye marble quarry in North Horn Formation is visible on the skyline to the east (right) (Text-fig. 88).

0.3 84.6 Pink outcrops of the tuffaceous Late Tertiary rocks exposed east of the road.

0.4 85.0 Three terraces can be seen to the west from about here: (1) a small terrace 10 to 15 feet above Thistle Creek; (2)



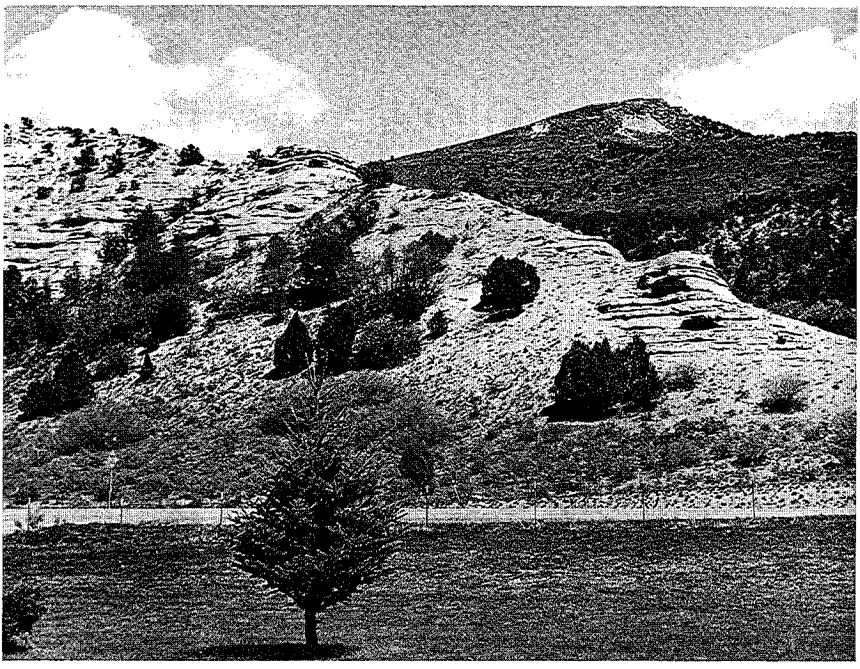
TEXT-FIGURE 87.—View northwestward across Thistle Valley to Mt. Loafer. Terraces in the foreground are cut across mid-Tertiary tuffaceous and conglomeratic rocks of the Moroni Formation. Mt. Loafer is held up by steeply dipping Oquirrh Formation with younger Permian and Triassic rocks forming hogbacks along its eastern foothills.

a major terrace at about the elevation of the road, 30 to 40 feet above the stream; and (3) the high terrace, approximately 100 feet above the road elevation.

0.2 85.2 Two terraces visible across the valley to the west represent pulses of downcutting of Thistle Creek.

0.6 85.8 GEOLOGIC STOP 8. PULL OFF ROAD TO WEST at the side road that leads to the ranches on the west slope of the canyon. The irregularly carved face of the quarry where the algal-ball limestones of the North Horn Formation were obtained can be seen to the southeast high on the skyline. This is the "Birdseye" marble quarry and was operated in the early 1900s. Some blocks of the "Birdseye" marble can still be seen at the old loading site along the railroad track about a hundred yards to the southwest of the road junction.

High-level terraces, up to 200 feet above the valley floor, show both east and west of the road but are most pronounced on the west side of the valley. Occasional ex-



TEXT-FIGURE 88.—View eastward, from the church grounds at Birdseye, to the Birdseye quarry on the hill on the skyline. Pink Moroni Formation forms the weakly sculptured ledges immediately east of the highway.

posures in some of the gullies show some of the characteristic stream-pebble gravels that form the terrace (Text-fig. 89).

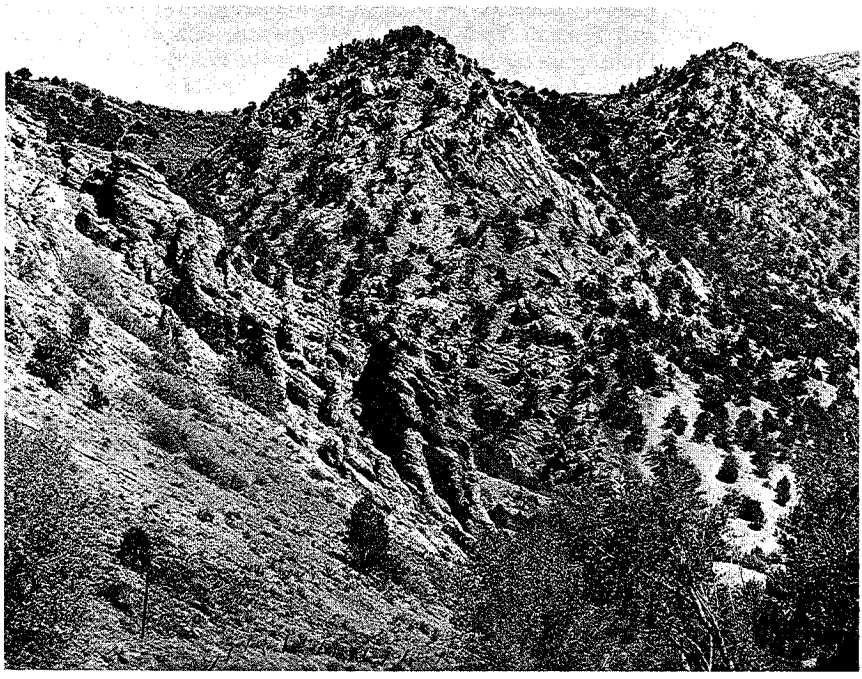
The floodplain of Thistle Creek was modified by high spring floods in 1952 and again in 1973. The valley bottom used to be broad pasture lands, but the floods of 1952 enlarged the meander pattern of the creek as the stream flow increased. The pasture lands were almost destroyed. Immediately south of the road intersection, road cuts on both sides show the coarse stream gravel characteristic of the terrace material. These gravel deposits partially filled the valley but are now being re-excavated; thus, Thistle Valley here is in part resurrected.

0.5	86.3	Cuts through tuffaceous units in the Moroni Formation. Small springs issue to the south of the road from the base of the tuffaceous unit. This road cut is usually damp all year long.
0.4	86.7	Double road cuts in alluvial fan and terrace material 70 to 80 feet above the valley floor. Sorting of the gravel is relatively poor, but the rounding is moderately good. This combination of characteristics is rather common in stream-

TEXT-FIGURE 89.—View westward from Mile 86 across coarse boulder terraces cut into tuffaceous rocks of the Moroni Formation. Mt. Loafer is the high peak in the background. Small springs that serve the local ranches issue through porous units in the Moroni Formation.

deposited material. Terrace gravels here are unconformable over the volcanic Moroni sequence.

0.4	87.1	Hoodoos are well developed in eastward-dipping Moroni Formation immediately to the west of the railroad bridge over Thistle Creek, on the southwest side of the canyon. The immediate canyon has been carved into these volcanic rocks for some distance from the south. Red Navajo Sandstone is exposed on the valley walls beyond (Text-fig. 90).
0.3	87.4	Moroni volcanic rocks are exposed in two road cuts on the east side, at the crest of a major bend in the highway. Basal beds of the formation are exposed on the south side of the small valley, which has a broad alluvial fan at its mouth.
0.2	87.6	Excellent exposures of very coarse Moroni volcanic conglomerate in road cuts on the east side of the road.
0.4	88.0	GEOLOGIC STOP 9. Outcrops of coarse volcanic conglomerate in basal beds of the Moroni Formation. These are dark grayish green outcrops and contain a variety of altered volcanic rocks. These conglomerates and associated volcanic rocks rest with angularity on the older tilted rocks below. The same formation is exposed in several road cuts on the east side of the road, but the eastward-dipping Mesozoic rocks are exposed to the west. Thistle Creek here is in a subsequent valley along the lower edge of the volcanic rocks and is, in some respects, a resurrected valley.



TEXT-FIGURE 90.—Hoodoos in the steeply dipping Moroni Formation in the foreground near Mile 87 are in coarse tuffaceous conglomerate. The Moroni Formation rests with angularity against the steeply dipping Navajo Sandstone that forms the rocky ledges in the background.

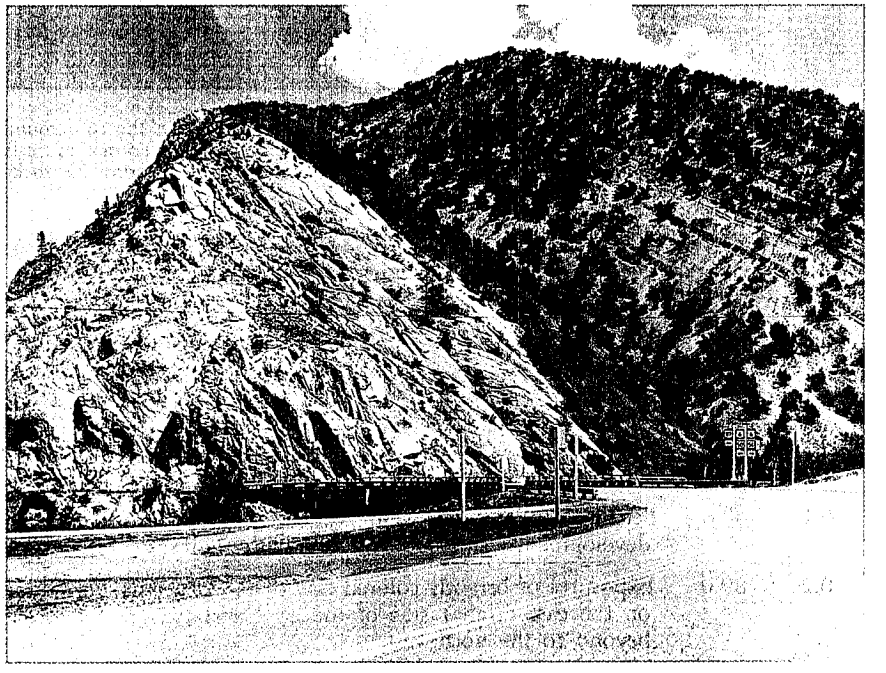
0.3	88.3	White Upper Cretaceous sandstone exposed to east in valleys. Flats are site of former town and mine of Asphaltum built to exploit asphaltic sandstone in Flagstaff Formation.
0.4	88.7	Outcrops of variegated pink and gray shales of the Flagstaff (?) Formation on the east side of the road. Entrenchment of Thistle Creek below the floodplain shows well in the canyon bottom to the west. Thick fill of poorly sorted alluvial-fan material exposed south of the road cut on the east side has entrenched into Flagstaff Formation.
0.1	88.8	Settling tanks to the west. Notice the gradual infilling and development of marshes in southerly tanks.
0.2	89.0	Exposures of brightly colored clay of the Flagstaff Formation on the east (right) side of the road and Navajo Sandstone beyond to the northwest.
0.5	89.5	Quarry in Twin Creek Limestone to the west. Bright red sandstone and siltstones of the upper part of the formation are exposed in bluffs to the east. High-level stream terraces are approximately 200 feet above the river. This terrace

marks a point of adjustment on the streams of Thistle Creek and Spanish Fork Canyon and may be related to renewed faulting along the Wasatch Fault at the mouth of the canyon or to downcutting through a step over Navajo Sandstone near Thistle.

0.2 89.7 THISTLE, SOUTH EDGE. Extensive road cuts in the upper part of the Twin Creek or Carmel Limestone. The angular blocky limestone is dipping gently to the east and is the upper part of the formation seen at Thistle.

0.2 89.9 Cross Thistle Creek to the west side. High country across the canyon to the west is a carved slope of Navajo Sandstone. Flagstaff and North Horn formations are exposed high on peaks to the east.

0.25 90.15 A basal, reddish, silty and sandy unit of the Twin Creek Formation is exposed in road cuts and on the north side of the highway junction, east of rounded exposures of Navajo Sandstone, near the bridge over Thistle Creek (Text-fig. 91).



TEXT-FIGURE 91.—Northward view of the massive Navajo Sandstone overlain by slope-forming Twin Creek-Carmel Limestone at Thistle Junction. Isolated large ponderosa pines mark one of the northernmost occurrences of this species in the Wasatch Mountains.

0.15 90.3 THISTLE JUNCTION. CROSS BRIDGE OVER SPANISH FORK RIVER. Crossbedded Navajo Sandstone is exposed at road level on the west. Basal beds of Twin Creek Formation are exposed just short of the bridge as well as in dramatic exposures beyond.

END OF PART 3

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NOTES

NOTES

STUDIES FOR STUDENTS

1 Guide to the Geology of the Wasatch Mountain Front, Between Provo Canyon and Y Mountain, Northeast of Provo, Utah: J. Keith Rigby and Lehi F. Hintze, 29 p., 1968. $.50

2 Guide to the Geology and Scenery of Spanish Fork Canyon Along U.S. Highway 50-6 Through the Southern Wasatch Mountains, Utah; J. Keith Rigby, 31 p., 1968. $.50

3 Bonneville—An Ice-Age Lake: Harold J. Bissell, 65 p., 1968. $.75

4 Guidebook to the Colorado River, Part 1: Lees Ferry to Phantom Ranch in Grand Canyon National Park: W. Kenneth Hamblin, J. Keith Rigby, Ray T. Matheny, and Joseph R. Murphy, 84 p., 1968 (reprinted and revised, 1972). $1.50

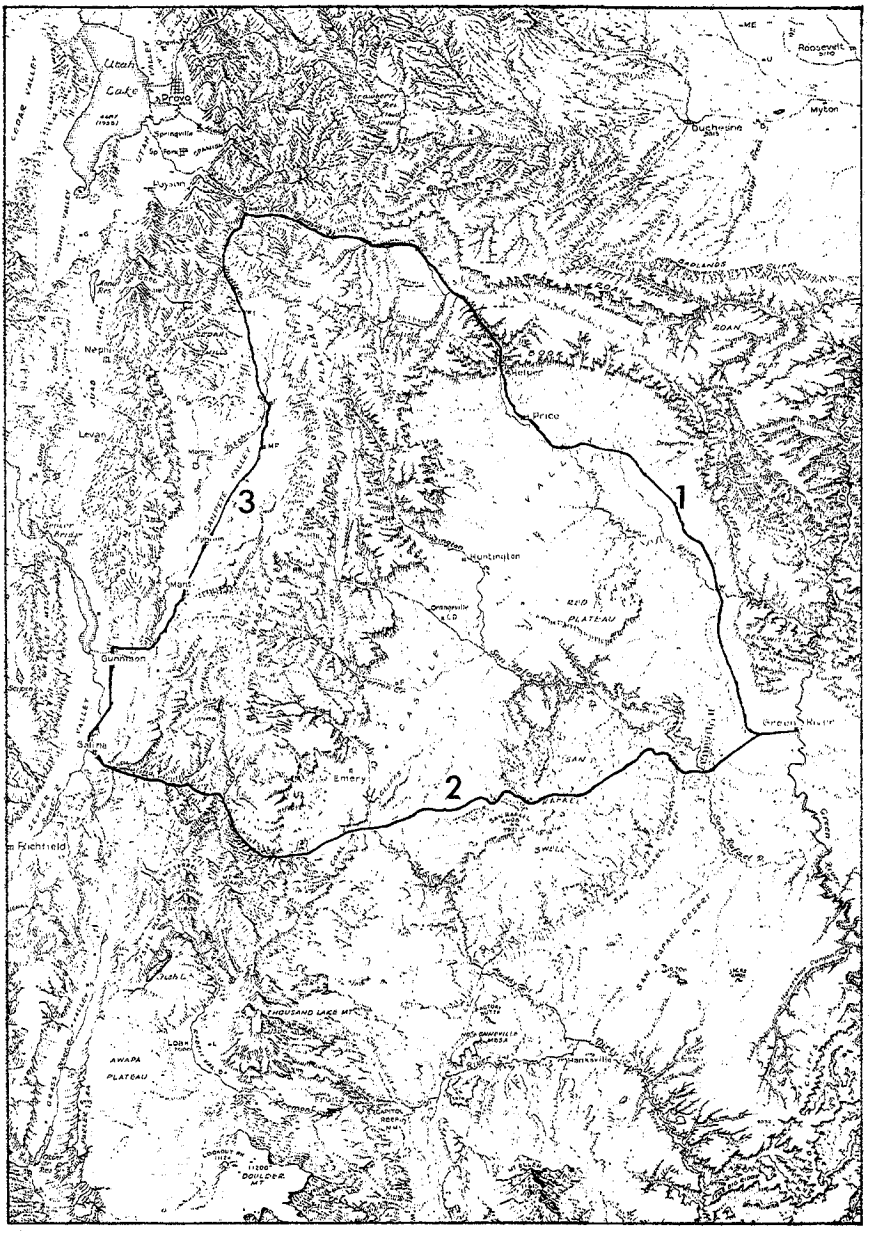
5 Guidebook to the Colorado River, Part 2: Phantom Ranch in Grand Canyon National Park to Lake Mead, Arizona-Nevada: W. Kenneth Hamblin and J. Keith Rigby, 126 p., 1969 (reprinted, 1972). $2.00

6 Guidebook to the Colorado River; Part 3: Moab to Hite, Utah, through Canyonlands National Park: J. Keith Rigby and W. Kenneth Hamblin, 91 p., 1971 (reprinted, 1972). $1.50

7 Geologic Road Logs of Western Utah and Eastern Nevada: Lehi F. Hintze, 66 p., 1973. $1.50

8 Geologic History of Utah: Lehi F. Hintze, 181 p., 1973. $2.00

9 Geologic Guide to the Northwestern Colorado Plateau: Part 1, Thistle to Green River, Utah, via U.S. Highway 50-6; Part 2, Green River to Salina, via Interstate 70; Part 3, Salina to Thistle, via U.S. Highway 89: J. Keith Rigby, Lehi F. Hintze, and Stanley L. Welsh, 117 p., 1974. $1.75



Index map of the three parts of the road log guide. Part 1 covers Routes 50 and 6 from Thistle to Green River. Part 2 is along Interstate Highway 70 from Green River to Salina and Part 3 is along U.S. Highway 89 from Salina to Thistle. Base from a physiographic map of Utah by M. K. Ridd.


THE GLORY OF GOD IS INTELLIGENCE