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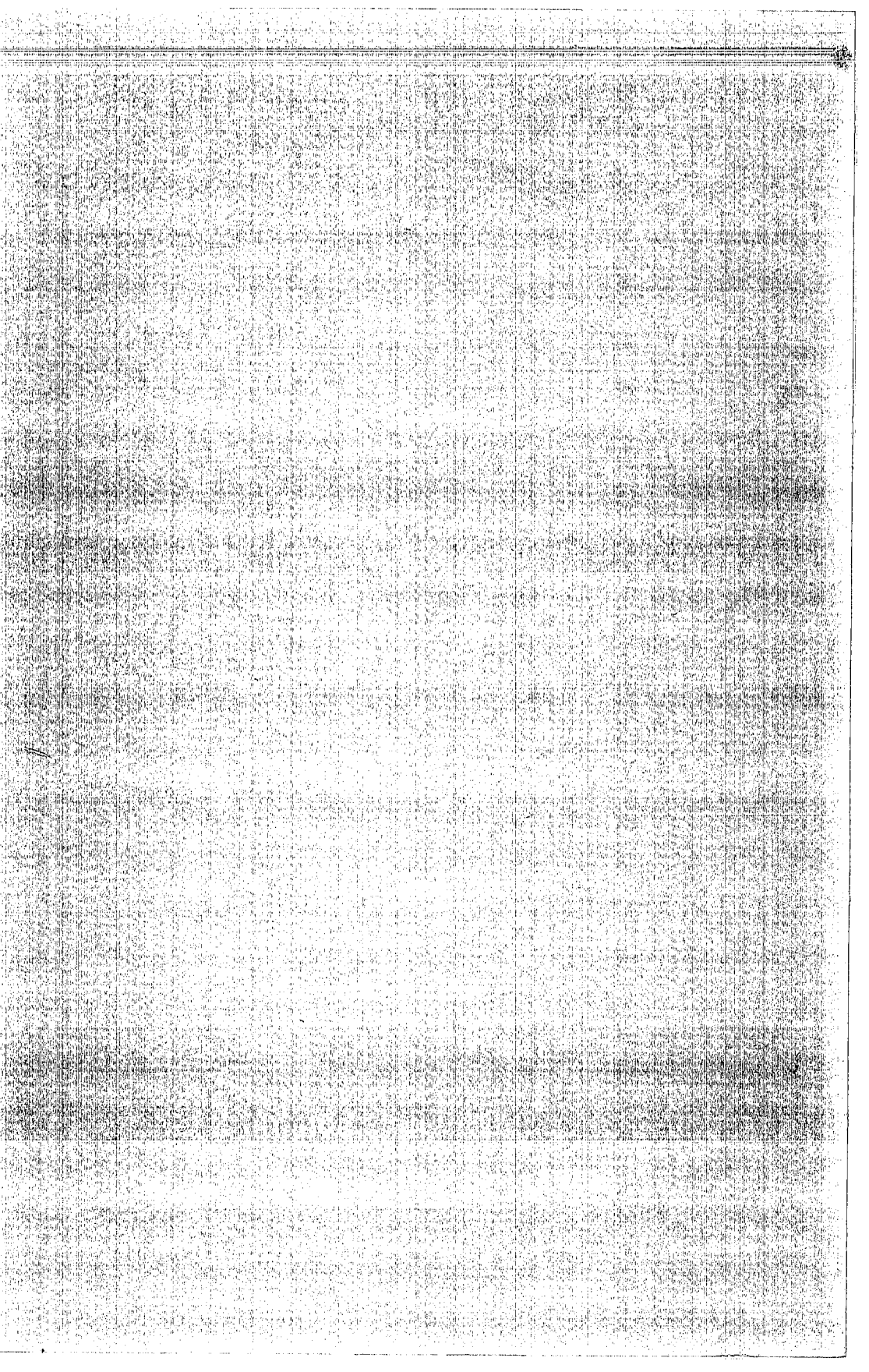

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Geology of the Pavant Mountains West of Richfield, Sevier County, Utah

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ABSTRACT.—36 square miles just west of Richfield, Utah, were mapped in detail to resolve stratigraphic and structural anomalies of earlier investigators. Bedrock exposed in the area includes the Flagstaff, Green River, Crazy Hollow, Bald Knoll, and Dry Hollow formations, all of Cenozoic age. The Crazy Hollow Formation is disconformable on the Green River Formation. The Green River Formation is present throughout the area; it does not pinch out, and is predicted to be present along strike to the southwest in the Sevier Quadrangle. It is recommended that the term *Grey Gulch Formation* not be used in the area of this report and that strata so called heretofore be included in the Bald Knoll Formation. Also the volcanic rocks are better assigned to the Dry Hollow Formation than to the Bullion Canyon Formation as previously suggested. This area is considerably broken by northeastward trending faults. Faulting and abundant local minor folding are the direct result of essentially vertical movement.

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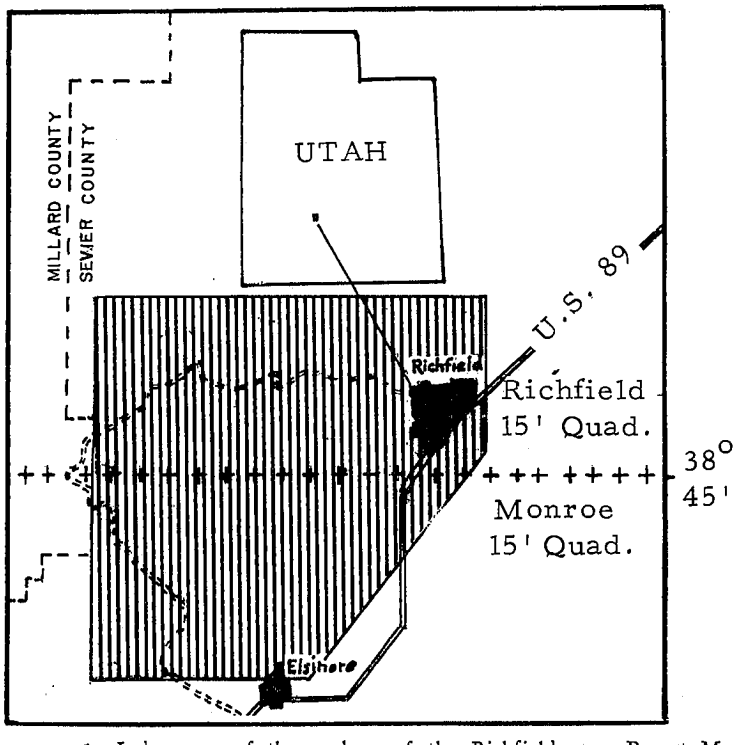
INTRODUCTION

This report deals with the geology of an area of approximately 36 square miles located west and southwest of Richfield, Utah (fig. 1 and plate 1). When viewed from Richfield the units, in sequence from oldest to youngest (fig. 2), appear to the northwest as pale greenish-gray Green River Formation, to the west as red sands and shales of the Crazy Hollow Formation, to the southwest as light buff, pale green, and pinkish-orange Bald Knoll Formation limestones, shales, and tuffs, and to the southwest along the abrupt Pavant Mountain-Sevier Valley border as dark lavas of the Dry Hollow Formation. These units form a predominantly "badland" topography which is not visible from Richifeld. The area of this report overlaps the borders of two previously mapped areas (figs. 1 and 3) in order to consider anomalies between the earlier works of Lautenschlager (1952) and Parker. Lautenschlager correlated sedimentary units into this area from the north, and Parker



TEXT-FIGURE 1.—Index map of the geology of the Richfield area, Pavant Mountains, Sevier County, Utah. Lined area shown on Plate 1.

(of Callaghan and Parker, 1961, 1962) traced the volcanics into this area from the south and southwest.

Field work of this study was accomplished during the summer of 1963. Initial field mapping was done on enlarged aerial photos at a scale of 1 inch equals 660 feet. The base map (scale 1:24,000) was compiled from two U.S. Geological Survey advance $7\frac{1}{2}$ minute topographic sheets (Richfield 1SE, Utah and White Pine Peak, Utah) for the area north of latitude 38° 45'. The scale of the topographic base was extrapolated south to latitude 38° 40' in conjunction with distances and locations obtained from the Monroe, Utah, 15' quadrangle of the U.S. Geological Survey. Drainage and geologic features were reduced and transposed onto the base map from aerial photo stereo pairs (scale 1:20,000) using a radial planimetric plotter with base control by the slotted template method.

Acknowledgments

The writer wishes to express thanks to the Department of Geology, Brigham Young University, for the use of their facilities and to DePauw University for research funds which helped to defray the expenses of this investigation.

CENOZOIC STRATIGRAPHY

Flagstaff Formation

This formation was defined by Spieker and Reeside (1952, p. 448) and later modified by Spieker (1946, p. 135). The type locality is on the slope of Flagstaff Peak in the Wasatch Plateau.

The part of the Pavant Range studied in this report is located about 50 miles southwest of the type Flagstaff. The Flagstaff Formation in the area studied is more clastic with less limestone than at the type locality where the formation consists dominantly of limestones and limy shales. The base of the Flagstaff Formation was not exposed in the mapped area although it is exposed to the north in the Pavant Range where it rests conformably on the Cretaceous-Tertiary North Horn Formation. The complete Flagstaff rock sequence was measured seven miles to the north in Strawberry and South Cedar Ridge Canyons continuously from the top of the North Horn Formation to the base of the Green River Formation for a total thickness of 1,900 feet.

Volume percentages of rock types that comprise the uppermost 400 feet of the Flagstaff Formation in the area studied consist of 4% conglomerates, 14% sandstones, 23% siltstones, 51% shales, and 8% limestones. Conglomerates are present in the upper portion and are mostly brick red and gray. Sandstones are silty, calcareous, and medium to fine-grained, and for the most part are light gray, red to dark reddish-brown, and dull purple. Siltstones are bright red, bright orange-red, and brick red with minor amounts of gray and purple. Shales vary in bright and dull colors of orange reds, brownish-reds, reddish-purples, and greenish-grays. Shale is generally evenly intercalated throughout the Flagstaff Formation of this area. The limestone is white and light purple, with minor amounts of pale yellow, and it is generally massive.

Lautenschlager (1952) extended the Flagstaff Formation into this area as part of E. M. Spieker's Ohio State University graduate mapping program. LaRocque (1960, p. 1) dates these rocks in central Utah as upper Paleocene to lower Eocene on the basis of the fossil assemblages.

The contact of the Flagstaff Formation with the overlying Green River Formation seems conformable but is not readily observed. However, a micaceous, organic appearing sandy clay dug out of the contact zone has the appearance of a soil zone. In the mouth of Cottonwood Canyon (center of section 23) this material has undergone incipient metamorphism, forming a hardened argillaceous sandstone at the contact of folded and faulted Green River limestone.

Green River Formation

This Eocene formation was defined by Hayden (1869, p. 190) along the Green River west of Rock Springs, Wyoming. This unit was extended into Colorado and Utah by Bradley (1929a, 1929b, 1931) and extended into the Wasatch Plateau by Spieker and Reeside (1925, p. 451). More recent work has extended this unit to the Gunnison Plateau (Katherman, 1948; Taylor, 1948; Hardy, 1948; Hunt, 1948, 1950; Babisak, 1949; Zeller, 1949), Valley Mountains (Gilliland, 1951), Long Ridge (Muessig, 1951), and Pavant Range (Lautenschlager, 1952.)

In the Pavant Mountains west of Richfield the Green River Formation is approximately fifty to sixty feet thick and is a key marker horizon to the local stratigraphy and structure. This formation is a white to gray limestone

with significant minor localized lithologic facies variations. Investigation along a continuous two-mile outcrop reveals local areas of siliceous limestone, fine calcareous quartz sand, limeclast red limestone, massive (lower) to thin bedded (upper) micrite limestone, pellital limestone and a dispersed faceted pebble conglomerate in limestone. Additional outcrops evidence spherical algal concentrations and dispersed black chert nodules and pebbles. There are coarse conglomerates (approximately 5-7 inches in diameter) at the boundary between the Green River and Crazy Hollow formations in the vicinity of the water tank immediately west of Richfield, Utah.

Lautenschlager (1952) extended the Green River Formation into the area of this report, where he believed it to wedge out. He stated (p. 62), "Here the Green River forms a tongue between the adjacent formations and thins southward until it disappears." His map of the area shows the "disappearance" to occur in the acute angle of a wedge formed by two faults. No evidence for the existence of the southeastern of these faults could be found by the writer, and the northwestern fault is believed to be extended erroneously to the southwest. The Green River Formation does not "disappear" or wedge out, but was traced by the investigator in proper relationship to the structure and stratigraphy throughout the mapped area. It is predicted to continue to be present in the Sevier quadrangle, southwest of the area of the present report (plate 1).

The relationships of the Green River Formation to the underlying Flagstaff and overlying Crazy Hollow formations are discussed under those respective formations.

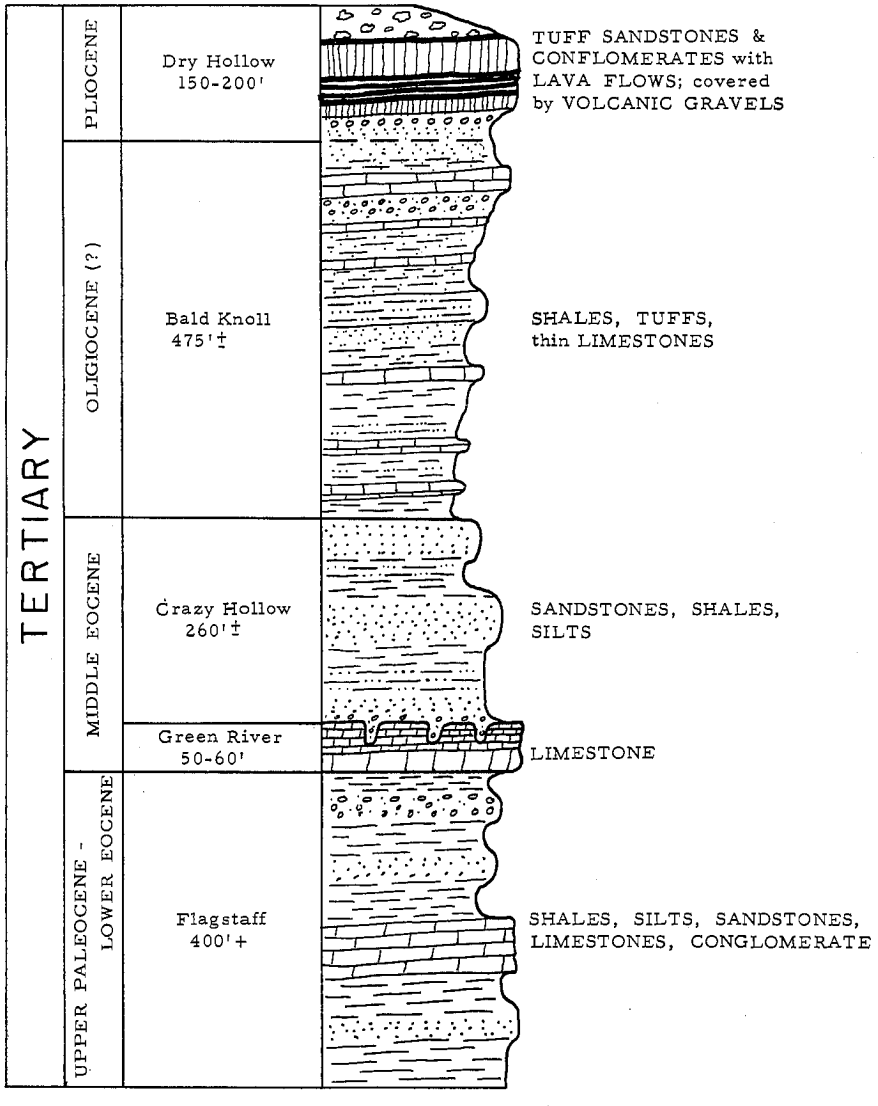
Crazy Hollow Formation

Spieker (1949b, p. 36) defined this formation as the clastic beds below the Gray Gulch Formation and above the Green River Formation in the type locality at Crazy Hollow on the south side of Salina Canyon $2\frac{1}{2}$ miles east of Salina, Utah.

In the area of this report the Crazy Hollow Formation is approximately 260 feet thick and forms the red hills just west of Richfield, Utah. This formation is composed of 60% sandstone, 10% siltstone, and 30% shale. Quartz sandstone units are tan, red, and gray and for the most part are quite massive. Sandstone varies from fine to very coarse-grained with local areas of pebble conglomerate in the upper portion of the formation. The massive tan sandstone units weather differentially, resulting in local areas of picturesque indentations and scallops in weathered blocks. Siltstone is not a dominant unit by itself, but is gradational and forms an integral part of the shales and fine sandstones. Shale is brick red and its dominant color associated with its ease of weathering causes it to wash over, cover, and color associated rocks, particularly the Green River in the Flat Canyon area.

Lautenschlager (1952, p. 69) assigned an age of middle Eocene for the Crazy Hollow Formation. He extended this formation into the area of this report and stated (p. 64), "Where the base is exposed the Crazy Hollow formation overlies the Green River formation conformably except southeast of Little Valley where Green River is not present. There it overlies the Flagstaff Formation in apparent conformity . . . ."

This quoted statement is believed to be in error. The Crazy Hollow is unconformable on the Green River as is evident where Crazy Hollow is present in channels in the top of the Green River along the east ridge of Little



TEXT-FIGURE 2.—Generalized geologic section of the rocks exposed in the Pavant Mountains west of Richfield, Utah.

Valley (NW ¼, NE ¼, Sec. 29, T. 22S, R.3W) and also in the west center of sec. 23, northwest of Richfield, where a red-colored Crazy Hollow channel is exposed in a horst ridge of gray Green River strata. In addition, in sections 23 and 26, T. 22S, R.3W, there is a limestone pebble size breccia (limeclast limestone) and a quartz pebble and boulder conglomerate at the boundary between the Crazy Hollow and Green River formations. Also, with reference to the above quote, the Green River Formation is present between the Crazy

Hollow and Flagstaff formations southeast of Little Valley where it forms the floor of parts of the canyons; consequently the Crazy Hollow Formation does not "overlie the Flagstaff Formation in apparent conformity" (plate 1).

Most contacts with the overlying Bald Knoll Formation suggest conformable relationships except in some disturbed and faulted areas where an indefinite two- or three-degree angular unconformity is indicated, but this may be the result of local deformation.

Bald Knoll Formation

The Bald Knoll Formation was defined by Gilliland (1951, p. 43) from the type locality at the mouth of Bald Knoll Canyon in the Valley Mountains (west of Gunnison, Utah). According to Lautenschlager (1952, p. 70) later investigations at the type locality have shown the presence of pyroclastic beds that originally were not detected.

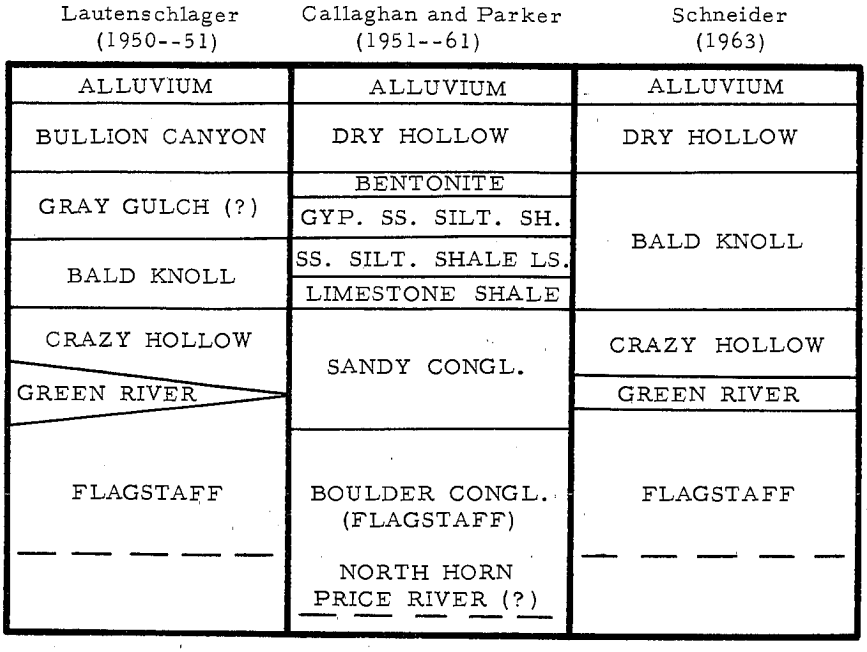
The thickness of the Bald Knoll Formation as used in the area of this report is approximately 475 feet and consists of 40% tuffs, 55% shales, and 5% limestones. Limestones and shales are most abundant in the lower portion. These gradually grade upward into an interspersing of altered tuff-shales, tuffs, and limestones and then into predominantly tuffs in the uppermost units (just below the Dry Hollow volcanics). Limestones in the lower portion are fossiliferous, and upon breaking the darker rocks a distinct petroleum smell is obtained. Limestones are 0.5 to 1.5 feet thick and range from light to dark brown in the lower part to light tan and gray in the upper. Shales range from light olive drab greens in the lower portion through purple and orange tan in the middle to green grays in the upper part. In the lower units and shales are paper thin and brittle while in the upper units the shales grade and mix with tuffs, thin gypsum stringers, and possibly bentonitic shales. Distinct tuffs are found in the uppermost part of the section and are predominantly gray with minor amounts of green. Tuff particles range in size from fine sand to pebble conglomerate in a tuff sand matrix.

Lautenschlager (1952) extended the Bald Knoll Formation into this area and on the basis of stratigraphic position assigned it an age of late Eocene or early Oligocene. He tentatively named the overlying unit "Gray Gulch?" on the basis of its being a pyroclastic unit and the suggested equivalence with the pyroclastic Gray Gulch of the Salina district (25 miles to the north), which is above the Crazy Hollow.

Lautenschlager (1952, p. 164) shows the "Gray Gulch?" to be composed totally of tuffs while Callaghan and Parker (1961) show their equivalent lithologies (fig. 3) to consist of gypsum, sandstone, siltstone, and shale. This investigator has found, in addition to all of these above lithologies, white limestone units (verified by then section analysis) in NE ¼, NW ¼, Sec. 4, T. 24S., R.3W., and NW ¼, SE ¼, Sec. 12, T.24S., R.4W., in the upper "Gray Gulch." Furthermore, white conglomerate and black rubbly limestone were found in NW ¼, SE ¼, Sec. 2, T.24S, R.4W., at the top of the "Gray Gulch?"

In the area of this report the bottom limestones and shales (Bald Knoll of Lautenschlager) are slightly different from the uppermost tuffs and limestones ("Gray Gulch?" of Iautenschlager), but the gradation is very gradual and at no place is there a distinct or discernible dividing unit.

Because of the gradational nature of the sequence and the presence of sediments (particularly limestone) within and above the section of "tuff?"



TEXT-FIGURE 3.—Correlation chart of lithology and terminology relationships of the various investigations.

measured and described by Lautenschlager (1952, p. 164) the term *Grey Gulch* designating a complete pyroclastic unit is not used by me and the rock sequence under question is included in the Bald Knoll Formation. As such, this is a practical, readily workable unit; however, if deemed necessary, one could make thin sections of the total section and perhaps arrive at an arbitrary boundary based on the varying percentages of pyroclastic material present.

The contact with the underlying Crazy Hollow Formation is discussed under that heading, and the contact of the overlying Dry Hollow Formation is conformable and, to a degree, gradational. The upper limit in the area of this report is a distinct green bentonitic tuff, which is not always readily observable, but can be discerned at the mouth of Flat Canyon (SE ¼, Sec. 17, T.24S., R3W.) and in places in the smaller canyons immediately to the north.

Dry Hollow Formation

The name *Dry Hollow Latite* was originally proposed and described by Callaghan (1939) and later (1951) redefined to Dry Hollow Formation and mapped into this area by Parker (Callaghan and Parker, 1961, 1962). The type locality is in Dry Hollow (sec. 8, T. 25S., R. 4W.). Kerr (1957, p. 23) described a well-exposed locality in the Silica Hills 5 miles north of Marysvale, Utah, where the formation is approximately 700 feet thick.

Because of faulting and the blanket nature of the volcanics in the area of this report, the total thickness is indeterminate but approximates 150-200 feet. Volcanics consist, for the most part, of rhyodacites-trachyandesites, (quartz

latites - latites), andesites, tuffs, tuff conglomerates, and volcanic boulder and gravel cover.

Rhyodacites-trachyandesites are reddish-brown and gray and generally porphyritic. Andesites are grayish-brown and suggest local flows. Tuffs are interlayered with the rhyodacites-trachyandesites and andesites and contain gravel, pebble, and boulder conglomerates. Most of these volcanics are covered by a volcanic gravel-boulder mantle and crop out only in canyons, ridges, and peaks. For the purpose of this report these general volcanic units were not differentiated in the mapping.

Lautenschlager (1952, p. 85) assigned these volcanics to the (Miocene?) Bullion Canyon Formation on the basis of Callaghan's (1939) data. Later Parker (Callaghan and Parker, 1961, 1962) completed mapping of the Sevier and Monroe quadrangles and assigned these volcanics to the redefined Dry Hollow Formation and dated them as Pliocene (?) in age. The rock descriptions of both Lautenschlager and Parker are essentially the same as those found by this investigator in the area under study. The present author therefore follows Parker in using Dry Hollow rather than Bullion Canyon as the formation to which these volcanics are assigned.

Alluvium

The alluvium is divided into three general catagories: alluvium, alluvial fan gravels, and alluvial landslide materials. The alluvium is the valley fill which has undergone cultivation. The fan gravels are the areas of alluvial fan deposition which, except for two areas at the head of Little Valley, are located at the intersection of the intermittent resquent stream mouths with Sevier Valley. Landslide alluvium is located in two minor areas as noted on the map with the area NE 1/4, SE 1/4, Sec. 25, T. 23S., R. 3W. developing between 1950-1958. The depocenter for the alluvium washed out of this area is the Sevier Valley which, according to Young and Carpenter (1961), contains approximately 800 feet of fill at Richfield, Utah.

STRUCTURE

The Pavant Mountains are a Basin and Range uplifted block bordered on the east by the Sevier normal fault and the west by an unnamed normal fault (Maxey, 1946, Crosby, 1959). This structural block is tilted relatively higher on the west, forming an eastward-dipping homocline. In the Richfield area the homoclinal dip averages 10 degrees to the southeast. The homocline is cut by normal faults and horst-graben structures that trend northeastward parallel to the Pavant Range.

Folding

Folded structures are minor features resulting mainly from associated faulting; however; numerous small anticlines and synclines exist throughout the report area. They are usually more obvious in the limestone beds, and a large concentration is located in section 23, T. 23S., R. 3W., in the Green River Formation. The relationship of the folding to faulting is described below.

Faulting

The most obvious major structural feature within this report area is the graben which forms Little Valley, with the topographic center located in

section 20, T. 23S, R. 3W. Within this major graben are two horst ridges bordering the lower portion of Little Valley at the junction of Cottonwood Creek. The structural trend of the Little Valley graben and associated horsts is northeastward. This structural trend is true for this whole area with the exception of occasional east-west trending minor cross faults. The cross-cutting relationships of the fault systems suggest the major northeastward system to be the oldest and the minor cross-cutting faults to be youngest .There is no evidence to suggest recurrent or recent movement.

All the fault planes appear essentially vertical except for the southeastern fault of the horst located at the SE 1/4, NW 1/4, SW 1/4, T. 23S, R4W, which dips southeast at approximately 45 degrees and the northwesternmost fault (NW 1/4, NE 1/4, NE 1/4, Sec. 25, T. 23S, R. 4W), which locally also dips approximately 45 degrees southeast. The tectonic activity of this report area seems confined to vertical adjustments. There appeared to be no horizontal offset or displacement on the faults. For the most part the folding is directly related to vertical forces as indicated by vertical slickensides, drag fold structures adjacent to faults, and fold structures that develop into vertical faults along strike. The structure in the vicinity of sections 6 and 7, T. 24S, R. 3W, consists of step and horst-graben faults with minor associated folding. The fault displacements mentioned below are approximate estimates and are included in order to give the reader some magnitude of measure.

Little Valley, located in the vicinity of sections 19, 20, 30, T. 23S, R. 3W, is a complex graben composed of the folowing faults described and numbered in order across the valley from the northwest to the southeast (plate 1):

(a) The northwesternmost two faults are step faults with a minimum displacement of 130 feet for the northwesternmost (major fault) and 30 feet for the second (minor fault) to the southeast. The second fault (minor) terminates at the southwestern margin of Little Valley and the major fault continues to the southwest with an increase of the minimum displacement to 300 feet.

(b) Faults Three and Four form the first horst which, at the junction of Cottonwood Creek, has a minimum displacement of 50 feet for Fault Number Three and 80 feet for Fault Number Four. This horst decreases in displacement to the southwest and merges into one fault 300 feet north of the intersections of the fault and the Forest Service road.

(c) Faults Five and Six form a second horst, which forms in part, the southeastern margin of Litle Valley. At the junction of this horst and Cottonwood Creek the displacement of the northwestern fault, Number Five, is 150 feet and the southeastern fault, Number Six, is 100 feet. This horst, like the one described above, also decreases in displacement to the southwest and merges into one major fault at the southeastern terminus of the topographic Little Valley. Where the forest service road starts down off the east ridge of Little Valley (SE 1/4, SE 1/4, section 20, T. 23S, R. 3 W), this horst has undergone extensive deformation as evidenced by the faulted and folded rocks. This deformation with the convergence of the horst border faults and the small magnitude (15 feet) of displacement of the southeasternmost fault compared with that at Cottonwood Creek (minimum of 100 feet), suggests that this area was a locus of the terminus and a pivot area for the vertical movement of the horst faults which diverge and increase in vertical displacement to the northeast.

The Little Valley graben extends northeast of Cottonwood Creek a minimum of 1-1/2 miles with the bordering faults diverging. At Cottonwood Creek the Little Valley graben is 1-1/2 miles wide, and this width decreases to the southwest with the convergence of the border faults to a width of less than 1/2 mile (SE 1/4, sec. 35, T. 23S, R. 4W). The topographic Little Valley comprises only the northeast quarter of the structural Little Valley graben.

SUMMARY AND CONCLUSIONS

Anomalies existing in the structure and stratigraphy of the geologic mapping by Lautenschlager (1952) and Parker (Callaghan and Parker, 1951-61) were resolved by detailed mapping (figs. 1 and 3). Cenozoic stratigraphy includes the Flagstaff, Green River, Crazy Hollow, Bald Knoll, and Dry Hollow formations (fig. 2). The lithology consists predominantly of sandstones, and shales with smaller amounts of conglomerates, limestones, tuffs, and rhyodacites-trachyandesites.

The Green River and Crazy Hollow formations are the key to local stratigraphy and structure, and both are present throughout the report area in their proper relation to the structure and stratigraphy (see plate 1). Green River strata contain many local facies variations along continuous outcrops. Crazy Hollow strata are disconformable on the Green River Formation.

In this report the term *Gray Gulch(?)* is not used because there is no adequate field distinction as to where to delineate a contact between the Bald Knoll and Gray Gulch Formations, due to the gradational nature of the strata and because of the presence of several limestone units in what was designated as a unit locally composed wholly of tuffs. The corresponding strata are included in the Bald Knoll Formation.

The volcanic sequence has been assigned to the Dry Hollow Formation after Parker (Callaghan and Parker, 1951-61), and Lautenschlager's usage of Bullion Canyon Formation for these same rocks has been dropped by this writer.

The structure consists of numerous minor folds, predominantly the result of faulting, with major and minor faults trending northeast (plate 1). The major faults with the greatest displacement are numbered at the northern border of plate 1. The major structural feature, other than the Sevier Valley Fault, is the complex Little Valley Graben, which contains two subsidiary horst ridges.

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