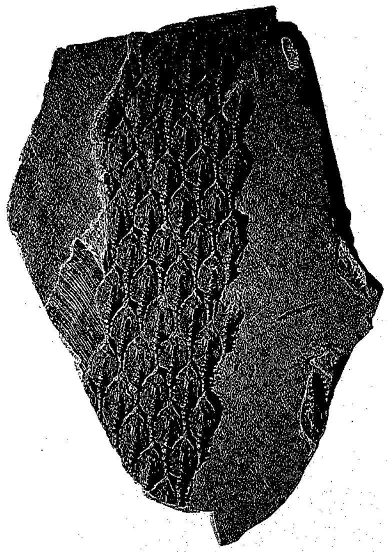
BRIGHAM YOUNG UNIVERSITY



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CONTENTS

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Cover: *Lepidodendron* sp. from the Manning Canyon Shale Formation. Donated by Gary Harris to the BYU paleobotanical lab.

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Geology of the Fairview $7^1/_2'$ Quadrangle, Sanpete County, Utah

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ABSTRACT

Stratigraphy and structure of the Fairview Quadrangle are transitional between the Colorado Plateau and the eastern Basin and Range. Late Cretaceous and Tertiary fluvial-lacustrine North Horn Formation, lacustrine Flagstaff Limestone, deltaic Colton Formation, and lacustrine Green River Formation are exposed in the quadrangle. Thick conglomerate units in lower and upper members of the Green River Formation were shed from a nearby northern source. A thick section of calcareous shale and limestone, previously differentiated as Crazy Hollow Formation, was mapped as the upper member of the Green River Formation because of its lithology. The sandy Crazy Hollow Formation was interpreted to pinch out a short distance south of the Fairview Quadrangle. Volcanic breccia and tuff of the Moroni Formation unconformably overlie the Green River Formation.

Quaternary deposits in the quadrangle include valley alluvium, alluvial fans, landslide of several ages, and a pediment gravel veneer that was deposited over the truncated upper member of the Green River Formation as the Moroni Formation weathered. High potential for future landslides occurs in steep-walled canyons and along the mountain front east of Sanpete Valley, particularly where the middle member of the North Horn Formation is exposed.

The Fairview Quadrangle is generally divided, structurally, into two parts by the Stone Quarry Fault, named here. The eastern part of the quadrangle is dominated by the west-dipping Wasatch Monocline, which is offset by contemporaneously formed faults. These faults apparently propagated northwestward in the southeastern part of the quadrangle and northeastward in the northeastern part of the quadrangle. The monocline becomes a normal fault in the Indianola Quadrangle directly to the north. West-dipping homoclinal beds, west of the Stone Quarry Fault, are offset by post-Moroni Formation faults that possibly occurred during Basin and Range extension.

Formation of the monocline has been related to salt diapirism south of the Fairview Quadrangle, but no unconformities, sedimentary thinning over salt bodies, or obvious gravity lows were located in the quadrangle. Instead, the monocline appears to be associated with basement movement.

INTRODUCTION

Origin of structural and stratigraphic relationships along the transition zone of central Utah has been the subject of some debate. It has been suggested that the Wasatch Monocline formed as Sanpete Valley collapsed due to the solution and removal of underlying salt (Witkind and Page 1984, p. 146). Previous studies have outlined the major geologic features in the northern Sanpete Valley region, but this more detailed study documents characteristics as well as nature and timing of Tertiary deformation in the Fairview Quadrangle (fig. 1). Surface mapping was supplemented by a gravity survey in order to evaluate the possible presence of subsurface salt masses.

Mass-movement potential is of major concern to Sanpete Valley residents because landslides and mudslides have disrupted roads, drainage, and water supplies in the last few years of above-normal precipitation. Exposures of certain rock units, such as the middle member of the

A thesis submitted to the Department of Geology, Brigham Young University, in partial fulfillment of the requirements for the degree of Master of Science, November 1985.

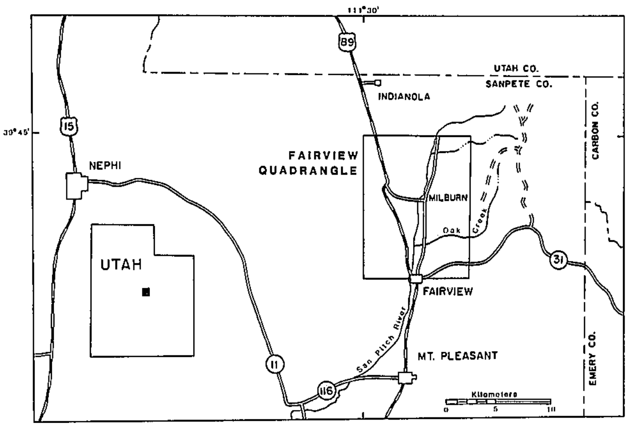


FIGURE 1.—*Index map of the Fairview Quadrangle.*

North Horn Formation, were evaluated for future mass-movement potential based on evidence of past movement in the quadrangle.

LOCATION AND ACCESSIBILITY

The Fairview 7½′ Quadrangle is located on the western slope of the Wasatch Plateau and includes part of the northern end of the Wasatch Monocline (fig. 1). It is about 86 km south of Provo on U.S. 89. Utah 31 passes through the southeastern corner of the quadrangle and meets Skyline Drive, from which the eastern part of the quadrangle is accessible during summer months. A network of unimproved roads give access to the remainder of the quadrangle during dry weather. Most of them are on private land, and permission to use them should be obtained from local land owners.

PREVIOUS WORK

The Fairview Quadrangle has been included, in part, within several regional geologic studies of the Wasatch and Gunnison Plateaus. Considerable work was done on the stratigraphy and structure by Spieker (1936, 1946, 1949a, 1949b) and by Spieker and Reeside (1925). The southeastern part of the quadrangle was mapped in reconnaissance fashion by Pashley (1956) in a study of the area between Spring City and Mount Pleasant. The western part of the quadrangle was mapped by Schoff (1951) and Fograscher (1956) in studies of the Gunnison Plateau. Hintze (1962) compiled a summary map of the southern Wasatch Mountains, which included the western part of the Fairview Quadrangle. Walton (1955) published a regional study on the Wasatch Plateau gas fields and noted several faults and folds on his structural maps of the plateau. Godfrey (1978) published a survey on surface instability on the Wasatch Plateau. Witkind (1982, 1983) and Witkind and Page (1984) have recently worked on structure, stratigraphy, and salt diapirism in the area, but their efforts have been concentrated largely to the south and west. Standlee (1982) discussed the effect of Jurassic rocks on the tectonic development of central Utah. Brown and Cooke (1982) did a regional gravity survey in central Utah that included some stations in the Fairview Quadrangle. Detailed studies in adjacent areas have been done by Runyon (1977) on the Indianola Quadrangle directly to the north, by Hawks (1980) on the northwest quarter of the Moroni Quadrangle directly to the west, and by Oberhansley (1980) on the Fairview Lakes Quadrangle adjacent on the east.

PROCEDURES

Stratigraphic and structural relationships in the quadrangle were mapped on 1:18,600 and 1:21,100 aerial photographs and compiled on a 1:24,000 topographic base. Surface mapping was supplemented by a gravity survey in the quadrangle and adjacent vicinity. The survey was done with a Worden-type gravimeter. Stations were chosen on the main roads and highways where elevations were either known or could be approximated to within 2 ft. Readings were taken at 60 stations with approximately 1 km spacing. Milligal readings were reduced to usable values with the Bouguer equation. Three of the best-exposed stratigraphic sections were measured, and one channel sample was taken from coal beds in the middle member of the North Horn Formation for later analysis for humate content by the Utah Geological and Mineral Survey.

ACKNOWLEDGMENTS

Appreciation is expressed to Dr. J. K. Rigby, who served as thesis chairman, for encouragement and valuable advice. Thanks go to Drs. J. L. Baer and L. F. Hintze for their assistance as committee members. Special thanks are given to the Utah Geological and Mineral Survey and the Associated Students of Brigham Young University Research Fund for financial assistance. I appreciate the constant support of my wife Valerie and our children.

STRATIGRAPHY

GENERAL STATEMENT

Rocks exposed in the Fairview Quadrangle range in age from Late Cretaceous to Recent (fig. 2). The North Horn Formation consists of interbedded sandstones, mudstones, shales, and freshwater limestone, with minor coal. The Flagstaff Limestone is dominantly a gray freshwater limestone with interbedded gray mudstones and minor red mudstone lenses. The Colton Formation is varicolored shales with minor limestone and sandstone beds. The Green River Formation is mostly green, buff, or light brown interbedded shale and limestone with several thin volcanic ash beds. The Moroni Formation is a quartzitic or volcanic conglomerate overlain by intermediate-composition volcanic flows, fluvial volcanic breccias and conglomerates, and ashflows. Weathering of the Moroni Formation has produced a pediment and gravel-veneered surface over much of the upper Green River Formation in the western part of the quadrangle. Alluvial fans, alluvium, landslides, and pediment gravels are differentiated Quaternary units in the quadrangle.

Summaries of the history of nomenclature, extent, and dominant regional lithologies of the formations exposed in the Fairview Quadrangle and surrounding areas have been presented by McGookey (1960), Moussa (1965), Hardy (1962, 1963), and Doelling (1972). The following discussions primarily concern rocks exposed in the Fairview Quadrangle.

CRETACEOUS-TERTIARY SYSTEM

North Horn Formation

The North Horn Formation covers much of the eastern one-third of the quadrangle where it crops out within canyons that cut rocks of the Wasatch Monocline as well as between canyons on frontal dip slopes (fig. 3). Spieker (1946, p. 133) divided the North Horn section into four informal units at the type area but noted that the four-fold division is less useful elsewhere. Pashley (1956, p. 38) used a two-fold division in the Spring City area. Hunt (1950, p. 74) used a three-fold division in the northern Gunnison Plateau. Oberhansley (1980, p. 78–79) concluded that a three-fold division is appropriate for these rocks in the Fairview Lakes Quadrangle, and essentially the same three-fold division is used in the Fairview Quadrangle. Boundaries of the three units cannot be mapped throughout the quadrangle due to poor exposures; but they can be recognized in Oak Creek Canyon. The upper two members are easily recognizable in Dry Creek Canyon (fig. 4). Contacts between the members are conformable.

The lower member is approximately 140 m thick and is mainly sandstone with interbedded shale or mudstone. Individual beds are generally less than 2 m thick. Sandstone beds crop out as rounded ledges and are usually covered by vegetation. The sandstone is generally light gray to yellow gray and very fine to medium grained. Interbedded shale and mudstone are represented by red, brown, or tan soil slopes.

The middle member of the North Horn Formation is about 225 m thick and is well exposed in the lower parts of Dry, Oak, and Cottonwood Canyons. These middle beds are interbedded gray to brown calcareous shale and limestone, gray mudstone, and minor sandstone and coal.

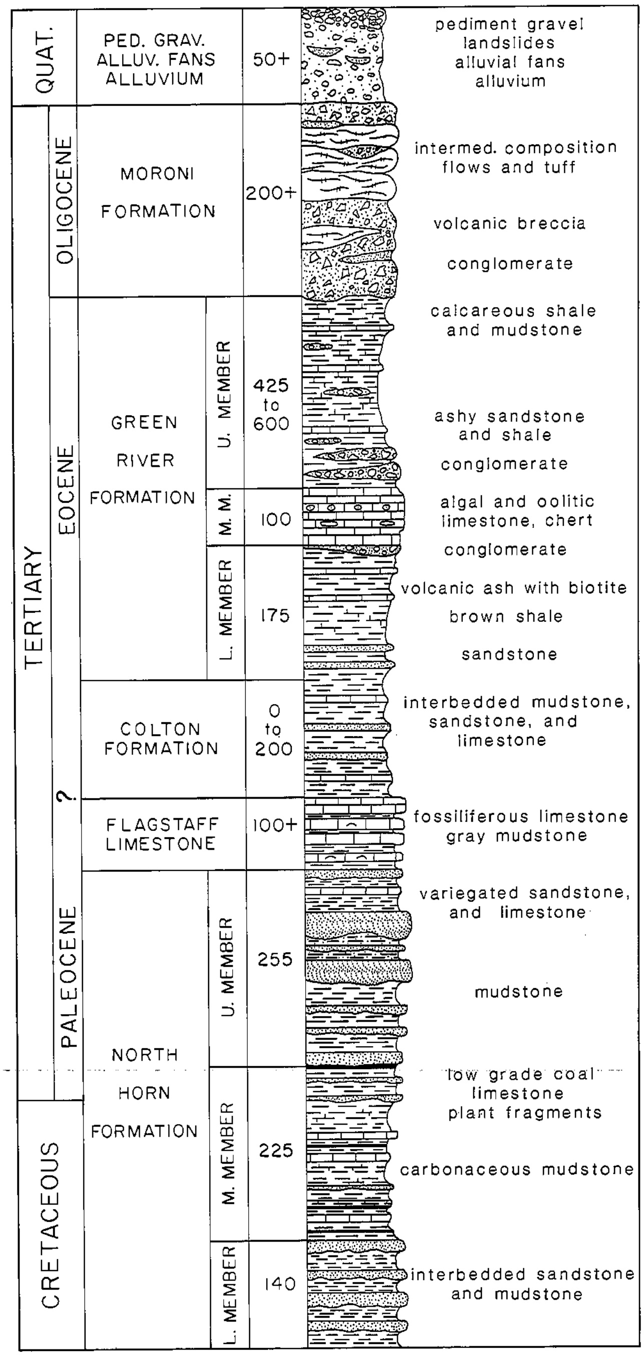
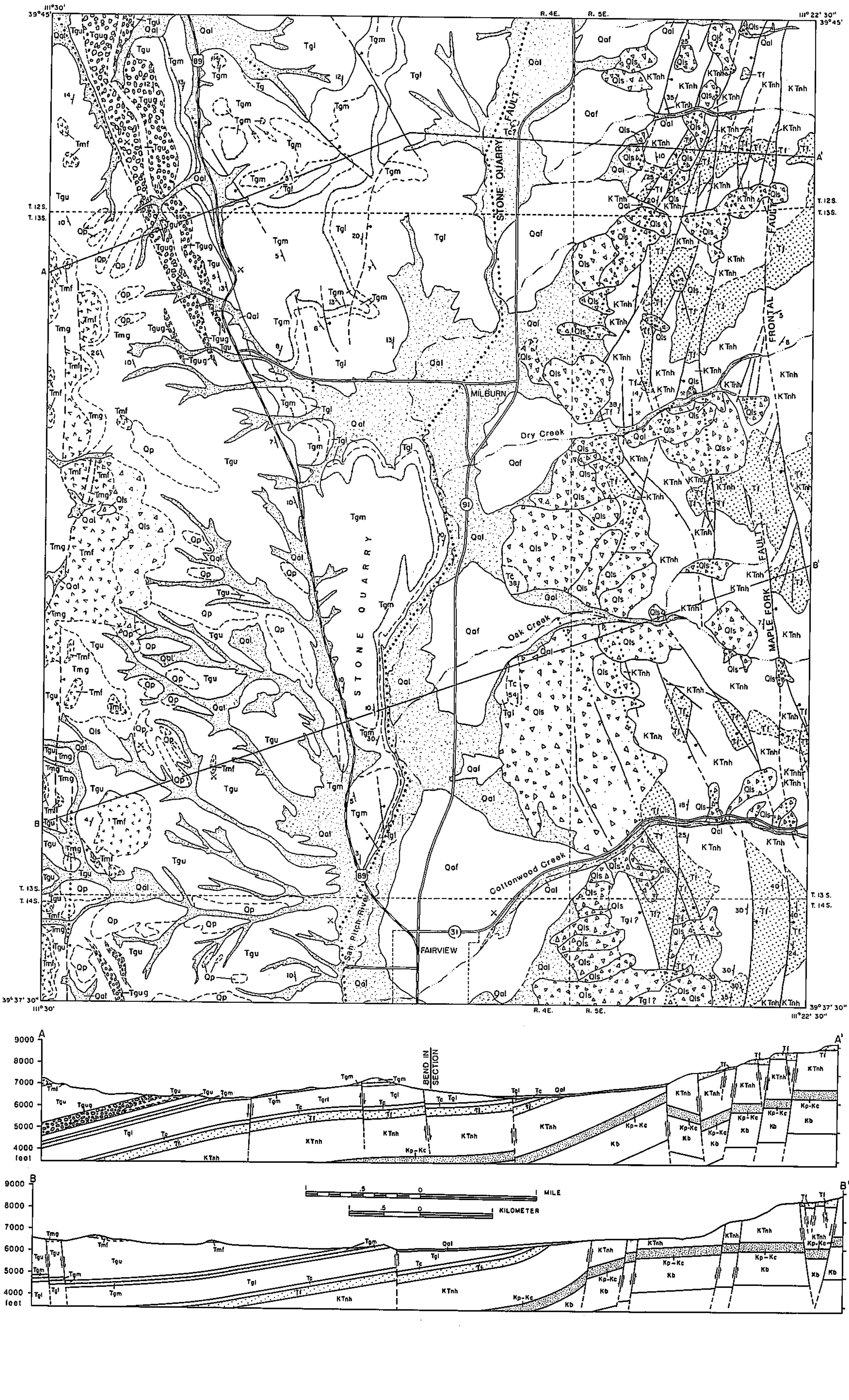


FIGURE 2.—*General stratigraphic column of the rocks exposed in the Fairview Quadrangle.*


111°30'
39°45'
R. 4E.
R. 5E.
111°22' 30"
T. 12S.
T. 13S.
T. 14S.
STONE QUARRY FAULT
FRONTAL FAULT
MAPLE FORK FAULT
STONE QUARRY
MILBURN
Dry Creek
Oak Creek
Cottonwood Creek
San Pitch River
FAIRVIEW
89
91
31
39°37' 30"
A
A'
B
B'
BEND IN SECTION
9000
8000
7000
6000
5000
4000
feet
MILE
KILOMETER
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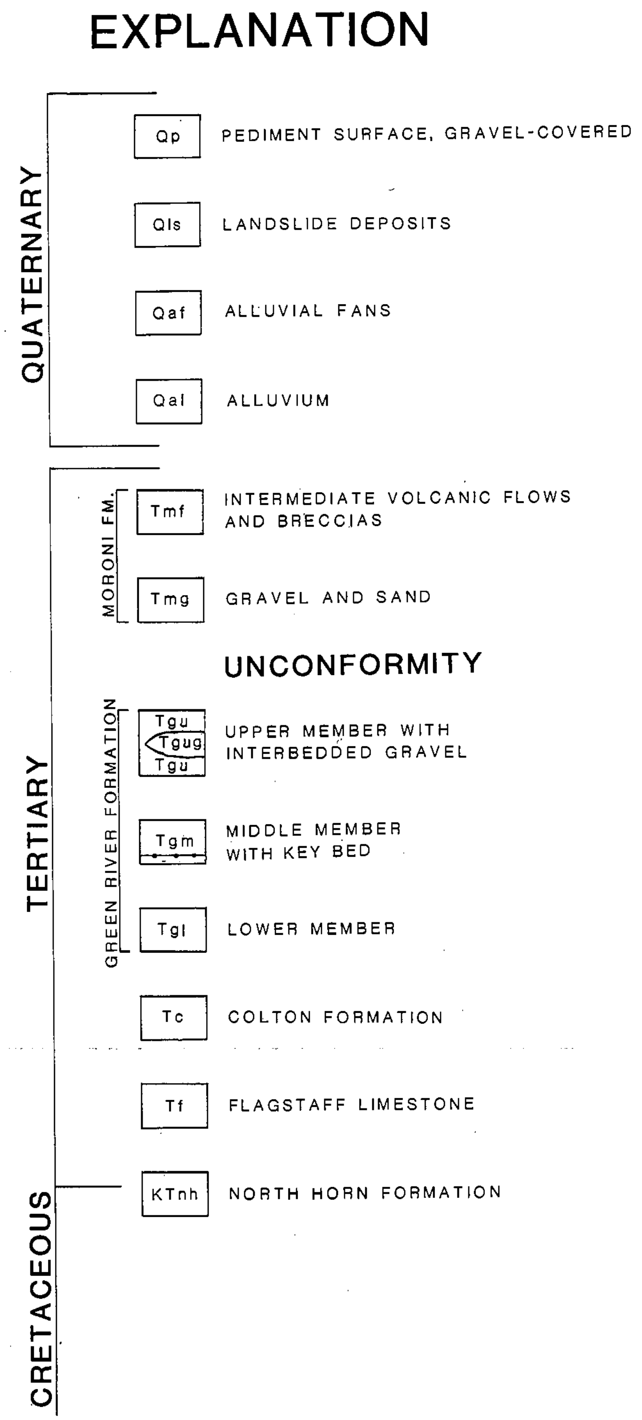

FIGURE 3.—*Simplified geologic map and cross sections of the Fairview Quadrangle (facing page).*

This member is correlated to the Wales Member in the Wales Coal Field, 15 miles to the southwest, where it was named by Bayley (1948, p. 28). Oberhansley (1980, p. 79) noted that these shales are rich in plant fragments. Gastropods, ostracods, and fish plates are also common to abundant. The low-grade coal in this unit, as noted by Pratt and Callaghan (1970, p. 59), is mined from the slopes of Dry Creek Canyon, but—as seen in figure 4—in a small operation. This member is the most unstable of the North Horn members and has been involved in the recent landslides, discussed below. The middle member is overlain by a distinctive 2-m-thick sandstone bed, well exposed near the mouth of Dry Creek, that begins the upper unit of the formation.

The upper member of the North Horn Formation is approximately 255 m thick and is exposed high on walls of all the canyons that cut the west slope of the plateau. This member is similar to the lower member and is mainly interbedded sandstone and shale. Sandstone beds are most abundant and commonly form prominent ledges. In Dry Creek Canyon, for example, two thick sandstone cliffs are held up by these rocks high on the south-facing slope. The upper of the two sandstones is underlain by 5 m of gray to variegated mudstone. The lenticular sandstone channel fill cuts into the mudstone and grades upward from a very coarse- to a very fine-grained sandstone.

A distinctive conglomerate bed occurs approximately 40 m from the top of the member and serves as a good marker throughout the quadrangle. The conglomerate is less than 3 m thick. Limestone and quartzite cobbles up to 10 cm across are dominant clasts. The matrix is a distinctive red, medium-grained sandstone, which makes the bed stand out. It is especially well exposed on the plateau margin between Lone Pine Creek and South San Pitch Canyon in section 30, T. 12 S, R. 5 E. North of the boundary between sections 29 and 30, T. 12 S, R. 5 E, it has weathered to form a gravel-covered dip slope on a hogback.

The top of the upper member of the North Horn is marked by a distinctive mottled to variegated limestone. From Dry Creek northward, this bed is near or at the top of a red-bed sequence that caps the formation. This red unit stands out on color photographs and provides an easily recognized contact with the overlying gray Flagstaff Limestone.

Upper and lower contacts of the North Horn Formation are gradational throughout much of the quadrangle. Oberhansley (1980, p. 80) mapped the basal contact at the lowest occurrence of red mudstone above the thick sandstones of the Price River Formation. Such a contact was not identifiable in lower Oak Creek Canyon where beds equivalent to the boundary exposed in Cottonwood Canyon may crop out, based on formation thicknesses.

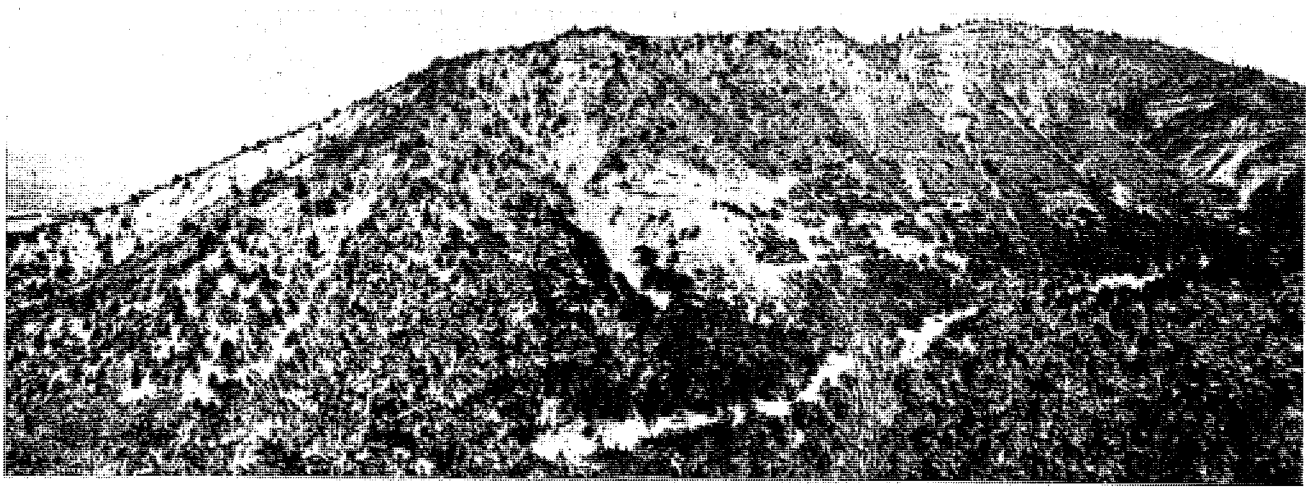

FIGURE 4.—*North wall of Dry Creek Canyon showing the American Ferto lignite mine and the Wasatch Monocline.*

The two formations are similar in this part of the plateau. Gill (1950, p. 18) noted that the North Horn and Price River Formations were difficult to distinguish in the Manti area.

The contact with the overlying Flagstaff Limestone ranges from completely gradational in the southern part to a sharp contact in the northern part of the quadrangle. South of Cottonwood Creek the limestone and red beds interfinger, and the exact boundary is somewhat arbitrary within a few meters. North of Cottonwood Canyon, however, the contact is sharp, for light gray shale of the Flagstaff Limestone lies directly on the bright red upper North Horn Formation.

TERTIARY SYSTEM

Flagstaff Limestone

The Flagstaff Limestone, like the North Horn Formation, is widely exposed in the eastern part of the quadrangle where the limestone caps ridges above canyons that cut the monocline. Flagstaff beds also crop out on the face of the plateau in dip slopes on the monocline where they have been faulted down against North Horn beds. Units in the Flagstaff Limestone are not easily mapped on the plateau face because of poor exposures.

A complete section of the Flagstaff Limestone is not exposed in the quadrangle. Oberhansley (1980, p. 81) noted that over 100 m of lower Flagstaff beds are exposed on Choke Cherry Peak, in the northwestern corner of the adjacent Fairview Lakes Quadrangle. His (1980, p. 81–82) description of the Flagstaff Limestone is of that section near the boundary of the two quadrangles, and equivalent rocks in the Fairview Quadrangle are similar to that section. Flagstaff beds shown in figure 5 are also exposed along Utah 31 near the mouth of Cottonwood Canyon in the NE 1/4, section 31, T. 5 E, R. 13 S, where a section of limestone 100 m thick was measured and described by Pashley (1956, p. 57–59). Several minor faults, discussed by Pashley (1956, p. 86), intersect the section and are readily evident in roadcuts.

The Flagstaff Limestone in the Fairview Quadrangle is composed of alternating ledge-forming limestone and slope-forming shale or mudstone. The limestones are gray and have undulatory bedding surfaces. Beds range from a few centimeters to 1 or 2 m thick, but average about 1 m. Gastropods, pelecypods, and ostracods are by far the most abundant fossils in the limestone beds, as was noted by Oberhansley (1980, p. 81). Oncolites up to more than 10 cm in diameter are also common, especially near the contact with the North Horn Formation.

La Rocque (1960, p. 81–82) noted that the freshwater limestones of the Flagstaff Limestone accumulated in a basin that formed in tectonical Paleocene time. Stanley and Collinson (1979, p. 312) suggested that the Flagstaff Lake formed in a foreland basin during last stages of Sevier folding.

Colton Formation

The Colton Formation is locally exposed as a thin unit in the foothills near the mouth of Oak Creek Canyon. Outcrops are poor because of extensive mass movement, vegetation cover, and float of weathered North Horn and Flagstaff beds from the mountain face above. Thickness of the formation here is impossible to determine but is less than 300 m. The Colton Formation is best exposed in the north central part of section 25, T. 4 E, R. 13 S, where unimproved roads have uncovered the steeply dipping beds. A small patch of red shale crops out next to Utah 91 in section 36, T. 12 S, R. 4 E. It may be an exposure of Colton Formation and was questionably mapped as such. If it is Colton Formation, the occurrence suggests that the Colton Formation lies between the Flagstaff and Green

FIGURE 5.—*Flagstaff Limestone beds included in monoclinal folding, roadcut along Utah 31, mouth of Cottonwood Canyon.*

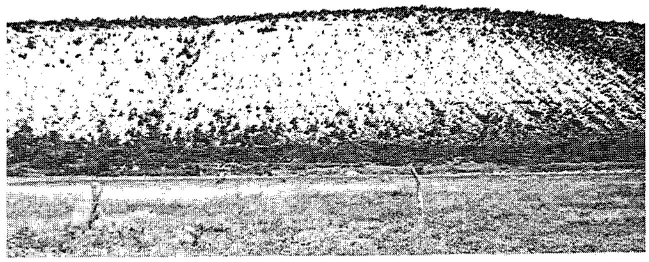

FIGURE 6.—*Green River Formation exposed on a cuesta face west of Milburn.*

River Formations throughout most of the quadrangle but is buried by alluvium. South of Cottonwood Creek, however, the Green River Formation appears to lie on the Flagstaff Limestone as noted by Pashley (1956, p. 63). Mase (1957, p. 39) noted that the Colton Formation does not occur in the Indianola embayment and that the Flagstaff Limestone lies in gradational contact with the Green River Formation. Such stratigraphic relationships suggest that the Fairview Quadrangle was at the limit of Colton deltaic deposition.

The fluvial-lacustrine beds of the Colton Formation, as Pashley (1956, p. 61–62) noted, are mainly varicolored shales interbedded with minor gray to brown sandstone and limestone beds. Pashley (1956, p. 61) also noted that the Colton beds appear to intertongue with Flagstaff and Green River beds.

Green River Formation

The Green River Formation is the most widespread formation in the Fairview Quadrangle. It is extensively exposed throughout the entire western half of the quadrangle, within and west of the prominent north–south-trending cuestas in the middle of the quadrangle (fig. 6). It is overlain unconformably by the Moroni volcanic section or Quaternary cover.

The Green River Formation was studied in detail by Faulk (1948) in the Manti–Spring City area and by Fograscher (1956) in the Cedar Hills, which include the western half of the Fairview Quadrangle. In both studies the formation was divided into three broad units on the basis of lithology. Fograscher (1956) measured and described several detailed sections and correlated them to rocks described by Faulk. For the purpose of this study the Green River Formation was divided into three members. The lower two members correspond nearly to the lower two units described by Faulk (1948) and Fograscher (1956), but the upper member used here includes all beds up to the base of the Moroni Formation, including those mapped as Crazy Hollow by Fograscher (1956).

The lower member of the Green River Formation is about 175 m thick. It is principally green and brown shale, sandstone, and conglomerate with lesser amounts of limestone. In the northern part of the quadrangle, in sections 34 and 27, T. 12 S, R. 3 E, over 40 m of interbedded sandstone and quartzite conglomerate are exposed near the top of the member (fig. 7). The coarse clastic beds thin rapidly southward until less than 10 m of conglomerate occur in the central part of section 10, T. 13 S, R. 4 E. At the north end of the prominent cuestas in the middle part of the quadrangle, the conglomerate appears to be only 1 or 2 m thick. Sandstone beds crop out at the base of the cuesta, but the conglomerate crops out more than halfway up the face of the cuesta. This suggests that the coarse unit interfingers with shales, southward. The sandstone beds are calcareous, poorly sorted, cross-bedded, and fine to medium grained. The greenish conglomerate beds are relatively resistant and form a ledge that was chosen as the contact between the lower two members of the formation. Quartzite clasts in the conglomerate range from an average of over 10 cm in diameter in the northern part of the quadrangle to less than 1 cm in diameter where the unit is exposed at the southern end of the cuesta.

The middle member of the formation is about 100 m thick and is mostly algal, ostracodal, and oolitic limestones with minor interbedded shale. Chert lenses and volcanic ash beds are common. Fograscher (1956, p. 25) noted 18 ash beds in the formation. Some of the ash beds, such as those that form small ledges on the cuestas west of Milburn, contain abundant euhedral biotite flakes. The resistant limestone beds of the member hold up prominent cuestas through the entire middle part of the quadrangle and cap western dip slopes. Ooids in the oolitic limestone weather out to form noticeable pockmarked float on several dip-slope surfaces immediately east of U.S. 89. Roadcuts along the highway—for example, in

FIGURE 7.—*Conglomerate cliff of the lower member of the Green River Formation, section 26, T. 12 S, R. 4 E.*

sections 28 and 33, T. 12 S, R. 4 E, and sections 22, 26, and 35, T. 13 S, R. 4 E—expose the limestones in the member.

The upper member of the Green River Formation is generally exposed west of U.S. 89. Thickness of the member varies from about 425 m in the northern part to over 600 m in the southern part of the quadrangle. The variable thickness is due to the unconformable relationship with the overlying Moroni Formation. The member is lithologically variable from north to south across the quadrangle but is dominated by nonresistant shales or mudstone. Shale beds in the lower part of the member are a deep yellow and are exposed along the railroad in the northern part of the quadrangle.

Several meters of quartzite conglomerate that has a muddy matrix lie directly above this yellow shale. The conglomerate beds have weathered to form gravel-covered dip slopes on hills in the northern part of the quadrangle and are best seen in sections 28 and 33, T. 12 S, R. 4 E (fig. 8). The conglomerate beds pinch out quickly to the south, however, and are replaced by several thin limestone and one or two sandstone beds in the southern part of the quadrangle at the same general stratigraphic level. Volcanic ash beds are interbedded with shale in the lower part of the member.

Shale beds in the lower part of the member contain fish bones and scales. Several fish bones and fragments were collected from the shale along the San Pitch River in section 2, T. 14 S, R. 4 E. The upper part of the member includes several shaly limestone beds that contain numerous gastropods, bivalves, and fossil plant fragments.

The nonresistant upper member forms a low hummocky topography that contrasts to the cuesta-forming middle member and the steep rugged ridges held up by the overlying Moroni Formation. Neither the upper nor the lower contact of the Green River Formation is well exposed in the Fairview Quadrangle. The lower part of the formation is only exposed south of Cottonwood Creek, where Green River beds appear to lie on the Flagstaff Limestone, and at the base of the Green River cuestas in the middle of the quadrangle, where the contact is either covered by alluvium or faulted off.

The upper contact of the Green River Formation with the overlying Moroni Formation is also poorly exposed and is commonly covered with vegetation and pediment gravels. In addition, several landslides have occurred in nonresistant upper Green River shale, and blocks of Moroni Formation have slid down across the contact. The contact appears to be unconformable, as earlier noted by Schoff (1951, p. 635).

THE CRAZY HOLLOW PROBLEM

The section of rock that occurs between the Moroni Formation and the resistant algal and oolitic limestone section of the Green River Formation was identified by Fograscher (1956) as Crazy Hollow Formation. The Crazy Hollow Formation is interpreted, in this study, to wedge out beyond the Fairview area.

Spieker (1949b, p. 36–37) named the Crazy Hollow Formation for exposures near Salina Canyon. There the formation is dominantly sandstone as it is in the Ephraim area where Bonar (1948, p. 91) mapped 100 ft of lenticular sandstone. Northernmost outcrops of the sandstone are a short distance southwest of Fairview, in section 15, T. 14 S, R. 4 E, where the sandstone pinches out (Fograscher 1956). That pinch out or facies limit is considered to be the northern edge of the Crazy Hollow Formation.

Fograscher (1956) mapped a band of Crazy Hollow Formation across the quadrangle between the Green River and Moroni Formations; however, Schoff (1951) had previously mapped the entire section as Green River Formation. Fograscher (1956, p. 30) noted bedded conglomerates in the section and suggested that the unit should be considered Crazy Hollow Formation. In this

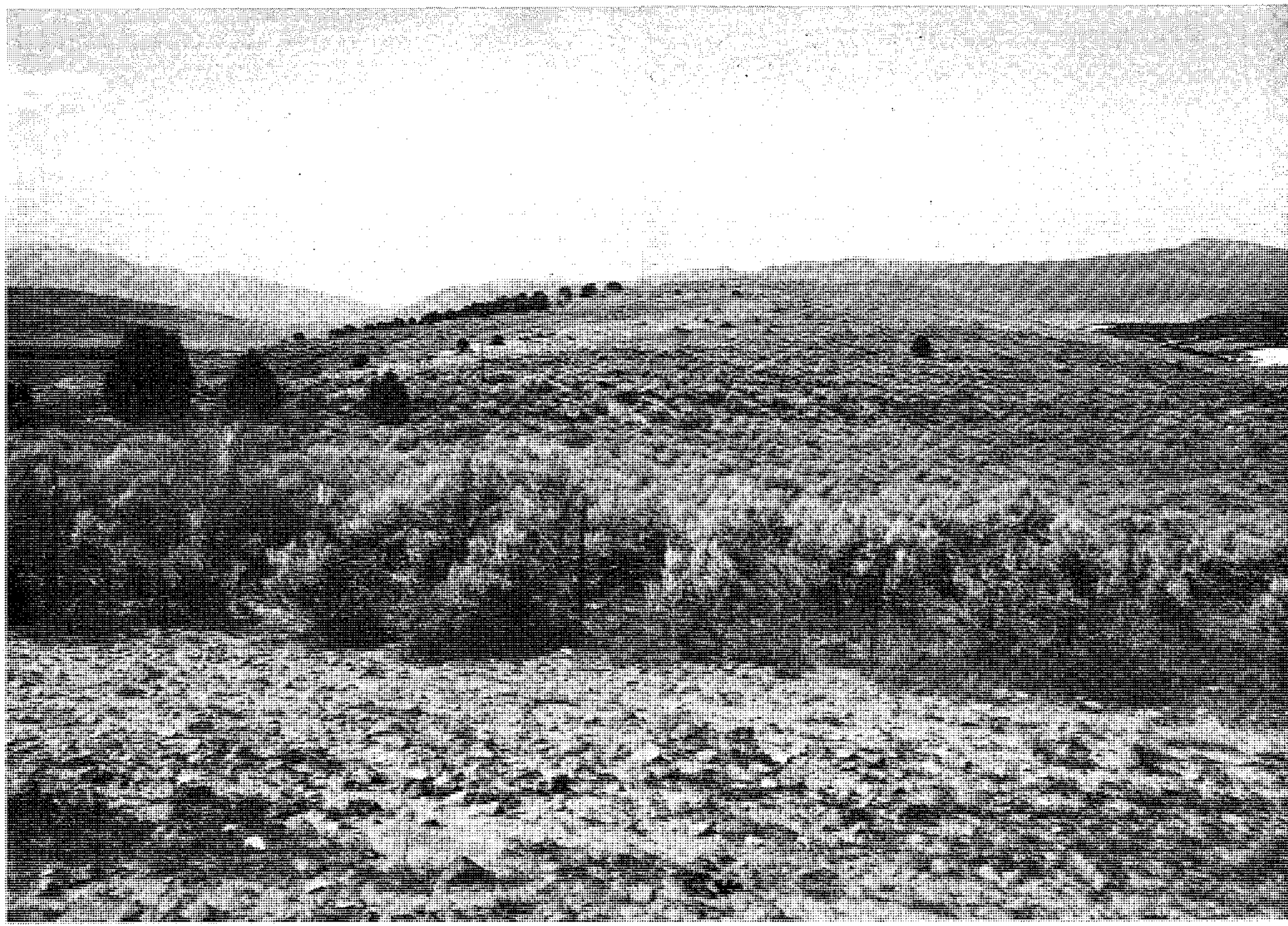

FIGURE 8.—*Conglomerate beds in the upper member of the Green River Formation weather to form gravel-covered dip slopes in the northwestern part of the quadrangle.*

study the entire sequence in question is mapped as Green River Formation because it is dominated by calcareous shales and limestones with very minor sandstone beds. The conglomerate beds in the section are exposed mostly in the northern part of the quadrangle and appear to pinch out rapidly to the south, which suggests a northern source unlike the sandstone of the Crazy Hollow Formation. Interpreting the section as upper Green River Formation is compatible with mapping by Runyon (1977) and Witkind (personal communication 1984).

Moroni Formation

The Moroni Formation crops out along the entire western boundary of the quadrangle where its resistant volcanic flows cap the high ridges. The formation was divided into four members by Schoff (1951, p. 634), which include, from the bottom up, a sandstone and quartzite conglomerate unit, a volcanic conglomerate unit, a massive white tuff unit, and a yellow to pink tuff and tuff breccia unit. The formation was divided into two map units in the Fairview Quadrangle. The lower unit is generally conglomerate with quartzite or volcanic clasts and some green sandstone and is probably equivalent to the lower unit of Schoff. Variously colored tuff and welded tuff of intermediate composition and thick volcanic breccia dominate the upper unit, which is probably equivalent to the second unit of Schoff. Tuffs contain a high percentage of plagioclase with subordinate biotite. Glass shards are abundant and visible to the naked eye. Tuffs vary in color, with shades of red most common. Tan and black tuffs are also present. The volcanic breccias have a gray matrix and dark volcanic clasts that range in size up to more than a meter across. Quartzitic conglomerate beds are only exposed as piles of quartzite clasts, but they appear to be identical to conglomerates in the Green River Formation. Good exposures of the section occur in the extreme southwestern corner of the Fairview Quadrangle on a hill in section 5, T. 14 S, R. 4 E, and in sections 8, 17, and 20, T. 13 S, R. 4 E, along the western edge of the quadrangle. Rocks in these exposures dip westward like the underlying Green River Formation.

FIGURE 9.—*East-sloping remnant of a pediment surface, west of Fairview at the southern border of the quadrangle.*

FIGURE 10.—*Typical pediment gravel surface on several of the ridges in the western part of the quadrangle.*

QUATERNARY SYSTEM

Quaternary deposits cover much of the Fairview Quadrangle. They have been differentiated as alluvium, alluvial fans, landslides, and pediment gravels. The pediment gravels may have been deposited during the latest Tertiary but have been considered as Quaternary because of the lack of other evidence. Landslides will be discussed in a separate section.

Alluvium is widespread in the quadrangle. Several streams from the Wasatch Plateau and the Cedar Hills have deposited alluvium on the floor of northern Sanpete Valley, and several streamside fingers of alluvium extend into the foothills of the Cedar Hills and along the numerous gullies cut in nonresistant upper Green River beds. The major perennial streams from the Wasatch Plateau have deposited a series of alluvial fans along the eastern side of the valley at the base of the monocline. These fans were differentiated from alluvial plains and terraces by their geomorphology and high content of boulders and blocks.

Pediment-veneering gravels are common in the western part of the quadrangle. Broad eastward-sloping surfaces were cut across the Upper Green River Formation and were veneered by debris from weathered Moroni Formation. This surface and gravel cover are now preserved in several gravel-capped ridges. One large remnant of the gravel deposits is located in sections 3, 4, 9, and 10, T. 14 S, R. 4 E, near the southern boundary of the quadrangle where it is shown in figure 9 as an east-sloping ridge at the skyline. Figure 10 shows the gravel veneer of another remnant in section 16, T. 13 S, R. 4 E. Pediment gravel is often difficult to distinguish from bedded conglomerate of the upper Green River Formation, but those bedded units, unlike the pediment gravels, appear to largely lack volcanic clasts and dip to the west.

LANDSLIDES IN THE FAIRVIEW QUADRANGLE

There has been an increase in landslides and mudslides throughout central and northern Utah during the past few years compared to the historic past. Slides have done considerable damage to both private and public property. Some areas in the Fairview Quadrangle have considerable potential for mass movement. This threat is greatest in the eastern part of the quadrangle, in the deep canyons that drain into Sanpete Valley.

On May 30, 1983, a landslide briefly dammed Cottonwood Creek, which flows directly through Fairview. Fairview was evacuated for a few hours because it was feared that the landslide dam might break after a large amount of water had collected behind it. Fortunately, the landslide dam was overtopped before enough water had ponded to cause great damage. Figures 11 and 12 are photographs of the slide in the summer of 1985 when the slide was still active. Several other slides in the canyon during the remainder of that summer and during the early summer of 1984 damaged Utah 31, which passes through the canyon.

To this point there have been few published studies on the potential for mass wasting in the region. Shroder (1971) described and classified the then recognized major slides of the state of Utah. Godfrey (1978) studied land surface instability in the Wasatch Plateau, but no effort was concentrated in the Fairview area.

The considerable potential for landslide activity in the quadrangle is evidenced by the number of old and recent slides and by the large area involved in such slides. Several factors are involved in the high potential.

First, nearly all of the rocks exposed in the quadrangle have a history of movement. Even the Flagstaff Limestone has interbedded mudstone layers that allow slippage when they become lubricated with water.

FIGURE 11.—*Landslide that originated in the North Horn Formation; this slide blocked Cottonwood Creek and destroyed a section of Utah 31.*

Second, dips on the Wasatch Monocline often exceed 30°. The steep dips allow gravity to more easily overcome internal friction of rock layers. The largest volume of landslide deposits occurs along the eastern mountain front of northern Sanpete Valley. The steep dip of beds of the Wasatch Monocline is undoubtedly a major factor in the abundance of the slides.

Third, extensive faults and parallel joints along the monocline provide passage for groundwater into the subsurface. Sag ponds produced by tilted blocks also provide water for lubrication, weight, and increased pore pressure in the underlying sediments (Godfrey 1978, p. 138).

Fourth, the most extensive rock unit exposed on the steeper and wetter eastern part of the quadrangle is the North Horn Formation. Both Shroder (1971, p. 14) and Godfrey (1978, p. 139) concluded that North Horn beds are responsible for slides nearly everywhere they are exposed. Numerous units of bentonitic mudstone and shale make the formation relatively incompetent, and numerous interbedded permeable sandstones provide aquifers for lubricating water (Godfrey 1978, p. 138).

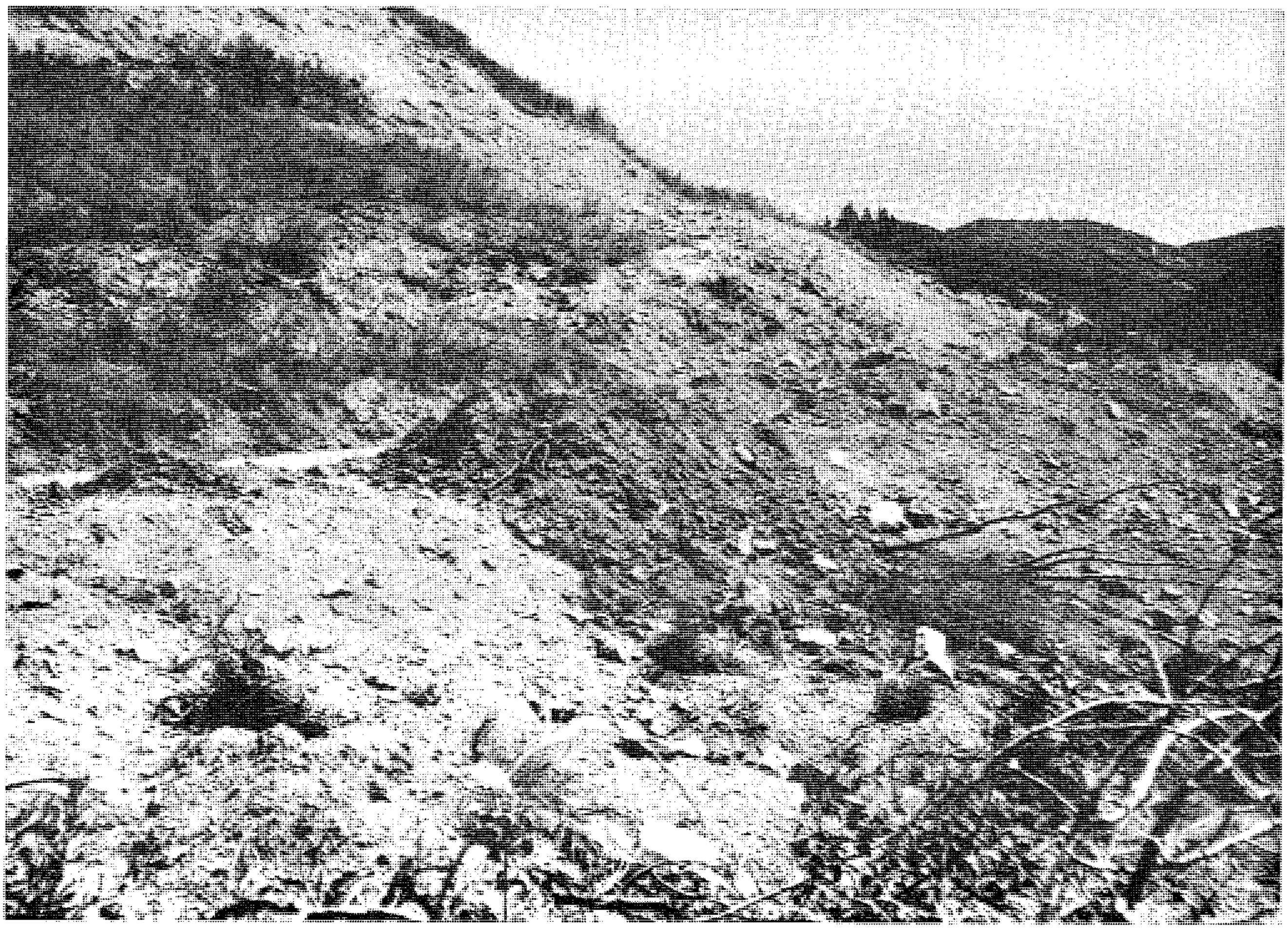

FIGURE 12.—*Closeup view of the landslide in figure 11.*

The most slide-prone rocks in the study area are in the middle member of the North Horn Formation. Many active slides have left scars where the black coal beds and gray shales of the member are visible. The decreasing number of slide deposits toward the north suggest that the risk becomes less in that part of the quadrangle. This is probably because the middle member of the North Horn occurs progressively lower in the canyons to the north.

Although North Horn beds are the major unstable units in the area, slides also occur in other formations. Older slide deposits along the mountain front seem to be made up of material derived from all members of the North Horn and Flagstaff Formations. Landslides along the foothills south of Cottonwood Creek involve sediments of the Green River Formation. Figure 13 is a photograph of an old slide south of Cottonwood Creek near the mouth of the Cottonwood Canyon. It is composed of Flagstaff and Green River beds. This slide has not been reactivated in recent years, except at the toe where undercutting by Cottonwood Creek has destabilized the lower part of the slide. Landslides containing material from the Colton Formation occur near the mouth of Oak Creek Canyon.

An exceptionally large slide deposit was noted by Pashley (1956, p. 111) at the mouth of Oak Creek Canyon; however, he mapped the foothills between Oak and Cottonwood Creeks as outcrops of Flagstaff Limestone. Although Flagstaff beds are the underlying sediments, there are few good outcrops in the area. Along Utah 31, near the mouth of the canyon, it is apparent that the deposits are unconsolidated debris from North Horn and Flagstaff beds that have been disrupted by mass movement. For this reason the deposits were mapped as landslides in this study.

In the southeastern part of the quadrangle in section 5, T. 14 S, R. 5 E, a mass of Flagstaff Limestone has slipped on a mudstone bed, leaving a stripped undulatory bedding plane of resistant limestone to form the dip slope of the monocline. Beds of the upper member of the Green River Formation are also involved in slides near the western border region of the quadrangle. Hawks (1980) mapped several slide masses in the upper Green River Formation a short distance beyond the quadrangle to the west. Although there is high potential for sliding of upper Green River beds, the risk of property damage is low because that outcrop area is mostly used for sheep grazing in summer months and other agricultural efforts.

LANDSLIDE POTENTIAL

High-risk slide areas in the quadrangle are along the east mountain front and in canyons on the east side of the quadrangle. The risk along the mountain front is evident from the percentage of landslide deposits in that area.

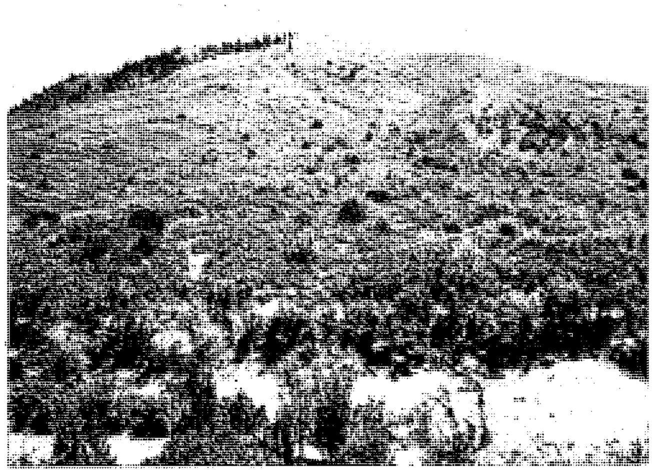

FIGURE 13.—*Old landslide south of Cottonwood Creek at the mouth of the canyon. This slide has been reactivated only at the toe in recent wet weather.*

Most of the slide deposits along the mountain front have reached equilibrium; therefore, recent movement is confined to small slides that occur where streams have cut the slides and over steepened canyon walls. Large quick-moving slides have occurred from where masses of rock and mud break away from the high mountain front along joints. A mudslide, which originated on the mountain face between Oak and Dry Creeks, flowed into an irrigation pond in the NE 1/4, section 24, T. 13 S, R. 4 E. The slide filled a sediment trap and a good part of the pond (Ronald Norton personal communication 1985).

North-facing slopes within the canyons have the highest potential for sliding. Shroder (1971, figure 5, table 7) and Godfrey (1978, p. 139) noted that north-facing slopes in the entire region are more apt to slide than are south-facing ones. Although north-facing slopes generally have greater potential, vegetation stabilizes them and results in relatively slow-moving slump masses that creep down as their toes are removed by stream erosion. Flowage cracks develop throughout the masses and allow water to enter at many places in the slide, aiding movement. Dense vegetation and positioning away from direct sunlight greatly reduce runoff and evaporation and hold moisture in the slides, keeping them completely saturated.

Cottonwood Canyon is an exception in that the greatest number of slide deposits are on the south-facing slope. Reasons for this might include stabilization on the north-facing slope by vegetation or perhaps slides have already reached some degree of equilibrium. Another important factor is the construction of Utah 31 along the north wall of the canyon. Construction of the highway has removed the toes of several old slide masses, destabilizing them. The large slide that blocked Cottonwood Creek and prompted evacuation of Fairview is such a slide. It is located in the NE ¼, section 32, T. 14 S, R. 5 E (figs. 11 and 12). The slide is soaked by springs from two faults that cut the bedrock. The spring on the western fault was reported to be flowing enough water to fill a 4-inch pipe at the time of the slide, in addition to seepage water that didn't flow out onto the surface. Since that time the highway in the vicinity of the slide has required continual maintainance through the summer of 1985 when the slide was still active.

Slides on the north-facing wall of Cottonwood Canyon are numerous but small. So far, damage has been limited to destruction of the water lines that were built on the canyon wall. Although potential for a major slide is less from the north-facing canyon wall, the possibility should not be ignored because blockage of the creek by sliding poses a threat to the town of Fairview.

In Dry, Oak, and Cottonwood Creeks, several fresh scars from recent slides are visible on south-facing slopes. One such slide occurred in Dry Creek Canyon during the spring of 1983 near the junction of sections 7 and 8, T. 13 S, R. 5 E. The slide caused a considerable inconvenience because it destroyed the road and trails in the canyon, a major access to forest lands for ranchers who use the canyon to drive stock to summer range.

Weather in 1985 has been considerably drier than it had been in the previous two years; however, it will take some time before the slide masses achieve the stability they had before the wetter weather. Sliding has left numerous vegetation-free slide surfaces and scars. Even in the event that several drier-than-normal years follow, there will always be a significant threat of landslides in certain areas within the Fairview Quadrangle.

STRUCTURE

The major structure in the Fairview Quadrangle is the Wasatch Monocline, which is a north-south fold located in the eastern part of the quadrangle. Its westward-dipping limb is cut by a system of north-trending faults. The monocline provides a structural transition between the Wasatch Plateau, to the east, and the eastern Basin and Range Province. Beds on the plateau are either horizontal or dip gently northwestward at less than 10°. Within two miles of the eastern boundary of the quadrangle, dips steepen abruptly across the Wasatch Monocline to more than 25°, then flatten again under Sanpete Valley to average less than 15°. The gentle dip is maintained across the quadrangle to the western boundary as shown on the cross sections (fig. 3).

MONOCLINE

The Wasatch Monocline is a 90-km-long flexure of beds that dip into Sevier and Sanpete Valleys along their eastern edges. To the south it is first recognized near Salina from where it continues northward to a short distance north of the Fairview Quadrangle in the Indianola Quadrangle. There the monocline becomes a normal fault that forms a steep-faced mountain front (Mase 1957, p. 44). Spieker (1949b, p. 44) noted that the monocline is less prominent at its northern end and that displacement is taken up by faulting instead of folding. Pashley (1956, p. 82–84) noted that the Frontal Fault took up the flexure between Spring City and Mount Pleasant.

In the Fairview Quadrangle the monocline occurs in the eastern one-third of the quadrangle, where its stratigraphic throw exceeds 1300 m. The monocline is offset by a group of faults whose trend parallels that of the monocline. The change in dip often takes place across one of the faults rather than across a fold. Beds step down across a series of faults as they approach the monocline, but retain a nearly horizontal attitude until an abrupt change in dip occurs across a normal fault.

In Dry Creek Canyon, in section 7, T. 13 S, R. 5 E, dip of the beds changes abruptly from less than 15° to more than 35° across a normal fault (fig. 4). In the area between Dry and Oak Creeks it is not clear how the change in dip occurs because the area is covered with landslide debris. South of Oak Creek the change in dip is taken up mostly by folding. This is visible along Utah 31 near the mouth of Cottonwood Canyon where beds of the Flagstaff Limestone are included in monoclinal folding (fig. 5). In the area south of Cottonwood Creek in the extreme southeast corner of the quadrangle, the change in dip again appears to be taken up by folding that occurs at approximately the eastern boundary of the quadrangle.

FOLDS

Attitudes are not constant over large distances anywhere in the quadrangle, but, besides the monocline, folding is not a major structural feature. An east-trending anticline occurs at the base of the monocline in the northern part of the quadrangle in sections 30 and 31, T. 12 S, R. 5 E, where attitudes change abruptly over a distance of less than 1 km. Very steep dips are also common at the base of the monocline, such as near the mouth of Oak Creek where Colton beds dip near vertically. It is possible that the steep dips developed during landsliding along the mountain front. Intense folding at the base of the monocline is not uncommon to the south (Bonar 1948, p. 96; Spieker 1949b, p. 46). Other localities where sudden attitude changes occur include section 26, T. 13 S, R. 4 E, where the dip of Green River beds changes from 10° to 30° in a distance of a few meters and in section 4, T. 13 S, R. 4 E, near U.S. 89 where the dip changes abruptly from 5° to 15°.

FAULTS

Faulting is common throughout the entire Fairview Quadrangle, but it is particularly common in the eastern part of the quadrangle in the vicinity of the Wasatch Monocline. Faults have steep dips, normal displacement, and a general north–south trend. Faults were initially identified in the field and then reexamined on aerial photographs. Actual truncations of bedding were only visible on south-facing canyon walls due to dense vegetation and mass movement on the north-facing walls. Most faults were traced by following fault line scarps, sag ponds, and topographic lineations.

Faults in the vicinity of the monocline are numerous, but only the major ones are included on the map. Pashley (1956, p. 86–90) described several minor faults in Cottonwood Canyon that offset Flagstaff and North Horn beds, but the minor faults have offsets of less than 10 m and are difficult to trace beyond the roadcuts where they are exposed along Utah 31.

Two main fault patterns are visible in the vicinity of the monocline. Those in the southern half of the quadrangle strike approximately N. 20° W. and occupy a zone about 4 km wide that includes the southwestern corner of the Fairview Lakes Quadrangle directly to the east. Even though there are a number of faults, the change in dip across the monocline occurs by folding of the beds in the southern part of the quadrangle, unlike the northern part where it is taken up entirely across faults.

Faults in the southern part of the quadrangle include two antithetic faults in the extreme southeastern corner of the quadrangle that are probably antithetic to the Frontal Fault. Pashley (1956, p. 85) noted that their offset was probably close to the height of the scarp, which is less than 30 m.

The Frontal Fault, which is downdropped to the west, forms a graben with the Maple Fork Fault, which is downdropped to the east. The graben extends northward to Oak Creek where the Maple Fork Fault ends. An interesting fault pattern occurs near the eastern boundary of the quadrangle in sections 8, 17, and 20, T. 13 S, R. 5 E, where the graben between the Frontal Fault named by Pashley (1956, p. 82) and the Maple Fork Fault named by Oberhansley (1980, p. 84) deteriorates. The Maple Fork Fault ends abruptly in section 17, but the Frontal Fault continues northward with a northeastern strike. To relieve the stress at the north end of the graben, several small northeast-trending faults have formed. The Frontal Fault is difficult to trace north of Dry Creek, but the offset appears to increase northward from less than 20 m at the head of Dry Creek to more than 100 m at the northern boundary of the quadrangle.

The group of faults in the northeastern part of the quadrangle strikes N. 20° E. and occupies a zone about 2.5 km wide. The faults possibly propagated southwestward while those in the southeastern part of the quadrangle possibly propagated northwestward. The northern group forms a graben since the faults to the east are downdropped to the west, and those to the west are downdropped to the east.

STONE QUARRY FAULT

The western boundary of northern Sanpete Valley in the Milburn area is defined by a series of cuesta faces in the middle of the quadrangle. A north-trending fault, here named the Stone Quarry Fault, is inferred to occur along the cuesta fronts. Although there is no trace on the surface, the fault is inferred from the linear zigzag pattern of the cuesta faces and from surrounding relations such as topographic lineation where the fault was mapped by Runyon (1977) in the Indianola Quadrangle to the north. It is not possible to determine the exact offset of the Stone Quarry Fault, but if the offset is similar to the relief of the cuesta faces it is about 150 m.

The Stone Quarry Fault divides the quadrangle into two structurally different areas. East of the fault the structure is dominated by the Wasatch Monocline and associated faulting. West of the Stone Quarry Fault the structure is more simple and faulting is less common. With the exception of the monocline, the beds in the eastern part of the quadrangle dip gently to the northwest. West of the Stone Quarry Fault, bedding has a gentle southwestern dip.

Faults in the western part of the quadrangle occur in two groups. One group is located in the northwestern quarter of the quadrangle where they offset beds of the Green River Formation. Their trend is about N. 30° W., and their offset is less than 20 m. It is not possible to relate these faults to others in the quadrangle.

The other group of faults occurs in the western border region of the quadrangle. They trend approximately north–south and offset the Moroni Formation and the upper member of the Green River Formation. Faults were often recognized where volcanic beds of the Moroni Formation have been downdropped against calcareous shales of the upper member of the Green River Formation. The trace was then extended on the basis of topographic lineation. Offset is very difficult to establish but could be as much as 60 m in some places.

ORIGIN OF STRUCTURE

Rocks in the Fairview Quadrangle have undergone several episodes of deformation. Because the quadrangle lies at the boundary between the Basin and Range Province and the Colorado Plateau, both structural styles are manifest. There has been considerable discussion on what caused the structure in the region, but much of the discussion has dealt with stratigraphic and structural relationships farther to the south in the region of the Gunnison Plateau and Sevier Valley. Spieker (1949b, p. 48) attributed the formation of the monocline to simple subsidence of the Sanpete-Sevier Valley block or to local uplift of the Wasatch Plateau. Since that time some authors have suggested that the removal of underlying salt could have allowed the collapse of the valley (Stokes 1956, p. 790; Witkind and Page 1984, p. 146). Baer (1976) and Moulton (1975) have also noted the importance of salt in forming many of the structural features in the region.

In the comparatively small area included in the Fairview Quadrangle it is difficult to find conclusive evidence for any particular model of deformation. Salt structures noted nearby have no counterpart in the Fairview Quadrangle, though it is possible that salt migrated from under the Fairview Quadrangle to those nearby structures. Other evidence for salt diapirism such as sedimentary thinning in the area, unconformities, or unusual bedding attitudes produced over mobile structures do not occur.

AGE OF FAULTING

The age of faulting in the quadrangle is not always clear, but some conclusions can be drawn. In the east, faulting is associated with the formation of the monocline, which is evidenced by the similarity of trend and the fact that change in dip on the monocline is commonly taken up by faulting instead of folding. The faults also occur in a definite zone in the vicinity of the monocline and are less common on either side. Beds up through the Green River Formation are included in monoclinal folding, so the timing was post-Green River. Spieker (1949b, p. 80) suggested that the folding probably occurred after Crazy Hollow time, or later than Eocene, but no such evidence was found in the Fairview Quadrangle.

Faults in the western border region of the quadrangle postdate the formation of the monocline because they cut the Moroni Formation, suggesting they are younger than Oligocene. Basin and Range extension (Miocene and later) is a likely origin for these faults.

GRAVITY SURVEY

A gravity survey was completed in the Fairview Quadrangle to investigate the possibility that the large elongate north-trending salt diapir, or salt wall, suspected by Witkind (1982, p. 21, and personal communication 1984) to occur in the Fairview Quadrangle might be detected. An in-depth gravity survey including modeling was beyond the scope of the reconnaissance type survey. After the gravimeter readings were reduced to usable values with the Bouguer equation, data were then plotted on an overlay and compared to the geologic map. Some of the major faults and highways are included for spatial reference and for comparison to surface mapping (fig. 14).

No obvious salt-related anomalies were evident in the results of the gravity survey, but rather, the contour pattern correlates well with the structure shown on the geologic map. In particular, the alignment of contours parallels fault patterns in the vicinity of the monocline.

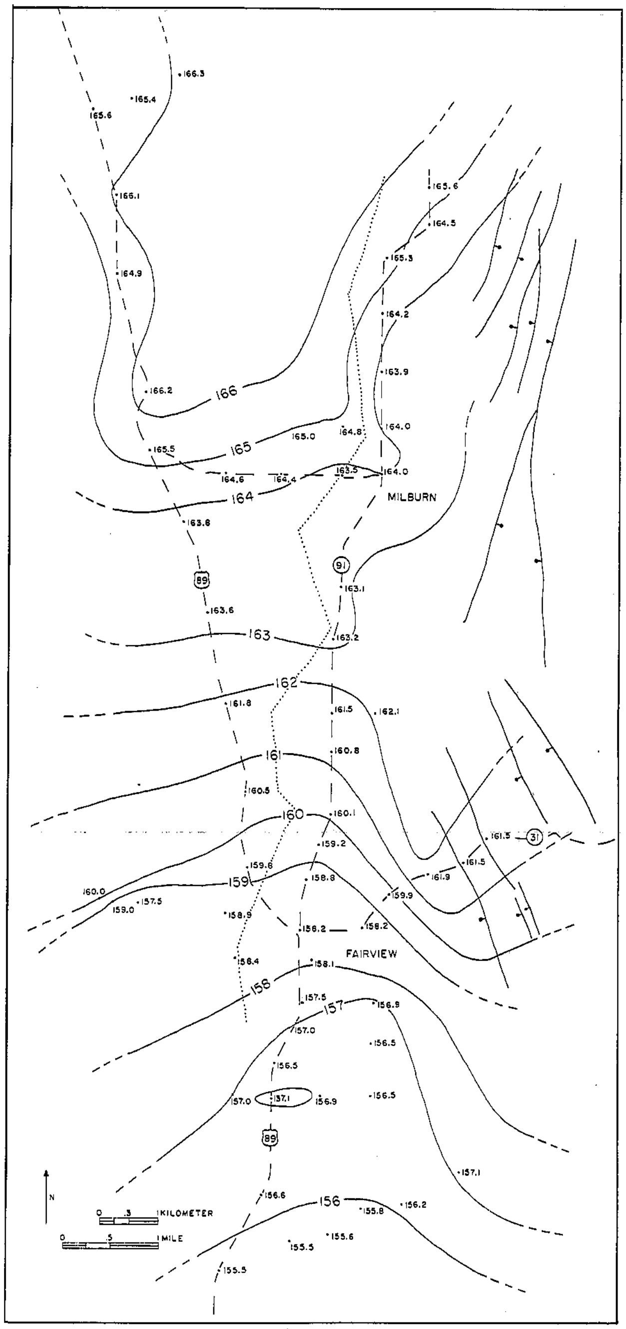

FIGURE 14.—*Bouguer gravity data contoured at 1 mgal intervals in the vicinity of the Fairview Quadrangle.*

Contours have a more uniform character west of the Stone Quarry Fault, demonstrating the more simple structure.

It is clear that the monoclinal flexure in the quadrangle is largely taken up by faulting. This, plus the fact that the monocline gives way to a normal fault in the Indianola Quadrangle, suggests that the formation of the monocline is closely related to extension. Perhaps salt movement and thrusting have minor roles in its formation.

ECONOMIC GEOLOGY

WATER RESOURCES

Water is an important natural resource in the agriculture-based economy of Sanpete Valley. A year-long supply of water is made available to most of the valley by streams descending from the Wasatch Plateau. The Wasatch Plateau receives up to 40 inches of precipitation per year, largely stored as snowpack (Pratt and Callaghan 1970, p. 21). Springs and wells supplement the water supply in the valley. Available surface water is covered by water rights, so further industrial or agricultural development is dependent upon better management of available surface water and further development of groundwater (Pratt and Callaghan 1970, p. 21). According to Marsell (1958, p. 32), the groundwater reserves in Sanpete Valley are great enough that production could be doubled without endangering the supply. As of 1965 there were over 1500 wells producing water for agriculture and domestic use (Robinson 1965, p. 64). Most of these wells are located farther south in the valley, between Manti and Moroni, and produce from shallow sources in alluvial valley fill.

Like the rest of the valley, water supply in the Fairview Quadrangle comes from drainage of the Wasatch Plateau and from several springs. Groundwater is largely undeveloped. Efforts to better utilize surface water supplies have been concentrated on building several small catch ponds along the eastern mountain front. Water is pumped from the ponds throughout the summer and is used in sprinkler irrigation systems. In years of below-normal precipitation or runoff, an alternate water supply would be needed.

SPRINGS

Springs in the quadrangle are controlled by faults or seep from permeable beds. Seepage springs are very common, especially in the eastern part of the quadrangle where numerous interbedded permeable and nonpermeable beds occur in the North Horn and Flagstaff Formations. The amount of water at any particular seepage spring is small, so their principal use has been for watering stock. The springs also contribute to water saturation of the numerous landslide masses in the area. Spring water, which appears to flow from the conglomerate beds in the upper Green River Formation, provides a valuable water source for stock in the otherwise water-barren northwest corner of the quadrangle.

Fault-controlled springs in the quadrangle provide a more consistent source of water. One spring located in section 11, T. 13 S, R. 4 E, was noted by Richardson (1907) to produce 20 gallons per minute. The large landslide in Cottonwood Canyon that dammed Cottonwood Creek was lubricated by a fault-controlled spring. Another fault-controlled spring occurs near the mouth of Dry Creek in the southwest 1/4 of section 7, T. 13 S, R. 5 E. It produces approximately 10 gallons per minute. Data on surface water in the area can be obtained from Pratt and Callaghan (1970, p. 21–23).

GROUNDWATER

Groundwater in the Fairview Quadrangle, although it has been largely unexploited, provides an attractive prospect for future water development. Similar possibilities have already been realized in other parts of Sanpete Valley.

Sources for groundwater are numerous. Alluvial fans provide many possibilities for shallow wells. Several wells noted by Richardson (1907, plate IV) produced from shallow alluvial aquifers in the valley between Fairview and Milburn in the late 1800s, but they have been largely abandoned. Richardson (1907, p. 23) noted that the water table slopes westward from the eastern mountain front but is progressively deeper toward the mountains because of the topography of the steep alluvial fans. In several localities in the middle of the valley the water table is less than 10 feet deep (Richardson 1907, plate 6).

Groundwater sources in bedrock include sandstones of the Upper North Horn Formation and oolitic limestones in the middle member of the Green River Formation. Both have known production in other parts of the valley (Marsell 1958, p. 29). A large well at the mouth of Cottonwood Creek was drilled 383 ft to the top of the North Horn Formation and continuously produced 700 gallons per minute (Marsell 1958, p. 30). Because the western part of the quadrangle lacks extensive developed water resources, the oolitic limestones provide an excellent target there. Westward dips in the quadrangle, especially on the monocline, provide the opportunity for an artesian waterhead. Artesian pressure would reduce energy needed for pumping.

Recharging of the aquifers is good because of the large surface area where permeable beds are exposed along the eastern mountain front and on the Green River cuestas in the middle part of the quadrangle. Numerous faults and fractures also aid recharging by providing numerous conduits for water to reach aquifers.

CONSTRUCTION MATERIALS

Several deposits in the Fairview Quadrangle have been quarried for construction materials. Among the first extensively used materials were blocks of limestone from the Green River Formation. These were scavenged from the dip slopes of the cuestas west and south of Milburn. The limestone was used by early settlers to build houses. The cuesta area is referred to as the Stone Quarries by local residents. Several buildings in the area are also constructed of sandstones from the North Horn Formation. Resistant limestones and sandstones of the Flagstaff and North Horn Formations have been used for road metal and building material in other areas, but no exposures in the Fairview Quadrangle are readily available for quarry operations. Resistant limestones of the Green River Formation have been quarried at Hill Top Station in the northwest part of the quadrangle for construction of U.S. 89.

The most widely quarried construction materials in the quadrangle are deposits of gravel, and these localities have been marked on the geologic map. A gravel quarry was opened northeast of Fairview, north of Utah 31, in valley alluvium. Quarries on Slick Hill and just west of Slick Hill produce gravel from upper Green River conglomerates, pediment gravels, and from conglomerates of the Moroni Formation. Bedded gravels in the upper member of the Green River Formation have also been quarried at several locations where they are exposed on dip slopes in the northwest corner of the quadrangle. Such localities include gravel quarries in section 33, T. 12 S, R. 4 E, section 4, T. 13 S, R. 4 E, and two quarries in section 28, T. 13 S, R. 4 E.

COAL

The only moderately thick coal exposed in the quadrangle is the lignite in the middle member of the North Horn Formation that is currently being mined in section 7, T. 13 S, R. 5 E, near the mouth of Dry Creek Canyon. This bed is currently being mined by the American Ferto Corporation in a small open-pit mine on the north canyon wall (fig. 4 and 15). Pratt and Callaghan (1970, p. 59) mentioned that the lignite is commonly mixed with turkey feathers to produce a soil conditioner.

The lignite is associated with freshwater limestone. It is dark brown to black, contains woody fragments, and is high in sulfur. The Utah Geological and Mineralogical Survey is presently running tests on the coal to determine humic acid content. The coal-bearing beds also crop out along Utah 31 in Cottonwood Creek Canyon, but beds there are too thin to mine economically.

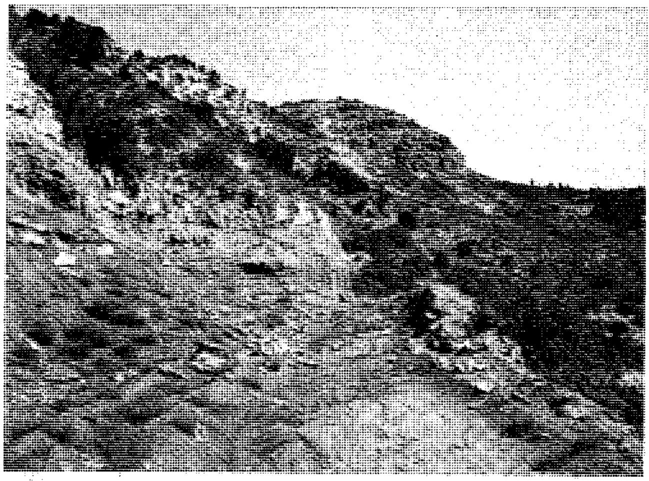

FIGURE 15.—*Closeup view of the American Ferto lignite mine in Dry Creek Canyon.*

OIL AND GAS

Interest in petroleum exploration has increased in the Sanpete Valley area since the discovery of oil and gas on the Wasatch Plateau. Seismic data have been obtained and some drilling has taken place in the valley region. Exploration efforts have not produced any commercial wells yet, but hydrocarbon shows are common in the wells near the Fairview Quadrangle. Nearby wells include the #1 Jensen unit in section 16, T. 14 S, R. 5 E, drilled by Colorado Interstate Gas in 1956. It had several hydrocarbon shows but no commercial deposits. The Sun Ray Midcontinent Oil Utah Federal C well was drilled in 1961. It is located in section 36, T. 12 S, R. 5 E, and had no shows. The Union Oil of California #1 G24 Browns Peak well was drilled in 1981. It is located in section 24, T. 11 S, R. 4 E, and tested as a 120 ft column of oil in the Entrada Sandstone but was not commercial. The Energy Reserves Group #1 Indianola unit was drilled in 1982. The well is located in section 27, T. 11 S, R. 5 E, and had shows of hydrocarbons. The Exxon #1 Mt. Baldy well was drilled in 1984 and is located in section 24, T. 12 S, R. 3 E. Again, the well had shows of hydrocarbons but no commercial production. At the present time (October 1985) Coors Energy is drilling the 1–11 WC Federal well on the Wasatch Plateau in section 11, T. 11 S, R. 5 E. No wells have yet been drilled within the Fairview Quadrangle. Judging from surface geology, there are probably no structures large enough to produce prospects unless fault traps have been created on valley-flanking faults or faults associated with the Wasatch Monocline along the east side of the quadrangle.

APPENDIX

MEASURED SECTIONS

North Horn Formation (Section 1)

The section was measured on the north wall of Oak Creek Canyon near the eastern boundary of the quadrangle in section 21, T. 13 S, R. 5 E.

Unit	*Description*	*Unit Thickness (meters)*	*Cumulative Thickness (meters)*
50	Limestone, variegated; forms a ledge.	3.5	624.2
49	Covered slope, light yellow sandy soil with sandstone cobbles, probably mudstone and poorly cemented sandstone interbedded.	7.6	620.7
48	Covered slope, sandy soil with numerous sandstone cobbles and boulders.	40	613.1
47	Sandstone, grayish orange, weathers light grayish yellow, calcite and limonite cement, cross-bed sets 5 cm high with northeast transport direction, conglomerate at the base of the unit; forms a broken ledge.	7.3	673.1
46	Covered slope, same as unit 2.	26	656.8
45	Sandstone, like unit 4, cross-bedded with 13-cm-high cross-bed sets, east transport direction; forms a ledge.	13.7	539.8
44	Covered slope, sandy soil with numerous sandstone cobbles and boulders.	23	526.1
43	Sandstone, same as unit 6; forms a prominent ledge.	30	503.1
42	Sandstone, several small sandstone ledges with intermittent sandy soil slopes, some of the sandstone beds approach conglomerate with clasts up to 2 cm across.	42	473.1
41	Sandstone, grayish orange, weathers light grayish yellow, calcite and limonite cement, cross-bed sets 5 cm high with northeast transport direction, very thick bedded, massive; forms a prominent ledge or cliff.	10.5	431.1
40	Sandstone, dark yellowish orange, weathers moderate orange pink, fine grained, not well cemented, cross-bed sets less than 10 cm high, very thick bedded, massive; forms a ledge.	16.5	420.6
39	Covered slope, light yellow sandy soil with sandstone cobbles, probably mudstone and poorly cemented sandstone interbedded.	40	404.1
38	Sandstone, same as unit 11.	11	364.1
37	Sandstone, light gray to orange gray, weathers gray orange to pinkish gray, medium to coarse grained, calcite and limonite cement, numerous limonite-stained veinlets; forms a steep slope or broken ledge.	18	353.1
36	Sandstone, grayish orange, weathers same, fine grained, calcite and limonite cement, thick bedded, massive; forms rounded ledge.	1	335.1
35	Covered slope, probably mudstone.	4	334.1
34	Sandstone, like unit 15 but has some pink staining on weathered surface; forms a broken ledge.	13.5	330.1
33	Covered slope, probably gray mudstone.	15	316.6
32	Sandstone, like unit 15 but not as well cemented.	4.1	301.6
31	Covered slope, quite steep, several limestone cobbles, fossiliferous with high-spired gastropods 1 cm in length, similar to covered slopes slightly lower in the section, but the limestones are much less carbonaceous and contain only shelly fauna, the soil becomes sandy near the top.	26	297.5
30	Sandstone, same as unit 15.	1	271.5
29	Covered slope, same as unit 20.	58	270.5
28	Sandstone, same as unit 15.	1.2	212.5
27	Covered slope, grades from dark carbonaceous soil upward to a steeper slope of light gray sandy soil, probably coaly beds interbedded with sandy mudstone.	1.1	211.3
26	Sandstone, like unit 15 but less limonite cement.	1	210.2
25	Covered slope, same as unit 24.	1.8	209.2
24	Sandstone, grayish orange, weathers medium gray orange, fine to medium grained, calcite and a little limonite cement; forms broken ledge to steep slope.	5.4	207.4
23	Covered slope, same as unit 24.	10	202
22	Sandstone, grayish orange, weathers same, fine grained, calcite and limonite cement, thick bedded, massive; forms rounded ledge.	3	192
21	Covered slope, light gray soil with numerous limestone chips, chips are thin bedded and contain gastropods, ostracodes, fish plates, and numerous plant fragments, unit is very carbonaceous, probably several thin coal beds interbedded with limestone; forms unstable slope.	9	189
20	Covered slope, like unit 30 except more carbonaceous.	39	180

19	Covered slope, numerous sandstone boulders, probably interbedded mudstone and medium bedded sandstone.	9	141
18	Sandstone, light gray, weathers light gray to light orange gray, fine grained; forms steep slope or rounded ledge.	4.5	132
17	Covered slope, same as unit 32.	8.5	127.5
16	Sandstone, pale yellowish orange, weathers gray orange to medium gray, fine grained; forms a ledge.	2	119
15	Covered slope, same as unit 32.	12	117
14	Covered slope, probably mudstone.	6	105
13	Sandstone, dark orange gray, weathers medium gray, medium grained, calcite and limonite cement, poorly exposed, probably has thin mudstone interbedded; forms steep slope.	2	99
12	Covered slope, moderately steep.	1.5	97
11	Sandstone, same as unit 38.	8	95.5
10	Sandstone, light gray, weathers light orange gray, well sorted, fine grained, calcite cement, medium bedded; forms steep slope or rounded ledge.	5.5	87.5
9	Covered slope, light gray to light brown soil, probably mudstone.	4	82
8	Sandstone, light gray, weathers grayish orange, fine grained, medium bedded, calcite cement, poorly exposed, with some thin mudstone beds between sandstone beds; forms steep slope or rounded ledge.	4.5	78
7	Covered slope, light brown sandy soil, probably mudstone with some sandstone interbedded.	2.5	73.5
6	Sandstone, light gray, weathers grayish orange, fine grained, medium bedded, calcite cement, poorly exposed; forms steep slope or rounded ledge.	2.5	71
5	Covered slope, same as unit 44.	21	68.5
4	Sandstone, same as unit 45.	1	47.5
3	Covered slope, yellow to medium brown soil.	16.5	46.5
2	Sandstone, light gray, weathers same, medium grained, thick bedded, massive; forms a ledge.	4	30
1	Covered slope, red probably mudstone.	26	26

North Horn Formation (Section 2)

This section of the upper member and most of the middle member of the North Horn Formation was measured on the north canyon wall near the mouth of Dry Creek in the southern half of section 7, T. 13 S, R. 5 E.

Unit	*Description*	*Unit Thickness (meters)*	*Cumulative Thickness (meters)*
22	Sandstone, medium gray to pinkish gray, weathers same, medium to coarse grained, poorly sorted, usually cuts into underlying variegated limestone or mudstone; forms a ledge.	2.4	322
21	Covered slope, reddish orange soil, probably red mudstone, notable on color photographs.	33	319.6
20	Covered slope, like unit 2 but has several cobbles and boulders of sandstone and variegated limestone.	21	286.6
19	Sandstone, pale yellow, weathers orange brown to medium gray, fine to medium grained, well cemented with calcite and limonite cement; forms ledge that is covered by vegetation.	17.5	265.6
18	Covered slope, pinkish gray soil with cobbles and boulders of sandstone and variegated limestone.	10.5	248.1
17	Covered slope, grades upward to poorly cemented sandstone.	21	237.6
16	Sandstone, light yellow gray, weathers moderate pinkish gray, medium grained, moderately well cemented, load casts on some bedding planes, undulatory contact with underlying mudstone.	5	216.6
15	Mudstone, gray to variegated, weathers to form pink muddy slope.	7	211.6
14	Covered slope, light orange gray soil with several sandstone cobbles and boulders.	31.5	204.6
13	Covered slope, probably gray mudstone.	2.8	173.1
12	Sandstone, yellowish brown, weathers same, very fine grained, well cemented, well sorted, medium bedded; forms rounded ledge.	1.6	170.3
11	Covered slope, same as unit 9.	18	168.7
10	Sandstone, Light gray, weathers light yellow-gray, beds of this unit are channeled into unit 14, graded from very coarse to very fine upward, massive, thick bedded, not well cemented with calcite and limonite cement; forms a prominent ledge.	7.5	150.7
9	Sandstone, like unit 14 only thinly bedded, forms the lower 2 m of the ledge.	2	143.2
8	Covered slope, same as unit 9.	58	141.2
7	Sandstone, light gray weathers light yellow gray, well cemented with calcite cement.	.5	83.2
6	Covered slope, same as unit 9.	5	82.7

5	Sandstone, orange gray to light orange brown, weathers light orange brown, poorly cemented to well cemented upward with calcite and limonite cement, graded from coarse to very fine grained upward, cross-bedded, cross-bed sets 10 cm high, eastward transport direction; forms prominent ledge.	5.8	77.7
4	Covered slope, same as unit 9.	22.5	71.9
3	Sandstone, orange gray, weathers same, fine grained, well cemented with calcite cement; forms a broken ledge.	1.4	49.4
2	Covered slope, light gray to pale orange gray soil, sandstone pebbles and limestone chips that contain plant fragments, much less carbonaceous than unit 22.	5	48
1	Covered slope, dark gray carbonaceous soil with dark gray brown limestone chips, limestone chips contain numerous plant fragments, small gastropods, and ostracodes, probably interbedded thin coal beds and gray mudstone.	43	43

Green River Formation (Section 1)

This section was measured on the prominent cuesta face west of the community of Milburn in the southwest 1/4 of section 14, T. 13 S, R. 4 E. A similar section was measured by Fograscher (1956) on the same cuesta face.

Unit	*Description*	*Unit Thickness (meters)*	*Cumulative Thickness (meters)*
32	Limestone, ostracodal, very light gray; forms ledge or steep slope.	5	150.7
31	Covered slope, numerous cobbles and boulders of algal limestone.	112	145.7
30	Limestone, very light gray, algal and ostracodal, thin to thick bedded; forms a ledge.	2.8	134.5
29	Limestone, algal, same color as above, mapped as key bed in the middle member of the Green River Formation; forms prominent ledge near the top of the cuesta.	2.7	131.7
28	Limestone, very light tan to buff, algal and ostracodal, thin to thick bedded; forms broken ledge under the prominent ledge above.	7.5	129
27	Covered slope, several cobbles and boulders of algal limestone.	11	121.5
26	Limestone, very light gray to light brown, thin to blocky bedded, fossiliferous, ostracodes, oolites, minor interbedded shale; forms slope with a few minor ledges.	5.7	110.5
25	Limestone, like unit 7 but also contains chert.	17	104.8
24	Shale, calcareous, brown to gray-green; forms a slope.	2.2	87.8
23	Limestone, very light gray, blocky, massive, numerous chert lenses.	.7	85.6
22	Shale, same as unit 9.	1.7	84.9
21	Limestone, light gray to tan, oolites and pisolites, chert lenses; forms a ledge.	.1	83.2
20	Shale, same as unit 9.	4	83.1
19	Limestone, very light gray to tan, oolitic, thin bedded, contains a thin ash bed with 5% biotite flakes; forms a weak ledge.	1	79.1
18	Shale, like unit 9 but has one or two thin ash beds and minor limestone.	17	78.1
17	Ash, dark orange gray, color banded, 1% biotite, very resistant; forms a ledge.	.5	61.1
16	Shale, same as unit 9.	11	60.6
15	Ash, like 16 but has 5% biotite flakes.	.4	49.6
14	Same as unit 9.	.8	49.2
13	Ash, same as unit 16.	.2	47.4
12	Shale, same as unit 9.	4	47.2
11	Ash, same as unit 16.	.4	43.2
10	Shale, same as unit 9.	5.5	42.8
9	Ash, dark orange gray, weathers pale yellow, graded with numerous biotite flakes in the lower part and very few at the top, becomes more resistant upward; forms a ledge.	1	37.3
8	Shale, same as unit 9.	3	36.3
7	Limestone, chalky, interbedded with green shale; forms broken ledge or slope.	.3	33.3
6	Shale, olive gray, calcareous, very fissile, very thinly bedded, contains some thin ash beds.	21	33
5	Sandstone, yellowish gray, weathers same, poorly sorted, medium grained, ashy, calcareous, cross-bedded, thin to blocky bedding, forms a ledge.	1.5	12
4	Shale, light yellow gray, calcareous; forms a shale slope.	2	10.5
3	Sandstone, same as unit 28.	3.5	8.5
2	Shale, same as unit 29.	4	5
1	Sandstone, same as unit 28.	1	1

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